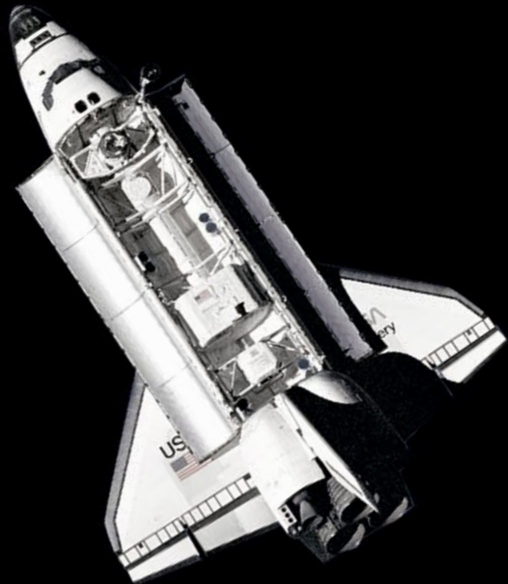

Marianne J. Dyson

A PASSION FOR SPACE

Adventures of a Pioneering Female NASA Flight Controller

Springer

PRAXIS

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This book is dedicated to the Apollo veterans and science fiction writers who inspired my passion for space, the teachers who equipped me with knowledge and faith to pursue this passion, and the men and women who continue to work behind the scenes every day to make space a place we can one day call home.

About the Author

Marianne J. Dyson was inspired by Apollo to become one of the first women flight controllers for NASA during the early space shuttle program. She has an undergraduate degree in physics and enjoys sharing her passion for space at schools, museums, and conferences. She has served as a technical reviewer for Scholastic, Enslow, National Geographic, and Hampton Brown. Her children's books have won the Society of Children's Book Writers and Illustrator's Golden Kite and the American Institute of Physics Science Writing awards and have been translated into multiple languages and excerpted for use in numerous state reading tests. A frequent contributor to *Ad Astra*, the magazine of the National Space Society, her science articles and science fiction stories for adults and children have appeared in national magazines and anthologies. She recently coauthored *Welcome to Mars* with Buzz Aldrin for National Geographic.

Preface

THE MOON LANDING, JULY 20, 1969

“Girls! Girls!” someone hollered from outside the big red barn. I was at Rambling Acres Horseback Riding Camp near Canton, Ohio. “Put your brushes away and come up to the house! They’ve landed on the Moon!”

I didn’t need a second invitation. I’d enthusiastically followed the space program since first grade, when John Glenn had orbited the Earth. I was 14 now, and I loved space even more than horses. That spring, I’d even hand printed a 60-page book, “The Apollo Program,” for my eighth-grade English class.

I dashed from the stall, latching the gate behind me, and ran up the dusty road to the camp owner’s house. “Wait up!” my best friend Chrisse France hollered as she scampered up the road behind me, followed by the other girls.

The owner, Mrs. Noll, insisted we brush dust and straw off each other’s clothes and remove our dirty shoes before entering her house. Then we filed into her living room and settled down cross-legged on the carpet, facing the television set. The TV was a box on legs about 3 ft tall with “rabbit ears” antenna. We crowded around the black and white picture.

The familiar face of CBS News anchor Walter Cronkite (1916–2009) appeared on the screen. In his deep voice, he explained that Mission Control in Houston had given Apollo 11 astronauts Neil Armstrong (1930–2012) and Buzz Aldrin (1930–) the “go” to exit their spacecraft. The men had been scheduled to sleep but were too keyed up after the exciting first landing on the Moon.

I was keyed up, too. It was the first day of camp, and I’d just met five new girls. We had plenty to talk about while we waited for the astronauts to leave the lunar lander. “Which one do you think is the cutest?” Sue asked me as we loaded our plates for dinner.

“It doesn’t matter,” I said, snatching a roll. “They’re married!”

Sue frowned and then sighed as she scooped beans onto her plate. “Wouldn’t it be dreamy to marry an astronaut?”

“Yeah,” I agreed. Then I added silently, “But even better if you could be one!”

We finished dinner, and the astronauts still hadn't emerged from their ship. We wondered what they were having for dinner. (I found out later, bacon cubes. Yuck!) [1] We trotted back to the barn for evening chores. I brushed the horse who shared my nickname, Red. Then we got our showers and returned to Mrs. Noll's house.

The television spurted static-filled voices of the crew talking with Mission Control. What was taking so long? Why didn't they just open the door and hop out? Bedtime came and went. Luckily, Mrs. Noll let us stay up for this historic occasion.

Finally, 6 h after Apollo 11 landed, the ghostly black and white "live from the Moon" image flickered on the screen. At 10:39 p.m. eastern time, Armstrong spoke the now-famous words, "That's one small step for a man, one giant leap for mankind," as he stepped backward off the ladder onto the lunar surface. I thought how I'd like to follow in his footsteps.

But in 1969, there was no such thing as an American female astronaut. No woman in my family had even gone to college. Yet, the previous winter, I'd written in my diary, "I wish very much to be able to be an astronaut. I'm sorry I'm a girl, but I'll have to try harder then."

As I gazed up at the half-full Moon that July night, I marveled that there were men up there looking back at me. If those men could walk on the Moon, then maybe a skinny red-headed girl from a small town in Ohio could find a way to go to college and one day work for NASA.

Houston, TX
March, 2015

Marianne J. Dyson

REFERENCE

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1

Space Girl Grows Up

In the book *Starman Jones* by Robert Heinlein (1907–1988), a boy wants to become an astrogator, a star navigator. "They" wouldn't train him because he was an orphan. It wasn't his fault he was an orphan. But young Jones prepares himself as much as he can. He memorizes his uncle's "astrogator" books. He takes a job as a cook on a starship. The ship gets in trouble, the astrogator dies, and because Jones has the knowledge, he becomes the astrogator (and saves them all).

I saw myself in this character. NASA wouldn't train women just because they were women. It wasn't my fault I was a girl. So I'd study astronomy and then take whatever job I could get in the space program. I'd be ready if an opportunity for an "astrogator" came my way.

Like Starman Jones, I'd to have to train myself without much help from my parents. It'd been this way since the divorce, when I was eleven.

I'd just started sixth grade. Mom swears she told me the divorce was coming, but I hadn't understood what it meant. So one day I came home from Edgefield Elementary in Canton, Ohio, and she was gone. While I was at school, she'd packed her things and moved out! I couldn't even call her—she didn't have a phone at her apartment. How could she just leave? As usual, Dad wasn't home—he left for work before I got up and came home late most nights.

But I wasn't alone. My brother Tommy, who had just started college at Kent State University, met me at the door. He told me not to worry. I'd see Mom again, just not at home. He noted that our brother Jeff, a high school freshman who had football practice after school, was also staying with Dad. I'd be okay. I nodded mutely and then went for a walk with questions scrolling through my mind. Who was going to make dinner? Who would pack my lunch and iron my dresses? Who would fix my hair and help me with homework? Who would answer my questions about boys!

Like Starman Jones, I was on my own. In these days before microwave ovens and prepared/packaged foods, I cooked dinner on the stove or baked it in the oven. Then I cleaned up afterwards. (We didn't have a dishwasher.) If I wanted my dress washed and pressed (we didn't have permanent press, and girls weren't allowed to wear pants to school), I did laundry and then ironed everything. I'd always cleaned my small bedroom, but now I also cleaned the bathrooms and the kitchen.

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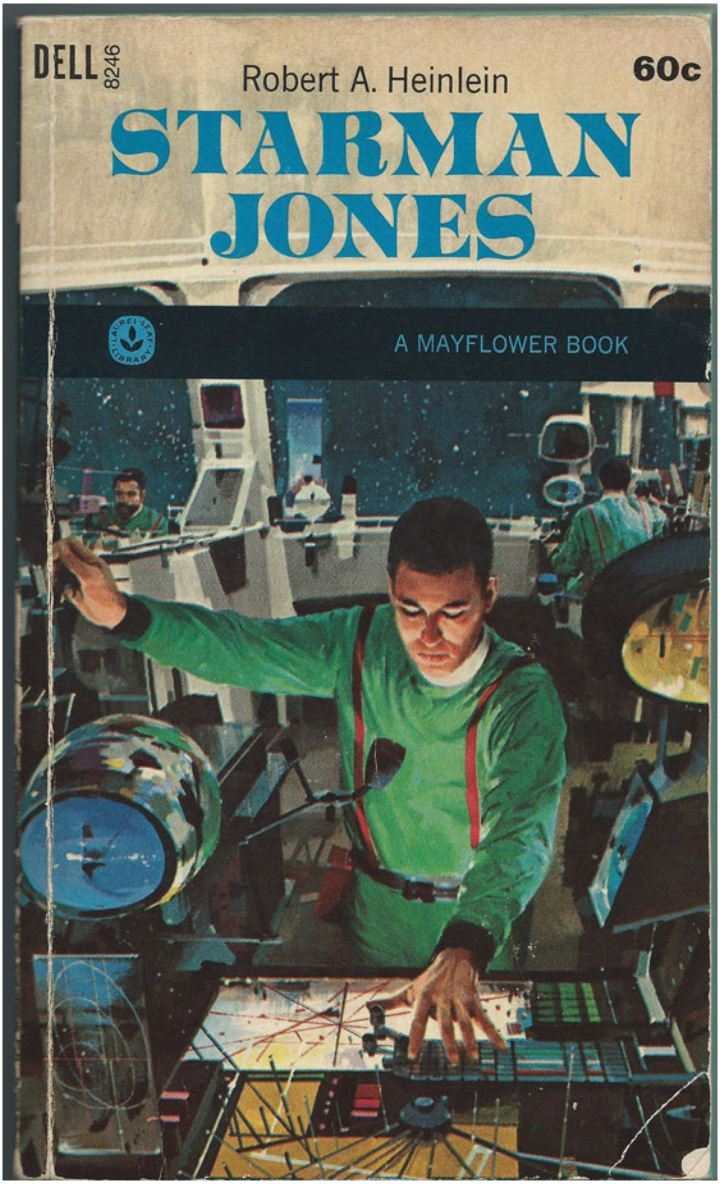


1.1 *Starman Jones* by Robert Heinlein inspired me to want to become an "astrogator." (Cover by Berkey, © Dell Publishing, 1967)

Even though I didn't want to do these "grown-up" things, at least I knew how. Mom had taught me well. I remember one night when Dad came home early and valiantly tried to make hamburgers for dinner. He got the stove too hot and filled the house with smoke. That won us a treat—dinner at McDonald's! On the weekends, we'd make dinner together. It was kind of nice to actually talk to my father about what I was doing at school while he and I made a batch of stew, and I baked snicker-doodle cookies for dessert.

I didn't talk about the divorce at school. I was embarrassed. My family was a failure, and I assumed I was at least partially to blame. I didn't know any other children whose parents were divorced. Other kids' parents were happy, like Ozzie and Harriet on TV, or so I assumed. My school didn't have a counselor, and we didn't attend church. So I just went on with my life, pretending as if nothing had changed. I dropped out of Girl Scouts because "it wasn't fun anymore," not because I didn't have time or a mother to drive me.

But I was angry. I wrote in my diary that I'd never forgive my parents for what they'd done to me.

My mother remarried the following year. She had met John (Jack) Wildey (1929–2001) at the Canton Player's Guild. I'd spent almost every weekend at the theater with her and my friend Chrisse, playing games with the props. My brothers both starred in productions, and I helped out backstage.

Surprisingly, my shy father (Tom R. Jakmides, 1922–2003) also remarried about a year later. A World War II veteran (he was a Lt. Col. in the army), he worked on military contracts for Goodyear Aerospace in Akron, Ohio, and often traveled to Washington, D.C., on business. On one trip, he met Donna Wolfe at a party.

I'd been "on my own" for almost a year when Donna moved in just before school started in 1967. I'd expected her, being the woman of the house now, to take over my chores. But Donna taught school and expected me to "do my share." She did take over dinner—but she was a worse cook than Dad! Why had Dad married her?

Within a year, Donna was pregnant. My mother was finished having kids—she was 38 when she and Dad divorced. He was 45. But Donna was only 29 when she married Dad.

Donna quit work after Carolyn was born in 1969, five months before *Apollo 11*. With Donna home more, she and I argued constantly about use of the phone (there was only one and no call waiting), noise (don't wake up the baby!), pets (the cats weren't allowed in the house), cleaning (why is it my job to wash your dishes?), etc. Donna and I were both happiest when I spent school breaks with Mom and Jack. After Mom moved to Johnstown, Pennsylvania, my freshman year, Jack invited me to move in with them. But I didn't want to change schools.

Not that I had many friends at Glenwood High School. My brother Jeff, who was a football player and quite popular with the girls, asked me why boys weren't calling for dates. "You're not even ugly," he noted. I joked that I was too smart for the boys my age. Girls weren't supposed to be good at math, and I actually liked math. I got A's in almost everything. Boys were uncomfortable around smart girls, and especially me, ever since the fourth grade.

When I was in fourth grade, the Plain Local School District administered an IQ test. The test was to identify children for enrollment in an experimental gifted program.

As far as anyone at Edgefield Elementary knew, Marianne Jakmides was just another somewhat above-average student. I'd noticed that getting all A's didn't win me any friends. So I didn't apply myself. When my social studies grade slipped to a D, Mom said I could do better. But no one seemed terribly upset.

A few weeks after the IQ test, one of the boys found out that our teacher had the results. "Mrs. Wolf! Tell us who's the smartest! Who has the highest IQ?" They bugged her all morning. She told them the results were secret. After recess, the boys badgered her even more aggressively until she said, “Well, I suppose it’d be okay to tell you who got the highest score.” She glanced in my direction. “The highest score in the fourth grade was Marianne Jakmides!”

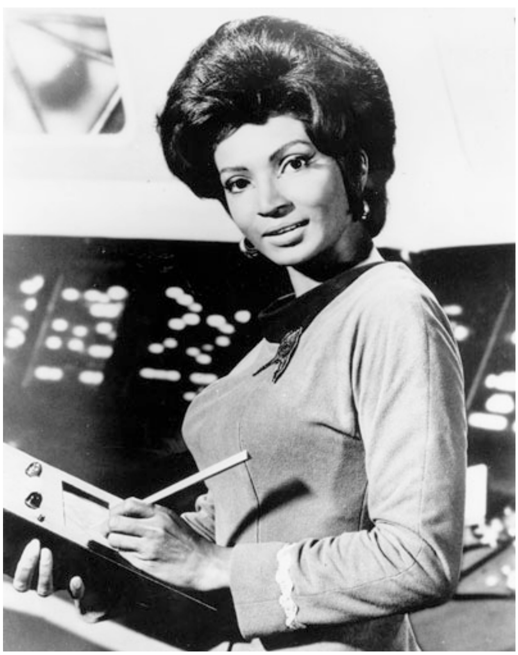
“No way a girl is smartest!” the boys insisted. “Who’s really the smartest?” Mrs. Wolf added that Tom M. had the highest score of all the boys.”

While being labeled “smarty pants” didn’t help my popularity, knowing that others thought I might have the “right stuff” did help me think that I could emulate Starman Jones.

As a result of the test, I was placed in a special class of about 30 students in seventh grade at Taft Junior High. We covered material at a faster pace than all the other classes. My 7th grade science teacher, Mr. Brady, even let me do experiments. In ninth grade, I tested the burning properties of a bunch of fabrics and won the Taft science fair. My 9th grade science teacher (Mr. Zeigler) then asked me to take a science aptitude test. I got a top score.

At Glenwood High School, I got A’s in algebra, trig, and geometry. I learned a little about these new devices called computers. I got A’s in biology and chemistry. I noted that astronauts needed leadership experience, so I got elected to Student Council. I was inducted into the National Honor Society as a junior. But despite my stellar academic performance, no teacher or counselor suggested I consider a career in science, or any career at all.

I didn’t know who to talk to about my dream of working for the space program. I’d never met a female scientist. My role model was fictional: Lt. Uhuru (played by Nichelle Nicols) on Star Trek. Maybe I could be the communications officer on the bridge of a starship!



1.2 Lt. Uhuru on Star Trek (played by Nichelle Nichols) was my role model (NASA photo)

When I asked the counselors for advice on how to prepare for a job at NASA, they didn't take me seriously. They suggested bookkeeping, shorthand, and typing. Starman Jones had been a cook. Maybe my way in would be as a secretary? I made sure to get an A in Office Skills.

I tried to follow the rest of the Apollo missions to the Moon, but football was more in the news than space in Canton, Ohio, the home of the Football Hall of Fame. I did hear about *Apollo 13*'s emergency, though. I loved how the men in Mission Control had used their knowledge of spacecraft to find a way to rescue the astronauts. If women couldn't be astronauts, maybe I could be part of the team that solved problems for them? That would be a cool job!

I was thrilled when Dad brought home posters of Neil Armstrong and Buzz Aldrin on the Moon. They went up on my wall near the poster of Peter Tork (1942–) of The Monkees.

Life at home got a bit complicated my sophomore year. Not only was there a new baby in the house, but my Dad's mother, Grandma (Eunice, "Jackie") Jakmides, moved in with us.

Grandma told stories about growing up in Alabama with her brothers who were railroad men. One of them was a redhead, which explained how I got my red hair even though my father looked like his Greek father. She and I both loved horses. She talked about how she broke her arm falling off a horse as a teenager. As soon as she healed up, she'd gotten right back on that horse and promptly broken the same arm again! We laughed about being stubborn ladies who didn't give up. I told her I wouldn't give up on going to college and working for NASA.

Grandma Jakmides died of heart failure just after my 16th birthday on January 2, 1971. Without her as a confidant and buffer, Donna and I argued constantly, mostly about the new house she and Dad had bought. "We're moving? But I don't want to move! Will there be any money left for me to go to college? You're getting a sheep dog?"

Mom thought if I moved in with her, Dad wouldn't pay for my college. She urged me to tough it out. That's what Starman Jones would do. It was only for two more years. But I was anxious to gallop away.

Many nights, I'd wait until everyone was asleep, climb out a window, and walk to calm my nerves. One February night after yet another argument with Donna, I thought I'd just keep on walking. Why should I go back? They'd be happier with me gone. The snow pelted my old coat, and my hands were cold despite the mittens jammed into my pockets. I could walk to the bus station and buy a ticket with my babysitting money. Let them wonder where I'd gone, beg me to come home. But what about school? If I dropped out, I'd never work for the space program.

I walked to a favorite spot—a clearing on top of a hill in a nearby cemetery. Perhaps I should've been afraid, a teenage girl alone at night, but I wasn't.

I directed my conversations toward the star Sirius in the Constellation Canis Major. Sirius is the brightest star in the sky, so since I'd first spotted it by standing on my bed as a little child, I'd assumed God lived there. I imagined that its twinkling light was a kind of code that I'd understand once I became an astronomer.

Although I'd said prayers every night as part of my bedtime "ritual," we didn't belong to or attend any church. My mother held a grudge against the Church for not helping her as a teenager. My father had distanced himself from his Greek Orthodox heritage (his father arrived on Ellis Island, NY as a teenager) to avoid the "immigrant" stigma while growing up.

I joined a Presbyterian church on my own in 7th grade. The father of one of my friends was the pastor. I took the bus after school to her house, and we went together every Wednesday. But after she moved, I didn't have a way to get there. So church for me was reading the Bible that Grandma Jakmides had given me. I'd read it cover to cover several times, but I still didn't know what to do about Donna, the move, or boys.

As I stood there on the hill on that cold snowy night, I asked God to show me what to do. Sirius winked and blinked in the cold night air. I felt that God had a plan for me. Running away wasn't the answer. I went home determined to "tough it out."

Soon after, in drivers' education class, I met a hippie carrying a Bible. He'd been to Woodstock the year before—"the" music festival of my generation. Mike Covert was part of a new movement called the Jesus People. We took walks in the park and talked about life, love, and the universe. My new "church" was a picnic table where me, Mike, "brother" Scott Holland and some others read the Bible and discussed it.

Those years of fellowship and independent study kindled my faith in a God that would always be there for me even when friends and family weren't.

But I kept my guardian angel busy! In the fall of my senior year, my boyfriend Jay H. and I went bareback riding. The gelding I was riding took off for a fence that I assumed he planned to jump. The horse totally ignored the attempts by this 95-pound girl to turn or slow him down. Rather than risk being impaled on a fence post, I decided to do a controlled fall the way I'd been trained. I slid down his leg and went into a spin, but WHAM and WHAM again, I hit that packed dirt road like a suitcase dropped from an overpass.

Afterwards, I couldn't move my legs. My left ring finger was bent sideways. Jay carried me to a nearby shelter and got the car. He met my father for the first time at the emergency room. My back was "merely" sprained.

By January, I felt fine except for this growing lump on my tailbone. I mentioned it to my doctor. He took one look and scheduled me for surgery to "have my tail removed." He said if the cyst on my tail bone burst, I'd be paralyzed. Yikes!

I had the surgery and missed a month of school. I remember lying in bed listening to Rod Stewart's song, "Maggie," and thinking yes, it really was "time to be back at school!"

I graduated from Glenwood High School 19th out of a class of 400 in 1973. My friend Marilyn DiMaio and I decided to be roommates at Ohio University (OU) in Athens, Ohio. I declared myself a math major. Marilyn chose French. We parted for our summer jobs. I went to Charlotte, North Carolina, where Mom and Jack had moved that spring.

OHIO UNIVERSITY

The week before I was to report to OU, I discovered that my tuition and board hadn't been paid. I called my father. "I'm sorry honey, but I don't have any money for you," he said. What! I asked him why not. He noted that my brother Jeff was in college, too. I knew Dad considered it more important for my brother, being a man, to get a college degree than it was for me. But why hadn't he warned me? Had I toughed it out with Donna for nothing?

I sat in my mom's kitchen staring at the phone in shock, my dreams of becoming an astronomer as impossible as the warp drive on the Starship Enterprise. My summer job at

Carowinds had only netted enough money for bus fare and textbooks. What was I going to do?

That night at dinner as I picked at my food, my stepfather Jack put his hand over mine and said "Your mother and I are going to pay your tuition." It was the second shock of the day. Jack, a title lawyer, had been laid off the week before, a victim of a recession in the construction industry. They'd sunk all their money into the new house and had almost no savings. Without a job, Jack couldn't afford the mortgage payments. He wasn't just giving me some money. He was giving me all he had. He insisted I accept it. "You are my daughter, and I want you to have it," he said. Not his wife's daughter, or his stepdaughter, his daughter. Whatever else Jack may have done right or wrong in his life, in that moment, he changed mine forever.

The dorm room was barely big enough for twin beds. The bathroom and showers were shared with the rest of the floor. But Marilyn and I loved it. I was on my way to the stars!

To help with the next quarter's tuition, I took a job at the OU Music Library. I played guitar at a local coffee house for tips. I set that money aside to buy a banjo kit that I built myself that spring. A banjo picker gave me lessons in exchange for pottery I made in ceramics class.

But like a lot of freshman, I had difficulty adjusting to college life. I'd never had to study in high school, and I'd signed up for astronomy, calculus, French, philosophy, and literature courses that all required a lot of homework. The Latin I'd taken in high school didn't help me at all with French. I got a tutor and managed to eke out a C with help from Marilyn.

I got A's and B's in my other courses, despite misunderstanding that calculus—which I was taking at the same time—was a prerequisite for astronomy. When Dr. Godecke learned of my ambition to become an astronomer, he worked with my calculus professor, Dr. Denbow, to prepare tests for me that only required the calculus I'd had so far. Years later, when I joined NASA, I wrote him a letter thanking him for the opportunity to be in his class. Thanks to him, I saw Comet Kohoutek that spring and considered it a good omen for my future.

But calculus was a struggle. All through high school, I'd been in an experimental math program that was self-paced and self-taught—we took tests every six weeks to show our progress. I'd gotten used to spending as much time as I wanted on a topic before taking a test. Unfortunately, college required me to learn on a schedule. So I fell behind my second quarter, with my B slipping to a C in calculus. Dr. Denbow took a look at my course load, and the fact I had a job in the library, and suggested I replace the last quarter of astronomy with something less taxing. So I signed up for voice lessons (which I'm sure the coffee house regulars appreciated!). My math grade improved, and I made the Dean's list.

By the end of the year, it was clear that I couldn't stay at OU. The college required freshman and sophomores to live on campus. Jack now had a minimum wage job. They'd sold their house in Charlotte and moved into an apartment in Chapel Hill, NC. Mom had gone to work, too. They'd paid my tuition and board for my entire freshman year. But their savings were gone. Even if I worked all summer and saved every penny, it wouldn't be enough. The school said I didn't qualify for college aid because my father made too much money. It didn't matter that he wasn't spending it on me.

Mom suggested I apply to the University of North Carolina and live with them. So I sent an application. With my good grades, I was sure they'd accept me.

Before I left for North Carolina, I decided to visit my brother Tommy, who had married his girlfriend from Kent and settled in California. He and Martine were expecting their first child in June. I found a ride off a bulletin board and planned a trip to San Francisco.

My next-to-last weekend at OU, a friend begged me to go for a ride on his motorcycle. I'd told him no all year, because a high school friend had lost a leg in an accident. But he made the case that the weather was perfect, the country roads deserted, and he'd not go faster than 30 mph. I gave in. The rolling hills around Athens were just as beautiful in the moonlight as he'd said. But at the bottom of a hill, the bike slid sideways on loose gravel. The bike tipped and slammed me to the ground. My foot was crushed under its weight.

CLOSE ENCOUNTERS

With a cast to the knee, I caught a ride to California. The driver was a nice Irish exchange student named Gilbert who wanted to see America. But the other two passengers were rather suspicious-looking. One had a black eye, and the other was sick and pasty-looking. The former, John Wilhelm, said he'd gotten the shiner at a graduation party—he'd just earned his degree in business. The latter was actually going through heroin withdrawal. By the time we reached Colorado, he confessed to being an escaped convict, too.

The car was an old junker, and the Rocky Mountains proved too much for it. The engine overheated and quit. Stranded by the side of the road between Boulder and Estes Park, a stranger picked us up and let us spend the night in his cabin. Worried about our addict companion, I snuggled up with John. By the time we got to San Francisco, he was talking about coming to North Carolina, and I was encouraging him.

I stayed in California a few weeks, visiting my brother and my newborn nephew, Patrick. A doctor in Berkeley removed my cast and then told me I needed another cast. I didn't have any money or insurance. So the doctor handed me some crutches and said to stay off the foot for three weeks. I made a little "sympathy" cash playing my banjo on the street corner that week.

To get to North Carolina, I posted a "Ride Wanted" note on a bulletin board at Berkeley. A banjo picker offered me a ride as far as Nashville. A high school friend, Jeff Neuwirth, had shown up in Berkeley while I was there, and gave me the number of a friend named Dan to stay with in Nashville.

I'd never been to Nashville, so I asked Dan to drop me off at a famous place called the Pickin Parlor while he went to work. A man there asked if I wanted to see how they made banjos. "Yes!" I replied. I wanted to improve the one I'd built. After seeing how they did fancy inlays and stretched the drums, he offered to show me the recording studio. I was so interested in the equipment that I didn't realize he'd locked the door. He spun me around with a smile on his face. "Don't worry girl, you can scream all you want. This place is completely sound proof!"

If this were "Star Trek," Capt. Kirk would come to rescue me. But this was the real world, and I needed to rescue myself. A friend had told me that nothing turned a guy off faster than a woman crying. So I turned on the tears. I told him how I was a Christian and saving myself for my husband. He ran his hands over me and said a Christian girl wouldn't dress like a "hussy," making a man all crazy. In my head, I realized he had a point—I was wearing white shorts and a blue halter top. I looked down at myself and shook my head like I'd never noticed my body before. "I'm so sorry!" I sobbed. "It's real hot out today, and I, well, I didn't think. I'm just a dumb teenager!" My heart was about to pound out of my chest.

"How old are you girl?"

"Seventeen!" I lied. I probably looked even younger. I was actually 19.

"Oh Jesus," he cursed. He pushed me away. "Don't you be coming 'round here again!" he shouted. He stalked out and left the door open.

Shaken, but thankfully in one piece, I rushed out to the nearest phone booth and called Dan. He speculated that a lot of women went there to court favor from the staff to land a singing gig at the parlor. The guy probably mistook me for just another groupie. I winced. If I wanted NASA to take me seriously, I'd better learn how to dress.

I'd had enough adventure for one summer. I called Mom. She lectured me about how dumb it was to be hitchhiking across the country. She bought me a ticket on a Greyhound bus.

UNIVERSITY OF NORTH CAROLINA

When I arrived at Mom and Jack's, I found a letter from UNC saying that they didn't accept transfer students. But my academics qualified me to be admitted to one of the branch colleges. The nearest one was UNC-Greensboro, formerly Greensboro Women's College. Could I find a cheap apartment within bike distance of campus? A part-time job? Mom promised to help with food and clothes, and Dad had sent me his "poker winnings" to cover a rent deposit.

We arrived at the registration office. The counselor said that not all my credits from OU would transfer. But I could still graduate in three years if I attended summer school. That sounded okay. We just had to pay tuition and fees. My mother paled at the sight of the bill. It was more than I'd paid at OU for both tuition and room and board!

The counselor explained that I was an out-of-state student because my father lived in Ohio. Mom explained that she and my stepfather had been residents for two years and that I lived with them except for when I was at school. But the counselor said that IRS records showed my father had claimed me as a dependent on his taxes. That made me an Ohio resident.

"But my father didn't support me!" I declared. "He said he was going to pay for my college, but he didn't!" Tears rolled down my cheeks. My college dreams were once again shattering. Mom was angry. She said I moved to North Carolina with her—that I had worked at Carowinds the summer before my freshman year, and that she paid my tuition at OU. Wasn't that proof enough for residency? The counselor asked us to wait while she talked to her supervisor.

As we waited, Mom assured me that we'd figure it out. I could live with them and get a job while I established residency. But I sensed her deep worry that if I interrupted my education, I'd never finish. I didn't know it then, but she hadn't finished high school because she'd gotten pregnant. She knew that once I dropped out, it'd be a struggle to go back and finish.

The counselor returned and said the rules weren't intended to make things harder for children of divorced parents. The registrar agreed that it'd be a shame for me to drop out because of custody issues that I had no control over. So they'd admit me as an in-state student!

I found a job selling cigars and making sausage biscuits at the breakfast counter of an Eckerds' drug store. I reminded myself that Starman Jones had been a cook. It was honest work while I prepared for my future job as an astronomer/astrogator. For $65 per month (about $325 in 2014), I rented an apartment in a poor neighborhood—no air conditioning, no screens on the windows, no ceiling fans, no carpet, and enough mice to cover the meatloaf keeping warm in the oven. Yuk!

To help with the mice, I adopted a wild gray tabby kitten (who had been hiding under the building) and named him Lenny.

With minimum wage at $2.00 an hour (equal to $10 in 2014), I had to work almost full time for me and Lenny to live in that dump. I was often awakened by flashing lights as the police came to question the local drug dealer upstairs. One morning I heard a crash and squeal and discovered an irate squirrel had fallen through the ceiling and was tearing up my bathroom. Too much of a challenge for Lenny, he and I waited outside until the squirrel found its way out through the living room window (which had no screen). But living in the slum was okay as long as I was back on the road to space!

Dr. Godeke at OU had advised me to major in physics and go to graduate school in astronomy. So, I changed my major to physics, without ever having taken a physics course.

1.3 I transferred from OU to UNC-Greensboro and became a physics major without ever having taken a physics course (Photo by the author)

Despite UNCG being mostly a women's college, I was the only woman in the Physics Department. I quickly made friends with two other physics students, Tom Alspaugh and

Tom Burkhalter. They both became good friends and study partners, but not boyfriends. I'd "imported" a boyfriend from OU—John Wilhelm, the man I'd met on my trip to California.

John's parents were well-to-do members of Baltimore society, and practically disowned him when he moved to North Carolina. When I lost my roommate in the middle of the semester, John paid her share of the rent—and moved in. In their eyes, I was now a "white trash tramp" who had corrupted their son. (They warmed to me after they met me in person.)

That first physics course at UNCG was a revelation. Dr. Clifton "Bob" Clark taught me about a world of light and heat and sound that I hadn't noticed before. The leaf falling off the tree was slowed by air pressure. A candle burning converts matter into light and heat.

Unfortunately, like calculus the year before, I got a C in that first physics course. Dr. Clark called me to his office. "Are you sure you want to major in physics?" I explained about my dreams of being an astronomer. "Well," he said, "if you're going to be a physics major, you're going to have to do better than a C." Uh oh. He was head of the Physics Department. He could end my career before it really got started.

However, he had no intention of doing that. He wanted to help. He suggested that I get some practical, hands-on experience with science. Sample problems in the books assumed student familiarity with gears, motors, belts, and axles—things male students easily imagined. They'd taken machine shop, worked with tools, played sports, and helped their fathers repair cars and appliances all their lives. I'd never even put gas in my father's car. Male gas attendants did that!

Dr. Clark therefore recommended I join the local astronomy club and build a telescope. He signed me up for electronics and optics lab courses. With help from Dr. Gerald Meisner, we started a chapter of Sigma Pi Sigma, the Society of Physics Students, and built a windmill. Dr. Gaylord Hageseth had me interpret bubble-chamber photos to determine which charged particles had been produced by various interactions. I had a blast! I became the secretary of the Greensboro Astronomy Club and even appeared on local television. Hands-on was the answer for me. Physics wasn't an abstract science—it was how the world and everything in it moved. My physics grades rose to B's and then to A's.

To add to my practical skills, I participated in some ground-breaking vision research in the Psychology Department that led to my first scientific paper, "A Pilot Study on Classification of Two Attended Stimuli," about the brain's response to shapes while the person is or isn't paying attention to them. Even though it was never published, my professor praised the work and gave me credit as part of my grade. I felt like a real scientist.

By sharing a house with six other women my junior year, I reduced my rent. I also earned more per hour by working for Big Star grocery, a union store. As long as I paid my dues and attended the AFLCIO meetings, I got good hours and all the day-old bread, bruised fruit, and dented canned goods I wanted. But it was a far cry from the bridge of the starship *Enterprise*.

My grades were good, but I knew I could do better if I had more time to study. I wanted my grad school applications to win me a scholarship. I asked Dad if he'd pay my tuition for the spring semester. He said he'd been lucky at poker, and sent me about half the money I needed. It was enough for me to cut my work hours in half. I got all A's that semester.

1.4 My boyfriend John took me on my first tour of the Smithsonian Air and Space Museum. I wanted to ride on Polaris like Tom Corbett of the Space Cadets! (Photo by the author)

John finally gave in to his parents and took a "respectable" job in D.C. So the summer before my senior year, I took a job as a counselor for autistic children at a camp in nearby Maryland. The children were part of a psychological study to see if behaviors learned in a structured setting would hold up in an unstructured camp environment. I had to remember to always put the toothpaste and brush in the same location, to help them dress in a certain order. This job was actually good training for writing procedures for astronauts!

Soon, the summer of 1976 ended. To keep me company back at school, John bought me the best gift ever—a Persian kitten. Jasper Kitty was my companion for the next nine years.

In May 1977, I graduated cum laude with a degree in physics and minors in math and psychology. Even better, I'd received a fellowship from Rice University's Space Physics and Astronomy Department in Houston, Texas.

CONGRESSIONAL INTERN

Immediately after graduation, Jasper Kitty and I moved in with a childhood friend of mine, Leslie Schworm, in Washington, D.C. I'd been selected for an amazing summer job.

I was an LBJ (Lyndon Baines Johnson) Congressional Intern for the Honorable Ralph Regula (R-Ohio, 1924–). He was on the powerful House Appropriations Committee (which he later chaired). He and his wife Mary treated me like a princess, inviting me to dinner in their home and arranging for me to meet my Ohio senator and childhood space hero, John Glenn. I had tea with him and his wife Annie at the Senator's office. He kindly signed a photo for me.

1.5 I worked for Congressman Ralph Regula as an LBJ Congressional Intern in the summer of 1977 (Photo by the author)

I reported to the Longworth House Office Building each day and then attended hearings of an energy bill working its way through Congress. I read about the pros and cons of nuclear power and other sources of energy in the Library of Congress, the most awe-inspiring place I'd ever been. Congressman Regula praised my research. One of the most exciting proposals for alternative energy was solar-powered satellites (SPS), championed by Princeton professor Dr. Gerard K. O'Neill (1927–1992). He suggested gathering solar energy in space, where the Sun never sets, and beaming it to "rectennas" on the Earth. While I was discussing SPS with other interns, I was recruited to join a new organization called the L-5 Society. L-5 embraced O'Neill's ideas and planned to build colonies in space. (L-5 is one of five Earth-Moon semi-stable orbital Lagrange points.) This organization later became the National Space Society. I'd later serve on its board of directors.

I also accompanied Mr. Regula to meetings of the Appropriations Committee. I watched in fascination as deals for millions of dollars were made with a smile and a handshake in the hall. I met a subdued Dr. Robert Frosch (1928–), who was confirmed as NASA Administrator that June, in the elevator after his Senate grilling. Little did I know I'd be working for him in just a few years. One thing I knew already, I'd come a long way from being "white trash." My work as an intern had even warranted a headline in the Canton paper.

While in D.C., John and I resumed dating. At the end of the summer, John, Jasper Kitty, and I took a car trip to his aunt's cabin in Wyoming. He'd graduated, had a good job, and was ready to get married. But I didn't share his love of business or sports, and he didn't share my passion for space or science. Was there someone out there who would be as loving and kind as John, yet not need me to explain why "Beware of quantum ducks: quark quark" was funny?

2

Welcome to Houston

Jasper Kitty and I spent our first night in Houston in a high rise penthouse courtesy of my ride's family (James C. was a fellow intern in D.C.). The guest room, in pink and white complete with canopy bed, looked like something out of a *Better Homes and Gardens* magazine. I'd never seen a bathroom so clean and perfect. Even the soap matched the towels and washcloths. I felt as if I were desecrating a monument when I put Jasper's litter box in the tub.

My taste of the high life, however, was short lived. My cousin Mike Cary helped me find a place that I could afford on my stipend from Rice. The efficiency I rented was in a complex on Richmond Avenue. I wrote, "I've covered the dirty carpet with newspapers so I don't have to look at it!" But the complex had a pool—something that felt like a luxury even though one of the other tenants called it a "cow trough."

I soon met my fellow grad students at Rice. I wrote, "My course selections look daunting: electromagnetism, classical mechanics, planetary atmospheres, introduction to astrophysics, and lab. The only bright light so far is that I may be able to teach an astronomy lab instead of a physics lab. . . I feel insecure in my abilities. I've come on like Miss Confidence without knowing anything. Anything? Well, I must know some. . . . I don't think I ever realized how really difficult this school is until today. I can feel fear inside and rumblings of excitement, too. I wonder if I'll really fit in?"

NASA announced they were hiring astronauts for the upcoming space shuttle program. I wrote, "I know I'm really not qualified yet. It gives me a goal to keep my motivation up."

Motivation was not going to be enough, though. Although I'd graduated with a 3.5 GPA, I'd soon discover huge holes in my prerequisites. For example, I'd taken an undergraduate course in electromagnetism (a.k.a. E&M), but it hadn't been as mathematically rigorous as the courses at schools like Rice or CalTech. I didn't understand what was wrong. I thought that perhaps I'd just not paid enough attention in my undergraduate courses.

After the first week of class, I wrote, "Yesterday I was very discouraged, feeling like I could never possibly plow through all those god-awful equations in Jackson's [textbook for E&M]. [Fellow student] 'N' didn't help by bragging about his mathematical expertise, making me feel more and more like I shouldn't be in graduate school. I finished the first chapter after many hours, and read about Green's functions and delta functions in the library this morning."

M.J. Dyson, *A Passion for Space*, Springer Praxis Books,
DOI 10.1007/978-3-319-20258-7_2

2.1 Would I fit in at Rice University in Houston Texas? (Photo by the author)

Several weeks into the semester, I admitted to my E&M professor that I was having trouble. On September 13, 1977, I wrote, “I discussed E&M with Dr. [Ian] Duck this morning and my perspective was greatly altered by it. I have never seen Fourier series, though he explained to me that the idea is you can expand any function in terms of sines and cosines. . .. Anyhow, this is all very well and good, but having never seen this before, I was very upset to hear that everyone else had. Dr. Duck bluntly and honestly told me that I could not survive this course. I feel so *stupid*!”

The department allowed me to postpone E&M until the next semester. Instead, I took a graduate course on the Solar System taught by Dr. Chamberlain, and an undergraduate senior course in quantum mechanics. Quantum mechanics, under the expert instruction of Dr. Ronald Stebbings, became a favorite course—one that opened my eyes to the beauty of how light comes in packets of distinct sizes that correspond to the energy levels in atoms. With this knowledge, astronomers were unlocking the secrets of stars and the very mysterious quasars.

That September, NASA announced the selection of the first women astronauts: Anna Fisher (1949–), Shannon Lucid (1943–), Judith Resnik (1949–1986), Sally Ride (1951–2012), Rhea Seddon (1947–), and Kathryn Sullivan (1951–) from among some 8000 applicants. I noted that all these women had Ph.D.s or M.D.s. Sally Ride’s boyfriend, Bill Colson, took a temporary job at Rice. I met them both at a party. She didn’t seem that different from me. Maybe someday I, too, could be an astronaut!

2.2 The first six women astronauts selected in 1977. *Left* to *Right*: Rhea Seddon, Kathy Sullivan, Judy Resnick, Sally Ride, Anna Fisher, and Shannon Lucid (NASA photo)

Women were totally outnumbered by men in the Space Physics Department. There were only two of us, me and Anthea Coster. The Physics Department, which shared a lot of classes with us, had none. All the professors were male except for one post doc, Patricia Reiff (who became a Rice professor). But at age 22, this wasn't a bad thing! I was surrounded by brilliant young single men from all over the world. And I'd soon find just the right one for me.

PHYSICISTS IN VALHALLA

The social scene consisted mostly of the Rice grad student bar—a dark cave with sticky floors and animal heads on the walls set under the stairs of the Chemistry Building. This bar is named Valhalla after the Nordic heaven where the bravest warriors lived forever.

I signed up as a bartender and got paid all the cheap beer I wanted. The bar manager was a physics grad student introduced to me as Thor. He explained that his name was actually Thornton. When he'd filled out his health certificate, the previous manager, a post doc, John Schroeter (1948–2006), immediately nicknamed him Thor. But he also went by Ted since his initials were T.E.D.

2.3 When I met Thor, he was manager of Valhalla, the graduate student bar at Rice (Photo by the author)

Thor and I were both members of the L-5 Society and fans of Gerard O'Neill's solar-powered satellites. The Society was cosponsoring a conference (with the American Astronautical Society) on the Industrialization of Space in San Francisco in mid-October. We decided to go. I wrote in my journal, "I'm excited about first the ride with Thor, then seeing [brother] Tom and California again besides the conference on space. I feel like a physicist tonight reading Quantum Mechanics . . . Anyhow, I've seen a lot of Thor this week. He came over and we walked Jasper at Dunlavy Park. He put his arm around me when I said I was cold, but he hasn't tried to kiss me yet. It's fun for me to take it slowly and wonder what he's thinking. . . . I'm excited like I always am before a new adventure. And I wonder who will be the main characters in this one, and how it will affect me in time?"

Another couple joined us, and we drove Thor's Plymouth Satellite and talked, and drove, and drove some more. Thor and I discussed everything from Star Wars to stellar spectra. I wrote, "I asked [Thor] if he had a girlfriend back in Houston, and he said, 'No, but I think I will now.' I feel so ALIVE. Here we go, a couple of physicists to a conference on our future in space."

Dr. Gerard O'Neill and Thomas A. Heppenheimer (1947–) were some of the visionaries who spoke at this conference, both emphasizing the role of space solar power in the future industrialization of space. We expected to be part of the workforce that would build this civilization in the next dozen years. Thor got an autographed copy of O'Neill's book, *The High Frontier*.

By the end of the week, I called my friend Tom Burkhalter from the conference, forgetting it was 4 a.m. in North Carolina, to say "I've met the man I'm going to marry!"

I wrote in my diary, "I feel so enchantingly ecstatically pleased that I cannot sleep. Is it really true? Have we finally been brought together? . . . Wow Lord, I'm still afraid to believe it's the real thing!"

My personal life was going great, and I was passing all my courses. I really enjoyed teaching astronomy lab—though I probably learned more from the undergraduates than they did from me. One senior kindly taught me how to develop film in the dark room. I took some photos of the Moon, developed them, and proudly sent a print to my mother. Here was tangible evidence that I was finally becoming an astronomer.

In November, Rice held a "Cosmo Chemistry" conference that included several famous astrophysicists, Fred Hoyle (1915–2001, who coined the term, "Big Bang"), and William Fowler (1911–1995, who published, with Hoyle, the "Synthesis of Elements"). Strangely, I didn't find their talks nearly as engaging as the ones at the space industrialization conference. Would I be happier operating spacecraft than analyzing spectra?

As Thor and I continued dating, I thought about how marriage and children could or should alter my career plans. Considering that the average time to get a Ph.D. at Rice was six years (it took Anthea that long), I'd be 29 by the time I graduated. I wrote, "I think I'll quit with a masters 'cause I want to have my children soon. Soon—3 years? Can I go into orbit with a baby? I realize the career ambitions are detrimental to having kids, but the drive is strong in me to be a mother. I keep telling myself to wait wait wait. I'm so impatient. . . . Basically, I want kids, I want my degree, I want money to live nicely, and someone to live with." I wanted it all.

In December one of my fellow grad students, Humberto Campins (who later became a professor in Florida doing research on asteroids), transferred to the University of Arizona. "There's an opening for you if you want it," he said.

I wrote, "It sounds like the perfect place for me there in the Lunar Sciences Department. What if I got accepted, then what? I don't mind leaving Rice especially, but Thor. I don't want to have to start all over again, and I like him so much."

I decided to give Rice, and Thor, at least another semester.

I had to choose a research project for the summer when my fellowship expired. Dr. Stebbings asked me if I wanted to join his group. I loved his class, and I was very tempted. But particle physics didn't have much application to space. On January 9, 1978, I made my choice. "I talked to Dr. [John] Freeman for nearly three hours and decided to work for him on space solar power satellites. I hope I've made the right decision. Looks like I'll be tackling an E&M problem [spacecraft charging effects] after all—the very thing I feel least confident about. I need to overcome my fears in that subject anyhow because I know it is one of the most fundamental and fascinating. I hope I don't lose my motivation through the 302 [E&M] course I must take now."

Again, motivation was no substitute for knowledge. Ten days later, I wrote, "I was real embarrassed today in E&M. I volunteered to do a problem, and after I wrote it on the board, I knew it was wrong. I erased it and wished I could have erased myself, too. He asked me what the expression for stored energy was in general, and I didn't know. Now I do: $U = 1/2 \int \rho\varphi dV$. (The stored energy is one half the charge times the charge density times the change in voltage integrated over the area.)"

I simply wasn't prepared and didn't know what to do about it. The guys never asked questions, and I was too intimidated to do so, especially after that embarrassing episode with the energy equation. A month into the semester I wrote, "Feel so depressed tonight. After class I told [the professor] the lecture hadn't done me much good because what he covered was basically in the book, and the steps I didn't understand were left out. He replied by pointing at the board and saying, 'If you can't get from here to here, you shouldn't be in graduate school at Rice.' My ego was crushed, and I felt more and more like an idiot."

By March 1978 I'd made progress in E&M, but statistical mechanics was a complete mystery. The professor had spent three weeks deriving an equation. He'd covered all three blackboards, and rather than erase anything, he continued on the wall! I'd dutifully copied all this down but had little idea what any of it meant. And we had a test Friday!

I worked up my courage to ask one of the guys after class. Steve T said, "Oh, that's just the Boltzmann distribution—the test will be easy. We just have to derive it, which is what he's been doing for the past three weeks." I smiled and thanked him. Then I went home and cried. It was the Fourier series problem all over again—everyone else had seen this before. I'd only ever seen the simplified case, called the Maxwell-Boltzmann distribution that predicts the distribution of particles in a gas. We were supposed to know, and derive, the general form that predicts energy states.

I failed the test. Dr. Freeman said I couldn't afford a failing grade on my record. He agreed to let me drop the course. But it was past the date to add a substitute. I'd have to make up the missing credits next fall. He suggested I audit complex variables, another course I was missing. The University of Arizona was looking better and better.

For spring break, I accompanied the astronomy lab to McDonald Observatory in west Texas. "On Saturday night as the Moon rose red over the hills, I thought of how it could just as well be the dim red sun rising over the barren landscape of Mars. It was a compelling vision." Space still captivated me.

However, the roller coaster high of learning something new, then my missing math skills dragging me down, kept up throughout the semester. The first part of April we were studying different kinds of radiation effects, including Cerenkov radiation produced when cosmic rays (which are actually particles) impact Earth's ionosphere. I had an "ah ha" moment in class, suddenly understanding why the shock front produced by these particles could have a phase velocity that is faster than light. I wrote, "The reason it's faster is because when it hits the ionospheric plasma it speeds up—it's easier for it to move in a plasma than in free space! I wish I could appreciate these ideas on a still deeper level. Slowly, I see that I am becoming a physicist after all, though I have doubts as to how quickly I can be transformed!"

Yet, two weeks later, I wrote, "I didn't do well on my E&M exam that I thought I had done well on. . . . Once again I ask myself if I wouldn't be happier working. . . I have a feeling there is no career already available that is what I want to be. What kind of job do I want? Reducing data? Doing research? Experimenting? Teaching? I am so confused."

Then I wrote something that, in retrospect, seems a bit prophetic: "I wish I were a writer, maybe that's my problem. I want to share my thoughts, and can't seem to do it."

I passed E&M and got average grades in my other courses. I'd learned a lot, but it hadn't been much fun. Still, I looked forward to working on the solar power satellite project for Dr. Freeman during the summer. Thor had also opted to work on the project, though not for his master's thesis—he was busy nursing a vacuum system for data on the magnetic properties of a chrome-vanadium alloy.

Unfortunately, my part of the research was the kind of "grunt work" that graduate students often end up doing. I spent countless hours in the dim light of the Rice library searching journal articles for data on the electromagnetic potential at different altitudes above Earth. We needed these numbers to understand how a giant array of solar cells would charge up in space. The biggest threat came during eclipse. As the array entered the Earth's shadow, discharges of thousands of volts could arc from one side to the other and short out the array. Thor worked on power conversion with Dr. Alex Dressler. We both had our names (though mine is misspelled) published in *Space Solar Power Research Program First Annual Review* (January 1977).

ENGAGE!

In June, Thor's landlord, who was drunk, got in a shouting match with Thor's roommate that ended with them being evicted. They had to forfeit their damage deposit. They'd have to find a new place and scrape up a deposit for it. Or. . .we could move in together.

I'd moved out of my threadbare efficiency into a one-bedroom apartment on Main Street after a drunk-driver crashed through my front door on New Year's Eve. (Fortunately, I wasn't home, and a terrified Jasper Kitty hid until I got there.) This one bedroom was nicer, but not any safer. I'd been robbed soon after moving in. The thieves had been in a hurry and missed my guitar and banjo under the bed. I worried they might return. I <u>wanted</u> Thor to move in with me.

I loved him, and he'd said he loved me, too. I figured the best way to tell if we were truly compatible was to live together. But I didn't want a roommate. If he wanted to live with me, I needed a ring. Assuming living together went well for six months, we'd get married.

We were in the kitchen of his place, dishes and papers piled everywhere. Roaches darted underfoot. "So, what do you think about living together?" I asked, rinsing out my coffee cup. "You know my condition." I was almost afraid to look at him. Was I pushing him too much? He didn't like to do things without lots of pondering.

He wrapped his arms around me and pulled me close. "I'm only going to ask you once," he warned.

"Well that's okay because the answer is yes!"

We kissed and stood there lost in our moment, full of joy. Neither of us had planned this. The ring came later—he had to save up the money. But we had made up our minds, and that's what counted.

COMPUTER SCIENCES CORPORATION

During the summer, I decided to leave graduate school. I'd discovered my chances of getting a job with NASA were actually better without a Ph.D. There were more openings at the lower pay grades. I didn't want to spend my life in a library looking up numbers or deriving equations. Also, I was tired of being poor, living off Ramen noodles and Kraft macaroni and cheese. Even some of Dad's charred burgers would be a luxury.

I talked to Dr. Freeman. "He said if I'm not sure that I want a Ph.D. more than anything else, then I'd better find out 'cause nothing less than my fullest effort will get me through this year. . . . But he also said if I could pass six courses this next year, take my orals by May, and write a thesis next summer, I could get a master's in a year. That's more than I can handle at the moment. So I'm going to start making applications."

Boeing didn't have any openings. At TRW, my academic background "was not as well suited as other applicants" to the position. NASA said it'd be months before I'd hear anything. But Computer Sciences Corporation (CSC) had just won a new contract and offered me a job as an Associate Programmer/Analyst for $1125 a month! (That's about $4200 in 2014 dollars.)

I'd taught myself a language called Basic as part of my physics labs. I'd taken a programming course in the business school at UNCG. I enjoyed creating programs, and I'd aced the course. It seemed ironic that my first job out of college had nothing to do with the math and physics I'd worked so hard to learn, but instead used my business skills. Maybe that counselor at Glenwood hadn't been so far off recommending typing and bookkeeping.

Being a programmer wasn't my dream job. But $1125 a month seemed like a fortune to me. And, like Starman Jones taking that cook's job just to get on the starship, I'd be working in the space business—CSC was a NASA contractor. Plus I could get a car! I accepted their offer and started work for CSC on September 5, 1978.

A car-savvy physics student (Tim B) helped me find my first car, a navy blue Datsun 510. My cousin Mike cosigned the loan for $700. The gas pedal was missing—only a nub remained. But unlike Thor's Plymouth, it had air conditioning. I joined a car pool with other former Rice students, Walt Croom and Val Stentz, who also took jobs with CSC. Every day we drove to Clear Lake, about 30 miles down I-45, the Gulf Freeway.

I was assigned to program an HP21MX computer using a language called Query and a FORTRAN optimization routine. The computer was in Building 30 at Johnson Space Center (JSC), the same building that housed Mission Control. I felt privileged to work there, and happily prepared the *Payload Planning Data Base Users Guide* for NASA management. I was especially delighted to go to Building 1 to give a tutorial. Building

1 was where the legendary Christopher Kraft, Jr., the first flight director who was now the director of JSC, had his office on the 9th floor. (Years later, Mission Control would be named after him.) Unfortunately, I didn't have my congressman around to introduce me to this famous man. But I did have a new friend, Mi-Mi. She had a master's degree in computer science and answered a lot of my programming questions.

THE INTERVIEW

I'd only been at CSC for a week when I got a call from NASA. Would I like to come in for an interview?! On September 13, I went to the second floor of Building 4 for an interview with John Wegener and Ed Pavelka (1939–2005) [1] in Crew Activities and Procedures. They asked about my internship in Congress, found it interesting that I'd taken Russian, and were impressed that I'd gone to Rice. Then they asked me to explain what a three sigma error meant. My heart sank. Was this their version of the Fourier series or the Boltzmann distribution?

I asked if this was an engineering expression, and they said it had to do with failure analysis. I explained that I was not an engineer, that my studies had focused on space physics, planetary atmospheres, orbital mechanics, and spacecraft charging effects. I admitted that I hadn't had much practical experience other than in astronomy and psychology labs and through the programming I was doing now.

I was afraid to breathe. Were they going to say "my background wasn't as well suited as other candidates" like TRW had done? Ever since I'd been that little girl staring up at the Moon, I'd dreamed of working for NASA. I wasn't sure I could stand to get this close and be rejected.

I wasn't. They wanted me! They wanted people with all different kinds of technical backgrounds, and, they'd been encouraged to recruit women.

I wrote, "They offered me $16,900 [a year]!! I almost said, 'Wow! I'll take it!' but I stammered out 'that's more than I'd expected' instead. I told them as far as I was concerned, I didn't need to think it over. Maybe in two weeks, I'll be there, at NASA JSC working on the space shuttle with the astronauts and mission control people. <u>ME</u>, Marianne, will really be part of the space program.

"When I told Thor, he looked serious and said if there's another opening, he'll leave Rice for it—after all it's what he wants to do when he gets out. We can also afford so many things now: a condominium, furniture, an airplane! I am so happy and so lucky!

"Seems I lived for holidays and weekends and school breaks, and now I'll enjoy every day! There's nowhere in the world like JSC, and I'm finally there."

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1. Bartlett Texas Online News. "Obituaries 2005." http://www.zyworld.com/bartlettnews/obit05.htm (Accessed 15 January 2015).

3

NASA Employee

"I work for NASA," I mouthed at myself in the restroom mirror just after getting my temporary badge on January 8, 1979. I ran a comb through my long straight hair and refreshed my lipstick. A silly grin spread across my face. The dream of that 14-year-old at horseback-riding camp was coming true ten years later.

I inhaled a deep breath and tried on my best "professional" look. Would the men take me seriously? I remembered the incident in the sound studio in Nashville, and let my breath out slowly, trying to calm down. My new friend Mi-Mi came out of a nearby stall and asked if I were okay. She'd started work for NASA on the same day in the same section. "Never better!" I replied, smoothing my knee-length skirt. "Time to get to work."

"See you at lunch," Mi-Mi said, as we headed off to settle into our new offices.

All the Flight Activities Branch offices were on the second floor of Building 4. The women's restroom was on the opposite side of the building from my new office. My heels clicked on the linoleum floor as I went down the hall, past the silent elevators.

For astronauts with the "right stuff," it was a matter of professional pride to use the stairs, often two at a time. Besides, the elevators were slow.

I sat my briefcase on my empty battleship-gray desk. Across the "aisle" from me was a woman with short dark hair talking on the phone. The phone was a standard black dial phone with square buttons across the bottom for extensions and HOLD. I sat on my gray vinyl swivel chair. "Whoa!" I gasped as the chair cocked backwards, almost dumping me on the floor. The chair was sized for a large man and could fit two of me in it.

My view of the window was blocked by a wall of gray metal bookcases as wide as my desk and as tall as a person. The woman's desk across from me had a similar wall. She hung up her phone and flashed me a smile. "Nice to meet you," she said. "I'm Diane Freeman."

I told her my name and asked who the little girls in the photo on her desk were. "My daughters!" She beamed. I was momentarily tongue-tied. The girls were black, and Diane was white. "Um, are they adopted?" I asked clumsily.

M.J. Dyson, *A Passion for Space*, Springer Praxis Books,
DOI 10.1007/978-3-319-20258-7_3

“No,” she said. “Their father is black.”

“Oh,” I said. Interracial marriages were rare in the 1970s. Here was a truly liberated woman. “They sure are cute,” I said.

“Yes, they are,” she agreed. Diane worked for McDonnell Douglas, affectionately known as “MacDac.” She’d worked Skylab as a Timeliner and was the lead Timeliner for the first space shuttle flight that was supposed to fly later in the year [1]. She explained that a timeline was the schedule and procedural callouts for everything that the astronauts did in space.

Diane said I was lucky to get a desk in a room with a window. She joked that the only way to get a window seat was if someone died and willed it to you. The coveted window positions in our office were occupied by John Whiteley and Wayne Huning. John worked for NASA, and Wayne was Diane’s supervisor at MacDac. Like Diane and most everyone else in our section, both men were working on documents in support of the first flight.

The systems’ controllers, who had offices on the first floor of Building 4, were responsible for creating the operating procedures for their systems, as well as what to do in case of failures. The people in the Flight Activities Branch that I’d joined took those procedures plus the test objectives for the flight and integrated them into the timeline. To do that job, I needed to understand how all the shuttle systems worked and how the crew interacted with them.

Who was going to teach me? Ways of handling data and organizing teams into various disciplines had evolved during Apollo and Skylab. But the knowledge of how the shuttle worked—or was supposed to work—was mostly in the heads of the engineers who’d designed and assembled the first orbiter, called *Columbia*.

Some of the “raw” shuttle data had been turned into training workbooks. Classes that went into more detail on engines and computers were taught by people who’d developed the equipment or by the instructors responsible for training the astronauts.

That first week, I collected a pile of workbooks from Crew Training. As I stared at the stack, I was grateful to my professors at UNCG for the hands-on experience with electronics that allowed me to “decode” the engineering diagrams and programming flowcharts in the books.

Thankfully, I wasn’t missing any prerequisites. No one cared if I were familiar with Fourier series or could derive the Boltzmann distribution. Space shuttle problems were new, and we’d solve them together as we went along. I was proud to be part of the team that would write the books on how to fly and operate this first reusable spaceship.

MY FIRST ASSIGNMENT

The Space Transportation System (STS) consisted of three main parts. Two parts were only used for launch: the external tank (ET) that holds the oxygen and hydrogen fuel; and the solid rocket boosters mounted on either side of the ET that provide thrust for the first two minutes. The orbiter was the “named” winged spacecraft that carried the crew and cargo.

The orbiter used different equipment for ascent (such as the main engines) than it did for orbit (such as radiators), or entry (such as landing gear). So after reaching orbit, ascent equipment and software were shut down, and orbit stuff turned on. When it was time for entry, orbit stuff was shut down, and entry equipment turned on. The transition from ascent to orbit was called post insertion. The transition from orbit to entry was called deorbit preparation.

My first assignment was to write the procedures for a case where Mission Control decided to bring the orbiter home during post insertion. These cases were called Launch Day Deorbits. I first had to learn the normal sequence of events. My office mate John was responsible for the nominal post insertion procedures. (No one at NASA said “normal.” They always said “nominal” instead.) I peppered him with questions.

Mi-Mi was assigned to focus on deorbit preparation procedures. The procedures for both post insertion and deorbit preparation were in a book creatively named Post Insertion Deorbit Preparation, abbreviated PDP. Ben Ferguson was the book manager.

Ben was one of three Flight Activities Officers (FAO) who would staff a console in Mission Control for STS-1. The FAO was responsible for overseeing all crew activities, procedures, schedules, attitude maneuvers, and timelines. There was an FAO for each flight phase: Ascent, Orbit, and Entry. Ben was the Entry Team FAO. Each FAO had a team of people, like Diane as a Timeliner on the Ascent Team, who supported them during the flight from consoles in a systems support room. I hoped to eventually qualify for one of those positions.

GETTING WITH THE PROGRAM

Both Mi-Mi and I’d been hired at least partially for our programming skills. The contract for NASA’s new automated crew activity planning system (CAPS) was being competed. NASA managers wanted some NASA employees able to supervise a new contractor if necessary. They also needed our help to debug the system for use by flight controllers.

The CAPS was quite sophisticated for its time. One computer could even run two screens! The computers I’d used at UNCG didn’t have screens at all. In contrast, CAPS drew the wavy lines of orbit maps and displayed text that was underlined and of different sizes like pages of a checklist. Being able to select a section of the screen using a cursor and enter type into it (scheduling a procedure at a certain time) was the cutting edge of technology in 1979.

3.1 The crew activity planning system ran on dual screens, the cutting edge of computer technology in 1979 (NASA photo)

The NASA point man on the project, John Bains, patiently guided us through use of the system. But using it was not enough. We were expected to be able to program it. Fortunately, after Jackson E&M at Rice, the *Harris FORTRAN Compiler Manual* was easy, as engineers like to say, “a piece of cake!”

Mi-Mi and I shared what we’d learned about CAPS and shuttle systems each day at lunch. One of her office mates, Marion Griffin, often joined us. Marion was a relatively shy older married man who was an expert in orbital mechanics. He was on the team trying some last-ditch efforts to save Skylab. Its orbit was rapidly decaying, and the shuttle wouldn’t be ready in time to boost it to a higher orbit.

Sometimes Carolynn Conley, the STS-1 Entry Team Timeliner, also joined our brown-bag lunches. She’d been hired by NASA about a year before us, and was happy to finally have some other technical women in the section. She complimented me on my business attire, especially my choice of a briefcase instead of a purse. “If you want the men to take you seriously,” she said, “You have to dress like a professional.”

And I did. Every day I wore a dress or a skirted suit with stockings and heels. The men wore dress slacks with belts, shirts with ties. Even though the hippie culture was widespread, most men wore suits at NASA and had short, military style haircuts.

INTRODUCTION TO MISSION CONTROL

About five weeks after I started work, the FBI finished my background check, and I was issued my permanent NASA badge. This badge came with a secret clearance in anticipation of supporting Department of Defense (DoD) payloads and missions. Now that I had an official "red" badge, my section chief, John Wegener, took me on a tour of the Mission Control Center (MCC). Mission Control was "across the duck pond" in Building 30, but in the windowless part versus the office side where I'd worked for CSC. The control rooms were on the second and third floors.

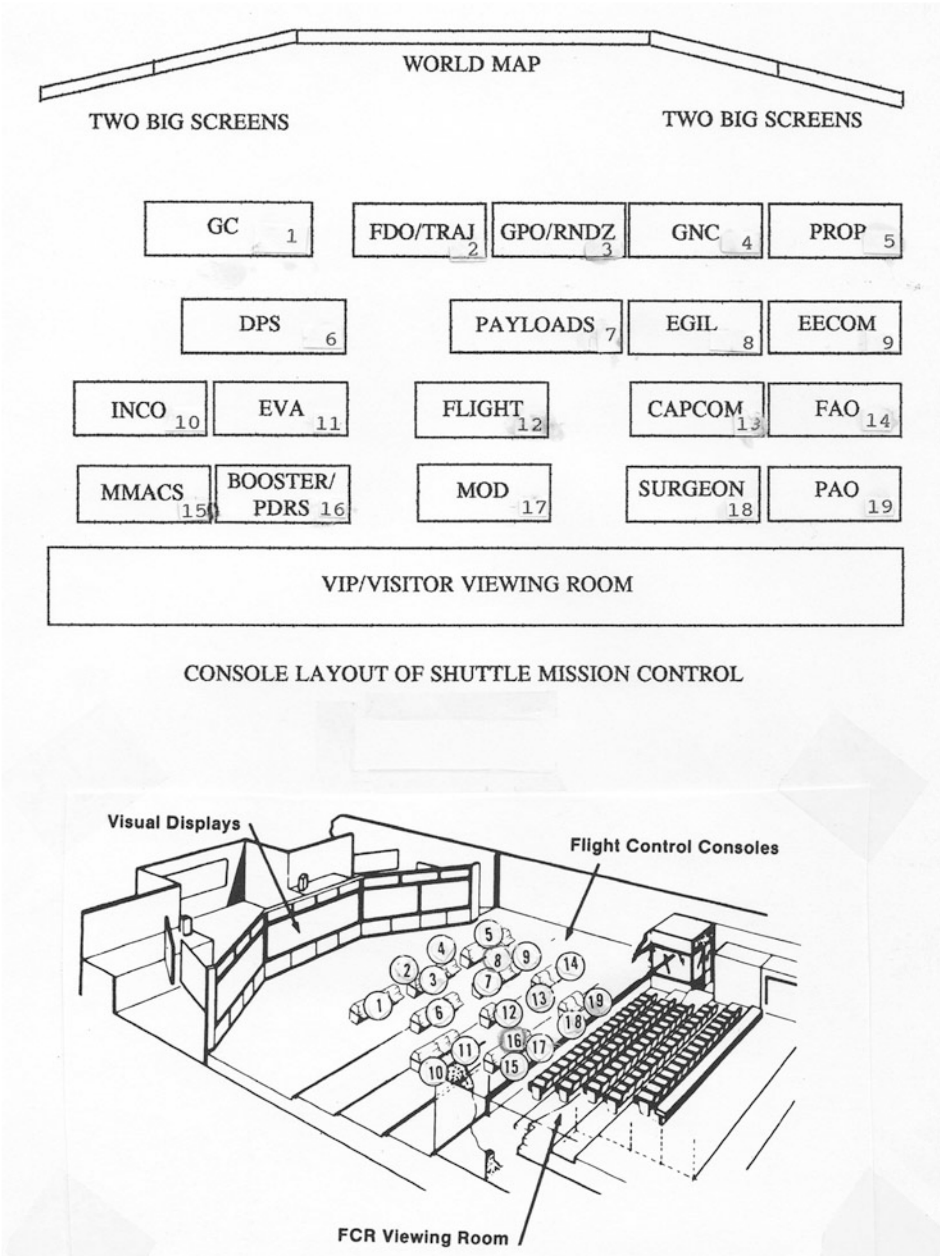
We crossed the lobby on the first floor and flashed our badges at a guard stationed by the main door. We turned left and got into an elevator that took us up to the third floor.

As Wegener held the door for me, I stepped into the third-floor Mission Operations Control Room (MOCR, pronounced "moe-ker") for the first time. I felt as if I were entering a cathedral. This was the very room I'd seen on TV as a child. The Apollo flights were controlled from here, and Wegener had worked Apollo in the propulsion area. Mission patches rimmed the walls on either side. Wegener explained that Skylab was being monitored from the identical room on the second floor, and that's the one we'd use for the first shuttle flights. This third floor room was being readied to support classified shuttle flights.

Four rows of consoles faced three giant screens. Like a theater, the back rows were elevated on tiers so all rows had a good view of the world map. Behind the fourth row was a viewing gallery for VIPs and reporters (and tourists after this MOCR was designated a national historic monument). A thick glass window separated this "peanut gallery" from the MOCR.

The room seemed smaller than what I'd seen on TV all those years ago at camp. Wegener explained that was because the TV camera mounted in the back corner used a wide-angle lens. We climbed up the tiers to the third row of consoles. We stopped at a gap in the center of the row. On the left, facing the front, was a green sign that said, "FLIGHT." "That's where the flight director sits," Wegener explained. Chris Kraft, Jr., the current director of Johnson Space Center, was the first flight director, the person responsible for the safety of the crew and success of the mission. All flight controllers report to Flight. It'd be 13 years before a woman answered to that call sign. (Michele Brekke was selected as a flight director in the mid 1980s, but transferred before serving. Linda Ham served as the first female Flight during STS-45 in March 1992.)

"Here's the FAO console," Wegener said, pointing to the console next to one labeled CAPCOM. The Capcom (capsule communicator) is an astronaut responsible for relaying all verbal messages and instructions, approved by Flight, to the astronauts in space. Because the FAO is responsible for scheduling everything the crew does, the FAOs and Capcoms work closely together. Would I really get the chance to sit here someday?



3.2 Layout of the mission operations control room (MOCR) for the early shuttle flights (NASA image)

3.3 Michele Brekke was the first woman selected as a Flight Director, but the Challenger accident happened while she was in training (shown here), and she transferred to another area (NASA photo)

Wegener explained that most of the people in our branch would support the flights from a system support room on the second floor. We exited the MOCR from the back, returned to the elevator, and got off on the second floor. We peeked into the second-floor MOCR. I saw some men in the front row of consoles, called the trench, with headsets on. They were monitoring Skylab (which came down on July 13, 1979). I spotted one woman: Bonnie Dunbar (1949–) was working at the Guidance, Navigation, and Control console. (Years later she'd be selected as an astronaut.)

The MOCRs were in the center of the building with a hallway all the way around them. The FAO support room was on the side opposite to the elevators, so we made our way around. We passed rows of lockers like the ones in high school. These were for use by flight controllers.

A set of gray double doors led into the FAO support room. I blinked when Wegener opened the door. Unlike the soft light in the MOCR, the lights in here were bright and harsh, suspended from a tiled ceiling about 20 feet high. The high ceiling and hollow floor caused our steps to echo as we entered. Two groups of greenish gray metal consoles with clear plastic desktops squatted in a line going away from the door.

The consoles were identical in design to the ones in the MOCR but seemed smaller in the large open room. Wegener said that once I was assigned a position, I'd be issued a head set to plug into a jack under one of these consoles. I remembered Lt. Uhuru on Star Trek wearing a headset. But hers was a prop, and mine would be real! By pressing the phone buttons, I'd hear astronauts on a real spaceship. My mind wandered as Wegener explained that the rows of buttons were mostly phone extensions so I could listen to the crew and other flight controllers.

As we made our way back to Building 4, I was excited, but also somewhat intimidated. Seeing the consoles reminded me of the real dangers inherent in the space program. The Apollo 13 crew might not have made it home alive if it hadn't been for the people in Mission Control. What I was learning in the workbooks and classes wasn't some academic exercise that I needed to memorize to pass a test. For the first time in my life, my ability to solve problems using the knowledge in my head might save the government millions of dollars or even someone's life.

PLANNING AHEAD: BACKUP FLIGHT SYSTEM AND STS-3

The best way to solve a problem is to prevent it in the first place. Flight controllers therefore anticipate failures and develop ways to prevent them or limit their effects ahead of time. So my fifth week of work, I slipped quietly into a darkened conference room on the third floor of Building 4 where the Flight Techniques meetings were held. These meetings addressed how this or that system might fail, how we'd know about it, and what we'd do to correct or work around it.

A horseshoe-shaped wooden table mostly filled the room. A boxy overhead projector sat on a rolling cart between the ends of the horseshoe and lit up a square on the wall behind it. The room reeked of tobacco smoke. The fan from the overhead projector hummed loudly, a constant backdrop to the discussion led by one of the flight directors who sat to the left of the projector. Extra chairs lined the walls on either side of the room. I took a seat along the wall behind my mentor, Ben, whom I noted, was impeccably dressed, as usual. (We ladies informally voted him "best dressed" in the branch.)

Sitting next to Ben was one of the few other technical women in our branch. Pearline Collector was book manager for the Ascent Checklist. This important book contained all the crew procedures for the first hour of flight. Post insertion, which was my current focus, covered the next three and a half hours during which the vehicle was configured for orbit.

NASA had lots of experience with space systems, but not much with computers. So, many Flight Techniques discussions centered on possible computer failures. One of the workbooks I'd recently read proudly exclaimed that each of these new computers had 468 KB of memory! That's about a fourth the size of one low resolution modern digital photo.

But the shuttle IBM AP-101 computers didn't have to support color graphics or music videos—those things hadn't been invented yet. Their purpose was to control the engines and flight surfaces, display critical data, and relay commands to the hardware. The shuttle computers didn't have to be fancy. They had to be reliable.

Despite shielding, managers feared that cosmic radiation could damage delicate computer hardware. So NASA required multiple backups. Instead of one or even two computers, they had five General Purpose Computers with four running the same program and comparing their results with each other.

The fifth computer, the Backup Flight System (BFS), ran programs coded by a different group of programmers to prevent any generic software "bug" from failing all the computers. Because of my programming background, I was tasked with finding how the BFS software differed from the primary software, and revising the entry procedures if it were used.

To process all the computing functions for all flight phases would've required about 1.8 MB of computer memory. But the central memory of each computer could only fit 468 KB. So the software for the mission was divided into nine memory groups and stored on magnetic tapes (mass memory units) that held about 4.1 MB [1].

Listening to the Flight Techniques discussion, I learned that because of memory limits, the BFS didn't support some navigational aids, including the radar altimeter that provided the crew with altitude data during entry. Therefore, in the Entry Checklist, where the crew normally activated this system, I needed to add a note, "Omit if BFS."

These meetings droned on for hours. Across the room from me, I spotted one of the six women astronaut candidates, Judy Resnick, stretching her legs out in front of her and rotating her ankles to get the blood moving. She caught me looking at her and we exchanged smiles. I felt a kinship with her because we were both from northeast Ohio—she grew up just 20 miles north of me in Akron where my dad worked for Goodyear Aerospace. During a break, we shuffled off to the ladies room together. As she freshened up at the sink, I complimented her on her shiny dark hair. I asked what kind of shampoo she used. She laughed and said, referring to all the time the astronaut candidates spent on the road, whatever the hotel provided!

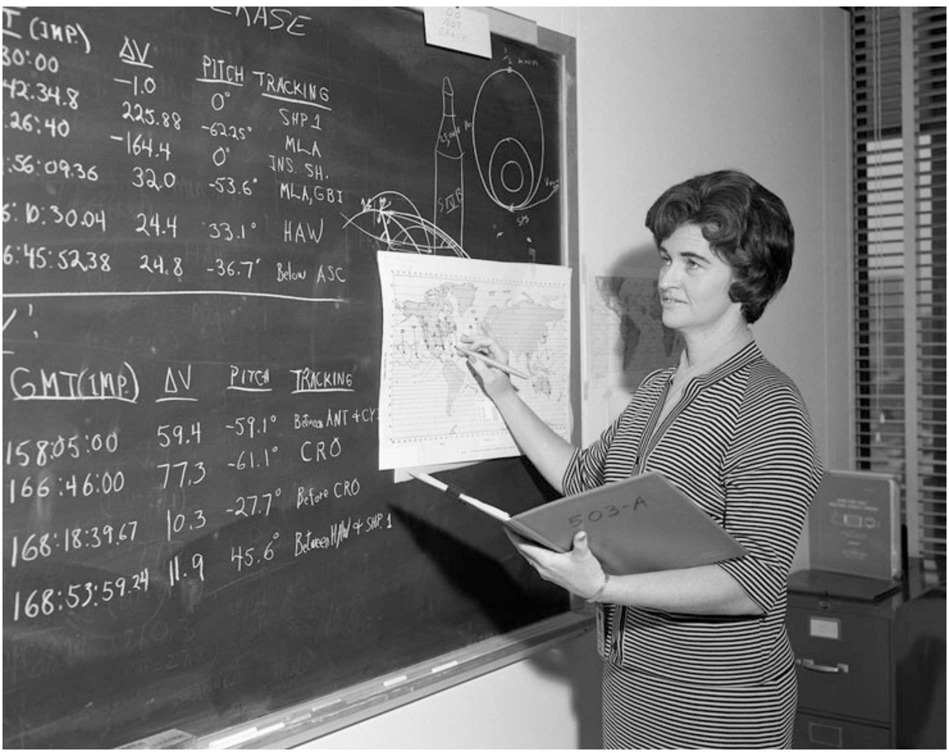
People were placing bets on whether Judy or Sally Ride would be the first American woman in space. Both had excellent skills with the robotic arm. Judy was the astronaut candidate that artist Robert McCall (1919–2010) was painting into the mural in Building 2. But many people said that Sally would make a better role model. Judy was divorced, and divorce still carried a negative stigma. I wondered if her parents' divorce had contributed to her inability to stay married, but I wasn't comfortable asking her about it. Thor and I'd set our wedding date for March 17, just a month away. I was determined not to repeat my parents' mistakes. Mom had at least partially blamed their lack of shared interests for the breakdown of their marriage. Would a shared interest in physics and space be enough to keep Thor and me together?

Returning to the meeting, I struggled to keep up with the NASA jargon. "The OI PCMMU format on C3 is normally set in GPC for entry and not much use if the BFS is engaged." Huh? I wrote down the acronyms and slowly translated this statement into "The operational increment for the pulse code modulation master unit, the part of the computer that collects data from the systems and payloads and prepares it for downlink to Mission Control, is set to receive data from the general purpose computers using a switch on center cockpit panel number three. It's not much use if the backup flight system is engaged because the program is loaded with orbit formats not supported by the backup flight system." Oh, yeah, of course!

My new knowledge was tested at the end of February 1979, when I was interviewed by George Abbey (1932–), then the head of the Mission Operations Directorate and later the center director. Though he was my boss to the 4th power, I was quite comfortable talking with him. He had a reputation for supporting NASA's effort to include more women in technical positions. He quizzed me about my work. He must have been satisfied at my growing understanding of shuttle systems because I received an additional assignment the next week.

In parallel with my work on the launch day and BFS deorbit procedures, I was assigned to develop the crew activity plan (CAP) for the third flight, STS-3. I immediately sat down with the “bible” for this flight, a thick book called the Flight Requirements Document. This book listed all the operational flight tests that I needed to schedule. The main tests involved pointing different parts (tail, nose, payload bay) to the sun and holding them for many hours. The sunlit side would be about 500 °F hotter than the side in the shade. Would this difference cause the orbiter to bend like a banana so that the payload bay doors wouldn’t close?

Using a timeline I drafted showing the sequence of these attitudes, Cathy T. Osgood, one of the first technical women at JSC, prepared the STS-3 supertape which was a trajectory showing the day-night times, communication passes, and landing opportunities for the launch date in early 1981.



3.4 Cathy Osgood was one of the first technical women at JSC (NASA photo)

Wayne Huning and I met with Herb Greider to discuss one of the payloads assigned to STS-3, the Electrophoresis Equipment Verification Test (EEVT). Electrophoresis is the separation of blood by electric charge. This process is difficult to do on Earth because the heavier molecules sink and separate by weight. Greider explained that acceleration from the engines firing would disturb the delicate charge separation, like shaking a bottle of oil and vinegar just after it has settled into bands. So they requested that no maneuvers occur during their tests. This constraint presented a major scheduling challenge on a flight packed with test maneuvers. We'd argue about this constraint for years and even during flight, not knowing that something totally out of our control would eventually ruin this experiment.

BECOMING A NASA FAMILY

Those first three months at NASA went by in a blur. I'd never been busier, or happier, in my life. I was at my desk by 8 a.m. each morning, and usually home around 6. After dinner and dishes, Thor and I'd watch whatever was "live" on the four networks: ABC, CBS, NBC, and PBS. A favorite was Wall Street Week with Louis Rukeyser (1933–) on PBS. We didn't have money to invest, but we planned to be ready when we did.

Most evenings I was preoccupied preparing for the wedding. We'd be married in the Rice Chapel and hold the reception in Willy's Pub on campus. Marilyn DiMaio, my freshman year roommate, was my maid of honor. Thor's brother Harry was groomsman, and my cousin Mike was the usher. Thor's best man was John Simmons, who, along with his wife Cindy, had become our closest friends. The four of us got together every Sunday for dinner and to watch "Battlestar Galactica," a campy science fiction soap opera.

I spent many evenings on the telephone. Could Charlotte (Wilford—a friend from Valhalla) pick up the flowers for us? Who would bring the beer kegs over from Valhalla to Willy's Pub for the reception? Yes Mom, I found some white shoes. No, I don't have the garter yet. My vows? Um. . . Thor, would your brother Harry mind watching Jasper Kitty for us during our honeymoon? Yes, Thor, you have to get your hair cut!

The night before the wedding, Thor stayed at John's house and Mom with me. She'd made my (gorgeous!) wedding dress, and we spent the last night making final adjustments. I wrote, "It's the night before my wedding and YES I am nervous, my stomach is jumpy, and I feel like I drank 12 cups of coffee. The rehearsal was sorta scary, but when I held his hand and looked in his beautiful blue eyes, I knew everything was OK. . .. I love Thor more than anyone in my life. I love him for going through this with me, that we are doing this together before the Lord and family and friends. I'm going to sleep now and dream of beautiful dresses and cakes and diamonds and smiling faces. And Thor will be there in the morning to make it all real."

The wedding was a marvelous Saint Patrick's Day event, complete with bagpipers and drummers that rattled the windows in the tiny chapel. At the reception, Dad promised to send a check for the expenses once he got home. He never did, but our friends came through for us, charging the food and allowing us pay them later. They covered the beer and champagne as an extra wedding gift. We stayed at the Shamrock Hilton that night, then drove to South Padre Island for a budget honeymoon.

3.5 *Left* to *Right*: Tom Jakmides, Joanne Wildey, Marilyn DiMaio, Marianne and Thor Dyson, John Simmons, Ruth and Ralph Dyson. I'm holding the Bible Grandma Jakmides gave me (Photo by the author)

All spring, we kept our expenses to a minimum—not going out to eat and buying only necessities because we planned to move to Clear Lake as soon as we had enough money for a down payment on a house.

Thor had interviewed with NASA soon after I did. He'd been offered a position in the Flight Dynamics Division. He'd start as soon as he finished his masters' thesis at Rice. But his thesis, "The Magnetic Properties of Chrome-Vanadium Alloy," required the use of a finicky old vacuum system that slowed down his data collection. He wouldn't be done until June.

PROCEDURES VERIFICATION

My responsibilities at work continued to grow. I graduated from updating procedures to verifying them. Verification was a lengthy process. After talking with system experts about the sequence of switch throws, we'd arrange to "walkthrough" the procedure in one of the mockups in Building 9. The walkthrough uncovered awkward sequences such as requiring the crewmember to "bounce" from the flight deck to the middeck instead of grouping the switches by location. Once the flow of the procedure was checked, we'd schedule a series of tests in one of the shuttle mission simulators in Building 5.

The simulators mimicked the shuttle cockpit as exactly as possible without being in freefall. Flipping switches caused lights to come on or computer displays to change. During a test, we'd watch for alarms or unexpected effects. A bank of computers operated by the training teams could also "fake" 4500 different failures [2]. For example, the operators could input high temperatures that would trigger an alarm and show up on one of the three cathode ray tube (CRT) displays in the cockpit. A maneuver shifted images of the constellations onto screens outside the front or overhead windows. The motion base simulator even shook and rotated up and down and jerked sideways like a carnival ride in response to computer and hand controller commands.

A procedures verification run provided a good show for the lucky tourists who happened to stroll along the enclosed "catwalk" on the upper floor that overlooked the simulator bay. Like Mission Control, only badged personnel were allowed "on the floor" and into the simulators. But in 1979, tourists could go just about anywhere on site.

On March 28, 1979 I participated in my first procedure verification test in Building 5. That night I wrote, "Today was an enjoyable one—so much that I hardly felt I was 'working' but rather there wasn't anything else that I'd rather be doing. I accompanied Carolynn Conley to the Fixed Base Simulator to monitor some CRTs while she went through the Time Critical Deorbit procedures. The tourists were watching from the window above, and I felt humble yet excited to be doing something useful instead of watching. And in two weeks, I get to be the one in the commander's seat! I went up for a few minutes and sat in the pilot's seat. All I could think was, 'Neat!' Man's most complex toy yet, but it gave me a thrill just like a new toy when I was little. I even opened the Payload Bay Door's window flap and waved at the tourists! Carolynn said, 'Marianne, we're supposed to be professionals!' I couldn't help it though—I wanted to share my joy with them. I wanted to wave and smile, not for 'look at me' but for them to see we are happy doing this stuff and that scientists aren't all serious-faced bores! Phooey on professionalism. I want to have a good time and show the public it's fun to work for NASA."

SIMULATING DISASTER

In April, I enjoyed my first on-the-job training sessions in the FAO support room. I donned my very own headset, plugged in at the Timeline console, and listened to the chatter on the communication loops. We simulated a shuttle entry with astronauts in Building 5 and all the flight controllers involved in entry at their consoles in Building 30.

"Flight, EECOM," the flight controller in charge of the Environmental, Consumables, and Mechanical Systems (EECOM) called.

"Go ahead," Flight replied.

"We see an EVAP OUT TEMP high," he said, reporting the value of one of the parameters on a display on his console. Carolynn was the Entry Team Timeline, and showed me how to call up the display by dialing in the TV channel. The simulated data came from a computer model of the orbiter's cooling system in Building 5. But what did this message mean?

Carolynn explained that the flash evaporator system (FES) sprayed water over pipes carrying Freon. As the water evaporated into space, it took the heat from the Freon. The warning indicated that if the temperature remained high, critical equipment would overheat and fail.

EECOM asked Flight to have the crew switch from the FES A controller to the B controller and wait 30 seconds to see if that lowered the temperature. If so, then they'd just lost redundancy. Flight told the Capcom to tell the crew to take this action.

Because this was a sim, the training instructors wouldn't make the problem that easy to solve. I watched the temperature on the display. Sure enough, it continued to rise. EECOM told Flight to have the crew turn off the cockpit lights to reduce the heat load. They also should turn off the evaporator system and its heaters that normally kept the vents from icing shut with evaporated water. Finally, they should shut off the data recorders which used a lot of electricity. If these actions didn't get the temperature down, EECOM said they'd have to abort the entry.

Huh? Wouldn't they want to get home as soon as possible if they had a major failure? They could be on the ground in an hour. Why would they abort the entry and stay in space?

To answer my question, Carolynn had me go through the Entry Pocket Checklist to see what equipment was Freon cooled and thus most likely to fail if we didn't solve the problem. The fuel cells that provided the electrical power to the vehicle were at the top of the list. Oh! Without power, the shuttle couldn't be controlled: it would burn up in the atmosphere.

Moments later the Electrical Generation Instrumentation, and Lighting (EGIL, pronounced "eagle") officer reported that the fuel cells were indeed overheating.

We <u>had</u> to get the temperature down. If the FES didn't work, then they had to open the payload bay doors and use the radiators to cool the Freon loops. The doors had been closed for entry. It was impossible to enter the atmosphere with the doors open. Thus, if we opened the doors, we had to abort the entry.

But they could only stay in space for a limited time before running out of fuel. If the weather would be bad for the next opportunity, maybe they should take their chances now?

The astronauts were just minutes away from firing the engines to begin the entry. Flight had to make a quick decision. He called the Flight Dynamics Officer (FDO, pronounced "fie-doh"). "FDO, how's the weather for the next opportunity?"

"I'll check, Flight," he responded. If the deorbit opportunities were good, then we could stay in orbit longer and work the problem. How long did the doors have to be open to bring the temperatures back down?

The temperature continued to rise. "Flight, EGIL. The fuel cells temps are rising. We have to get the doors open <u>now</u>," he said.

Carolynn reminded FAO (Ben) that the procedure was in the PDP, and that book was stowed for entry. Ben reminded Flight of this fact.

FDO said that Edwards (Air Force Base in California) reported a crosswind, but should be acceptable. Northrop (in New Mexico) was a solid backup. So we could postpone entry.

Flight told Capcom to tell the crew they were no go for the deorbit burn and that the procedures for opening the doors were in the PDP which they'd already stowed.

"Roger, Flight," Capcom replied. I was surprised to hear a female voice. Sally Ride was training to be a Capcom.

The crew opened the doors. Then we had them maneuver to an attitude that shaded them from both the sun and the Earth (called a "cold soak" attitude). We powered off as much equipment as we could and left the payload bay doors open until the last possible minute.

We did the entry burn and hoped the fuel cells would last until the ammonia spray boilers started cooling the Freon loops. This system kicked in during the last seven minutes of the entry, from about 100,000 feet to the ground. (Water evaporation cooling used by the FES is not as effective in air as it is in space. We didn't use ammonia the whole time because of its weight.) We decided to turn the ammonia system on earlier.

Mission Control had given the astronauts a shot at survival. But unfortunately, it wasn't enough. The fuel cells overheated and shut down before the ammonia system kicked in. Without electricity, the shuttle quit flying. Before it "hit" the ground, the simulator crashed.

After each sim, the simulation supervisor (Sim Sup, pronounced "sim soup"), the crew, and Flight held a debriefing with the entire flight control team. Sim Sup (John D. "Denny" Holt) admitted that the software model was too primitive to show temperature drops when individual pieces of equipment were turned off. The model also couldn't cope with using the payload bay as a heat sink—making it cold by shading it from the sun. Everyone agreed this was a good idea, but the model simply reset the payload bay temperature once the doors closed again. No one knew how long the doors had to remain open to get the temperature down, or how early the ammonia system could be activated and not run out of ammonia before they landed.

So EECOM took the action to request a thermal analysis and report the results at a Flight Techniques meeting. Then we could write flight rules to guide actions for this case.

A week after the sim, I was assigned to write the procedures for the loss of FES deorbit and entry. I met with Tommy Holloway, an Apollo FAO who was now a flight director, to work out a timeline to use for the thermal analysis. We created a plan based on the simulation and reviewed it with Entry Flight Director Don Puddy (1937–2004). Holloway then added a discussion of the Loss of FES entry to the agenda of the 41st meeting of Flight Techniques. I'd give the presentation! I'd really come a long way in just a few months, from an observer barely able to follow the jargon, to a presenter at one of these important meetings. Fortunately, I'd just finished a class called Briefing Techniques.

SPEECHIFYING AND HOUSE HUNTING

The two-week Briefing Techniques course was designed to help employees get over their fears of public speaking. We were given "canned" speeches to memorize and then, using index cards as memory aides, present to the other members of the class. The instructor, Eugene Horton, video-taped our performances. Did I really say "you know" like, you know, every other word! And I didn't seem able to hold still—a classmate remarked he was exhausted just watching me. But at least I didn't stick out my tongue like one guy. By the end of the two weeks, we were all much improved at our "speechifying."

To celebrate our “graduation,” Horton invited the class sailing on his 27-foot yacht. Thor joined me, and we enjoyed a glimpse of the good life as we glided quietly over the waters of the Gulf and watched the stars twinkling brightly above us. “Maybe someday we can get a boat like this,” I remarked.

“I’d rather get an airplane,” Thor replied. He’d gotten his private pilot’s license years earlier and dreamed of owning his own plane.

“Well, I’d rather get a starship,” I joked, leaning back against him while we looked skyward. “But an airplane would be nice—though we really ought to get a house first, don’t you think?”

We’d already started scouting for a house in Clear Lake, anticipating that Thor would finish his thesis and start work at NASA in mid-June. My car loan and the wedding expenses had made saving for the house difficult. Because we didn’t have much for a down payment, we couldn’t take over an existing mortgage. We were therefore limited to neighborhoods with new houses.

We liked Meadowgreen in Clear Lake best because it offered the shortest commute to JSC. In mid-May, I wrote, “Tomorrow we will have been married two months and already we’ve spent all the money we’ll make in the next three years, only it will take 30 years to pay for it—it being our house!

“We sat on the carpet in the living room like ordinary people sitting in an extra ordinary house. A house that costs $69,500. We have to have $4700 more by July 1. It will be close, but we will make it. I felt that strange 6th sense ‘Fate’ feeling when I walked into that house. My sense said. ‘This is it, Marianne, take it.’ And I tried to tell myself the living room was too large or something, but I looked at Thor and he said, ‘We’ll fill it up. I like it!’”

WOMEN SPEAKING

I took time from preparing my presentation for Flight Techniques to attend “Women’s Week” at the Gilruth Recreation Facility at JSC. One of the speakers was Dr. Carolyn Huntoon (1940–). Although some women had worked in Mission Control in support room positions during Gemini and Apollo, she was one of the first, if not the first, woman assigned a “front room” flight control position supporting experiments during Skylab. She’d one day be the first woman director of JSC. At the time, she was chief of the Biomedical Lab Branch and deputy for personnel development in the Astronaut Office. The NASA *Space News Roundup* quoted her opening the program. “There are 662 female JSC employees. Of those, 178 are classified professional.” (In 2010, there were 1700 female civil servants out of 16,650 total.) Another speaker was Anngie (sic) Johnson, an engineer in Payload Operations who was destined to be the first black woman flight controller. The *Roundup* article characterized her presentation as “a pep talk, mass therapy, and career advising session” [3].

I shook my head. They’d never describe a man’s presentation that way! Was there any hope I’d be taken seriously as one of those 178 professional women? I’d soon find out.

On May 10, I gave my speech to Flight Techniques. The butterflies in my stomach fluttered as I got up in front of a room full of experienced flight controllers, astronauts, and flight directors. But thanks to Horton's class, I didn't jump around like a kid on Christmas or end every sentence with "you know." I took a deep breath and walked through the procedures planned for entry in the case of a failed flash evaporator system. I didn't use a laptop computer or a PowerPoint program. Those hadn't been invented yet! My timeline was hand-drawn on a sheet of paper and transferred to a clear sheet of plastic. This was laid on top of a Vu-graph machine that projected it onto a screen.

I reviewed the failure and its consequences: that the loss of FES meant that the Freon loops wouldn't be cooled from the time the payload bay doors closed until the ammonia boiler system activated. To reduce the heat load during this cooling "gap," the payload bay doors would remain open until just prior to the deorbit burn.

Why not leave the doors open until entry interface someone asked. I looked at Holloway, and he nodded that I should answer. I appreciated his confidence in me. "The consensus was that the doors be confirmed closed and latched prior to the burn because an entry with a door stuck open or not latched would be catastrophic." I couldn't help but glance at one of the new astronaut candidates attending the meeting. If we ever lost the FES, would these procedures be enough to save his life?

Someone asked why the burn was delayed seven minutes? I explained that this allowed more time for the doors to remain open. How much more fuel does that use? I didn't know. One of the FDOs responded with an estimate.

I continued through the timeline. To keep the power level down, the plan called for cycling on and off the pumps that provide hydraulic fluid to the flight controls.

One of the astronauts said that remembering to cycle these pumps would be difficult during the crowded entry. Could we turn off something else and leave it off? How about leaving one of the three fuel cells off? Was the power from the third fuel cell worth the extra heat it generated?

We tentatively decided to go with two fuel cells for entry and leave on all three hydraulic pumps to absorb some of the heat. This decision would be revisited many times in the coming months. I reported, "A detailed thermal analysis should have final results in about four weeks."

My first presentation to Flight Techniques had gone well thanks to Horton and Holloway. Now that the proposed Loss of FES procedures were approved, I had to get them tested in the simulator and published in the Flight Data File.

NASA NEWLYWEDS

Thor finished his master's thesis in physics at Rice. He joined me at NASA on Monday, June 18, 1979. His office was on the first floor of Building 4, practically underneath mine. Our office mates teased us for walking into work holding hands. ("Aw, look at the newlyweds! Aren't they cute!") We kept doing it just to annoy them.

We commuted together from downtown for two weeks. Then, on the Fourth of July weekend, our friends from Valhalla helped us move into our new house in Meadowgreen.

Our living room furniture consisted of two mismatched old platform rockers, a futon we used as a sofa, some boards suspended between cinder blocks that served as shelves, and a particle-board plant stand I'd found at a garage sale. The console TV was a castoff from another friend that we got for seventy-five dollars. It was my first color TV! We were living in style now. . .. It was actually quite a pitiful pile of junk to scatter around a brand new house. But it didn't matter. I wrote, "Our love is the most wonderful gift we have. One we keep unwrapping and enjoying and sitting under the Xmas tree and wondering what it'll be. We tell each other how lucky we are, and I really believe it."

A week later, we had a house-warming party. Jasper Kitty was the hit of the night. Poor thing wasn't quite sure what to do with all the attention. He slunk around for days afterwards.

PROGRAMMERS ON PER DIEM

I'd barely unpacked from the move when it was time for my first official business trip. NASA had decided that both Mi-Mi and I should be able to program the CAPS computers in case the contract changed hands. So we flew to Harris Computer Corporation's headquarters in Florida for two weeks of training in machine language—the language of 1's and 0's that underlies all other computer languages.

On July 15, 1979, Mi-Mi and I and a woman from the training area, Sharon Conover (years later, manager of the space station Vehicle Management Integration Office), boarded an un-air-conditioned very hot Metro flight from Clear Lake (there was an airport on Route 3 between El Dorado and Bay Area) to Intercontinental (now Bush) Airport. There, we boarded a flight to Ft. Lauderdale, Florida.

NASA provided a set amount of money per day, called the per diem, for employees to spend for food. We were allowed to keep what we didn't spend. If I ate cheap, I could save enough for the fabric I needed to make drapes for the house. These good intentions melted away with one look at the menu at "the Caves." I wrote, "The artichoke hearts were the best part, and the asparagus soup was fantastic. . .Mi-Mi and I had a great dinner—Maine lobster! I never had one whole." Thinking of the sheets tacked up over the windows at home, I added, "It was good, but not worth $13. The total bill was $17! I went over my per diem $1 today. Some money saver. Oh well, got to splurge while I can, I guess. . .. The Italian restaurant Way Marie was very good. Sharon and I finished a whole bottle of wine, and then the owner came over to play the piano. I got up there and sang, because 'If Ever I Would Leave You,' has always been a favorite of mine." We sure had fun.

At the end of the Vulcan Familiarization course, I knew how user inputs were transferred to data registers and moved around based on various If/Then algorithms. My programming skills had definitely gone up a notch. I worried what this might do to my career. I wrote, "I feel more computer-oriented this week than ever before. I have to watch myself though—I don't want to advertise my ability too much in that area, or I may never get to be an FAO."

While I was in Florida, Tropical Storm Claudette dumped 20–40 inches of rain on our part of Texas, flooding all of Clear Lake. Unfortunately, the brick veneer on our new home had not been properly sealed. With no gutters, the water ran off the roof and straight down the bricks, draining into the house. The carpets were soaked. The contractor then sprayed our bricks with silicon sealant. We added gutters to the list of home improvements to be done as soon as we could afford them. I wrote, "We had only minor leakage via the bricks in front. The worst thing is the smell where Jasper peed! Poor thing—Thor didn't change his box for 2 weeks!"

I continued working on CAPS after my return. But, I need not have worried about being pegged as a programmer. My work on the contingencies had garnered a lot of attention.

CONTINGENCY PROCEDURES

Besides learning to program CAPS, I was now juggling Launch Day Deorbits, Loss of BFS, Loss of FES, and STS-3 assignments. Of these, the Launch Day Deorbits were the most "mature," having gone through procedures verification and publication in the Flight Data File. While reviewing the Flight Rules for these procedures, I realized that a return on orbit 2 or 3 wasn't much different from a return on orbit 4 or 5, currently separate sections of the book. Why not combine these and save some checklist pages? I met with my section and branch chiefs, FAOs Elvin Pippert and Bob Nute, and Carolynn to go over this proposed merging. We then met with the prime and backup crews to discuss the changes. "They accepted the combined timeline as an improvement," I reported. The next week, the prime crew and the whole Ascent Flight Control Team did a sim with a deorbit on orbit 4 using my procedures. It was kind of like having a story I'd written turned into a play. I enjoyed seeing what the "actors" did with it!

The first draft of the Loss of FES case had been rushed into print in June after only a quick walkthrough with Carolynn. She "played" the part of the commander, and I served as pilot. To keep track of where we were in the timeline, we developed a new format for the procedure that keyed to the activity titles in the nominal timeline. The astronauts said it was easy to "pen and ink" (hand mark) the nominal via these titles.

I'd taken a marked up a copy of the current book to a contractor called Kentron. They typeset, proofread, printed, and distributed all the procedures for use in sims. My primary editor with Kentron was Cadie Howard, a petite woman with a ready smile and good sense of humor.

But changes to the nominal procedures took precedence over the contingency cases, and Loss of FES had to wait in line at Kentron. So two months after I'd first drafted the Loss of FES procedures with Holloway, and a month after Flight Techniques had reviewed them, the procedures finally got printed. It was time to test them in the simulator with a crew. Joe Neel, an Air Force officer who had joined our branch, was working on two other deorbit cases: the Loss of 2 Water Loops, and the Loss of 2 Fuel Cells. Those cases required a power down similar to the Loss of FES. So I joined Joe's procedure verification session on June 13, 1979 hoping to verify at least part of my procedure.

Joe and I had expected to have the STS-1 backup crew, Joe Engle (1932–) and Dick Truly (1937–). But at the last minute, they weren't available. Instead, we drew Jack Lousma (1936–), who had flown on Skylab, and Rick Hauck (1941–), a member of the 1978 astronaut class. This was Hauck's first procedure verification. I reported, "It was hoped that the procedure verification (4 hours) would cover all of the PDP activities and maybe some of the entry procedures. However, with 0 minutes of simulator time left, we were 5 minutes from completion of the critical point in the PDP for this case—the closing of one payload bay door. . .

3.6 Astronaut Rick Hauck, shown here in training with Dick Truly in 1979, did his first procedures verification run on my Loss of FES case (NASA photo)

"The delay was mostly caused by an attempt to achieve tail-to-sun attitude. The maneuver was painfully slow. When the attempt was aborted, the stabilizing maneuver resulted in an empty reaction control system tank." In other words, the hot shot astronauts had run out of gas and lost control of the vehicle!

The only way to refill the tanks was to reset the simulation and start over. This was a tedious process and took a whole hour. We ran out of time.

However, this "failed" session ended up leading to a new way of doing things that would benefit all the contingency cases. Based on their remarks about having to flip back and forth between documents, I met with Holloway to discuss streamlining the procedures. We decided to use the same basic power down for all the contingency cases, and divide it up into groups according to the severity of the problem. In a real flight, they were a lot more likely to get behind the timeline than to run out of fuel!

Two weeks later, Joe and I ran the contingency case with Engle and Truly. We found that the simulator didn't model the thermal effects of our procedures. My report said, "When the radiators were stowed, there was no increase in the Freon loop temps. There was no increase when one door was closed. When the second door was closed, the temps decreased about 90 degrees even though no cooling was available!"

But the verification run did uncover some quirky software issues that impacted our power down plans. One of these involved the rate gyro assemblies that told the crew how fast they were rotating about each axis. Normally, all four assemblies would be on for entry. To save power, we turned off three until the final phase of entry. The sim revealed that when we turned on a second one, the software declared the first one failed—even though it was working fine! Until and unless the software changed, we couldn't power off the assemblies to save electricity.

We also discovered that when we added a third computer, it couldn't just copy the software it needed from one of the other computers. It required a mass memory unit—which we'd planned to turn off to save power. The switches were out of reach during entry, so we had to turn the memory unit on before the crew strapped themselves in—two hours before landing.

Joe and I updated our procedures, wondering what other software issues we still hadn't uncovered that could come back to bite us.

After my trip to Florida, I scheduled a procedure verification run with Lousma again. This time he was paired with Gordon "Gordo" Fullerton (1936–2013) that he would fly with on STS-3. Gordo had been the pilot of multiple shuttle approach and landing tests in 1977 with the space shuttle *Enterprise*. But despite his familiarity with the shuttle, he had little experience with contingency cases. So, I scheduled a practice of the power down sections for two hours in a single-systems trainer. "This session was very productive," I reported, "and made the simulator session run much more smoothly." However, having a well-prepared crew was necessary, but not sufficient, for a successful test run.

With computer memories limited to kilobytes, a copy of all the data from a long simulation was not possible. Instead, sessions were "frozen" and a data "snapshot" taken. These snapshots were called "data stores." There were no options to fast-forward or reverse the flow of time in a simulation. So if human error or a system glitch caused the computer to crash, we had to reboot and start over from the last data store.

"Even though we lost 1¾ hours due to simulator failure, we attempted to achieve a data store point to verify the entry procedures in a later session. . . . Everything was ready for the data store, and an operator did not configure the computers correctly so that the data store was lost. The session will have to be repeated—and unfortunately not in time for the latest rev of the Entry Checklist." So the procedures were published without having been verified.

However, once again, the failed test run had uncovered something useful. We discovered that turning off one switch doubled the time to close the doors in the AUTO mode. We'd leave that switch on now.

JOINING THE TEAM

Simulations continued, eight hours a day every day throughout the summer. So it happened that on STS-1 Pilot Crippen's (1937–) birthday in September, he was in a sim. After sweating our way through yet another set of failures, I came back from a break to hear someone singing, "Happy Birthday to you, happy birthday to you," over the air-to-ground loop from the cockpit. "That voice sounds familiar," I said. Then Crippen got on the loop and thanked none other than John Denver (1943–1997).

Little moments like this reminded me that we weren't just sitting through yet another ascent drill: we were preparing for the first historic flight of a new spacecraft. And that "birthday boy" over there in Building 5 was betting his life on us getting it right.

I'd been with NASA for nine months now. I'd taken responsibility for three different contingency cases, been trained to use and program the CAPS, presented to Flight Techniques, been designated as the lead planner for STS-3, verified procedures with the astronauts, gone on my first business trip to Florida, and oh yeah, gotten married, bought a house, and moved! It had all happened so fast, I'd hardly had time to process it all.

Then on September 24, 1979, I got the best news yet: I'd be in the FAO support room in Mission Control during the first flight! I'd support Diane (Timeline) via a new position called Timeline 2. I couldn't stop smiling. "I really will be there when they take off for space," I wrote in my journal. "And I'll feel like I know them and they know me. It's a good feeling, a feeling of accomplishment. . . . I have definitely come a long way, but is it far enough? My intern review is coming up in a month. I'd better start studying—it's like exams all over again!"

TRAINING

We were all students and also teachers. While I learned more about computers and planning, I also helped train the astronauts and other flight controllers on the procedures that I'd developed. I therefore met with Bob Williams and Anne Accola in the Training Division to develop scripts to use in sims.

3.7 Anne Accola was a Simulation Supervisor in the Crew Training Division. *Left* to *Right*, back row: Gary Steinbeck, Tony Marino, Steve Ham, Ronnie Lanier. Front row, Anne Accola, John Poffinberger, Chuck Shaw (in uniform), George Laski, Keith Todd, Chirold Epp, and Tandi Benson (later Bagian) (NASA photo)

We were like game masters coming up with mischievous plans to force our characters to find solutions or face disaster. I needed a failure that would cause the team to execute one of the launch day deorbit procedures. It couldn't be something that they could fix easily or put off dealing with until the next flight day. How about a hole in the cabin? Yeah, that would work! Anne and Bob wrote down the timing of the leak (after they'd made it to orbit), and what the leak rate had to be to force the team to exercise the Orbit 2 Deorbit procedures.

Now, how about orbit five? Why not have a failure that required them to use the backup flight system as well? One of the main activities of the post insertion phase was to transition from one software load to the next, so we could insert some sort of problem there. . . Before long, we had a couple of good scripts outlined. We did a script checkout in the simulator the next week.

In October, I conducted two procedure verification sessions for the Loss of FES. Lousma was once again assigned as my astronaut commander. The pilot was Class of 1978 Astronaut Brewster Shaw (1945–) who'd not yet done a deorbit prep or entry in the simulator. Like I'd done with Fullerton, I scheduled a class with Shaw prior to the run.

Lousma and Shaw noted that moving around the cockpit with the lights shut off to save power slowed them down. I hadn't thought about that. They also noted that delaying the time of ignition (TIG) of the deorbit burn messed up all their time cues in the Entry Checklist.

Joe Neel and I subsequently met with Entry Timeline, Tucker Pierce (1948–2015), and Entry Checklist authors Bill Anderson, Ken Patterson, and their Section Chief Chuck Dietrich to discuss how to handle the time issue. We decided the sequence and not the time since TIG, was the most important. So, rather than change the times for the failure case, we deleted the times in the nominal checklist. "An added benefit will be that the Entry Checklist procedures will not have to be updated every time a new [launch date] 'cycle' comes along," I reported. Communication times would be placed on one page or on a cue card. I added, "Crippen approved the change." I felt very good about the way testing my contingency procedures had led to an improvement in the nominal checklist.

As in previous procedure tests, we had lots of computer issues with the simulators, waiting hours for reboots and 30 minutes just to copy a few files from one computer to another. But we also uncovered problems with the flight software that might have caused grave consequences during flight. One example was the simulated Loss of FES on launch day.

To reduce the power, and thus the heat load, we'd shut down three of the active computers and operated on one plus a backup. For entry, we wanted to add another primary computer for redundancy. When we brought this second computer online, the navigation data stored in it wrote over the more current data. The shuttle then had the wrong set of targets. There wasn't enough time to uplink a new set of targets before the wrong ones would execute. If this happened during a real flight, the shuttle might come down in the ocean somewhere! We submitted a request to change the software, thus allowing us to safely power cycle computers if it ever became necessary during flight (it did).

We also couldn't be sure if the problems we had during the run reflected the way the real vehicle would behave, or if it was merely a problem with the model. With cooling failures, the physical location of heat sources such as cameras and motors was an important consideration. If the shuttle needed a computer in one compartment to stay cool, then we might turn off equipment near it. That often meant switching from an "A" to a "B" position of a switch.

During one run, we found that the simulator didn't recognize a normal B position of the auxiliary power units (APU) heaters needed to warm up the hydraulic fluid that moved the control surfaces. So, five minutes before these controls were needed, the APUs wouldn't start. I reported, "This caused a delay at a critical time, and added to the problem of loss of vehicle control." In other words, we crashed.

With all these issues, we could never be sure if the procedures were actually "right." Had we turned off enough equipment? Had we done it in the right sequence? "The simulator cannot verify the procedures any more than it has already," I concluded. Therefore, "this set of procedure verifications will not be repeated. We'll have to hope the thermal analysis is at least done before the final checklists are printed."

While I waited for the thermal report, one other aspect of the procedures remained a primary concern: the timing. Responding to this failure took time during a phase of flight that didn't have any time to spare. To give the crew the best possible chance, we had to have clear instructions in all the right documents. When something went wrong, the crew first turned to a pocket checklist, sized to fit in a suit pocket. Each of the three phases of flight, ascent, orbit, and entry had a pocket checklist. Each of these assumed a certain set of software in the computers, and that software determined what information the crew had available to diagnose the problem.

For the Loss of FES, the Orbit Pocket Checklist didn't have any trouble-shooting procedure because the doors were open during orbit, and the FES wouldn't be active (the radiators in the doors provided cooling). But the normal timeline included multiple payload bay door tests during the orbit phase—even the initial door opening in Post Insertion used orbit software. And whenever a door closed, the FES could activate, and therefore, it could fail. I reported, "Holloway has asked me to look into the options."

Tracking down all the various places in the timelines that the crew may be during a FES failure was a bit like writing one of those "create-your-own" adventure tales. I hoped that I'd covered all the possible paths through the checklists.

In late November, NASA thermal systems expert Jim Jaax and Rockwell engineers in California involved in design of the orbiter provided feedback on the Loss of FES case. They told us, "Preliminary results show the power down to be sufficient to prevent loss of equipment." This was wonderful news, but a long list of questions remained, mostly involving assumptions. "They don't take into consideration the efficiencies of the various components, and they also don't simulate the duty cycles of the heaters which are major power users." But Holloway was satisfied we'd followed a sufficiently conservative approach.

We'd rushed these procedures assuming STS-1 would launch in the fall or at least next spring. But an engine static firing test went wrong in November. The engine was supposed to fire for 510 seconds, but stopped after nine. The test was repeated in December, resulting in damage to the test article. The STS-1 launch was then delayed to June 30, 1980 [4]. Soon after the new year, it would be postponed to October.

THE QUESTION FROM MR. KRANZ

My first year with NASA ended with a Technical Intern review in December. I made my way to Building 1, passed the guard in the lobby, and rode the elevator to the 9th floor. I then appeared in front of a panel of managers including the legendary "tough and competent" Gene Kranz (1933–) (always *Mr*. Kranz to me!) who was deputy director of Flight Operations. I reviewed my education, prior experience, and mustered my very best briefing techniques to present an overview of the work I'd done on the contingency cases, STS-3, CAPS, and on-console training. I asked if they had any questions. Other interns had told me to expect a grilling. My future in flight control depended not only on the technical accuracy of my answers, but my ability to deliver them clearly. I braced myself.

Someone asked me what a LBJ Congressional Intern was. I explained that it was a scholarship program named after former President Johnson and that I'd acted as a staffer for Congressman Ralph Regula who was on the House Appropriations Committee. I mentioned meeting Senator John Glenn and also NASA Administrator Frosch after his confirmation hearing. That raised a few eyebrows. Did they think I'd been hired because I knew someone? I hadn't asked Mr. Regula for a reference or anything—I was hired for my physics and computer skills, wasn't I? Or was it because they needed more women?

Kranz asked me about STS-3 and launch day deorbits. He nodded approval at my answers. I allowed myself to breathe a little easier. This wasn't so bad! Even if I'd been hired because of being a woman, I'd proven myself competent. Then he furrowed his brow and steepled his fingers. His eyes met mine. "There's just one thing I want to know," he said in his deep voice. "Where's the Roo?"

"The Roo?" I repeated to make sure I'd heard correctly.

He nodded with the hint of a smile. The other men kept quiet, following his lead.

The Roo was the kangaroo stuffed toy mascot of the Payloads team chosen in honor of an Australian satellite that was to fly on an early mission. The Payloads team proudly sat the "Roo" on their console during one of the sims. The flight controllers soon made a game of "kidnapping" it when the payloads officer wasn't looking. Sometimes, it'd show up on one of the Mission Control TV channels, tied to a chair with a ransom note. Recently, despite being chained to the console, it had disappeared again.

I took a deep breath. I didn't know why he was asking me this, but I knew the answer. "Last I heard, it was at the bottom of [Payload team member] Rob Kelso's swimming pool, Sir."

He chuckled. "That's what I heard, too." Then he turned to my Division Chief Jim Bilodeau with an observation that he'd noticed that interns with physics backgrounds always seemed to adapt especially well to the flight control environment. Bilodeau smiled and nodded his agreement. They sent me out of the room.

A few minutes later, Bilodeau came out to tell me I'd done fine, and he'd walk back to Building 4 with me. I asked him why Kranz had asked me about the Roo. He said Kranz used it as a way to judge if women were being included and accepted as part of the flight control teams. And I'd shown him that I was indeed "in" on the joke!

Thor and I went to North Carolina to spend the holidays with my mother and Jack in Chapel Hill, and then with his family who'd rented a place at the beach.

At my mother's, I wrote, "Thor's lying here next to me on this foldout sofa where I wished and dreamed about meeting him someday, where I anxiously slept the night before I left for Houston to find him. Seems funny, all those dreams and prayers were answered, and I thought they were so unreasonable! But here he is, and I love him so much. . .. All I meant to say in this entry is that I am very happy and looking forward to the next 5 minutes as much as the next 50 years."

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4

Shuttle Procedures and Training

On January 24, 1980, we “launched” the shuttle as part of our first 30-hour sim. Apollo 16 Moonwalker John Young (1930–) was the commander and Bob Crippen was pilot. I served as Timeline 2 during ascent with Diane as Timeline 1 and Bob Nute as FAO.

Mission Control only got data when the orbiter passed over simulated ground sites during acquisition of signal (AOS). The AOS times and duration of the pass were marked on the timeline. We made a game of figuring out what the crew had done since last contact without asking them. I went through the procedures line by line for switch changes or computer commands that showed up on a display. “Diane,” I’d say, pointing to a display on my black and white monitor. “See there—they just did the ‘OPS 106 PRO’ command. That means they’re doing the computer configuration on page 1–4 of Post Insertion.”

We recorded activity times to build the “as-flown” timeline. This timeline allowed engineers to correlate the effects of crew actions on shuttle systems post flight. Was a measured acceleration because crew exercise shook the ship or had a maneuver occurred? An accurate as-flown timeline was a key product of the Operational Flight Test Program, and we produced it.

We couldn’t use the Crew Activity Planning System in Building 4 to create this product. CAPS wasn’t portable. A second CAPS for use in the support room was considered too expensive. And besides, CAPS couldn’t “talk” to the mission operations computer (MOC) that took up the entire first floor of Building 30. Trying to do that would be like trying to draw a 3-D color portrait with an Etch-A-Sketch.

The original mainframe processors of the MOC, five IBM computers, accepted data from the communications system and used it to drive strip-chart recorders and meters on consoles. A backup computer processed the same data. The outputs were compared for problems such as timing errors. A Gemini 4 press release (1965) proudly stated Mission Control had 52 million feet of wire—roughly the roundtrip distance from Houston to the North Pole. Because of budget cuts after Apollo, not much had changed by 1980.

MOC’s display and control system provided the data we monitored in Mission Control. The system drove indicator lights on consoles. For example, the MOC might receive temperature data from the flash evaporator system. The software would compare this temperature with the previous one. If the temperature exceeded a certain value, a red light

M.J. Dyson, *A Passion for Space*, Springer Praxis Books,
DOI 10.1007/978-3-319-20258-7_4

activated on a console. An operator who saw that light knew the crew had gotten an alarm onboard and were executing my Loss of FES procedures (Lord help them!).

The displays we watched in Mission Control were not computer displays. They were video monitors. The world's largest collection of television equipment, 136 cameras and 354 receivers, was needed to provide these displays. There were 104 TV channels. Most employed some sort of background template for the labels and then had the computer add in the data such as temperature or switch position.

The FAO had only one channel which was attached to a camera mounted next to my console. We kept the camera pointed at a timeline showing the current and scheduled crew activities, and sometimes copies of messages to be sent to the crew. This camera couldn't zoom, so as we moved from one book to another of a different thickness, I adjusted the height using phone books to keep it focused.

In addition to tracking crew actions during the sim, I followed equipment failures and switch changes that might impact downstream procedures. This sim was the first time for us to practice handing over this list to the Orbit Team.

The Orbit Team Timeline 2 was Bill Holmberg, another MacDac employee. Bill was a few years older than me, and totally unflappable. He might easily have been mistaken for an English professor. His diction was as careful as an actor's, his grammar as precise as an engineer's slide rule, and his puns always worth a groan. Even his handwriting was as neat as his pressed shirt. Handover went smoothly.

Thor was on the Orbit Team, so he was on shift while I was off, and vice versa. I left him a note after my first shift. "Sure was hard to sleep today," I said. "Jasper got me up at 5 p.m. on the nose (literally, he was on *my* nose!). Channel 11 (CBS) interviewed [Flight Director] Don Puddy. Bob Gist (the reporter) was obviously *very* nervous, his hands shook and his voice quavered while Don sat there looking almost bored with the whole thing. It was funny. There was a note on the radio [about the sim] too. Nice to get some free publicity. . .. I'll see you soon for a few minutes anyway. I wish we were on the same team. P.S. Feed Jasper!"

A report in the *Roundup* said that about 500 people were involved in this drill, including the prime and backup crews. Capcom and Skylab astronaut Ed Gibson (1936–) said, "We learned a lot about how to fit all the phases together. . .This was especially important during the ascent phase. We were able to see what effects our actions would have 10 hours later" [1].

LOSS OF 3 IMU FANS

A week after the 30-hour sim, Holloway assigned me another contingency case; the loss of all three Inertial Measurement Unit (IMU) fans. The IMUs, together with two small telescopes called star trackers, provide attitude and velocity information to the orbiter. Without them, the orbiter can't maneuver—it would be literally lost in space.

The IMUs are like the inner ears on people that tell us where the Earth is no matter which way we turn. Each of the three IMUs is a spinning gyroscope attached to a platform. The three platforms point in three different directions. As the orbiter moves, the gyroscopes sense the motion, so the orbiter always knows which way is "down" or "up," forward or back, despite being in freefall. The IMUs need power to run the motors that make them spin, and fans to blow air on the motors to cool them. If the three fans were lost, the motors would fail, the IMUs would stop spinning, and the orbiter wouldn't know which way was what.

Ben had developed a draft for this failure which I then reviewed with Pointer Mark Rolwes, a perpetually cheerful redheaded MacDac employee. The Pointers supported the FAO in the support room and were in charge of the orbiter's attitude (orientation). They worked for the FAO, but coordinated all maneuvers with the Guidance Navigation and Control (GNC) officer, who was in charge of the IMUs and star trackers; and with the Flight Dynamics Officer who tracked the orbiter's trajectory from the ground. All of the Pointers were men with expertise in orbital mechanics, a favorite subject of mine.

In the coming weeks, I met with Holloway and explained that I wasn't able to come up with a scenario in which all three fans would fail. He said that the Apollo teams couldn't have foreseen the loss of the oxygen tank during Apollo 13 either, but it happened. He urged me not to worry about how this triple failure might come about, but what to do if it did.

I met with the GNCs to better understand ways to deal with the loss of these fans. We developed procedures which were basically ways to reach the ground before the IMUs failed. But by the end of March, we'd determined that the loss of three IMU fans was not a realistic case. I reported, "The only identified failures which would cause this case are: a loss of three main [electrical] buses, a cabin pressure drop below 5 psi; or gallons of loose water in the cabin. All of these failures present much more serious consequences than loss of the IMU fans. The three main bus loss would indicate three fuel cells down [no power]. The cabin pressure drop would mean loss of the computers [no control], and the water loose in the cabin would mean loss of the IMUs themselves (long before the fans would stop). With this information, it was decided not to write a Deorbit Prep for the loss of three IMU fans."

UNCERTAIN PLANS FOR STS-3

I completed a draft of the STS-3 Crew Activity Plan in February, including a list of all the flight test objectives and when their associated activities were scheduled. Bob Nute, the FAO that I'd been working with on console, was assigned as the lead FAO for STS-3. He'd oversee and approve everything I did and become the STS-3 CAP book manager.

I was glad to have his help working a problem that required someone with more clout than a Timeline to solve. I'd been working with Herb Greider in the Life Sciences Directorate (mail code SD) to codify the operating procedures and constraints for the electrophoresis experiment for STS-3. This information was in the Payload Integration Plan (PIP) Annex 2. "He has refused to provide anything more than a sequence of events," I reported, "considering it not his responsibility to write the Annex." It turned out to be a "political" problem, so we kicked it up to the next level: the Shuttle Payload Integration and Development Program Office (SPIDPO). SPIDO Chief, Leonard Nicholson, agreed it was not our job to write PIP Annexes.

The next week, I got a draft of the Annex. We thought the problem was then solved, but unfortunately turf battles got in the way. "The EEVT Flight Planning Annex has been pigeon-holed in the sign-off loop by Space Life Sciences Directorate," I wrote in March. "We received another copy of their version without our comments incorporated and were told they would not sign the copy we sent them simply because it was not typed."

Later that month, I reported, "The mysterious EEVT PIP Annex has refused to make its presence known. SD [Space Life Sciences Directorate] contact Herb Greider says he mailed it to us, but it never arrived. Bob Nute and I will rewrite our comments on an older version and call a meeting to get this Annex signed off."

A new draft was prepared by Charles Chassay. This simple document was finally signed in mid-July, though it was destined to come back to me again. Considering the difficulty we'd had getting agreement on requirements for one simple payload, I wondered how we'd ever manage to launch complex payloads on a regular basis.

An even bigger uncertainty for STS-3 was the launch date. The primary test objectives for STS-3 were the thermal effects of different attitudes. Depending on the time of year, the shuttle would spend more or less time in Earth's shadow, thus changing the thermal effects. A new super tape for a September 30, 1981 launch date was planned, but the Flight Test Program Panel declared the STS-3 "official" target launch date was August 31, 1981.

The first detailed STS-3 CAP was due at Launch minus twelve (L-12) months, which was now August, but by then, the launch date had slipped to December 1981. It wasn't until November 1980 that MPAD provided a trajectory tape to reflect the December launch date.

Bob and I were then ready to lay out the attitude timeline, but only two experiments were certain: the Electrophoresis and the Monodisperse Latex Reactor which was added in September. It was a materials' processing experiment destined to create the first product manufactured in space, spheres of latex larger and more uniform than could be produced on Earth. Both of these were middeck payloads to be mounted in the pressurized cabin below the flight deck.

The rest of the test objectives were on hold because of a controversy about which flight software load would be on STS-2. If the software wasn't ready to support certain tests on STS-2, then those tests had to be postponed to STS-3. But the flight duration was 171 hours and some minutes compared to the 56-hour STS-1. Cynthia Wells, one of the first technical women at JSC, of Mission Planning and Analysis Directorate (MPAD) had run a consumables analysis and warned that we had a cryogenics [oxygen and hydrogen used for fuel and power] problem even without the additional tests.

Nonetheless, in the fall, I was asked to assess the impact of adding a major scientific payload from the Office of Space Sciences (OSS) to STS-3. OSS-1 contained four instruments to evaluate the orbiter's environment [2].

LOSS OF FES THERMAL ANALYSIS

The thermal analysis on the Loss of FES case finally arrived in February. A whole team of people met to review and discuss the results including Jim Jaax, Bob Payne, Bruce Graumann (Rockwell), Al Behend, and Gary Rankin. The results showed that cycling the hydraulic pumps was a good way to keep them cool and could be started 20 minutes earlier.

The last week of March, Rockwell presented the Loss of FES thermal analysis to Flight Techniques. The procedures had taken a year to draft, review, verify and analyze. I felt a deep sense of satisfaction that the thermal analysis had confirmed that the proposed power down and equipment management were sufficient to get the crew and vehicle to the ground safely. I sent a summary to Holloway and received a note back that really made my day: “M—Thanks for the summary on the data you got. . .. Sounds like you have the FES failure case well in tow—Keep up the good work.—T. W. Holloway.”

At a meeting of all the contingency procedure authors, Ben assigned me to create a “quick look” overview/comparison matrix of equipment that would appear on the tab page for each contingency case. Using this matrix, the crew and flight controllers would know the assumed initial conditions, the problem description, and the rationale behind the procedures.

I worked on the matrices with Astronaut Rick Hauck who was assigned as the crew’s Flight Data File point man. He may have been a point “man” for the astronauts, but the women who worked for Kentron affectionately dubbed him an honorary “Flight Data File Lady” because he spent so much time fussing over the formats. At one of the parties, they even gave him a blonde wig which he good-naturedly donned for them.

ASTRONAUT CANDIDATES

NASA began another round of astronaut selections. The current six women astronauts all had Ph.D.s or M.D.s. Since I only had a BS, I didn’t apply. I also thought if I somehow managed to get selected, I might have to give up my plans to start a family. Our best friends, Cindy and John, were expecting their first child in August. We decided that we’d hold off on trying to have children until after STS-1, which was unfortunately a moving target. When I’d started with NASA, the first flight was to be in the fall of 1979. Now it was scheduled for the fall of 1980, and unknown to us at the time, would not actually fly until 1981.

Thor also decided not to apply. Like me, he’d been assigned to a position in Mission Control for STS-1 that was keeping him plenty busy. He’d serve as Winds in the FDO support room, collecting and reporting balloon data on upper atmospheric winds to aid in the go/no go decision for launch. His office mate, Bill Crimmel, an Air Force officer detailed to NASA, was also working the Winds position. Bill was one of the 3122 people who applied for one of the 10–20 astronaut positions. He made it to the finals and was interviewed, but wasn’t selected [3].

But some other people we knew were selected for the Class of 1980. One of these was Capt. Jerry Ross (1948–) who was also with the Air Force and had been working in the Payloads area. Many years later, when he found out Thor and I’d never seen a launch in person, he kindly invited us to travel to Florida to watch him launch on the first space station assembly flight [4]. Another was Bonnie Dunbar who had worked in Mission Control for Skylab.

4.1 Astronaut Class of 1980. Standing, *Left–Right*: Robert Springer, Michael Smith, John Lounge, Bonnie Dunbar, Jerry Ross, Mary Cleave, Franklin Chang-Diaz, John Blaha, Bill Fisher, James Bagian, Bryan O'Connor. Kneeling, *Left–Right*: Claude Nicollier, Wubbo Ockels, Richard Richards, Sherwood Spring, Roy Bridges, David Hilmers, Charles Bolden. Not pictured: Guy Gardner and David Leesma (NASA photo)

LONG SIMULATIONS

In April, the STS-1 team ran a simulation of the entire flight, starting one hour before launch and extending to one hour after for a total duration of 56 hours. My first shift started with launch on Tuesday morning at 7 a.m. "For ascent, we lost GPC 2," I wrote. "It was busy with Diane working on the GPC replacement and memory dump scheduling and me watching the FES (controller A down) and trying to answer John Whiteley's questions." John didn't have an assigned position for STS-1, so he assumed the role of "Mother hen."

I went home around 3 p.m. and had to be back that night at 9:45 p.m. I'd work until 7 a.m. Wednesday. As I'd learn, management had little regard for how much sleep flight controllers got!

While I was off console, another computer failed. Using the procedures that Diane had coordinated with the Data Processing System controllers the night before, Engle and Truly replaced one computer with a spare onboard. This exercise had also been verified with real hardware in the Shuttle Avionics Integration Lab in a building across the parking lot from Mission Control. This was good practice for a failure that we'd see on STS-9.

Also on the second day of the sim, the orbiter's avionics system had a partial failure. During entry, this failure would cause the crew to sacrifice either backup attitude control or backup navigation data. The debate on which system should take priority raged for ten hours. The Orbit Team handed over the problem to our team. Flight Director Neil Hutchinson decided the attitude control was more important than the navigation (which ground could help with).

4.2 Neil Hutchison was the Ascent/Silver Team flight director for STS-1 (NASA photo)

We sent the crew a huge long list of timeline changes in the morning. This too was good practice, especially for Engle and Truly who were the crew for STS-2 which would experience a major failure. After this sim, I had a very good feel for what it'd be like to work real missions. As Hutchinson told *Roundup*, "If we can overcome similar problems in an actual flight, we could definitely call that flight successful" [5].

We didn't get meal breaks on console, and the cafeteria wasn't open at night, so everyone packed a lunch and often brought goodies to share. I joined in the team spirit by making some chocolate chip cookies from scratch. Unfortunately, I tend to get distracted while cooking and leave out ingredients. "I made cookies last night and forgot to double the butter," I wrote. "So I added more butter after the first batch and got brown cookies." The cookies looked strange, but like most of my kitchen mistakes, tasted fine. Thor never complained about my absent-minded cooking. He just ate the "mystery" cookies, even tuna and noodles without the tuna!

I didn't have much time for "experimenting" in the kitchen, though, especially the week of the sim. That week, Thor's parents came down from Michigan. We toured the shuttle mockups, saw the Gossamer Albatross (flown on first human-powered flight by Bryan Allen across the English Channel in 1979), visited the San Jacinto Monument, and stopped in Seabrook for lunch at Tookies. We hiked around the Armand Bayou Nature Center and then drove to Galveston to shop along the Strand. Everyone agreed eating out in Galveston was way better than having me cook.

LOSS OF FES GOES TO PRIME TIME

After a full year of development, analysis, verification, and more analysis, the Loss of FES was finally ready for prime time. On May 22, 1980, the crew and Entry Team had to tackle the loss of FES in a sim. I monitored the sim closely and prepared an Informal Note that identified 13 action items that resulted from this test. Some of these were minor inconsistencies between checklists such as the switch settings. Others were items that had been previously overlooked such as the need to dump excess water because the FES wasn't using it.

The most serious item involved protecting against a failure during the deorbit burn. Normally, the two large orbital maneuvering system (OMS) engines perform the burn. If these engines failed, then the smaller RCS engines automatically took over—a process called downmoding. Because the RCS engines were smaller, they had to fire longer than the OMS to slow the orbiter down the same amount. Normally, the burn was timed so the RCS could take over if necessary. In the FES case, the burn was purposefully delayed so that the time between payload bay door closing and when the ammonia cooling kicks in was as short as possible.

I wrote, "When there are two OMS available, the burn will be slipped the maximum amount, and RCS downmoding will be lost. But with a one OMS case, we decided not to give up the RCS capability to avoid a possible one-orbit late under poor conditions."

Another problem identified with the late burn was that it left the orbiter "nose heavy." The OMS fuel tanks (which could also be used by the RCS via a crossfeed line) were in the tail. A late burn, like a sudden exit from a freeway, required faster braking, and hence used more fuel by the aft engines. Normally, enough fuel remained in the tail to balance the fuel in the forward tanks. This balance was critically important because the orbiter must enter the atmosphere with the nose angled up, i.e. tail heavy. The balance point, or center of gravity (cg), was carefully managed throughout the flight for this reason. If extra aft fuel was burned, to shift the cg back, the forward fuel had to be burned, which controllers called dumping. "However," I noted, "the power down includes closing the forward manifold and turning off the jet heaters [preventing the forward jets from firing]." So I added a new procedure to the entry section.

My Branch Chief, Ed Pavelka, wrote, "Marianne—Super write up!"

4.3 Every May, the Flight Operations Directorate held a Chili Cookoff. The Payloads' Roo team, shown here, won in 1980. *Left* to *Right*: Rob Kelso as the Roo, Bonnie Dunbar, John Hoover, Gary Renick, B. Molnar, Dave Ballard, T. Bruce, Maryann Albilier, Bill Boone, unidentified woman, Yanis Plesums (Photo ©Bob Castle)

THE LOSS OF 2 FREON LOOPS: I.E., THE BASKET CASE

Having done a good job on the Loss of FES, I was assigned yet another contingency case: the Loss of 2 Freon Loops. This was the ultimate "cooling" system failure. The job of the FES was to cool the Freon loops. The Freon loops cooled the water loops that cooled the air. So if the Freon loops failed, everything overheated, starting with the fuel cells which were directly Freon cooled. Without fuel cells, the orbiter had no electrical power. Without power, the orbiter couldn't return from space.

Like I'd done with the Loss of 3 IMU fans, I first considered whether or not this case was credible. The loops ran through the payload bay doors and radiated their heat into space. To fail, both loops had to be cut or blocked so the Freon leaked out or quit flowing. I decided that an explosion of some equipment, perhaps a fuel tank on a satellite in the payload bay that sent shrapnel into the radiators would do the trick. Years later I'd use this scenario in my first published science fiction story, "Fireworks in Orbit" (Analog, August 1990, reprinted on Kindle).

So I'd found a credible scenario, but "From the info I have gathered so far," I reported, "it looks like we'd be pressed to make it to an immediate deorbit. Instead of asking what to power down, we need to ask what to power up for a known ditch-type case. Analysis so far shows about 8 kilowatts (kW) is the max load for the fuel cells to survive 30–60 minutes."

During normal fuel cell operation, hydrogen and oxygen combined to produce electricity. The byproduct steam condensed to water and was stored in a tank for use by the crew or FES. Without cooling, the byproduct water wasn't condensed out and flooded the fuel cell. But there was one other way to remove water from the fuel cells—vent it to space.

This venting, called a fuel cell purge, was normally scheduled twice a day to remove inert gases and other contaminants that accumulated in and around the electrodes in the cells and reduced their efficiency. The fuel cells continued producing power during a purge, so this looked like a good way, and the only hope, to postpone flooding the cells long enough to get the crew home. The three cells used the same vent line, so only one could be purged at a time in series. The automatic sequence purged each fuel cell for two minutes. This wouldn't be long enough to do much good. But a longer purge would send a lot of hydrogen and water vapor to vacuum, causing it to freeze and clog up the vent line with ice—drowning the cell. The vent lines were heated during the purge and "baked out" for 27 minutes afterwards to prevent this. But with a continuous series of purges, the vent heater would be overwhelmed. How long would that take?

Shelby Owens in the Engineering Directorate ordered a three-day test to answer this question and to check if the heat buildup in the cell would thaw the line enough to restart the fuel cell. He found that the lines didn't freeze at all, which was good news.

But even if a continuous fuel cell purge kept the fuel cells working long enough to reach the ground, how quickly could the crew power off equipment to get to the necessary 8 kW level? I reported, "Pinning down the minimum required response time to the failure has been a difficult task. Depending who you ask, the loss of the Freon loop cooling causes the fuel cells to cease operation within 15 seconds to 10 minutes. The majority vote is for 10 minutes, so the procedures will assume that time." So if the crew got the purge going in 10 minutes, they had a chance to survive this "basket" (as in "going to hell in a hand basket") case.

However, the control switches for the fuel cells were on a panel in the aft station of the cockpit. The astronauts couldn't reach these switches while strapped in their seats for entry. It also wasn't obvious if the crew could land the shuttle with only 8 kW-worth of equipment. This case reminded everyone of the power down required for *Apollo 13*.

The Loss of 2 Freon Loops case was the most difficult "real" problem I'd ever tackled. I enjoyed the challenge and decided that, as Kranz famously said, "Failure is not an option!"

OUTSTANDING EMPLOYEE

I'd discovered back in January that NASA would pay for classes at the University of Houston, which had a Clear Lake campus. To increase my chances for leadership positions, I'd decided to get an MBA, though I only had time for one class per semester.

In June, I got an A in my first class, Management Processes, taught by Warren Chaney. Encouraged, I immediately registered for another class, Human Behavior in Organizations.

June also marked my one-and-a-half year anniversary with NASA. That meant it was time for that "report card," too, i.e., my employee evaluation. Every civil servant was graded in six areas: Relations with Others; Attitude—Application to Work; Judgment; Dependability; Ability to Learn; and Quality of Work. Each area had five descriptive rankings. I got the top rank in 5 of the 6 areas: "exceptionally well accepted; outstanding in enthusiasm; above average in making decisions [versus "exceptionally mature," the top choice]; completely dependable; learns very quickly; and excellent."

My Section Chief Wegener gave me an overall rating of "Outstanding." He listed my strengths as: "Good hard, consistent worker—solid employee; excellent quality work; enthusiastic; establishing good contacts and good coordination—good credibility; developing excellent technical competence and good application of acquired knowledge; realistic goal setter." He also listed my weaknesses: "Time management—working diverse tasks; and diplomacy in working requirements and changes."

I was promoted from a GS-7 to a GS-9, the same pay grade I'd have had if I'd stayed at Rice and finished my master's degree.

Lots of people got promoted and moved offices that summer. My whole management chain changed. I got new section, branch, and division chiefs. Soon after my promotion, I was offered a coveted window seat. I was really moving up in the world! Bill Holmberg, one of the other Timeline 2's, moved into my old spot by the door.

We loved to chat about all sorts of things, but one thing we never discussed was politics. Since 1980 was a presidential election year, we were reminded that the Hatch Act (relaxed in 1993) didn't allow government employees to endorse candidates, wear buttons, put bumper stickers on their cars, or discuss politics at work. Supposedly this prevented a manager either discriminating against or favoring an employee because of their party affiliation. I believed that this forced ambivalence of NASA workers deprived the space program of valuable public support. People who weren't allowed to talk about politics at work tended not to discuss it outside of work because they socialized with the same people. I sometimes felt as if I were the only one who cared about what was going on in D. C. More likely, my coworkers, especially those Like Diane and Bill who worked for contractors, were afraid that if they shared an opinion, even on a local issue, they'd get in trouble for trying to influence a government employee.

But I was a former Congressional intern who was keenly interested in the candidates. The previous November, Iranian militants had seized the U.S. Embassy in Iran and taken hostages. President Carter had ordered a rescue in April that not only failed, but killed eight servicemen and one Iranian. So on July 17, 1980, I watched the Republican National Convention nominate Ronald Reagan (1911–2004) and George H. W. Bush (1924–) while 52 Americans hostages remained in captivity in Tehran. I wrote in my diary that I liked Bush, but I wasn't too sure about Reagan. I thought a presidential candidate should have more experience at the national level. Little did I know at the time what a difference his support for space would make to NASA's future.

PLANNING FOR HIGH FLIGHT RATES

NASA had just hired eight new pilots and 11 mission specialists. More flight controllers joined our ranks every month. How would all these new people get trained with only two simulators and two MOCRs? How much training on console was enough to qualify a person to make life-and-death decisions?

To address these issues, each flight control division was tasked to come up with career paths for future console operators. My Branch Chief asked the STS-1 lead FAO, Elvin Pippert, to write down his thought on "Transforming the Qualified Rookie into an FAO." This Informal Note dated June 20, 1980, was of special interest to me, one of the "rookies." The note began with a definition. "An FAO, at the most basic level, is a "Jack of all trades" with "A sound working knowledge and understanding of all the Orbiter's systems and capabilities, of orbital mechanics, and of the experiments and their support equipment. ... An ability to be able to see the big picture as well as understand the details of each piece making up the big picture. ... "Ability to rapidly rebuild a timeline in a short time to accommodate real-time failures or changes in experiment objectives."

To obtain this level of knowledge, Elvin recommended that the rookie first complete the basic classroom training with emphasis on "the Flight Control System, propulsion and crew systems for the Orbiter operations." He also suggested that "The candidate should be assigned as a Pointer for a flight to provide him with a good understanding of what is involved...to properly schedule activities to minimize maneuvers...After a trainee... is deemed ready to work a flight as one of the FAOs, a mission on the other teams (ascent, entry) should occur before being assigned as lead FAO and flight planner for a flight."

According to Elvin's training plan, I was well on my way to becoming an FAO. I certainly didn't anticipate that these criteria would later be applied differently to men than women. At the time, what these criteria suggested was that I'd have to be a Timeline on STS-2, lead Timeline on STS-3, then a Pointer on STS-4 before I'd qualify to be an FAO.

Should I hold off on getting pregnant until I'd been an FAO? I was 25, my mother's age when she'd had me. "I fluctuate from wishing I were pregnant now to wanting to wait until after STS-1 to start trying," I wrote. "It's like an overwhelming instinctual urge and seems unnatural to prevent it. Here I am madly in love with my husband and happily settled in a fantastic house with good salaries to buy all we need, and we are waiting—or rather I am waiting. Somehow I know I'll look back and it will seem silly to me to have worried about missing the first flight. There will be so much going on after the first flight that I'll be involved in that it seems I'll wonder why I didn't do it while I wasn't so busy!"

LADIES FIRST

In the spring, I'd supported a Launch Day Deorbit training session with Young and Crippen. The training team blasted the prime crew with a combination of failures: one computer, one fuel cell, and one water loop down. "Crip did an excellent job of doctoring the procedures to include the off-nominal positions of the switches due to the failures, though it slowed him down somewhat," I reported afterwards. I was really pleased that he found only one item in the Launch Day procedures which he wanted changed, and it wasn't because it was incorrect—it was just repeated in the Entry Checklist.

Two weeks later, the flight directors decided that they preferred Orbit 5 to Orbit 4 as the primary opportunity. "The reason is that for cycle 3 [data supporting the November launch date] there is no Guam [communications] coverage for Orbit 4, but there is for Orbit 5," I explained to my boss. So on April 29, the crew and Ascent Team did an end-to-end "verification" run of Orbit 5 Deorbit. I wrote, "It went very smoothly. Not a single switch was found to be out of configuration after the deorbit prep!" This was a nice feather in my cap.

At the end of July, I showed up at the simulator in Building 5 to do a run on Orbit 2 Deorbit with the backup crew, Engle and Truly. As I walked in, I found the two astronauts sitting casually on the floor, leaning against the base of the ladder that led up to the cockpit. I asked if they were ready to get started, and they looked at each other and grinned. "Ladies first," Engle said, winking and indicating the ladder with his upraised palm.

"Oh yes, after you," Truly added, smiling.

I had on a dress as usual. If I went first, they'd both have an excellent view up my skirt... My face reddened in embarrassment as they both laughed. I mumbled something about men and rolled my eyes. As soon as it was clear that I'd gotten the joke and wasn't going up the ladder, they climbed into the cockpit. I then went up after them, and was careful to make sure I was the first one down!

The session went fine, and the astronauts treated me professionally throughout. Truly asked me to annotate the computer transition to show which parts were optional if time was short. This idea ended up being expanded to the other launch day procedures, especially after an ascent sim of a cabin leak that required deorbit on Orbit 4. The crew didn't have time to run around the cockpit and turn things off. So even though the Launch Day Deorbit procedures were considered "done," there was still room for minor improvements.

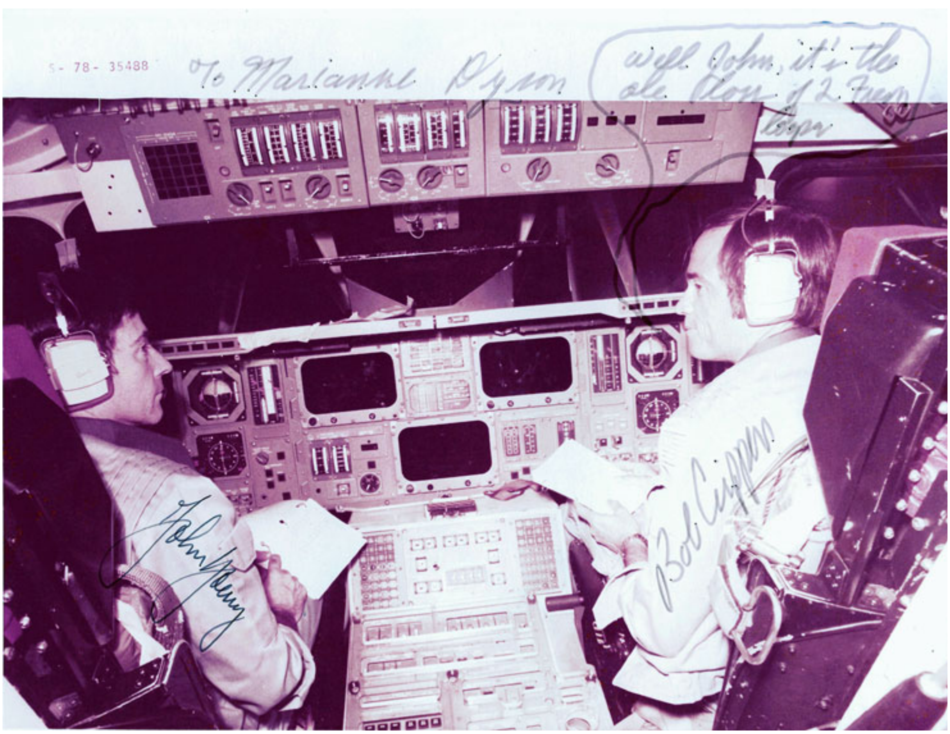
LOSS OF 2 FREON LOOPS, ASCENT CASES

In contrast, the Loss of 2 Freon Loops had a long way to go. I met with Holloway, Carolynn, and EECOMs Jack Knight, Charlie Dumis, and Bill Bates, and electrical power system controller, Bill Moon, to review the return-to-launch-site (RTLS) and abort-once around (AOA) options for this failure. An RTLS brings the orbiter back to KSC in about 25 minutes, using the shuttle main engines to slow it down before jettisoning the tank. An AOA can be performed any time after the window for the RTLS has passed and takes about 90 minutes.

They suggested some equipment configurations. Then I asked what Mission Control could do to help, and learned that the purge could be commanded from the ground—the crew wouldn't have to struggle out of their seats to reach that aft panel. To implement this change, we'd have to launch with the switches in a different position—we'd previously had them off.

On August 13, I conducted a run on the modified Loss of 2 Freon Loops AOA. I reported, "The simulator was down two hours of the session, and when we did get it to run, the power down tripped it up, and it crashed several more times. The Fuel Cell Model doesn't seem capable of coping with a total loss of cooling even at an 8 kW total load. The fuel cells flooded in about 30 minutes. We did not complete the procedures."

Hoping that a faster power down would allow the simulator to survive long enough to verify the procedures, I tried again the next week with the most experienced crew, Young and Crippen. I reported, "John accidentally powered off GPC 3 instead of GPC 4 which invalidated the avionics bay temperature data. Otherwise, it was a smooth run. . . .The fuel cells probably would have flooded in another few minutes." I concluded, "The simulator can support an integrated sim of these two cases as long as the fuel cell stack temps are kept artificially low after 20–30 minutes."



4.4 Every time we tried the Loss of 2 Freon Loops in the simulator, the computers would crash, causing the screens to go blank as in this photo. So Crip wrote: "Well John, it's the ole Loss of 2 Freon Loops." (NASA photo)

I met with Holloway and Hutchinson and some of the ascent flight controllers to discuss the communications plan for this case. They decided we'd power communications post "blackout" (when the orbiter was unable to communicate with the ground during entry because friction created a hot plasma under the vehicle) in case the state vector had to be updated. If the state vector (calculated position and velocity) was wrong, the orbiter might miss the landing site. Updating the state vector is the job of the Guidance officer, the position Thor was training for.

Bill Bates and I submitted the forms to get an electrical analysis done for the Loss of 2 Freon loops procedures. I reported, "We expect (believe it or not) to get a tape from MPAD in less than two weeks." The request probably got priority because I'd presented it to Flight Techniques that week. Rockwell took an action to assess the impact of deleting some of the entry activities, and a thermal analysis was needed to answer questions raised by Flight Techniques.

SPEAKING OF SPACE

With my growing knowledge and practice presenting tough cases to Flight Techniques, I felt confident enough to represent NASA in public. I signed up for the NASA Speaker's Bureau in the Public Affairs Office (PAO). They assigned me my first speaking engagement on August 20, 1980, for the Welcome Wagon of Baytown, Texas, northeast of Houston. The group had requested a female astronaut, but the six were too busy with training. I hoped my audience wouldn't be too disappointed with the "female astronaut substitute" speaker.

To prepare, I (of course) made myself a checklist: "Get slides from Frank Hughes, Carl Shelley, and PAO office and organize them; Borrow slide projector from Karen Flanagan; Get extra bulb and automatic advance; Take green slip (approval) and government drivers' license to Building 1, room 122 (travel office); Get screen, electric pointer, model slides, and handouts loaded into car; Be sure to get directions from person who requested speaker!"

My speech was "The First Flight of the Space Transportation System," and it was 30 minutes long. I arrived at the Wyatt's Cafeteria in Baytown and set up the 100-scale model of the shuttle I'd gotten from Louis Parker in Public Affairs. My audience of 20 women listened intently as I walked through my 43 slides, explaining the phases of flight and crew activities.

PAO required a report, including a record of the questions asked. These were, "What are the Soviets doing, and are they sharing their information with us? [Working on a space station, and no.] Why are the crew so busy—don't the computers do most of the work? [Ha! Don't we wish!] How were the astronauts selected for the first flight? [They were nominated by the military, tested, and selected by NASA based on skills, health, and experience. Now astronauts can be civilians.] How much do you think the elections will impact NASA's budget? [I'm not allowed to discuss politics.] Does each crewmember have their own unique space suit? [No. The upper and lower sections come in standard sizes and the helmets are one-size fits all. Only the gloves are fitted to each person.] How long does it take to train an astronaut? [A year for the initial training, and usually 2–3 years after that.] Do you still feel awed by the Space Program?" [Absolutely!]

I enjoyed the interaction with the public, and PAO was pleased with my performance. I gave the same talk again in October. I was tickled to get a thank you letter from the organizer, Ginnie Ferraro that read, "On behalf of the Baytown Junior Forum and on a personal basis, I wanted to extend our thanks for your program at our monthly meeting. It certainly gave us information to answer questions and raise our awareness level of the shuttle program. You are an outstanding young woman and we wish the best in your exciting career."

While I was out representing NASA, the Agency was busy figuring out how to better integrate women into the workforce. So September 9–10, I was paired up with a manager in my area (Dan Bland) to attend a two-day pilot course called "Working with Women" taught by the Employee Development Branch. I evaluated the class as if it were a flight procedure. "The first day of the course did not address the problem topic of working with women. Case studies were read and questions answered by each of the five groups within the class. . . .The instructor served merely as a moderator and did not (in my opinion) add much to the discussions. We all left the first day wondering what we were supposed to have learned and with a homework assignment which was never mentioned the next day.

"The second day was much better after the class persuaded the instructor not to attempt to follow his lengthy agenda. We discussed concerns women have working with men, and vice versa by listing them on the board. One of the women's concerns was the lack of mentors available to them. One of the men's concerns was that they had to 'watch their language' with a woman around. Both sexes discussed dress code as an issue, but neither group felt it was their responsibility to get individuals (male or female) to conform to any kind of standard. The consensus on that issue was, 'you get what you tolerate.'

"All in all it was a good experience to find out that women have the same concerns in common and ones that are not that different from the men's. We all left with a decision to take our concerns of working with men/women with a liberal dose of humor."

I made some suggestions to improve the course. "The shyer members of the groups could not easily participate in verbal arguments with a group of supervisors present. A few questionnaires could have been used with success.... The men and women should be divided for one discussion so that they will not feel inhibited to criticize the other sex as they might with them present. . . .Young men do not have the same attitudes toward working with women as older men do. They should be included in these classes."

Part of the reason there was so little friction between people at work was because we were friends outside of work. FDO Willis Bolt regularly held parties at his condo. Bill Bates, one of the EECOMs, loved the outdoors and often organized canoe trips. The second weekend in October, Thor and I joined one of Bill's campouts to Canyon Lake, west of Houston. We rented a canoe and went up the Guadalupe River about 12 miles. We had plenty of time to chat with our peers and share a few beers.

I also made friends with other women at NASA. By 1980, there were more than enough to form ten volleyball teams and play against each other in a women's league. Our team, the IFS (In-Flight-Service), did pretty badly in the summer season, winning 11 and losing 16 games. So we changed our name to the Maybes for the fall season. Sharon Conover, who had gone with Mi-Mi and me to Florida, was our team captain and one of our strongest players. With practice, we really improved, winning 19 and losing only 8. We qualified for the playoffs against the Hustlers and 1st Gear. We lost the final game but came in second. I'd never played a team sport before coming to NASA and was rather proud of our success.

4.5 Carolynn arranged for this photo of women (NASA employees and contractors, technical and nontechnical) in Mission Operations in front of Building 4 in early 1981. *Left* to *Right*, *Row 1*: Robin Cobbs, E. M. Eav, Rowena Burns, Maridene Lemmon, Iva Doyle, Monica Davis, Mindy J. Cohen, Cadie Howard; *Row 2*: Anne Fox, Elaine Hilliard, **Marianne Dyson**, Anne Flippin, Panna Amin, Ann Johnson, Delores A. Couch, Teresa McDonald, Sandi Kovar, Anne Accola; *Row 3*: Carolynn Conley, Helen Meester, Eva Hernandez, Maria Garza, Carmen Cruz, Pat Engel, Sharon C. Conover, Karen Flanagan, Georgie Huepers; *Row 4*: Marie Gibson, Nina J. Weaver, Irma Cortez, Sara Beck, Pearline Collector, Nancy Harris, Patsy Smith, Susan Wilson, Mary Barth; *Row 5*: M. Edson, M. E. Mabry, Ruth Ann Brinkworth, Barbara Hopkins, Dianne Murphy, H. A. Barnes, Terry Stanford, Kathie Abotteen, Michele Brekke, Alice Van Gilder, Mi-Mi Lau, Dianna Watson, Cynthia Nagy (NASA photo)

A DIFFERENT ENTERPRISE

Thor and I took a welcome break from the high-stress world of flight control in October. We flew to Canton, Ohio for my cousin Jill's wedding to Randy Hutsel. As happens in small towns, even though this cousin was on my mother's side of the family, some of my father's side were also there, specifically, my dad's brother Jack Jakmides and his daughter Lisa McCleaster. The "Jack Midas" Band played jazz trumpet and Lisa sang at the reception. Despite living in Canton all those years, this was the first time I'd ever heard them perform. I was enthralled!

Also at the reception, I met a vice president of Goodyear Aerospace in Akron, where my dad worked. When he learned that Thor and I and my cousin Mike (Jill's brother—the one I'd stayed with when I'd first arrived) lived in Houston, he offered to arrange for us to ride on the Goodyear Blimp. Only four blimps were in operation, and only one, the Enterprise based in Florida, was available for rides. We were privileged indeed to get this opportunity to fly on a ship that could only take six passengers, and by invitation only.

A few weeks later, Thor and I, my cousin and his fiancé Donna, and Thor's brother Harry met at the airfield in Spring, west of Houston, for our VIP ride on the Goodyear Blimp. Our chief pilot was Larry Chambers. He explained that each ship was staffed by a crew of 23, including five pilots, 17 ground crewmen, and a public relations representative. The ground crew "captured" the mooring lines and gently brought the gondola down for us to get in. The huge helium balloon billowed above us with the Goodyear logo on the side. The seats were benches on both sides with windows all around. The ride was gentle—I loved it! We simply floated up and cruised around the city.

When Capt. Chambers heard that Thor was a pilot, he invited him to the cockpit. He explained all the unique controls—the strangest being a large elevator wheel mounted beside the captain's seat. This wheel controls the up and down direction of the airship, kind of like the yoke on an airplane. We floated back down and the crew grabbed the lines. It was over all too soon. Chambers gave us blue cards that he signed to show we were now members of the Goodyear Blimp Club. I tucked those cards and the pilot's business card into the brochure they gave us called "Aerial Ambassadors."

Plans were underway for another kind of flying adventure: Thor and two other flight controllers, Ed Gonzales and Brian Perry, had purchased the plans for a Long-EZ homebuilt aircraft. The design was by Burt Rutan (1943–) who'd built the first plane to fly around the world without refueling. (He'd later design SpaceShipOne that would win the X-Prize.) Thor and I both dreamed of traveling around the world in a spaceship one day, but in the meantime, the Long-EZ would be very useful for visiting our geographically scattered family.

Nearly every weekend, the smell of epoxy filled our garage workshop. The guys cut and sliced blocks of foam and coated them with rolls of fiberglass soaked in resin that hardened and became the fuselage and wings of the plane. The epoxy had to be warm, which wasn't a problem in Houston. Bugs getting stuck in the epoxy while it dried was an issue, though. So we built framed screens to cover the garage door opening. The forms had to be cut very exactly, and so the guys built a huge table. Our cars were delegated to the driveway. Unfortunately, the fumes gave me nasty headaches and made me nauseous. Tests confirmed my allergy to resin.

4.6 What flight controllers do in their spare time: build airplanes! Brian Perry, Thor, and Ed Gonzales ("speak, hear, see no evil") began work on a LongEZ homebuilt aircraft in our garage in 1980 (Photo by the author)

LOSS OF 2 FREON LOOPS: ORBIT CASE

Once we had an initial set of procedures for the RTLS and AOA cases, I created procedures to bring the crew home if both Freon loops failed in orbit. On October 1, I wrote, "This deorbit prep is to follow an on-orbit wait with one fuel cell operating at a 1 kW load for approximately three hours." This time period was needed to provide for a landing on land versus ditching over water. As the Earth rotated "out from under" the orbiter, there were times of up to three hours when the orbiter didn't pass over any landing sites. "After talking with our only source of data on this case, Rex Moses of Rockwell Downey, I have come up with some alternative ideas for the on-orbit wait which I will outline for Flight Techniques."

Two weeks later, I told Flight Techniques that "The deorbit prep was written to power up equipment only as needed and at the latest possible time. . . . Data from previous Flight Techniques indicated three cells could sustain about 8 kW for 10 minutes before flooding. The deorbit prep requires a much longer time and higher loads than can be maintained." Therefore, I recommended an immediate deorbit be done instead of an on-orbit wait.

Holloway agreed.

Carolynn and I presented the Loss of 2 Freon Loops power down and deorbit procedures to Flight Techniques in November. Then, just before the holidays, I checked out the Loss of 2 Freon Loops with Engle and Truly in the simulator. “The power down and deorbit procedures are not ‘doable’ in time to make an immediate deorbit,” I reported. “The crew suggested pictorials for the power down to speed it up. As usual, the simulator couldn’t cope with this level of failure. We crashed three times.”

CHRISTMAS IN NEW YORK

Thor and I spent the holidays with his extended family in New Jersey. His cousins joined us on a trip—my first—to New York City. We toured the Metropolitan Museum of Art and lunched at the Four Five Six Chinese restaurant on Bowery Street. Thor’s uncle was a physicist with Bell Labs, and had inspired his youngest daughter, Martha, and Thor to study physics. On top of the World Trade Center, the group of us physicists debated how much a penny, thrown from up there, would penetrate the sidewalk below. None of us could ever have imagined that 21 years later, the twin towers would be destroyed in a terrorist attack.

Thor’s family had introduced me to cross-country skiing the year before, and we hoped to do some more on this trip. There wasn’t enough snow in the Catskills, but we drove up to a YMCA camp in the mountains anyway. We enjoyed trying, unsuccessfully, to beat Thor’s cousin Dan Kane, an actuary and math wizard, at the card game called Hearts.

We were also treated to some extraordinary “home movies” from Thor’s cousin Martha’s year in Antarctica, thanks to her boyfriend Mike Savage who’d shared that experience with her and joined us on the trip. Martha had graduated with a degree in physics in 1979, and decided to do a year in Antarctica before going to grad school. She was only the second woman in history to winter over at the South Pole Station. She was the only woman on that tour with 18 men during a very stressful nine months of isolation [6].

Just before the last flight left the Pole in January, one of the crew, Casey Jones, was killed in a cave-in. I listened intently to Mike and Martha’s stories of how they dealt with the grief over their friend’s death and the isolation that followed this tragedy. Mike said that the men tended to vent physically, and the basketball games got very rough—resulting in one broken arm. Tempers flared over use of the HAM radio, their only voice connection to the rest of the human race. Adding to the problem was an abundance of free time and nowhere to go because of the minus 56 °F average temperature. Martha’s cosmic ray research only occupied a few hours a day when she’d bundle up and go to the surface to check her instruments.

But during the long dark months, Martha and Mike fell in love. She decided to transfer from Stanford to the University of Wisconsin to be with Mike. Their wedding would come in a few years, but first, we all gathered back in New Jersey for a beautiful New Year’s Day wedding of Thor’s cousin Dan to Janine O’Mara. Thor’s amazing and talented family was growing.

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5

The First Flight of the Space Shuttle: STS-1

On my second anniversary with NASA, I was excited and optimistic about the future of the country, the space program, and our plans to start a family. On January 20, 1981, the hostages held in Iran were released, restoring America's international image. Newly-elected President Ronald Reagan, a strong supporter of space, took office. Dr. Alan Lovelace (1929–) was named NASA Acting Administrator. We anticipated approval to build a space station.

The January 2, 1981 issue of *Roundup* included an article speculating on what NASA would be doing 20 years later. Would the vision I'd seen as a child of people living and working in space in the movie, *2001*: *A Space Odyssey*, come true? The staff writer for the *Roundup* wrote, "It is possible [by 2001] there would be mining camps and launch sites on the Moon or Mars. We know the Moon contains metals in its soil . . . A Moon mining base could provide materials for a metals construction module in Earth or Moon orbit where astronaut workers would process high strength lightweight steel for use at the space construction site and also to transport to Earth."

He continued, "Some people in the scientific community—Gerard O'Neill of Princeton, Isaac Asimov among them—see all polluting industry moving into space so Earth can be like a preserve, or park. They write about whole pieces of the population moving out into space—Mars, the moons of Jupiter—on huge orbiting structures the size of cities—to start colonies. And some of them think it could be done in the next 20 years, or at least started" [1].

Sign me up! Thor and I hoped to live inside an O'Neill city-sized cylinder at the fifth Lagrange point (L5) where we'd oversee the operation and construction of solar power satellites.

"But the main difference between then and now," the *Roundup* author predicted, "is there will be people whose normal working environment is a space station."

If someone had told me that 20 years hence, instead of the thousands of people I envisioned living and working in space colonies, there'd be only three people in space—all men—in orbit in 2001, I'd never have believed them. The Voyager spacecraft had just flown past Saturn and was on its way to Neptune. *Columbia* was on the launch pad. The universe beckoned us to explore it, and we were answering its call. How could we *not* have colonies in space?

M.J. Dyson, *A Passion for Space*, Springer Praxis Books,
DOI 10.1007/978-3-319-20258-7_5

Shuttle Program Manager Robert Thompson declared that the upcoming Mission Evaluation Test was not a training exercise, but a demonstration of flight readiness [2].

With Center Director Chris Kraft Jr. proclaiming we were on track for a March 14 liftoff, the mantra in Building 4 became, “We will launch in March!” A 1981 calendar was circulated that guaranteed this by showing the months, January, February, March, March, March. . .

Even though the procedures were stabilized, now that we were really going to fly them, it seemed everyone suddenly had a suggested improvement.

All change requests were filed on a form called a 482. These were reviewed by Flight Techniques and approved up the chain of command. Until approval, we weren’t allowed to change the official documents—and so we’d set a publication deadline, and then postpone a week, then a month, waiting on the 482s to clear the system. Invariably, just as we finally got approval on the “last” 482, another would be submitted, delaying publication again.

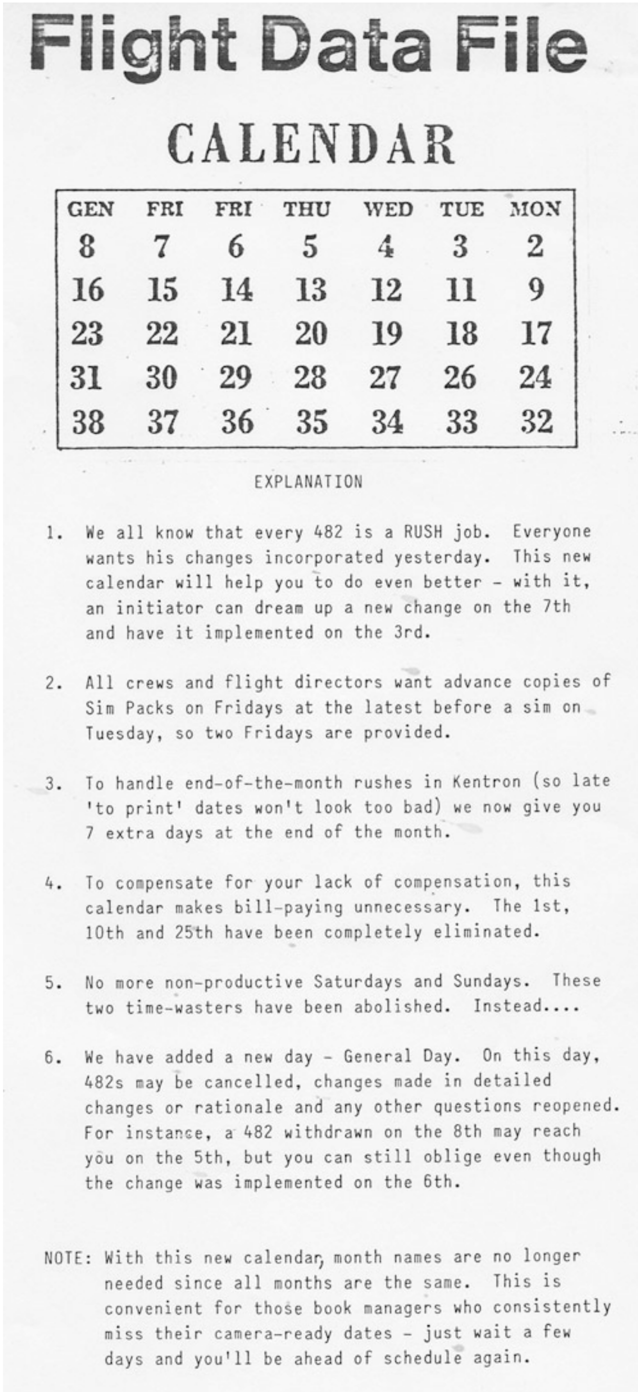
So as one deadline after another fell victim to the “better is the enemy of good” syndrome, management put its collective foot down. Only those changes absolutely necessary for crew safety or mission success would be approved. All requests had to be reviewed by a Crew Procedures Change Board (CPCB). The rest would be deferred to STS-2.

The second week of January, I was tracking five of these requests for the Loss of FES. The most important had to do with moving the door closing closer to the deorbit burn, which gave the crew more margin during entry. Despite the changes being coordinated ahead of time with the Flight Director’s Office, the EECOMs, and Rockwell, these 482s had to “get in line” with all the others. Therefore, a month passed before the 482s made the CPCB agenda. Like I’d done for Flight Techniques, I stood before this august group of Apollo-era flight directors, managers, and astronauts, and explained the rationale behind leaving the doors open to provide a heat sink for entry. The CPCB approved my 482s less than a month before launch.

The Loss of 2 Freon Loops Deorbit Prep had yet to be published. But I couldn’t submit the 482 to add these procedures to the flight book until we’d at least tested them in the simulator. The simulator was running 24 hours a day to get all the last-minute procedures tested while keeping the prime and backup crews sharp. So I was very fortunate to get Engle and Truly in the simulator to test these “worst” case procedures on March 4, 1981.

As the crew had suggested, Carolynn had converted the power down to pictorial displays, and these worked beautifully. (So well in fact that this method of doing powerdowns was still in use for STS-135, 30 years later.) But the simulator offered its usual challenges. I wrote, “Once again major procedural and technical difficulties arose requiring three runs to resolve. But, we did discover the error in the IMU alignment sequence that caused our gross navigation errors which in previous runs was muddled in with all the power down problems and not detected.”

After the run, I edited the deorbit prep, had it retyped by Kentron, and made it “camera-ready” in record time. The deadline for the final book printing had passed a week earlier—but the launch date had slipped to March 17. I had time to make a pitch to the CPCB.



Flight Data File

CALENDAR

GEN	FRI	FRI	THU	WED	TUE	MON
8	7	6	5	4	3	2
16	15	14	13	12	11	9
23	22	21	20	19	18	17
31	30	29	28	27	26	24
38	37	36	35	34	33	32

EXPLANATION

1. We all know that every 482 is a RUSH job. Everyone wants his changes incorporated yesterday. This new calendar will help you to do even better - with it, an initiator can dream up a new change on the 7th and have it implemented on the 3rd.

2. All crews and flight directors want advance copies of Sim Packs on Fridays at the latest before a sim on Tuesday, so two Fridays are provided.

3. To handle end-of-the-month rushes in Kentron (so late 'to print' dates won't look too bad) we now give you 7 extra days at the end of the month.

4. To compensate for your lack of compensation, this calendar makes bill-paying unnecessary. The 1st, 10th and 25th have been completely eliminated.

5. No more non-productive Saturdays and Sundays. These two time-wasters have been abolished. Instead....

6. We have added a new day - General Day. On this day, 482s may be cancelled, changes made in detailed changes or rationale and any other questions reopened. For instance, a 482 withdrawn on the 8th may reach you on the 5th, but you can still oblige even though the change was implemented on the 6th.

NOTE: With this new calendar, month names are no longer needed since all months are the same. This is convenient for those book managers who consistently miss their camera-ready dates - just wait a few days and you'll be ahead of schedule again.

5.1 As requests for updates to documents piled up, creative flight controllers posted the flight data file calendar (Photo by the author)

I was bluntly honest with them. “We have no systems analysis or even a good verification we can point to and say what we’ve got is ‘correct.’ We do know it’s close to survivable if the crew can immediately jump into action when the failure occurs. This is unlikely. . . .they have not been trained on these procedures at all.” The CPCB agreed that something was better than nothing. So they approved adding the Loss of 2 Freon Loops Deorbit Prep to the flight data file.

Another late change was the addition of a primitive fax machine on the orbiter—called a teleprinter. This device spit out paper in a continuous stream, printing one line at a time like a very wide register receipt. We’d use it to send timeline updates to the crew. This equipment “belonged” to the FAO. All messages were typed by the Pads console in the FAO support room. I got the activation procedure added to Post Insertion, the checklist that I’d taken over from Whiteley. We’d tested it during our last long-duration sim in February.

FAMILY PLANNING

However, as the launch approached, I was more nervous about the working of my body than new equipment on the shuttle. Thor and I felt pretty sure that STS-1 would indeed launch in March (it actually launched in the “second” March!). That feeling, plus the new Reagan budget for NASA (in 1981, it was $5.5 billion rising to $6.5 billion by 1983) gave us confidence that our future at NASA was secure. Everyone expected the space station to be approved and get started in 1984 (when the shuttle fleet was done).

So we quit using birth control. Even if I got pregnant right away, I wouldn’t miss the historic first flight (though I didn’t know the flight would be delayed into April). I’d be back before the flight rate ramped up to build the space station.

However, my irregular schedule made it hard to figure out when I might be fertile. So, in typical flight controller fashion, I recorded and analyzed my menstrual cycles for the past three years. I determined that my average cycle was 33 days, but I had four “regular” cycles followed by one as short as 19 days, followed by one up to 43 days long. “It’s now been 39 days. If it doesn’t start in three days, I’ll figure it’s not going to.” Later that week, I reported, “My period started on the 42nd day—exactly like I’d calculated the latest day to be.”

PAPER SIM ON TILES

The *Roundup* reported, “During propellant tanking tests last month, two areas of insulation on the external tank. . .became debonded. . . . A preliminary estimate of the time required for the repair indicates the launch date will be no earlier than the week of April 5” [3]. The Flight Readiness Firing at the Cape was successful, and the launch was scheduled for the week of April 7. Everyone instantly went into “panic” mode: 482s had to be approved, books had to be printed, training had to be scheduled.

The simulators and Mission Control were focused mostly on ascent and entry training for the prime and backup crews. So those of us working on "orbit" contingencies had to come up with creative ways to practice our cases.

Thus Carolynn organized a "paper sim" to address the problem of loss of orbiter thermal tiles. Paper sims were basically role-playing games for flight controllers. An experienced person would present a problem (on paper) to the trainees. The trainees would then walk through solving the problem. Paper sims were cheap. And, like the Loss of 2 Freon Loops, using paper sims was better than nothing.

Tiles protect the aluminum skin of the shuttle from melting while the orbiter descends through the atmosphere at high speed. The orbiter enters belly first, so the black tiles on the underside get the hottest. An April 1980 *Roundup* article said these tiles, made of a ceramic carbon that looks and feels somewhat like a black sponge, "can handle temperatures exceeding 2300 °F." It explained that the white tiles are made of the same stuff but coated with a different material. They "are designed to handle surface temperatures up to 1200 °F" [4]. The concern was that the vibration of launch might shake some tiles off, exposing equipment to potentially catastrophic overheating. (Tile damage caused the loss of *Columbia* in 2003.)

The sim exercised "Team 4," a concept implemented after the Apollo 13 emergency that required experienced flight controllers to work out details of procedures in the simulators while the regular three teams continued their shifts. The STS-1 Team 4 was made up of experienced controllers and led by Flight Director Harold Draughon.

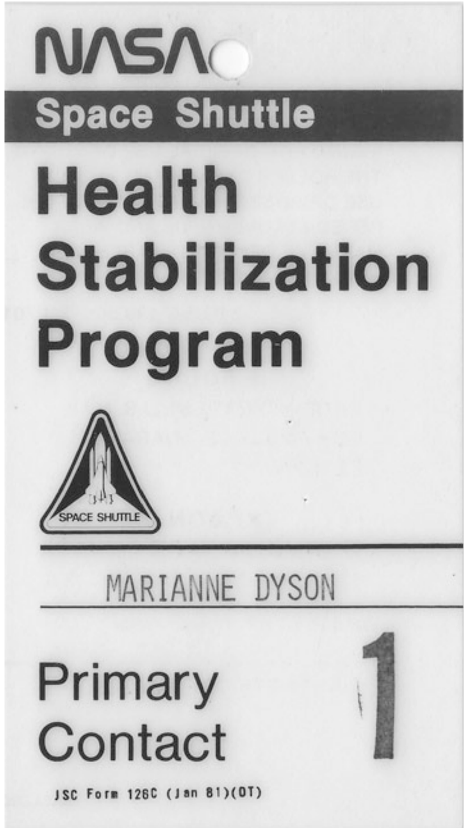
The sim assumed six tile areas had experienced losses. EECOM Al Ong met with Draughon and identified the equipment "under" those areas. As a result, the team recommended a power down and a cabin depressurization to prepare for a spacewalk. The team ordered analyses on melt through penetration and expected effects.

After the sim, a payload officer's support rooms was "wallpapered" with charts of tile locations and underlying equipment to aid in quickly identifying potential failures.

PRIMARY CONTACT

After *Apollo 13*, when astronaut Ken Mattingly (1936–) had been grounded and replaced with his backup because of exposure to the measles (which he didn't get), NASA had imposed a preflight quarantine Health Stabilization Program. Any person who'd come in contact with the crew during the last two weeks before launch, had to pass a physical and be immunized against communicable diseases.

To go over last-minute changes to procedures with the crew, I had to "pass" a primary contact physical. In 1981, there weren't vaccines for the measles or chicken pox, so only people who'd already had them were allowed to be primary contacts. I'd had both in fourth grade. They checked me for TB, that my tetanus shot was up to date, and that I'd had the polio vaccine. I was declared healthy and given a white primary contact badge.



5.2 Because I had to meet with the crew while they were in quarantine, I was issued a Primary Contact badge (Photo by the author)

About ten days before launch, I rode up the elevator in Building 1. Someone checked my primary contact badge and then let me into a room to meet with Young and Crippen. Though I'd worked with these men for several years now, I saw them in a different way that day. Here were the men who were going to fly the space shuttle on its maiden flight. This vehicle, unlike all previous space vehicles, had never had an unmanned test flight. They were betting their lives that people like me, each of us responsible for some small part of the Shuttle Program, hadn't overlooked something that would kill them. I couldn't help but wonder, like the IMU issue that showed up in the Freon loop case just two weeks before, what might I have missed? If they had to come home on Orbit 5 or using the BFS or without the FES, would the procedures I'd written get them home safely? As they thanked me for "all my hard work," I told them it'd been my pleasure, and we were all looking forward to a beautiful launch.

LAUNCH ABORT

The crew left for the Cape, and we got the FAO support room ready. The books had been printed before all the 482s could be approved. The approved changes, almost all of them related to the launch slip, were distributed as Page Change Notices (PCNs) and numbered in sequence for each book. The nominal PDP Volume 1, had three PCNs, and the contingency PDP Volume 2, had two. I neatly hand-printed the changes into the console copies of these books.

I was particularly anxious the Tuesday before launch. Once again it'd been 42 days since my period. I went to my gynecologist who confirmed I wasn't pregnant. I wrote in my journal, "The doctor said if I don't ovulate in six months, then she'll talk to me about fertility drugs. It never occurred to me that I might not be ovulating." Stress was most likely to blame.

Diane and I were on the Ascent, or Silver Team, for STS-1. Our Flight Director was Neil Hutchinson who expected only the best and no excuses. And well he should. If something were going to break, it'd most likely happen during the dynamic ascent phase.

About a week before launch, Mission Operations Director Gene Kranz called the Silver Team into the auditorium in Building 30. His speech wasn't the "go team" speech that I'd expected. It was more of a warning and a blessing mixed into one. He reminded us that the space shuttle was the most complex vehicle ever designed by man. "Things break and fail," he said bluntly. "But," he added, "*You* won't fail." He said that each of us had been trained more thoroughly for this flight than any team in history. Our managers and the crew were counting on us to make the right calls at the right time. He said he trusted us and that we should in turn trust each other and trust our training. He left us with the sobering absolution that "If the mission fails, it won't be because of something *you* did."

We filed out of the auditorium quietly, each of us lost in thought. No one had ever flown such an unwieldy vehicle, an airplane with stubby little wings strapped to a giant tank with rockets bolted onto the sides. Did we really know what we were doing? Apparently, Mr. Kranz felt that we did, as much as anyone could in a test program. After all, if we knew everything about how this vehicle would fly, we wouldn't need test flights. He'd expressed the ultimate confidence in us without any false pretenses. He'd sat in on all the long sims. He'd seen us wrestle with failures and find ways to work around them. He knew every one of us by name—had questioned us in briefings, in meetings, and seen us let off steam at social events. He trusted us to do everything humanly possible to prevent or mitigate the consequences of any failures.

Even though I was just a lowly Timeline 2, I felt an immense responsibility to justify Mr. Kranz's confidence in me. This was no game or simulation. Two men I'd worked with for more than two years were going to eat steak and eggs for breakfast, suit up, and climb aboard the space shuttle *Columbia*. The procedures I'd written for transitioning the computers, for opening the payload bay doors, for what to do if the FES or Freon loops, or the primary computers failed, were stowed onboard. My name was on the inside cover of those books. Though others had reviewed and approved them, I felt responsible for those procedures.

I was too keyed up to sleep the night before the launch, scheduled for 45 minutes after sunrise, Florida time, on Friday, April 10. Thor was already on console for the countdown. He was Winds in the FDO support room. “We started launching weather balloons about 48 hours ahead of time,” he remembered. The balloons were launched from the Cape and the data sent to MCC from there. I snuggled up with Jasper Kitty and managed a nap before my alarm went off around 2 a.m.

I wore a patriotic white jacket and a blue and white striped shirt. I proudly put my STS-1 and my silver team pins on the lapel of my jacket. I headed out, briefcase and sack lunch in hand.

Thor had taken my little blue Datsun (with the hole in the floor) and left the new silver Subaru for me. I drove to JSC, feeling every bit as nervous as I had when going to a dance recital as a little girl. I wished Mom were around to squeeze my hand! She and Jack were very excited about my involvement in the flight. Jack had a friend at the newspaper in Durham who’d written a story about me and Thor entitled, “Duo on Space Team.”

I drove to the “back” gate, but it was locked. I’d forgotten about the extra security for the launch. *The launch*. It didn’t seem real. Had it only been three years ago that I’d been struggling with homework at Rice?

I drove around to the front gate, and the guard waved me through. The parking lot lights made little pools of light in the dark. I easily found a space in the lot beside Building 30. As I walked from the car, I glanced up at the stars. Soon, the shuttle would be up there. And surely it wouldn’t be long before I’d be there, too.

I flashed my badges at the guard, though he recognized all of us by now. He waved me through with a big smile. I rode the elevator to the second floor of the windowless building. I retrieved my headset from my gray metal locker and my personal copies of the checklists I’d use on console. My steps echoed off the high ceilings as I walked down the hallway.

Once at my console, I fished a small instamatic camera out of my briefcase. We weren’t supposed to have cameras, but I hoped no one would mind if I took a few snapshots in the back room. I popped the square flashbulb on top. I took a photo of the row of controllers, with Diane in front. I handed the camera to Diane to take one of me. Unknown to us in those days of film cameras, all these pictures blurred. Afraid a manager might yell at me, I put the camera away.

5.3 A photo taken during STS-1 handover shows, *Left* to *Right*, Chuck Dieterich, Bill Holmberg (partially obscured), Tucker Pierce, John Whiteley (blocking me), Mark Rolwes, Rick Hieb, John Rivers, Diane Freeman, unidentified AF guy, and Chuck Knarr (mostly obscured) (Photo © Rick Hieb)

The FAO support room filled with people as the countdown progressed. After a sim in the fall where managers had constantly interrupted and pestered us for updates, my section chief had issued a memo explaining that the Timeliners would provide updates on a regular schedule. Despite the memo, our room had the ultimate draw: a portable 15-inch television. No TVs were allowed in the MOCR, and all of the other support operators were admonished to be watching data, not the news. So the managers gathered around the television that sat between the Crew Systems and Timeline consoles. Like the TV back at horseback-riding camp, this one was black and white. I had a real déjà vu moment hearing Walter Cronkite's voice. Only he wasn't talking about *Apollo 11*, he was talking about STS-1.

While I listened to the chatter on the flight loops, Cronkite's voice droned in the background. He might have been reading from the *Roundup* that had published the schedule and described the mission two weeks before, "Extensive testing of orbiter systems, including the space radiators and other heat rejection systems, fills most of the STS-1 mission timeline. The clamshell-like doors on *Columbia*'s 4.6 by 18-meter (15 by 60-foot) payload bay will be opened and closed twice during the flight for testing door actuators and latch mechanisms in the space environment" [5].

I thought, “With the payload bay to Earth when the doors open an hour and 20 minutes into flight, it should be a pretty picture. But we won’t see any downlink until a half hour later.”

Cronkite rattled off that the inclination was 40.3 degrees and the orbit would be 130 nm at first and then boosted to 150 nm. *Roundup* had said, “*Columbia*’s two orbital maneuvering system hypergolic engines will fire at approximately 53.5 hours over the Indian Ocean to bring the spacecraft to a landing on Rogers Dry Lake at Edwards Air Force Base, California about an hour later” [6]. If we got off on time today, we’d land Sunday afternoon.

Like in football games where the clock is stopped for time-outs, the countdown clock stops at certain times in the prelaunch preparations while controllers check data. During the hold at T-2 hours and 4 minutes, Young and Crippen were strapped into their ejection seats. If anything happened during the launch or the latter part of entry (below about 100,000 feet), those seats would blow them out of the cockpit. This capability was only available during the first four test flights and was the reason the crew size was limited to two astronauts.

Even though the Launch Control Center at Kennedy was in charge until the vehicle cleared the launch tower, Houston Flight had to give a “go” for the launch to occur. Hutchinson wouldn’t give that go unless he got a go from each member of the Silver Team. The countdown proceeded until the T-20-minute hold. Everything was going great, and we all refreshed our coffee and made final trips to the restroom.

When I plugged my headset back in, I heard a heated discussion on the data processing system loop. As DPS Randy Stone (1944–2013) related in his oral history session, “When we came out of the T-minus-twenty-minute hold, we had four good primary computers, but the backup computer couldn’t see two of the flight control strings in the vehicle. Clearly it was unacceptable to fly your first flight when the two systems didn’t match,” he said [7].

There was nothing Diane and I could do but listen and wait. Having written the “If BFS Omit” procedures, and because of my programming background, I appreciated how easy it was for a software bug to go undetected until a unique set of circumstances occurred.

Stone said, “My back room was analyzing the data, and . . . they came to me on the loop and said, ‘There is nothing wrong with the backup. The problem is with the primary computer system. It’s not sending data’” [8].

I heard Stone call the Flight Director, “Flight, DPS.” [Quotes are from the STS-1 Air-to-Ground Transcript, accessed via the UHCL Library, NASA Archive. Future quotations from this source will not be individually cited.]

“Go, DPS,” Hutchinson said.

“We want to transition everything back to OPS-9.”

OPS-9 was the prelaunch mode for the computers. So they did this and Stone said, “The computers all looked good, and I’m thinking, ‘Man, if we come out of this hold and it works, am I go to fly?’ I’ve talked to my back room, and Gerry Knori and Jim Hill and Bill Lychwick all said, ‘We don’t understand it. We don’t want to fly today’” [9].

By now the countdown had progressed to T-9-minutes and was on hold for ten minutes. The weather was beautiful. The astronauts were strapped in and ready. Hundreds of thousands of people, including politicians and celebrities, were waiting and watching. And so was Mr. Kranz who’d reminded us all of the seriousness of our responsibilities. The decision rested heavily on Stone’s shoulders.

While he contemplated the computer issues, one of the fuel cells showed abnormal acid levels. The countdown was halted. The fuel cell was quickly determined to be okay, and the countdown was set to resume after the hold.

Stone said, “I made a decision with the help of the folks in the back room that it is not the right day to go fly. So I got on the flight loop. . . . I said, ‘Flight, I don’t care what happens when we come out of the T-minus-nine-minute hold. DPS is no go for launch.’ And man, you could have heard a pin drop in that room. I mean, it went from a lot of buzz to quiet” [10].

On the Flight loop, Hutchinson asked, “Are you sure you are no go for launch?”

Stone said, “Yes, sir. We do not understand what happened here. If it works this next time, I can’t guarantee it’s going to work through ascent, and I can’t guarantee it’s going to work when we bring these computers back alive to do entry. I am no go for launch.”

When we came out of the hold, the computers still didn’t match up. But even if they had, Stone had already made his decision, and so had Hutchinson. Would the managers support this decision to scrub the launch? It was an expensive choice. The eyes of the world were on us, and the launch had been slipped again and again. But a flight controller had trusted his training and made a difficult call, knowing that even worse consequences might have resulted if he hadn’t.

The team at KSC and in Houston worked for three hours unsuccessfully to trace the source of the computer problem. Finally, the Launch Director halted the countdown clock and declared a scrub at just before 10 a.m. Young and Crippen, who had been lying on their backs for six hours, were helped out of the cockpit.

Stone said, “My claim to fame is I was the guy that was no go for launch on STS-1 before we ever found out if it was okay or was going to work when we came out of the hold again. And truly, I believe that was a turning point in my decision-making process where I was confident enough to say no in an environment when everybody else wanted to say yes.”

After the flight, the Center Director Chris Kraft, Jr. pulled Stone aside and told him that he’d made the right call, scrubbing the launch. About three weeks later, Stone was selected to become a flight director.

5.4 Randy Stone (*left*), shown here with astronaut Dick Truly and Computer Command Liz Cheshire in the background, made the call that scrubbed the first shuttle launch attempt on April 10, 1981 (NASA photo)

I stopped by Thor's console. The launch was now planned for Sunday. That was 48 hours away, so he had to stay and monitor more weather balloons. Too wired to go home and sleep, I went to my office in Building 4 and reviewed my notes on the computer systems.

We soon learned that the problem with the computers was a timing error that caused them not to sync up with the backup machine. Stone said that once his team understood what happened, they were prepared to recycle the machines and resume the countdown. IBM fixed the flaw in the software after the first flight so it couldn't happen again.

SECOND CHANCE FOR THE FIRST LAUNCH

In the wee hours of Sunday morning, April 12, I got ready for work. I wore a simple blue blouse and skirt, an outfit I'd bought when working at the House of Representatives nearly three years before. It wasn't fancy, but it was comfortable. It was going to be a long day.

I left around 3 a.m., about the time the crew had breakfast with former Apollo 17 Astronaut Harrison Schmitt, Apollo-Soyuz Astronaut Deke Slayton (1924–1993), their boss, and one of the new astronauts, El Onizuka (1946–1986), our neighbor in Meadowgreen.

The scrub had acted like a dress rehearsal. All of us were more relaxed. One of the Pointers in training, Rick Hieb (1955–), who'd later become an astronaut, had changed from a formal white shirt and necktie on Friday to a navy polo shirt today.

I asked FAO if it'd be okay if I borrowed the green MOCR visitor's badge and came to the front room to take his picture. Bob said that'd be fine.

But first, I stopped by the FDO support room which was right beside our room. I snuck up behind Thor and planted a wet kiss on the top of his bald head. He said the winds were good, and so far everything was go for launch. One of his friends took a photo of us with my camera.

5.5 Thor was Winds for STS-1, and I was Timeline 2. Like all flight controllers, Thor wore his headset around his neck with the earpiece going up (Photo by the author)

The crew were onboard by 3:30 a.m. Houston time. As we watched the countdown clock and waited through each hold, I wondered what was going through Crippen's head. Young had flown in space three times already, on *Gemini 3*, *Apollo 10*, and *Apollo 16*. But this was Crip's first flight. He'd told the *Roundup* two weeks earlier that there was no such thing as too much training. "It is the extended training time that has allowed us to prepare for much more catastrophic kinds of emergencies. John would say that if we'd been as well prepared back on *Apollo 13*, instead of the guys calling down and saying, 'Houston, we've got a problem,' they would have called and said, 'Houston, we're on Mal Number 5332, Block 8, taping up the lyle [LiOH, lithium hydroxide used to scrub carbon monoxide] canisters.' We've got contingency programs where we're well prepared to handle just about anything" [11].

"But please Lord," I prayed silently, "not the loss of 2 Freon loops!"

The TV was on again, though the sound was down low so as not to disturb any of the controllers. PAO said that there were 80,000 invited guests at the launch in temporary bleachers around KSC, and 4000 journalists at the press site. He said something earlier that I hadn't known, "On Apollo launches, there were more than 500 people who were monitoring the various aspects of the vehicle system. Because of the great advances that have taken place in the computer area, we only have approximately 150 who are monitoring a much more complex vehicle for this morning's launch." I was very proud to be among those 150 people.

Diane was keeping the official console log, but I wrote a few notes while I kept my eye on the displays and mission clock. We all tensed up around 5:30 a.m. when we approached the computer transition. Was the timing problem solved? Randy verified that all was well, and a little cheer erupted in the front room.

I noted that at T-23 minutes, the helium isolation switch moved to GPC. It was supposed to have been there at crew ingress hours earlier. Had it just been overlooked until now? I hoped all the other switches were in their right positions. During the hold at T-9, Hutchinson polled the team. Everyone was go, even DPS. Crippen said, "PLT is definitely go!"

During the hold, Launch Director George Page (1918–2002) read a message from President Reagan. "You go forward this morning in a daring enterprise and you take the hopes and prayers of all Americans with you." He then quoted a poet and added, "For all Americans Nancy and I thank you and the 50,000 others who have worked to make this day possible."

"You're welcome," someone whispered, and we all smiled.

Diane and I stared at a black and white live view of the shuttle on one of the console channels while we listened intently to the Air/Ground, Flight Director, and the FAO loops in our headsets. At T-6 minutes, Crip began the prestart of the three auxiliary power units that provide pressurized hydraulic fluid to the flight control surfaces. I followed the procedure in the Ascent Checklist. EECOM Charlie Dumis told Flight that the APUs looked good. About a minute later, I checked an EECOM display to see that the Flash Evaporator heaters on panels L2 and L1 had been shut off by Young. I'd gotten good at tracking the crew.

By T-2 minutes, EGIL Bill Moon reported that the fuel cells were using onboard supplies.

"DFI recorders on," someone reported at T-40 seconds. These development flight instrument tape recorders were like the black boxes on jets but much fancier. *Columbia* was loaded with sensors that fed data to them that would tell us how well the vehicle performed.

T-30 seconds. My right hand clutched Diane's left hand. We held our breath and stared at the screen. T-7 seconds, "Main engine start," someone said. We watched spellbound as clouds of steam billowed out from under the engines, and the shuttle stack swayed with the thrust of 1.1 million pounds. Once all three main engines were confirmed good, the two solid rockets on either side of the giant white fuel tank ignited, adding 5.3 million pounds of thrust. Eight hold-down bolts were explosively severed and the ship blasted into the sky.

"Lift-off confirmed, Flight," FDO said. A cheer went up in the FAO support room.

In the background on the TV, the PAO said, "We have lift-off of America's first space shuttle, and the shuttle has cleared the tower." Houston was now in control.

I followed the electrical and cooling systems, comparing the real vehicle's performance to the data from two years of simulations. Would any of the Post Insertion procedures have to change? If they had to do a Launch Day Deorbit, were there any switches out of configuration?

Minutes passed and they were go for the solid rockets to separate. I punched PRINT to capture two displays on my console. The hardcopies would arrive with a clunk in the p-tube in a little while. The separation was two seconds later than predicted in the Ascent Checklist. Would Pearline have to write a 482 for those two seconds?

About 20 seconds later, Young reached over to panel L1 and turned on the flash evaporator system. At three minutes, the crew reported the Evap was go, meaning the FES was working and keeping the Evap Out Temp less than 60 degrees. The display called ECS showed the temp. I jotted a note that it was steady at 44 degrees. *No Loss of FES or Freon Loops today*!

If any of the three engines failed in the next two and a half minutes, we'd do an abort back to Florida. After that they couldn't turn around. They'd instead abort to a landing site overseas or go around the Earth and come back to Florida. We all watched the Mission Elapsed Time (MET) clicking up past the four-minute mark. The checklist called for the "Negative Return" call at 04:29. It happened at 04:25 MET.

I jotted Crip's enthusiastic comment in my log, "What a view, what a view!"

Young's heart rate was reported to be between 85 and 90 while first-timer Crip's was 130. Post flight, Young quipped, "That's because I couldn't get mine to beat any faster."

FDO calculated the main engine cut off (MECO) time to be two seconds early. Capcom Dan Brandenstein (1943–) relayed this to the crew, "*Columbia*, Houston. MECO at 8 plus 34."

We could hear the crew fine, but apparently they had trouble hearing us over the noise in the cockpit. Capcom told them we were switching to a communications relay in Bermuda. Young, with his typical folksy language replied, "Roger that. Okay doke, that good."

At L + 5 minutes, the Ascent Checklist called for Crip to turn the oxygen and hydrogen tank heaters to the Auto position. I watched the ECS display and hadn't seen it. Neither had EGIL Bill Moon who noted the omission to Flight.

Hutchinson remarked, "The first crewman that turns those turkeys on time gets a medal" [12]. We all chuckled, remembering multiple sims where they'd been missed.

"Go for MECO," Capcom said.

The altitude was now 63 nautical miles. They'd flown 650 miles downrange in just eight minutes. "Okay, MECO," Young reported, "25,670 feet per second."

"Confirm shutdown," Capcom replied.

We were in space! I wrote, "Fabulous! What a sight! It looked so awkward, but boy did it go go go. We cheered and clapped and smiled 'til we couldn't stand it."

I quickly returned to monitoring displays, noting the electrical usage. Next up was the first of two orbital maneuvering system (OMS) engine firings that would circularize the orbit.

We expected the burn to occur while we were out of touch, but the data appeared just as the signal was lost. "I wasn't expecting that," Ascent FDO Jay Greene told Flight.

When we got comm over Madrid, Flight polled the room for a status to see if we were go for OMS 2. The crew reported having a low helium pressure on the center engine, but that it looked nominal now. Capcom told them it was just bleeding down.

We now had 20 minutes of shuttle flight time under our belts. So far, so good. We wouldn't have comm again for about 13 minutes, so I headed for the restroom. So much had happened that it seemed hard to believe we still had about five hours of our shift ahead.

We settled back in our gray chairs in the support room with fresh coffee and doughnuts. FDO Greene reported that the OMS 2 burn would be at 44 minutes 17 seconds and should result in a 132-nm (172 mi) circular orbit. Contact with the crew resumed over the Indian Ocean station. "Well, the view hasn't changed any," Young said. "It's really something else."

Crippen added, "I tell you, John has been telling me about it for three years, but ain't no way you can describe it. It's hard to get my head in the cockpit to do my procedures." Thinking of the cryo heaters, Diane and I shared a smile.

Just before we lost their signal, the crew reported that they were on page 1–5 of Post Insertion and had transitioned the computers to OPS 2. Crip was ahead of schedule, as usual.

Next big item was opening the payload bay doors. The doors had to be opened for the radiators, mounted on the inside of each door, to cool the Freon loops. The FES was doing that now, but only had enough water for a few hours of operation. If the doors didn't open, they'd be coming home (using my procedures) on Orbit 5.

Operating the doors was the second of four main tasks had to be accomplished during post insertion to avoid coming home on Orbit 5. The first was the computer transition which they'd already done. The OPS 2 software was needed to support all on-orbit activities, including the door tests and the IMU alignment.

The IMU alignment was the third thing and was scheduled after the door opening/closing activities. If the IMUs couldn't be aligned, the navigation platforms would drift and accumulate errors. The rate of the platforms drift wasn't known, but was estimated to be too much to trust the navigation after eight hours. So if the IMUs didn't align, they'd be coming home on Orbit 5.

The fourth thing that had to be accomplished was the purging of at least two of the three fuel cells with hydrogen. Purging was considered necessary to maintain efficiency and provide enough power to support entry. Like the IMU alignment, the fuel cells were considered good (without a purge) at least long enough to get them home on Orbit 5. The purge test was scheduled just six minutes prior to the go/no go for orbit ops at 3:20 MET.

We'd made it through the dynamic ascent. Would the computer, mechanical, thermal, navigational, and electrical systems let us stay in space overnight? Or was I about to find out just how good my Launch Day Deorbit procedures really were?

It'd be 25 minutes before we'd have communication coverage again. If they were on schedule, they were both now in the aft station opening the doors.

First, they'd cycle the latch groups, and then they'd open the right door. Then they'd close the right door, cycle some latches, and open the right door again. They'd leave the right door open, cycle some latches, and then open the left door. Then they'd close the left door, check it, reopen it, and leave it open. With both doors open, they'd deploy the radiators that were mounted on the inside of each door.

So many things could go wrong with the sequence. Any of the four latches at each bulkhead or the 16 latches running down the centerline could hang up or be blocked by debris.

At 1:31 MET, the crew reported they were ready to open the right door. We had no TV yet. Young reported, "You're missing one fantastic sight. Here come the right door, and boy that is really beautiful out there." I noted they were about ten minutes ahead of the timeline.

Crew reported, "Okay. I just got the right door closed. All that came back nicely."

While this was going on, someone noted that the DFI recorder was in continuous mode. The recorder would run out of tape if left in continuous mode. I assumed the crew had missed the switch change callout in the Post Insertion checklist, which told them to go to High Sample at the end of the OPS 2 transition. This was to provide 15 minutes of data after the engine burn.

The crew reported that the DFI was in Hi Samp mode. They were asked to put it in Low Sample instead. The crew did this, but the talkback indicator didn't change—meaning the recorder kept going. So Capcom told them to stop it. Crippen said, "Okay. We are in Stop." But he added, "My talkback is still gray."

"Roger, *Columbia*," Capcom said. "We show it stuck running."

Discussion followed on the Flight loop. A few minutes later, Capcom said, "We'd like for you to pull the circuit breaker to see if we can get that thing stopped."

The crew soon reported it was pulled. "That stopped it for us. Thank you."

The mystery of what had happened to the DFI recorder wouldn't be solved until post flight. At the moment, my job was to make note of the switch changes for the next shift.

We were on our second orbit when the first TV pictures came down. Young reported, "Doors are all opened up and hunky dory. We are ready to proceed with rad deployment."

I watched in awe as the TV showed junk floating out of the payload bay, reminding me of a scene from *2001*: *A Space Odyssey*. "Especially saw a ring of some kind," I wrote in my journal. "Then Crip zoomed in on the aft pods and there were tiles missing."

MISSING TILES NOT CRITICAL?

The crew described what we saw on the downlink. "Off of the starboard pod there's basically what appears to be three tiles and some smaller pieces. And off the port pod it looks like I see one full square and it looks like a few little triangular shapes that are missing."

Mission Control sucked in its collective breath. If tiles had come off of the OMS pods, where else were they missing? The crew were obviously wondering the same thing. "From what we can see of both wing tops," they said, "all fully intact." The wing tiles were critical, as we'd painfully discover 22 years later during *Columbia*'s last entry. Still, we had no way to check the underbelly. What if some had come off down there?

Yet only a few minutes after LOS, PAO announced that "JSC Engineering and Development Director, Max Faget, is in the Control Center and watched the television transmission of the missing tiles. He reports that these are not critical tiles. These tiles that are missing represent no hazard to the vehicle and crew. Dr. Faget further states that the worst that can happen is that after landing a small patch of skin underneath the tiles may have to be replaced."

Max Faget (1921–2004) was considered the "father of the space shuttle," so his statement was reassuring. I put the tile issue out of my mind and focused on tracking switch changes. The crew verified that a circuit breaker had popped on one of the overhead panels. I made a note in the Master Switch List that the crew would check before entry. The crew said, "we just got a high load [FES] duct inboard light on. You want us to turn those duct heaters off now?"

"That's affirmative," Capcom said. I made another note in my log. The hi load flash evaporator that had sprayed water on the Freon loops had been shut down now that the radiators were cooling the loops. The duct heaters had successfully boiled off any excess water in the vents so ice wouldn't form.

Despite Faget's assurances, I overheard plenty of discussion on the EECOM loop about those missing tiles. What equipment was located under those tiles? How hot was it going to get? Was any part of the tile or glue still there or was the skin exposed? I was glad that Carolynn had gotten that support room wallpapered with tile locations and equipment: looked like we'd need it.

EECOM had a group looking over the 70 mm launch film at KSC to check for other tile damage. The EVA support guys who were in our support room informed FAO that if someone wanted to do a spacewalk to check for tile damage to the belly, they were ready to support it. However, an EVA was considered too risky for the benefit of knowing if tiles were missing. There was no tile repair kit onboard anyway.

But there was another way to check the belly—from the ground. The orbiter was going to pass over the best telescopes in the world on Hawaii during the next few orbits. But the orbiter would have to change attitude—right now the top was facing Earth. To check out the bottom, they'd have to flip over. Plus the bottom would need some illumination so that "bare" or "hot" spots would show up among the black tiles. I assumed this meant they'd have to schedule the observation when it was afternoon in Hawaii. That wouldn't happen until after my shift.

Some Air Force "blue suits" passed through our room looking very serious. We were cautioned not to discuss using ground "assets" to view the orbiter. The military didn't want our enemies to know that we could use these "civilian" telescopes to reveal details of spacecraft.

Next pass we did our first troubleshooting procedure of the Shuttle Program—an attempt to recover the DFI recorder. Unfortunately, the procedure didn't fix the problem.

While Crip did the troubleshooting, Young did the IMU alignment. The IMUs had not drifted very much at all. Everything was looking good for staying in space another day.

The fuel cell purge was the only mandatory item left. The crew reported that the fuel cell purge heater "is going out of limits around 302." On the flight loop, EGIL said he was go for the fuel cell purge and to tell the crew to leave the heater on.

The original plan called for the purge to be done automatically. I heard chatter that the flow rate was too high. The manual purge went well, though the temperatures seemed high to me. Would the continuous purge planned for the Loss of 2 Freon Loops actually keep the fuel cells cool like we'd planned?

Hutchinson polled the flight team to see if we were go for orbit ops. Capcom relayed the news, "You guys did so good, we're going to let you stay up there for a couple of days."

Capcom also told the crew that the solid rocket boosters had landed right where they were supposed to, and "the boats were getting ready to fish them and bring them back."

Soon after the go for orbit ops, Crip said he was thinking about burritos. Mission Control had a tradition of getting burritos delivered when the sims lasted into dinnertime. Dan replied, "We don't eat burritos this early in the morning!" The crew had been up a long time, but it was indeed still morning in Houston.

The crew reported they were just getting out of the pressure suits they'd worn for launch and would be activating the teleprinter. Capcom joked that "we can't wait for that. We have a couple [of messages] ready already."

Crip replied, "I should have known." We chuckled in the support room. We were busy handing over to the Orbit (Bronze) Team headed by Chuck Lewis (1931–2013). We'd soon return to generate messages while they slept.

I went over the switch list changes with Bill. We were supposed to go home at the beginning of Orbit 4, but Hutchinson wanted one more try at reviving the DFI recorder. They got the switch talkback to change from gray to barber pole. They thought it'd maybe run out of tape. So they tried reverse, but there was no motion of the tape.

Carolynn was called in during handover to work with Draughan's Team 4 reviewing the orbiter tile loss. At the press briefing, management said that "the tile loss should not shorten the flight or endanger the lives of the astronauts when *Columbia* plunges back into the atmosphere." But we flight planners knew the difference between "should not" and "would not." I was glad that Carolynn was involved because she'd developed all the major power down scenarios.

It was now Mission Elapsed Time 4:30, and it was the Bronze (Orbit) Team's turn. I closed my copy of Post Insertion and unplugged my headset. I was due back around 10 p.m. that night.

I'd finished my first shift as a flight controller, and it felt good. As I left the building, it seemed strange to see the sun high overhead—it was just shy of 11 a.m. How was I going to sleep?!

I couldn't. I changed into my bathing suit and laid out on the patio in a vain effort to put some color in my cheeks. I jotted some notes in my diary about the fuel cell purge and DFI recorder and added, "I am so happy. I felt real good about my performance. I found parameters I forgot to look for in sims and everything flowed so well. The crew was ahead of schedule all the time, except Crip got his suit off late 'cause he was looking out the window!

"For something that looked like it would have problems, [the shuttle] was as close to perfect as you could ask for."

As I drove back to work that evening, I noticed the parking lot across from the Building 2 visitor's center was jammed with news vans. I hadn't had a chance to listen to the news. I wondered what they were saying about the flight so far.

When I arrived, the Orbit/Bronze Team wasn't ready for us. I wrote, "Holmberg and Tucker did not handover to us until about an hour after handover." Tucker (Timeline 1) stayed to mark up the CAP with the proposed activities for the next day. He shouldn't have bothered: our team changed that list anyway.

Also, two extra people being there after handover really cramped Diane and I. Besides all the extra notebooks, logs, and assorted coffee mugs, Bill and I, and Diane and Tucker, shared plug-in locations on the console. Our phone cords got tangled and wrapped around our chairs as we climbed over each other to get copies from the p-tube and change the TV channels.

The crew reported a similar problem with their headsets in space—only they had the added dimension of freefall. Crip said, "Sure would be nice to have some cordless mikes up here. That's the only thing you got to worry about [in freefall], staying connected and not getting yourself wrapped around something." They'd get wireless for the crew on STS-2, but flight controllers never did get wireless headsets.

We had about three and a half hours remaining in the crew's sleep period to prepare "the morning news" teleprinter message listing changes to the onboard CAP. I carefully marked up a copy of the CAP with the changes Flight approved. I placed this copy under the TV camera next to my console so that the team could see it. The camera wouldn't zoom, leaving many items on the timeline too small to read. So I stacked Houston phone books under it to bring it closer to the lens: a primitive solution, but it worked!

Because we'd launched two days and an hour later than shown in the published plan, the locations on the ground—called the ground track—that the orbiter passed over at a particular MET had changed. Activities that required live communications with Mission Control had to be shifted either earlier or later. Also, the delay shifted the orbiter's day/night schedule. Activities such as payload bay door opening required sunlight for photographic documentation. The result was that most of the activities were moved about 20 minutes forward in time.

Besides shifting everything, we were asked to add some activities. The data for some RCS jet tests had been lost in one of our garbled comm passes on Day 1. These would be repeated. There'd been a big solar flare the day before, and the scientists expected some bright auroras at night. We added in some time for the crew to look and take photos. Also, a team of engineers and astronauts had devised a way to reach the DFI recorder's circuit breaker during entry using a stick. They wanted the crew to try it out during the entry rehearsal.

These were all things we expected. But one new activity we hadn't anticipated, and was suddenly a top priority: a live press conference with Vice President Bush. Originally President Reagan had planned to visit Mission Control and talk with the crew in person. That plan had been cancelled after he'd been shot on March 30. I wondered why no one in management had bothered to warn us that this call was coming? The first hint I had of it was Sunday night when I arrived for my shift.

In addition to the live event which we were told should last about 17 minutes, we needed to shoehorn in 15 minutes of camera setup prior to the event, and another 10 minutes to stow the equipment afterwards. This was a challenge in an already packed schedule. We also had to schedule it during a ground site that carried television—Hawaii, Mila, Madrid, or Guam.

We tried to protect the crew meal time, knowing it was their only chance to catch their breath or use the space toilet (which took about 15 minutes). But the timeline was jam packed, and we had no other viable choices. So their one-hour meal ended up starting late because a door test had slipped forward for ground coverage. It was also interrupted in the middle with a jet test, and cut short to allow time to set up the TV with the Vice President. They couldn't dally either: they had an IMU alignment maneuver and manual fuel cell purge immediately afterwards. And too bad if they had to use the toilet—they had to practice getting their spacesuits on and had less time than originally scheduled because they had to stow the TV equipment!

I was tasked to use CAPS to make the changes on the timeline. In the fall, we'd added a CAPS terminal to the support room. It didn't interface with the mainframe, and we had to take tapes to Building 4 to print anything, but it was a start. This first "flight test" uncovered issues in the software. When I shortened the crew meal to add the TV setup, it shortened all the crew meals. If I tried to put it in the middle, it said I had a conflict. Like a good flight controller, I soon devised a workaround. I called our technical support person, Jim L. McGavern, but he couldn't get it to work, either. Eventually I simply wrote it on the page.

While I struggled with CAPS, I listened to the EECOM support loop in my headset. Someone reported that the food warmer was active. Someone was up a half hour early. We all bet it was Crip taking in the view out the window. We kept radio silence until the scheduled end of the sleep period. They played "Blast Off *Columbia*" by Roy McCall as their wakeup music.

I'd finished getting all the timeline changes into the CAPS system and ordered a printout from the Versatec machine in Building 4. I planned to put it under the TV camera for the team (and news media) to follow the crew's day. Unfortunately, we had no way to send this timeline to the crew. For them, we prepared a long teleprinter message with instructions for moving, adding, or deleting activities in their printed books. We marked up a console copy of the CAP with these instructions so the next team could follow along.

But I'd lost all track of "real" time. It was 4 a.m. I couldn't get the printout from Building 4 because it was locked. In all our sims, we'd never thought about that. I made a note to ask for a Versatec machine to be added to our support room before the next flight (it wasn't).

The cabin temperature had dropped during the night. Some of this was blamed on air leaking to space, as expected, but the heaters should have compensated. When Capcom asked if they were shivering up there, the crew replied, "Well, it certainly got a little chilly last night. I was ready to break out the long undies."

We had the crew change some switches so not as much heat would be removed from the air by the water loops. We hoped to see the temperature rise quickly, but it held constant at 76 degrees. I wondered if we'd been too conservative on the cooling cases?

The crew were eating breakfast in between troubleshooting on the cabin heat issue, repeating a jet test, doing an IMU alignment, a fuel cell purge, and setting up cameras. Crip called down, "You guys have tacos for breakfast?"

Dan replied, "We haven't had any breakfast yet. It won't be long, though." It was just after 4 a.m. Houston time, and we were about to get off shift.

"Okay. I figured it was time for your donut run."

Dan replied, "No. Not today—watching my weight." Ha! More for me. . .I was actually sitting there eating a donut which the Entry Team had brought in to share with us. *Hmm*, *cake donuts with cinnamon sugar!* I handed over to Mi-Mi and Diane handed over to Carolynn. This was the first shift for the Entry, or Crimson, Team. They were anxious to get started.

5.6 Mi-Mi Lau was Timeline 2 and Carolynn Conley was Timeline 1 for the Entry Team during STS-1 (Photo by the author)

This time when I got off shift, it seemed that because the crew was up and eating breakfast that the sun should be up in Houston, too. But it was still pitch dark outside. I walked through an eerily empty parking lot with only the sounds of crickets chirping. I felt somewhat disconnected from reality while I drove home, expecting the car radio to be transmitting air-to-ground instead of Dolly Parton's "Working 9 to 5." When I got home, Thor was sound asleep. I slipped into bed beside him. I didn't hear his alarm go off an hour later.

My grumbling stomach woke me up in the afternoon. Thor was gone—he was getting in some training time as a future guidance officer with the Orbit Team. I called the control team "hot" line at 5:30 p.m. in case I needed to go in early. The recording hadn't been updated yet. Thinking I wasn't due in until 7:30 p.m., I ate dinner and watched the news.

I saw a clip of Young and Crip's press conference with the Vice President that we'd worked to schedule. Bush said he'd hoped to come to Houston to welcome them home, but he wasn't going to get to (because Reagan was still recovering from being shot). They chatted about what was next on the timeline (RCS test and suit donning), and promised he'd be watching the landing "with great interest. On behalf of the whole country, I'll tell you, everybody will be."

The headline of the Houston Post declared "Shuttle orbits after flawless launch." I chuckled at the interior article entitled, "Controllers confident, calm at JSC" by Rick Nelson. We were only calm on the outside! The paper also reported that President Reagan had watched the launch from seclusion in the White House and called it "a spectacular sight." Then it said, "Bush was planning to talk with the orbiting spaceship *Columbia* astronauts from his White House office Monday" [13].

So the press had known about the event last night before *I* had! I rolled my eyes at Jasper Kitty and said, "Even you knew about this before I did, didn't you?" He stared at me with his big innocent eyes. I wondered what surprises awaited me on my next shift.

I called the hot line again at 7 and discovered the recording had been updated at 6 p.m. to say we were due in at 7! I grabbed my briefcase and sped into work as the sun set.

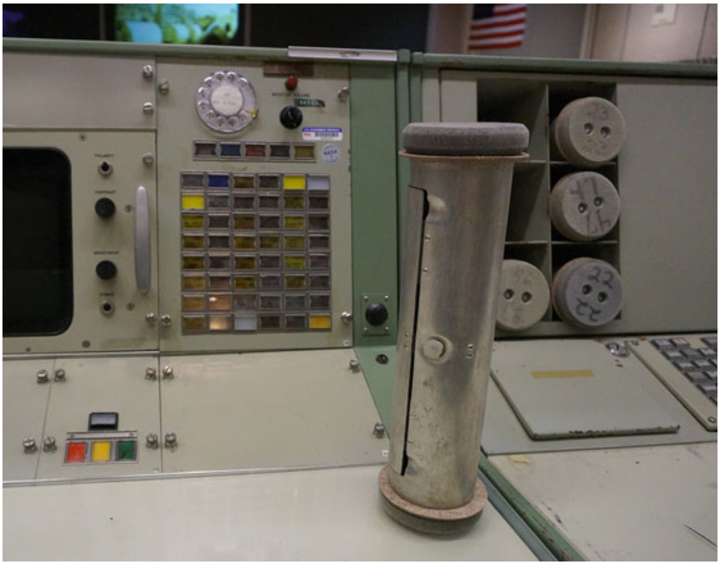
I got to my console at 7:30 p.m., a half hour late! I was embarrassed, but there was nothing I could do except get busy with handover. But whereas Bill and Tucker had stayed an hour late last time, this time they left 15 minutes early.

I wasn't the only one running a little late. It was now 8 p.m. on Monday night. Crew sleep was supposed to have started at 7 p.m., but they were just now eating dinner. The Orbit Team had been ordered to clear a whole hour for the crew to disconnect, remove, and replace the DFI recorder. With few "holes" in the schedule, the procedure bumped their evening meal. Poor guys had their lunch cut short and interrupted, and then their dinner, too. Unfortunately, the replacement attempt failed when two of the 12 bolts they had to remove wouldn't budge. We wouldn't get the detailed engine and thermal data we wanted for this first test flight.

The crew were due up around 3 a.m. Houston time. Landing was scheduled for just after noon. The dry run of deorbit had gone well. So mostly, I just had to make a list of the switches that were in a different position than originally planned. Surprisingly, there weren't that many.

After every shift handover, Flight and management representatives headed over to Building 2 to brief the news media on significant events. This press conference was played on one of the PAO loops. Since the crew had gone quiet and I'd missed most of handover, I tuned in to the briefing. Kranz was asked about the tiles. He reported that 11 of 17 tiles on the upper part of the orbiter had come loose. He added, "there is no hard evidence at this time that leads us to suspect that there is any problem with the underside of the orbiter." He then said that attempts on orbits 17 and 21 had been made to photograph the underside of the orbiter as it passed over the USAF station at Malabar, Florida. Neither attempt had been successful—one because of look angle, and the other because of clouds. He confirmed that more attempts might be made from other DoD sites. Asked where those were, he answered, "That's classified."

All night, the schwoosh and clunk of the p-tubes kept up a steady beat, delivering copies of displays, flight notes, and draft procedure changes to review. I'd thought we'd made a mess during sims, but it had been nothing compared to the real flight. The FAO support room looked as if it had rained paper onto every horizontal surface. Periodically, I'd open the p-tube door, and three or more canisters would plunk out onto the floor. I'd open the little spring-loaded door to remove the paper inside—oftentimes breaking a fingernail in the process. Periodically, I'd call out, "Who ordered DPS Config?" When no one answered, it became a fresh layer of "snow" on top of the drift from previous shifts.



5.7 Hardcopies were sent to consoles via a pneumatic (p) tube system. To the *right* of the empty canister shown here at the FAO console is the metal door that had to be lifted up to drop the canister in. The support room's system was mounted in the wall behind our row of consoles (Photo by the author)

One of my jobs was to tally the Flight Test Objectives that had been accomplished and deliver the list to managers around midnight. The objectives were identified in chronological order and published as a section of the Crew Activity Plan. I adjusted the times to when they were actually done, crossed out any that weren't done, and added unplanned actions such as photos of the aurora. This list allowed management to say we'd satisfied all our objectives.

While I was compiling this list, the crew were awakened by an onboard alarm. Capcom told them to cycle a heater switch and that fixed the problem.

All the systems were performing well. Prop reported a slight helium leak on the left engine that changed a couple entry procedures to keep the leak isolated. We'd also get rid of some excess fuel through the aft engines to lighten the load—a lighter vehicle didn't get quite as hot during entry. We'd used up just the right amount of fuel in the nose during jet tests to keep it from being nose heavy. I noted in my log, "No forward dump [of fuel] needed for entry."

Balancing the propellants and the loss of the DFI recorder resulted in changes to a mere 17 switches out of about 1200 in the orbiter. As for the timeline itself, we scrubbed one camera activity as unnecessary, and left everything else alone. The only significant change to the printed book was the time of ignition (TIG) of the deorbit burn. It would occur six and a half minutes earlier than planned. Thinking of that pile of 482s we'd recently processed, I was astonished that there were so few changes.

We'd finally warmed the cabin by bypassing the radiators. The radiators were better at getting rid of the heat than expected. The Loss of FES plan to use the radiators as a heat sink would work better than expected, too. That was reassuring!

About an hour before the crew wakeup, the crew systems folks in our support room reported to FAO that the food warmer had been powered on. FAO reported this to Flight. Hutchinson decided to let them enjoy the view for another 40 minutes.

The official crew wakeup call was a comedy routine by two Houston radio DJs, Hudson and Harrigan. They said, "It's splashdown, and Crip, you could both use a shower." When they finished their routine, Capcom Dan Brandenstein said he had a "Realtime 482" to read up. Diane and I exchanged puzzled looks. "What 482?" I mouthed at her. But before she could answer, Dan said, "in that last wake-up song, we would like for you to scratch out the splash down and insert touchdown."

Diane and I laughed. It was one of Dan's better jokes.

The conversation on the loop revealed that the early riser had been Young, not Crip. I guess no one ever tires of that view. I imagined what it must be like, whipping around the Earth at 17,500 mph, seeing the stars of both hemispheres just by looking out the window.

While the crew ate breakfast, Dan said, "You'll be happy to know that we had midnight burritos."

Crip replied, "I knew it would come to that."

It was about 5 a.m. Houston time, and I was getting hungry—but not for burritos. The Crimson Team had just arrived and brought a fresh batch of donuts.

The flight loop was busy with chatter about auxiliary power unit 2. Cycling back and forth between heaters in the night had cleared the alarm, but not warmed it up sufficiently. It was about a hundred degrees cooler than the other two. If it got too cold, like a car engine on a cold morning, it might not start. The APUs are critical for controlling the vehicle during entry. However, only two of the three APUs were needed. The team reported that test data showed that even if the temperature dropped another hundred degrees, the unit would still start, though it might be a bit sluggish. Mission Control would keep an eye on it.

Diane and I handed over to Carolynn and Mi-Mi. About five minutes after 6 a.m. Houston time, I unplugged from the console, my official duties for STS-1 now complete. The deorbit burn was five hours away, the landing six. I planned to follow the last few hours of the flight, so I put my copies of the PDP and Entry Checklist into my briefcase. I grabbed my "I'd Rather Be Orbiting" coffee mug, said good-bye and good luck to Mi-Mi and Carolynn. I went out the double gray doors into the quiet hallway.

As I walked around to my locker to stow my headset, I marveled at how far I'd come since my first tour of Mission Control two years ago. From now on, I wasn't just another person in training. Like the astronaut candidates weren't really astronauts until they'd flown, I hadn't been a real flight controller until now. Flight controller. I liked the sound of that!

It was about six hours until landing. Too keyed up to go home and sleep, I headed over to the office. I followed the rest of the flight from a room in Building 4 that had a loudspeaker hooked up to the Air/Ground and Flight Director's loops, and a television so we could watch the news coverage of entry.

While I listened and waited, the orbiter was clipping along, covering five miles every second. The trick to staying in space was speed. At five miles a second, I could've zipped home, checked on Jasper Kitty, and been back at JSC in two seconds. That would've been pretty cool—except that moving that fast through the atmosphere would've created so much friction that I'd have been incinerated.

The orbiter had to lose about 93 percent of its speed, but lose it gradually. Entry was all about slowing down without burning up. The deorbit burn only took away enough of that speed (about 300 ft/sec or 204 mph) to drop the orbiter into the atmosphere. Friction against the orbiter's belly did the rest. Most of that speed was converted to heat. The tiles had to keep that heat from the vulnerable skin underneath.

At the press conference after the orbit shift the night before, the flight directors had reiterated that they weren't worried about the missing tiles. The ones they saw on the tail weren't going to be an issue. I believed them. But what about the belly tiles? Kranz had said that the attempts to check them from the ground with spy cameras had failed.

I heard the crew say that the payload bay doors were closed. I assumed the FES had taken over cooling from the radiators without any problems. PAO reported that aerial photos of Edwards showed a six-mile long string of traffic waiting to join the thousands of people who'd come to watch the landing.

I sat with my copy of the Entry Checklist on my lap, checking off items as I heard them completed. Page 3–5, there was a call out at TIG minus 17 minutes that read, "MCC/CREW GO/NO GO for DEORBIT BURN" in bold type. I listened for this all-important call.

Instead I heard a voice on the flight loop that wasn't one I'd heard before. "Flight, Surgeon. Still got one crewman with no tracing." The crew had just gotten into their seats and apparently the biomed data wasn't showing up on the downlink. But just a few minutes later, Surgeon said again, "Flight, we've got it."

Capcom then told the crew they had good biomed data on them, to which Crip replied, "Well that ought to scare you!"

They got their go for deorbit burn. Capcom added, "Everything aboard looks good to us." Crip asked if that included the crew, and Joe Allen said, "We report the crew looks terrific."

Laughter came over the air/ground as Crip said, "You haven't seen us lately!"

Fifteen minutes later, Young reported that the "Burn was on time and nominal." Then Crip said that he had two APUs running. The recalcitrant APU had started just fine despite its low temperature.

Everyone was in a buoyant mood. The burn had slowed them down so that perigee, the lowest point in the orbit, would intersect the ground in California in about 45 minutes. The weather was perfect. The clocks, which had counted down to TIG, now counted down to the time when the orbiter was predicted to first encounter the atmosphere. This is called Entry Interface (EI) and occurs when the orbiter is at an altitude of about 400,000 feet.

Crip was obviously enjoying the view. He said, "Joe, whoever said that space is black was not kidding you. It is really black."

Joe replied, completely deadpan, "Roger, you have convinced us."

Still dependent solely on line-of-sight ground communications, we lost touch with the crew again for another five minutes. Guam would be the last ground site before EI. Flight Director Don Puddy took this time to remind the Crimson Team of their duties post-flight. The crew wouldn't leave the orbiter until about 45 minutes after landing because all the systems had to be shut down and safed. He said, "You will experience a certain amount of exhilaration at touchdown. You'll have 15 seconds to vent that exhilaration, and then I expect it to be quiet." I laughed and jotted this quote in the margin of my Entry Checklist.

At Guam, on their final orbit, Crip called down to a few of the flight controllers by name. "Tell Gary [Johnson, EECOM] his vent doors are coming closed at this time." He referred to the closing of eight of 18 vents that ran along the sides of the orbiter. All of these were open during orbit to vent any gases in the forward jets, payload bay, and OMS compartments. All of these were closed when the crew transitioned to OPS 3, but the forward and aft vents had been opened to vent gases from the burn. These now needed to be closed to prevent hot plasma entering the vehicle. All the vents would automatically reopen lower in the atmosphere.

During this air-to-ground exchange, the TV commentator asked his companion what doors Crip was talking about. The companion didn't have a clue. He said, "Well, we're sure they aren't talking about the payload bay doors." No indeed! They wouldn't have done the deorbit burn until those were closed. I laughed and recorded this quote in my checklist, too. Just before LOS, Joe said, "Everything looks perfect going over the hill."

"Roger that," Young replied.

Communications went silent, what we call "blackout." The shuttle was now being baptized with fire so hot that it would vaporize aluminum. I worried about the tiles and said a quiet prayer for the crew to return safely.

PAO reported that blackout would last about 16 minutes. We'd be out of touch an additional five minutes because the shuttle wouldn't be over any ground stations. We'd not hear from them until they made radio contact with the landing site.

The cameras showed the standard view of Mission Control showing the front screens which had changed from the Earth map to landing charts. Five minutes before AOS, a power failure was reported at Vandenburg Air Force Base which the news said might delay initial radar and telemetry signals. I chewed my lower lip, still thinking about the tiles. *Be okay. Be okay.*

It was noon. I'd been up since about 5 p.m. the day before. I should've been sleepy, but I was wide awake. As the time to AOS counted down second by second, I could hardly breathe.

Finally, at eight and a half minutes after noon, the squawk box crackled, "Hello Houston. *Columbia* here." They'd made it!

On the Flight loop, FDO Willis Bolt said, "Flight, they look exactly nominal." I saw the numbers on the big screen: they were going Mach 10.3 at an altitude of 180,000 feet.

Allen told them, "*Columbia*, you've got perfect energy, perfect ground track."

Not only had they made it, they were perfect! They were still too fast and too high for the ejection seats, should something go wrong—but everything was going right. GNC Don Bourque told Flight that all three IMUs agreed. Crip reported that all three APUs were running fine. Young was busy executing two big "S" turns that were slowing them down for landing.

Capcom let them know when they were below 100,000 feet and were "positive seats," meaning they could eject if necessary. A few minutes later, we got television from Dryden. About 17 minutes past the hour, at around 50,000 feet, *Columbia*'s speed dropped below that of sound. A triumphant double sonic boom thundered across the dry lake bed for 150,000 people to hear. The cameras showed a tiny speck growing larger.

Young guided the ship into a turn around the heading alignment circle (HAC). Capcom said, "We're seeing 1.3 g's coming around the HAC. . .your winds on the surface are calm."

“That’s my kind of wind,” Young said.

They were about 13 miles away and finally down to 25,000 feet—the altitude of the 1977 approach and landing tests. On TV, we saw the view from one of the chase planes. The landing gear hadn’t come down yet. It wasn’t supposed to descend until about 300 feet. I watched for it.

At 300 feet, there was still no landing gear. *Come on!* At 250 feet, the gear finally came down. It took eight long seconds to lock into place. Touchdown was 11 seconds later! Capcom said it all, “Welcome home, *Columbia*. Beautiful, beautiful.”

The 15 seconds of cheerful exhilaration commenced in the MOCR and at every NASA center and just about everywhere on Earth that had a television. We now had 2 days, 6 hours, 20 minutes, and 52 seconds of flight experience with the space shuttle.

5.8 Kranz logs some notes while Center Director Chris Kraft celebrates the successful landing with a traditional cigar, obscuring the man beside him while “Father of the Space Shuttle” Max Faget (hands on hip) grins ear to ear (NASA photo)

Young got rather impatient waiting to get out of the vehicle. Technicians in protective suits had checked for toxic fumes and then used a giant wind machine to clear the air around the vehicle. (The TV announcers, with dead air time to fill, noted that this was the same kind of machine Hollywood used to fake storms.) We watched while the ground team hooked up long elephant trunk hoses to aid the cooling system and purge the inside of fumes as well. After nearly an hour, Young said, “We’re still here, you know. And if we’re going to get this thing operational, this is one of the parts we’re going to have to work on more.”

Crip added, "John doesn't think the passengers are going to wait this long to de-plane."

Capcom was quick with a joke. "Would you verify that you have your stubs for your bags on your body?"

Young replied, "Uh-oh! I knew I forgot something."

Finally, the hatch opened, and the crew emerged.

I hitched a ride with some other controllers to a bar called the Lighthouse across the street from the front gate of JSC. I recall clinking glasses with Hutchinson who wondered where the rest of the Silver Team was. Someone said, "At home sleeping!" Having been up nearly 24 hours, I rode back on site, got the car, and went home. Thor arrived later and got me up in time for the crew's welcome home celebration at nearby Ellington field.

Thor and I showed our badges and were let into a special VIP area to wait for the crew. We joined a crowd of about a 1000 people gathered in a roped off area next to the runway. We were right in front of a small platform that had been set up with a podium on it. The Gulf Stream carrying the crew and their families was supposed to land around five, but because of the delay getting out of the vehicle, they didn't make it until 6 p.m. I was asleep on my feet, which is probably why I forgot to take my camera.

Some people had waited for hours. Kids sprawled on the concrete, doing their homework, and some sleeping despite the bright sun. It was hot, and I was glad for the breeze. A few people had planned ahead and brought lounge chairs and coolers. I was thankful to have Thor to lean on.

Finally, the plane arrived. The Houston Post reported, "As first Young and then Crippen stepped from their plane, they were confronted with a roar from the crowd that yearned to equal the sonic booms that preceded their return from space."

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6

Preparing for STS-2

The historical aspect of what I'd just experienced didn't really sink in until the letters and postcards began arriving. My Grandmother, Esther Canterbury (1909–1996), wrote from Ohio, "Congratulations to both of you for the part you have played in the perfect flight of the *Columbia*. We got up at 6:30 Sunday morning to watch the blast off. It made me break out in large goose bumps when it took off. I sat with your letter, Marianne, trying to get a glimpse of a wee lassie in that control room.

"You both must feel great to have had a part in all this—have you signed up for a mission yet? They told what was required and read some of the applications on TV today. Dan Rather (1931–) said he wanted to fill one out. The landing was beautiful, he sat it down as lightly as a butterfly landing on a flower. Since Young and Crippen are both Navy men, a person could liken the sky to a vast ocean—you remember the poem, 'Your sea is so vast and my boat is so small.'"

Relatives and friends that we hadn't heard from in years all sent congratulations. Mom sent along a clip that her department store ran about us in their newsletter.

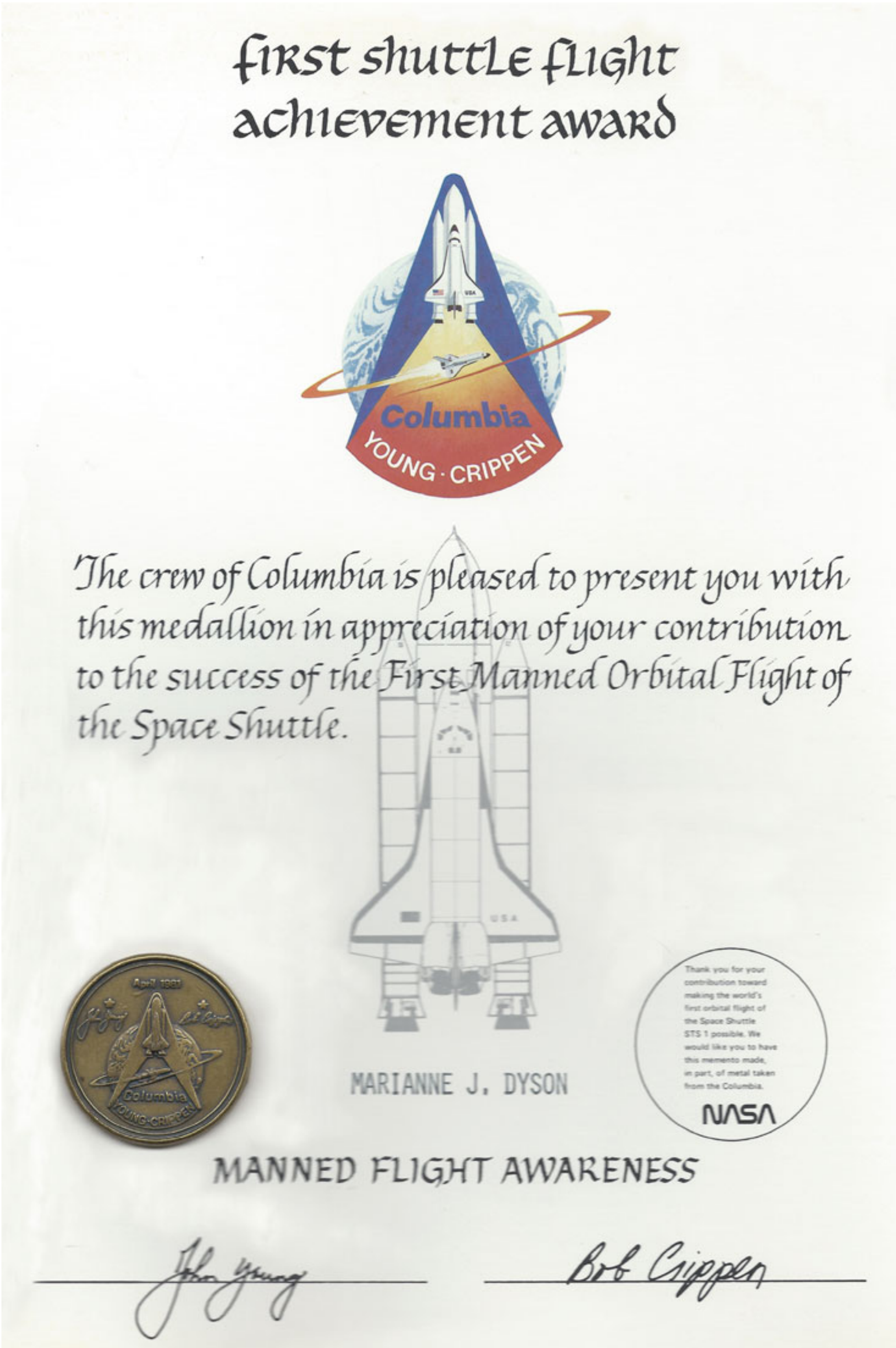
Like our parents, everyone in Building 4 practically glowed with pride. But we were also keenly aware of the pressure on us to do it again. STS-2 was scheduled to launch in August. To repeat our success required a detailed examination of the vehicle's and crew's performance on the first flight. I was back at work after only one day off to catch up on sleep.

The crew provided their feedback through a series of debriefings held in the Building 30 auditorium. These briefings started at lunchtime and went on into the evenings for days.

Always plain-spoken, Young didn't mince words. The 35 mm Nikon camera he'd used to photograph the payload bay door tests "should be thrown the hell off the spacecraft!" he grumbled. "The only way to get that camera to work is to have a degree in photography." In contrast, he said, "The 70 mm was damn near idiot proof."

I jotted these quotes in my copy of the meeting handout. As a Timeliner, I was especially interested in which activities took less or more time than we'd scheduled. Young and Crip agreed that all camera set ups took much longer than scheduled. Also, the lithium hydroxide canisters that were changed out had to be wrapped. This had been an easy task on the ground, but "it took 10 minutes at $2000 a minute" in space, Young quipped.

M.J. Dyson, *A Passion for Space*, Springer Praxis Books,
DOI 10.1007/978-3-319-20258-7_6



6.1 NASA provided employees with small U.S. flags flown on the shuttle and a medallion (shown) made from metal taken from Columbia on a certificate signed by the crew (Photo by the author)

The crew said there wasn't enough storage for trash. All the lockers had been crammed so tightly, they had trouble getting stuff out—and it would never go back in.

They noted some differences between the simulator and the vehicle, too. Crip said the "bounce" in the payload bay doors was about eight inches, and he couldn't tell if the radiators were stowed or not. He said the shoulder harnesses "are 20 times worse" in the simulator, and the noise level in the simulator was three times louder than the real thing. When the main engine's cut off, there was no pitch forward as they'd simulated, and they couldn't hear any noise or bump when the tank separated. But they could hear the primary jets firing. The orbiter shook every time, and flames 40–50 feet long shot out from the nozzles. They couldn't hear the smaller vernier jets at all. When asked if he could sleep with the primary jets on, Young deadpanned, "in between firings." Thus we decided to use verniers during crew sleep periods.

My ears perked up when they mentioned the flash evaporators, but the comment didn't really apply to my procedures. They said the venting caused the vehicle to roll and yaw.

They reported lots of debris floating in the cabin on launch day, and suggested that we add cabin filter cleaning sometime on the first day. I penned another note.

My favorite part of the debriefing was when the crew reported that they were "very happy" with Post Insertion. The only big change was to make the suit doffing in serial so one of them would be available to watch over the systems. Young didn't want to "to go in the cockpit in my underwear" to answer the radio.

A few minor tweaks resulted from the performance of systems. One of these changes was to the IMU alignment. The star trackers easily picked up the navigation stars in orbit, unlike in the simulator. We discovered that the 20-degree occultation disk we'd used for the Earth was unnecessarily conservative. So that activity was shortened from 12 minutes to six. However, because we'd do the maneuver with vernier jets, and it took longer to get into attitude that way, we actually increased the time for the whole activity.

The fuel cell purge was easier to do manually than in auto-mode. The heaters didn't need to be on an hour ahead of time, either—15 minutes was plenty of warm up. The waste water dump heaters were also more efficient than expected. They only needed a minute of warm up.

Teleprinter messages were to be restricted to low-activity times. Young said to never send a message close to the burn time or "somebody's going to go down there with a hammer."

We combined the crew's annotated checklists with our logs and display data from the systems controllers. Just a few weeks after the flight, we published the *As-flown Summary Timeline* and the list of when each of the flight test objectives had been met.

I incorporated what we'd learned into the STS-2 Post Insertion procedures. Software updates also resulted in STS-2 changes. The computers no longer needed to check a mass memory unit for software transitions. This let us turn them off for the contingency cases. I also added two new activities, the power up of the robotic arm, a.k.a., the remote manipulator system (RMS), and the activation of the heaters in the payload pallet. The Canadian-built arm was making its debut flight, and we were all anxious to see how well it would work.

NEW PAYLOAD FOR STS-3

Bob Nute, Sy Liebergot (an Apollo-era EECOM), and I went over the summary STS-3 plan back in February. We generated a list of issues to resolve and circulated it to various parties. We discovered to my complete surprise that because of a typo eight months ago, the Electrophoresis Flight Planning Annex still hadn't been published.

In July of 1980, I'd noticed that someone had mistakenly converted 10^{-3} to 0.01 g instead of 0.001 g. I'd attached a note to the Annex stating that the 10^{-3} g acceleration requirement would be used because it was in the Flight Requirements Document. I'd sent the document to Charles Chassay in the Program Office for approval and publication. In August, unknown to me, he'd sent MPAD off to do an analysis of the acceleration requirement. In October, MPAD came back and said the requirement could be met [don't ask me how] by a software change costing millions of dollars. Program Manager Leonard Nicholson said no—and the requirement was removed from the Payload Integration Plan in January, 1981.

So in February, the PIP Annex landed on my desk once again—still unpublished. I removed the requirement and sent it on its seemingly unending journey to publication. The first week in March, the Life Sciences people responsible for this experiment determined that the Annex wasn't really needed. I wrote, "The mysterious Electrophoresis Flight Planning Annex is dying a slow death. . . . Does anyone really care?" I'd have to wait a few more months to get an answer to that question.

The week before STS-1, we'd held the first official STS-3 On-Orbit Flight Techniques meeting, chaired by Ted Guillory. Guillory was especially focused on the planned thermal tests.

One test was to see if the thrusters in the tail would fire after being chilled. Sy Liebergot noted that to get the jets as cold as possible, the left primary jets had to be inhibited for 10 hours. Then, one jet, L3L, would be fired for 100 seconds and shut down for another five hours.

Firing just one jet would cause the orbiter to spin. The Flight Techniques panel said that 100 seconds would induce "incredible rates, so that is out." The panel looked at firing it for just 10 seconds. With the rest of the jets inhibited in the back, a forward jet would have to offset the rotation. But this used a lot of propellant. So I was assigned to review the test "to determine if using another jet would alleviate these problems or it there is a control problem with uncoupled roll control using the Y translation option." I was to coordinate my findings with Don Nelson so he could reflect them into the propellant budget.

Bob Kain presented the robotic arm test objectives. I was assigned to: "Evaluate scheduling cold case tests during awake periods so the arm is not left uncradled and powered up during a sleep period."

After nose-to-sun to chill the tail, the orbiter would be turned top-to-sun for 26 hours. Having the bay face the sun is the hottest attitude for payloads and also the least efficient for the radiator panels to provide cooling. With the radiators in the sun, the FES would provide cooling and use up a lot of water. Cynthia Wells was assigned to check that we had enough water.

My third action from the Flight Techniques meeting had to do with scheduling the door tests after each of the three attitudes. Guillory noted that if the doors wouldn't reopen, we'd have to deorbit before we ran out of water for the FES. Opportunities for landing clustered during the first half of the crew day. But most of the tests were currently at the end of the crew day. So I was assigned to "Determine if the door and other major activities can be scheduled earlier."

Just as I was tackling these three assigned actions, management made a major change to STS-3. The success of STS-1 convinced them to replace the conservative "crash-test dummy" payload flight test article with a real payload: the Office of Space Sciences (OSS-1) payload they'd had me assess last fall.

The OSS-1's Plasma Diagnostic Package would be picked up and held aloft at the end of the 50-foot robotic arm for 20 hours, measuring ion and electron densities as the orbiter "plowed through" the thin plasma in orbit. Scientists were curious (and I was, too) to see if the orbiter produced a wake in this plasma, sort of like a boat does as it passes through water.

The OSS-1 wasn't just something to use to test the arm, though. It was a set of really cool experiments mounted on a reusable pallet. The experiments would measure: (1) the Sun's ultraviolet and X-rays; (2) contamination of the space environment by orbiter propellants and waste water dumps; (3) the number of micrometeoroid hits; and (4) the effectiveness of a nine-foot tall thermal canister to protect against the extreme temperatures of the space environment [1].

My favorite was the Vehicle Charging and Potential Experiment that would shoot 1000-V pulses from an electron "gun" to measure vehicle charging effects. If I were still one of Dr. Freeman's grad students (and I'd finally mastered that darn E&M stuff!), I might use the resulting data to help determine solar power satellite charging effects. The scientists predicted that the crew might see the glow of the plasma beam (They did!).

NO SKIRTS ALLOWED

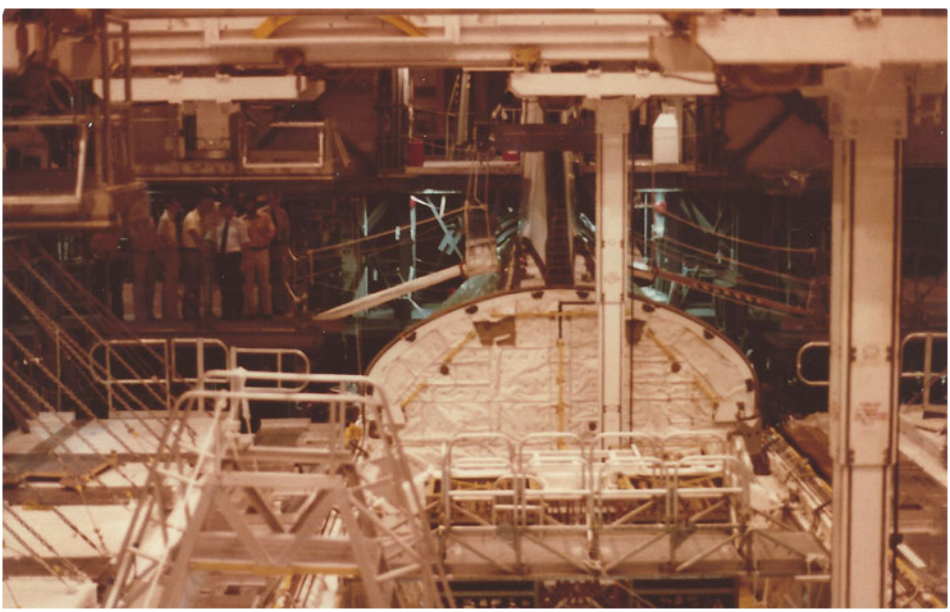
So, after my intern review in June, I headed to KSC to attend the OSS-1 Investigators Working Group. Our group from JSC included Bob Nute, Wayne Huning, myself, and Payloads Officer Bill Boone. We were tasked with trailblazing how to coordinate and integrate payload requirements into flight operations. I described the trip in a letter to Thor's parents afterwards.

"This was one those weeks you never forget. Last Thursday, I found out I was going to KSC Monday. The purpose of the trip was to attend a meeting on a payload that was recently assigned to the 3rd flight. . . .OSS-1 consists of 8 experiments, all very different and all with different people in charge of them (they are called PIs for principal investigators). To confuse the matter further, Goddard (NASA in Maryland) is in charge of integrating OSS-1. In other words, they are the middle men between JSC and KSC and the PIs who are sponsored by universities or other government agencies (like the Navy). This meeting was supposed to iron out who was responsible for what and by when. Bob Nute who is lead FAO for STS-3 and myself need constraint data from the PIs so we can integrate their activities into the timeline. It took us three days to explain to them just what it is we want. . . .It was a whole new world for me, and I thoroughly enjoyed it.

“Of course we couldn’t meet at KSC and not see the orbiter! We were loaded into a bus and taken to the OPF [Orbiter Processing Facility] building which is next the Vehicle Assembly Building which is the one I’m sure you saw on TV. It is the 2nd largest building by volume in the world. It is right near the launch pad and very far from anything else! Anyhow, our tour guide assured me the previous day that I could see the payload bay doors up close.

“We hopped off the bus and the site manager (a woman) looked us over, singled me out, and said I couldn’t go in. She explained there is a dress code of closed-toed shoes and pants (I was wearing a skirt and sandals) and that I would have to stay behind. They all went off and left me there alone!

“I was so frustrated to be there and not see the shuttle! So, I decided instead of standing there feeling sorry for myself, I would try out the old ‘where there’s a will there’s a way.’ I asked a guard if I could get some coveralls somewhere. He said he thought so, but couldn’t leave his station to show me where. About that time a girl my age walked by. I asked her to show me where to get coveralls. She said they are called bunny suits and sure she’d show me. I was half way there! All I needed were shoes. She (Paula) said she knew someone would be sure to have an extra pair of shoes, and started asking around. She couldn’t find any, so she kicked off hers and said, ‘Go ahead, take ‘em.’ I told her I was forever indebted to her, and went to join the tour, shuffling along in her too-big shoes and this oversized white bunny suit.



6.2 I took a photo of the guys near the orbiter’s tail from a gang plank that crossed the payload bay. They’d left me behind because I was wearing a skirt (Photo by the author)

"I took my camera and took lots of pictures of the shuttle. I felt so proud to be part of it! I also felt proud of myself for taking the initiative to get into the building. The site manager, when she saw me said, 'Well, I see you figured out how to get yourself in. I'm glad 'cause I hated to discriminate against you.' I felt like she could have suggested it to me at least!

"One of the best parts of this trip was getting there on the Gulfstream. It's NASA's VIP private airplane. We left from Ellington at 5:30 a.m. and landed on the shuttle runway! It was as wide as a mall parking lot. I was impressed. . . .

"We flew back Wed. night from Orlando to Houston . . . the flight to Clear Lake City was delayed, and I was on standby and had to wait 1.5 hours. . . .One of the guys who missed [the earlier flight] sat next to me while we waited. He had also just come from KSC and said he worked for Rockwell. I told him how a Rockwell girl had helped me out and related the story of the shoes. He wrote her name down and said he'd send her a note. I asked him what he did at Rockwell, and he said 'I'm the Vice President for all Rockwell personnel departments.' I really felt that Fate had intervened by keeping him from getting his plane so that Paula could get the reward she deserved for being such a nice person."

Back at work, I modified the STS-3 CAP to include major OSS-1 activities. I owed a set of 12-hour summary timelines to Ted Goldsmith, my contact at Goddard. He in turn needed to write up all of his requirements for a new edition of the Flight Requirements Document. Now that we all had met in person and hashed out who was responsible for what, we expected STS-3 planning to go smoothly.

PROMOTION OF THE WET CAT

The day after my return from Florida was my intern review. I had to give a speech to Mr. Kranz about what I'd accomplished for the past 2.5 years. If I did okay, then I'd be promoted from a GS-9 to a GS-11. Thor was already a GS-11 because of his master's degree. Had I learned enough to have the equivalent of a master's degree? Management would decide based on my performance. I described my day in another letter.

"That morning it absolutely poured a tropical storm on us. I wore a cream white suit. I got into the car, and the steering wheel came off all over me (black crud). I already had wet feet, and it was pouring. The car took six tries to start. I was more than a little upset when I realized the seatbelt had left a streak across my skirt! We (our directorate) had a meeting at 8:00 sharp that would announce our reorganization, and all of us had to be there, so I was rushed already.

"I arrived at NASA feeling like a wet cat rolled in beach tar, so I hurried off to the restroom to dry off, wipe off, and comb out. I missed most of the meeting.

"Thor and I are now in the same division, different branches and sections. Everyone is shuffled around and not looking forward to moving. [I moved from the second floor to the third.]

"Anyhow, at 9 a.m., I went to give my speech. There were three people ahead of me, including Ed Gonzales who is one of the airplane builders with Thor. It was nerve-wracking to wait 1.5 hours! But it came out better than I'd rehearsed it, and I mumbled through the questions OK. I'm now a GS-11. I decided my raise will go into a 'new car' fund!"

TRAINING FOR STS-2

On June 17, I had my one and only procedures verification run on STS-2 Post Insertion. Mi-Mi, who was now the PDP book manager, and I ran the test with Karol Bobko (1937–), one of the astronauts hired in 1969 who hadn't yet flown. (He'd pilot STS-6, and fly twice more after that.) We found that some payload information was not yet modeled in the simulator, but otherwise, Post Insertion was verified ready for STS-2. Sort of.

The next week during sims, I gathered more changes to implement before STS-2. One change was especially welcome: to end post insertion a half hour earlier, at 4:00 MET instead of 4:30. This got the crew into the CAP sooner and also allowed the Ascent Team more time off before we had to be back to support the overnight replanning.

The changes to all the flight documents quickly overwhelmed the manual system, and the CAPS still wasn't operational. After a sim on a Tuesday in June with me as Timeline and Carolynn serving as FAO, I wrote, "The crew, flight director, and ourselves were the only ones with STS-2 procedures because the simpacks weren't due out until Thursday."

That Thursday, we had another post insertion sim. I wrote, "We all learned a great deal about the first day of the CAP as we tried to schedule a computer replacement and a memory dump. Then we cancelled OMS 3 and 4 and started looking for arm work to do in the extra time." Little did we know we'd have to do something similar during the real flight.

The pace of sims, training exercises, document updates, and planning for future flights had all of us rushing from our desks to the simulators and consoles and back—trying to keep up with the pile of yellow phone messages that inevitably accumulated while we were out. I hardly had time for lunch and often worked late to meet some deadline.

To reduce the workload, management decreed that lead FAOs would no longer staff a console for the flight immediately before and after their flight. This meant that Bob, lead FAO for STS-3, wouldn't man a console for STS-2 or 4. Elvin, who was lead for STS-4, wouldn't work STS-3 or 5. This was great news for me because it meant they'd need a lot more FAOs real soon. There weren't many of us in the pipeline!

First in line in terms of experience was Diane, but she wasn't eligible for promotion because she was a contractor. Next was Tucker Pierce, and sure enough, he was assigned as Entry Team FAO for STS-2. (Entry team was considered the "easiest" for FAOs because there was no replanning to do.) So it seemed that management was going by seniority—which meant Carolynn was likely to become the first woman FAO on STS-3.

Although the official policy (summarized in Elvin's memo from 1980) stated that candidates for FAO should have both timeline and pointing experience, in practice, there hadn't been time for Tucker to be a Pointer. Did it really matter that he couldn't calculate the attitude for an IMU alignment? Couldn't he just trust his Pointer to do his job like the flight director trusted each of us to do ours? Besides, his team's Pointer was a super-sharp "blue-suiter" named Mark Brown (who would later become an astronaut).

But ideally, an FAO should have as much knowledge of the support room positions as possible, and certainly must know how to do the Timeline job. So, to increase the pool of future FAOs, management decided to “cross-train” our most experienced Pointer, Marion Griffin, as a Timeliner. He was assigned as Timeline 2 on “my” team for STS-2. Chuck Knarr, another of the “blue suiters” that had joined us in 1980, served with me and Marion as a trainee. Our Pointer was Gregg Walding, a new guy Marion had trained.

By this time, Marion and Mi-Mi and I were good friends. We ate lunch together whenever we weren’t in sims. He and I’d attended Mi-Mi’s wedding, and Mi-Mi and I’d gone to Marion’s house near the water in Seabrook and been treated to all kinds of wonderful seafood. His fresh steamed crabs were amazing, and his chili recipe won the Flight Operations Directorate Chili Cook-Off at least once. He was a soothing person to be around, always calm and cheerful and patient with my endless questions about everything. And now I was supposed to train him to be a Timeliner?

But during one of our lunches, Marion confessed that he really had no interest in being an FAO. He liked doing attitude and pointing, not dealing with all the “political” stuff that was involved in scheduling crew activities or pleasing upper management. He also didn’t argue or complain. So when they assigned him the Timeline 2 position, he shrugged and went along with it. We joked that his being pushed toward FAO was merely the Peter Principle at work: in a hierarchy every employee tends to rise to his level of incompetence. But I doubted that Marion would be incompetent as an FAO. He’d just be happier as a Pointer.

On the other hand, Chuck Knarr (who’d later become a flight director) was an enthusiastic sponge that naturally soaked up all aspects of the Timeline task. I’d show him something once, and he’d have it mastered and suggesting improvements.

I remained on the Ascent/Planning Team for STS-2 because of my intimate knowledge of Post Insertion and Launch Day Deorbit procedures. Carolynn, whom we all assumed was being groomed to become FAO on STS-3, was on the Orbit Team. Her Timeline 2 was John Bains, a quiet and competent man that Mi-Mi and I had both worked with on developing CAPS and who was an arm expert. Mi-Mi remained on the Entry Team because of her knowledge of the Deorbit procedures which she’d taken over from Ben, now lead FAO for STS-2. Tucker had some knowledge of entry, but his STS-1 experience had been on the Orbit Team. So it made sense that Mi-Mi should remain on the Entry Team to advise him. But instead of being promoted to Timeline 1 like me, she remained a Timeline 2. Bill Holmberg, who’d been Timeline 2 for Tucker on STS-1, became the Entry Team Timeline 1. I didn’t understand why they’d promoted Bill over Mi-Mi. Mi-Mi was a NASA employee, and Bill was a contractor. And why was Diane not working STS-2 at all? It sure looked like discrimination, but I kept quiet about it.

At least the number of women on the team was on the increase. Pearline Collector, who remained the Ascent Checklist book manager, was slated to sit in the front room with Elvin as the ascent phase specialist.

Another woman in the FAO support room was our branch secretary, Virginia Nester. She had worked as a support person on Apollo Soyuz. She was an excellent Pads operator. She could type faster and more accurately than probably anyone else in Building 4.

More detailed analysis of data from STS-1 gradually filtered into our plans for STS-2. Marion took a look at the propellant usage to maintain different vehicle orientations. He put out a “note of interest” on June 26, reporting that—ZLV, which was payload bay to Earth, used three times more fuel (3.7 lb/hr versus 1.1) than we’d predicted. The BBQ mode called PTC (Passive Thermal Control) used about twice as much (11.4 lb vs. 5.4 lb) to start than we’d predicted. He wrote, “Except for PTC maintenance, propellant consumption was significantly higher than was predicted before flight.... Note that this data means a 300 % increase in the currently planned usage for ... STS-2.” Ouch.

We held the first STS-2 long-duration sim in July. Marion, Chuck, and I supported Elvin as our Ascent Team FAO. The scenario included the failure of a computer that the crew needed to replace. This was the same failure we’d simmed in June—obviously, management felt this was our most likely failure, and wanted to be sure we could deal with it. We also (like we’d done in June) canceled the OMS 3 and 4 burns and focused on arm activities that could be done during that time.

6.3 The Ascent/Silver Team for STS-2 was led by Flight Director Neil Hutchinson, tall man with beard on the far right in dark suit with no one behind him. Most of the women are in the front row, *Left* to *Right*, unidentified, Linda Patterson, Carolyn Blacknall, unidentified man, unidentified woman (might be Jan Wrather), “Gap” Pennington, Marianne Dyson, Pearline Collector, Virginia Nester, Anngie Johnson. Behind Carolyn is Jenny Howard (NASA photo)

All these sims sparked some ideas for stories in my head. I shared some of these with my college friend Tom Burkhalter. He wrote back a ten-page letter detailing his thoughts on what a future Mission Control might be like. He predicted that within 10 years, the "constant sim drill will be cut out as operations become more 'routine,' i.e. enough experience will be pooled that less time will be spent on contingencies. . . .Enormous efforts in training for specific missions will no longer be possible or necessary when STS missions become more commonplace. The emphasis in training should go to systems operation in general." His predictions were right. Already there was talk of publishing the contingency deorbits as a third book by themselves (guaranteeing they'd be ignored), but we sure weren't there yet. I was getting tired of sims.

FIRST FLIGHT WITH THOR

Now that STS-1 was over, I was anxious to get pregnant—but my cycles continued to be irregular. In July, I wrote, "Thor is in the garage working on the plane with Brian. It seems like the same old story, the same old "hope" that has disappointed me these past six months, but my period is late once again and maybe this time I am pregnant. I'm afraid to even say maybe to myself for fear my period will start just to spite me. The optimist in me says it's only a matter of time, and God will know when the time is right. I am much more calm now than in the spring. I'm also in better physical shape. I've got a grip on my workload, too. There's hope for me yet!"

But once again, a few days later, the flames of my optimism were snuffed out. Thor suggested we plan a trip away right after STS-2 to help me relax and increase our chances. He was now current on his pilot's license. How about if we rented a plane and went to visit my brother Tommy in California? That sounded great, but I had yet to fly in a small plane. "Well, how about I take you flying this weekend?"

"It's a date!"

So Saturday, August 1, I put on my STS-1 T-shirt, and we went out to Houston Gulf Airport (now a neighborhood) in League City. Thor opened a hangar door, and used a tow bar to drag out a Cessna 172 that he'd rented. He walked around the plane, doing his "preflight" checking that there was no water in the fuel, that the prop wasn't nicked, and that the flaps moved freely. I imagined the team at the KSC doing a similar (but more complicated!) inspection prior to the shuttle launch. We climbed in and adjusted the seats. We went through a checklist, and then he yelled "Clear" out the window to let anyone we couldn't see know that we were about to start the engine. It roared to life, and the prop spun around and blasted us with hot summer air. He used the rudder pedals to "drive" the plane along the taxiway. Once we were near the end of the runway, he did what's called the run-up. He pushed the throttle all the way in and revved the engine to full power to check all cylinders were working. He set the radios to the local frequencies. He turned to me and asked, "Ready?" I gave him a smile and a thumbs up.

6.4 Thor rented a Cessna 172 and took me on my first flight (wearing my STS-1 shirt) in a small plane in 1981 (Photo by the author)

"We took off and flew around the area. He showed me how the yoke, the steering wheel of a plane, works. When I pushed in, the nose would go down, and when I pulled back, the nose would pitch up. When I turned the yoke left or right, the plane would roll in that direction. If I wanted a pure yaw, I could use the rudder pedals. I'd been working with roll, pitch, and yaw for more than two years in the timelines. Now I could 'feel' them. I had a whole new respect for the astronauts who had to fly the shuttle as well as keep track of all the switches. I discovered that the hardest thing about flying was to keep the plane straight and level!"

After my first flight, I was ready to plan our trip west. Flying would be so much better than driving all that long way like we'd done from Rice, and way better than hitchhiking.

STS-3 CARGO INTEGRATION REVIEW

Though I spent a lot of hours training for STS-2, planning for STS-3 took the bulk of my time in the summer of 1981, especially preparing for a meeting with top management called the Cargo Integration Review (CIR). A CIR was scheduled for STS-3 in August. But OSS-1 had only been assigned to STS-3 a month previously. So the second week of July, Bob presented an overview of the timeline and our concerns to Leonard Nicholson, representing the Shuttle Program Office, in a "dry run" CIR. We had a rather long list of concerns to resolve prior to August.

Basically, the scheduled activities required more power and fuel than might be available. And we hadn't established the priorities for various payload activities in case we needed to scrub something or shorten the flight to compensate for shortages.

We also realized that most of the experiment procedures would have to be verified by "desktop analysis," i.e., our best guess! We only had ONE 30-hour sim scheduled. This would be the only training the payload operations control center folks at Marshall Spaceflight Center in Alabama would get to learn how to deal with anomalies.

One payload issue we resolved using the 1-g trainer mockup in Building 9. We verified that a Get-Away Special canister mounted on the longeron wouldn't block the targets the crew needed to check the alignment of the payload bay doors.

By the second week in August, the launch date for STS-2 had slipped to November, and STS-3 to January 18, 1982. The STS-3 CIR was held on August 19 on the 9th floor of Building 1. Al Bishop provided the overview. The flight was to go to 130 nm orbit and a 38 degree inclination. Landing would be at Dryden (part of Edwards AFB), California.

Paul Jaschke then described the OSS-1 payload, and Charles Chassay reviewed the electrophoresis. Its low-g requirement was still alive and kicking, despite being removed from the official book. The problem was the plan to mount it just two middeck lockers away from the teleprinter that shook big time when printing. My meeting report said, "The EEVT people want the teleprinter inhibited during 75 minutes of each of their eight runs. Flight Operations thinks this is unreasonable." Later in the meeting, they requested to move the teleprinter farther away.

A. J. Bordano went over the vehicle performance, saying that we had a 1766 pound margin (of fuel). G. L. Hunt reviewed the launch window constraints, noting that the crew couldn't be in their seats more than three hours prior to launch. Cynthia Wells said that the hydrogen budget was critical. If we wanted to go seven days, we'd have to power down. A Flight Techniques meeting was scheduled to address this.

The flight planning section followed, with Bob providing the crew activities overview. He asked how the ground would decide if the last attitude of the flight would be PTC or Top Sun. Top Sun was preferred by the OSS-1 folks, but it wasn't clear if that "hot" attitude would require more power or cooling than would be available at the end of the flight.

Bill Boone took the floor to discuss payload support. He noted that the first sims didn't start until Dec. 1 because they couldn't use STS-2's software load for STS-3 sims. Dudley Long said only four on-orbit sims and one long sim were scheduled. Someone from Goddard said that because of a lack of travel money, they could only support two sims anyway. I shook my head. How would we ever support 24 flights a year?

Ken Kissin of Goddard was more concerned about tests that needed to be done on the ground prior to launch "We will not fly without end-to-end testing," he said. Apparently an end-to-end test required the payload bay doors to be open. Once they were closed for hauling the orbiter to the launch pad, the test couldn't be done. A discussion of payload priorities followed.

Ted Goldsmith remarked, "It's not in our authority to decide payload priorities, and the people whose authority it is won't do it, either." Sigh. No one wanted to be the one to say no.

The "take-away" message from this CIR was that two months wasn't enough time between flights for the desired testing and training. But when push came to shove, management wouldn't delay launch for either reason.

But we did have to solve the performance (fuel) problem before we launched. One suggested solution was to lower the orbital inclination from 38° to 28.5°.

Inclination was something I'd learned about in astronomy class back at OU. It's the angle of the orbit plane with the equator. A satellite in a 90-degree inclination orbit would orbit the Earth from pole to pole. Because Earth spins from west to east, it takes the least amount of energy, and fuel, to launch directly east. So a lower inclination would save fuel.

But the inclination is limited on the low end by the latitude of the launch site. Launching directly east from KSC would put the shuttle into an orbit with an inclination of 28.5°, which is the latitude of KSC. Because the shuttle would start out 28.5° above the equator, to orbit the center of the Earth, it must pass 28.5° below the equator on the opposite side of Earth.

Theoretically, a shuttle could be launched into a 90-degree inclination orbit from any latitude. But because of the potential for an explosion, launches out of KSC weren't allowed to head directly north or south over populated areas. All launches had to head out over the ocean. This limited the inclination to just under 60° (like the International Space Station). To reach polar orbit which was especially useful for military and weather satellites, a launch site at Vandenberg Air Force Base in California was being readied for use.

An inclination of 38° would maximize the number of landing opportunities. Edwards in California was about 35° above the equator. The shuttle had the ability (called cross range) to adjust its landing by about 1000 miles. So it could launch into a 28.5° inclination orbit and still land at Edwards. But there would be fewer opportunities, and no one-orbit-late chances for cases like the Loss of FES. With only one flight so far, were we ready to give up those opportunities? I reported, "If we go to 28.5 degrees, I understand it causes a three-week delay in simulator availability for sims. We will have about two months of training." (STS-3 flew at 38°.)

A TYPICAL STS-2 SIM

On August 4, 1981, I participated in a simulation with the Ascent Team. This was one of only a few sims that covered the post insertion phase. Being a "seasoned" team now with one actual flight under our collective belts, the sim team input multiple systems problems simultaneously for us to untangle. Thus as soon as we got data, we saw the flash evaporator temperature going up, the arm out of position, and a problem with one of the IMUs.

While I followed the EECOM's discussion about a possible Freon loop problem, the arm procedures experts in the FAO support room talked to FAO about a switch being out of place, and Pointing reported that one of the star tracker doors was stuck closed (so it couldn't find the guide star to align the IMUs).

I noted that the Orbit Pocket Checklist had a mistake and sent the crew to the wrong procedure for troubleshooting the temperature problem. Was this why the crew had activated the hi-load FES instead of switching from B to A of the primary system? EECOM reported this to Flight who had Capcom ask the crew to turn B off and A on.

The crew reported that they'd switched FES primary controllers already and that hadn't fixed the temperature problem. This was a sim, so we weren't surprised this easy fix didn't work.

Capcom asked the crew to confirm that the arm was rotated out, and they said, "Yes it is. We didn't do anything to cause it." We decided the simulator had started with the switches in the "deploy" position by mistake. The crew solved the problem by turning the switches off.

We told the crew to use a different star for the IMU alignment.

The Freon problem was solved about an hour into the sim. We gave the crew the "Go for orbit ops." But the sim wasn't over, and we had more problems to solve.

The crew reported that they'd hooked up the teleprinter, but it was receiving spurious inputs. They turned it off and on again, even unplugging it, but reported it "put out garbage." I smiled and leaned over to Marion and said, "What do you want to bet the crew just doesn't want to go up and down the simulator ladder to get teleprinter messages?"

"Yep," Marion said.

Every member of the team was busy working some problem, though the DPS console was rather quiet. So not surprisingly, the sim team put in a problem for them: the Backup Flight System computer failed. I logged, "Unwilling to do OMS 3 and 4 burns without the BFS unless over AOS." Without being over a site, the team couldn't monitor the tank pressures that were normally tracked by the BFS. This was the third major sim that had cancelled OMS 3 and 4. I joked that it seemed we weren't very anxious to do these burns!

But we soon had a bigger problem: nitrogen was leaking from the crew cabin. The crew switched from system 1 to system 2 but that didn't stop the leak. (Of course not!) Also, a heater on the APUs failed, and something funny was going on with the pitch control.

In the midst of sorting out the computer and cabin leak, the crew continued activating the payload and discovered a problem with that, too.

Instead of cancelling OMS 3 and 4, the team decided to delay them so they'd be over ground sites. The crew reported that the teleprinter was fixed. I laughed, knowing that the sim was due to end shortly, and we'd not have time to use it.

The problem with the payload was determined to be related to the BFS failure. The BFS controlled some of the payload's electrical buses.

The cabin leak was constant at 5–10 lbs/hour, so that meant the flight would be cut short. We told the crew we'd come home the next day. The sim ended with all of us feeling rather smug. Sim Sup could throw the book at us, and we'd just catch it and keep going. After all, we'd endured hours and hours of "disaster" sims prior to STS-1, and the vehicle had performed flawlessly. STS-2 would be a piece of cake. Little did I know how wrong I was about that!

CAN'T PLAN ON ANYTHING

We had a 56-hour sim a few weeks later. Afterwards, I rushed to a training session for post insertion specifically set up for the STS-4 crew. I got there to discover it was canceled. The crew had gone to the Cape. The next week, I went to support a post insertion suited run and was told it was delayed an hour, and then not to support it." I vented to management that we "can't plan on anything!"

My schedule issues were just a small part of a larger problem at NASA. While we struggled to prepare the crew and documents, the team at Kennedy had to get the vehicle ready. *Roundup* reported that "Operation Graysteak, the modification to the launch platform being made to compensate for the STS-1 overpressure problems, is running behind. Crews are working around the clock, seven days a week to make platform changes" [2].

By the Sept. 11 issue of *Roundup*, the launch had been delayed to October 9, 1981 "as a result of a series of minor problems." The change in launch date caused trajectory-related changes to the checklists. In making the update, I discovered that the launch day deorbit procedures in the final published books still used the 150 nm altitude instead of the new 137 nm altitude. The ground site coverage was very different. We had to share a lone microfilm processor with every document needing printing at JSC. The nominal timelines naturally took priority, so I had to hand-draw the formats showing the day/night cycle and the ground stations for the launch day procedures.

We'd hardly begun the process of updating the books when, on September 22, there was an accident at KSC while workers were loading propellant into the forward RCS module. *Roundup* reported, "Nitrogen tetroxide, the highly corrosive substance which ignites on contact with hydrazine, the RCS fuel, spilled down the starboard side of the orbiter when a quick disconnect valve failed to seat properly. . . .Many of the tiles came off easily in the hands of technicians cleaning up the spill. Over 350 were finally removed from the vehicle as engineers sought to find the limits of the damage" [3].

As a result of this accident, the launch of STS-2 was delayed to November 4, 1981.

FLYING WITH GUIDANCE

With launch delayed, Thor rented a plane and took me and two other flight controllers, Gayle Weber and Brian Perry to Kerrville, Texas for a "Fly In." Gayle would become the first woman Guidance Officer, and Brian was training to be Flight Dynamics Officer, in charge of where the vehicle is going and where it has been.

I wrote, "I navigated and it was fun. We saw some finished Vari-ezes [like the plane Thor and Brian and Ed were building in the garage]. Unfortunately, we also saw one of the stunt pilots crash and die. He went into a yaw [flat] spin. It looked neat with the smoke going up vertically as he spun around. When we saw the black smoke though, it gave us all a sick feeling. I couldn't watch the show after that. . . .

"On the way back, with Brian navigating, we got lost! We looked out the window and said, 'What city is that down there? Sure is big.' Brian replied 'Must be San Marcos.' Well it was San Antonio! We ended up completing our flight in the dark with half our instruments broken. 'Is that Route 45?' 'No, must be 59.' 'No it's 45!' 'Does anyone know where we are??' Thor [who knew exactly where we were] was totally pleased with himself for days afterward!"

6.5 Thor flew me, future first female Guidance Office Gayle Weber, and FDO Brian Perry to an airshow in Kerrville in October, 1981 (Photo by the author)

On September 30, the day that STS-2 had been supposed to launch, I went to my doctor to discuss what I could do to increase my chances of getting pregnant. I was in the waiting room when Mi-Mi came out. Somewhat surprised to see her, I couldn't help but notice the glow on her face. "Are you pregnant?" I blurted out in my usual blunt fashion.

"Yes! Dr. Abbott just confirmed it!"

I hugged her and congratulated her. "Don't tell anyone," she asked. She wanted to wait until she was showing to tell anyone at work. I assured her I'd keep her secret.

I couldn't help but wonder why it was taking me so long. On Sunday, October 4, I wrote, "I called and made an appointment for Nov. That gives us one more shot at it before we go in for a consult. I bought a basal thermometer to get her some data and help us time things optimally. I felt the worst telling Mi-Mi. I know she was really hoping to share her pregnancy with me."

But I was thankful that Thor and I were still happy together. We bought a new TV and enjoyed watching Walter Cronkite on CBS News every night. When he reported problems with the shuttle, we took it a little defensively—that was our shuttle he was talking about! It was the most complex vehicle humans had ever built. Of course there were problems. The purpose of the test program was to find and fix them. But at the same time, we were as frustrated as everyone else with the delays. I wrote, "Thor and I's great vacation plan is in jeopardy. We want to go to Grand Canyon then San Francisco but may only get a week off. It's been so long since I've seen Tommy! It may be our last chance for a vacation in a while, with the flight rates going up and maybe a child in there somewhere (hopefully) soon."

With only a week off, we decided to postpone the San Francisco part of the trip, and just go to Grand Canyon. I packed a pup tent, sleeping bags, a camp stove, and our backpacks. My head full of romance, I couldn't wait to snuggle up in a tent with Thor. We rented a single-engine Piper Warrior and took off on October 12.

Thor wasn't yet an instrument-rated pilot. Flying under what are called visual flight rules (VFR) means that visibility has to be at least three miles—VFR pilots aren't allowed to fly through clouds. Thor listened to the weather report and said that there was a storm in the middle of Texas, but it was supposed to clear up by the time we got there.

But as we flew west of Houston, the scattered clouds gradually merged into a solid bank. The bank got darker and then raindrops hit the windshield. As long as the clouds were 2000 feet above us, we could keep flying. But the cloud deck got lower and lower. The sun was setting in the direction we were flying, making it hard to see through the rain. "Looks like we're spending the night in Big Springs, Texas," Thor said. I shrugged. We were landing at an airport. We'd get someone to give us a ride into town, and we'd stay at a hotel. No problem.

We landed and parked the plane near a large hangar. Rain fell in sheets now. I really needed a restroom. I dashed to the nearby hangar. Thor sloshed along behind me. "Hello? Anyone here?" we hollered. No answer. He went one way, and I went the other—all the doors were locked. Dogs barked and howled inside. "Sounds like a mother dog and a bunch of puppies," Thor said.

"Did you find a bathroom?" I asked, getting a little desperate.

Thor grimaced. "Sorry, no. Guess we'll have to find some bushes."

All thoughts of romance fled. After the rain turned to drizzle, we set up our little tent in a patch of grass between puddles. We crawled in and ate the sandwiches I'd packed, trying not to get crumbs in our sleeping bags. Rain pounded all night. I discovered that Thor can sleep through anything: wind, rain, thunder, lightning, and even puppies yip yip yipping. When morning finally dawned, I crawled out of the tent feeling like yesterday's dishrag, and probably not looking much better. Thankfully, the hangar door was open.

Thor went in first. He returned to announce happily, "They have a shower we can use!"

Showered and filled up on vending machine Snickers bars and Coke, we took off for Carlsbad. Again, I was navigating. But I couldn't see the airport at White City. "Are you sure that radio is working?" I asked.

"Yes, it's working!" Thor shouted over the engine noise. "It's a dirt strip. It's at 11 o'clock," he said, using the standard way of telling direction with 12 being the nose of the plane.

A dirt strip?! No wonder I couldn't see it. There was no runway! I also didn't see any orange wind sock. I checked the map again. The little circle marking the airport was next to a road. "There's a road at the base of that hill—I think the strip is over there," I offered. "I see something orange, but it's not a wind sock."

"Oh!" Thor exclaimed, looking out the window. "That's a wind triangle. Which way is it pointing?"

He needed to land with the nose into the wind to help slow us down and use less 'runway' such as it was. "I can't tell."

"Okay, I'm going to circle around."

Darn. The seat belt pressed tightly on my bladder.

We hit the ground, bump, bump, rattle. The prop kicked up a cloud of dust. We skidded to a strop about 30 feet from a cactus. I looked to my right. "The wind triangle! It's pointed the same direction as we are!" We'd landed with the wind pushing us instead of slowing us down.

"I couldn't see it," Thor admitted. We both saw why—the bushes had grown over it.

I got out into the blazing Sun. "There's no hangar?" What I really meant was, there's no bathroom! Bushes had been bad enough, but cactus?

This airport consisted of the dirt strip, the wind triangle, and a telephone pole with a phone on it. While Thor towed the plane off the landing strip, I picked up the phone. "Front desk," someone answered.

"Front desk? Um, my husband and I just landed at the White City airstrip. Can you come and get us?'

"Sure, we'll have a car over in about 15 minutes."

I hung up and smiled. I could hold it for 15 minutes—we were going to a hotel!

In the morning, we took the tour bus to Carlsbad Caverns. I marveled at the formations in the deep, dark cave, wondering if someday I'd be exploring a similar cave on Mars. At sunset, we watched as thousands of bats blackened the sky on their way out to catch bugs for dinner.

Being on a budget, we camped at the White City campground that night. Thor got out our Coleman stove and set it up at a covered picnic table. The water quickly boiled, and I tossed in the hot dogs. I turned away from the stove to get the buns, when KaBoom! The stove exploded. Our hot dogs were practically launched into space. The top of the pan hit the ceiling of the tin roof, sounding almost like a rifle blast.

People from nearby campsites came running. "Is anyone hurt? What happened? Did someone get shot?"

As soon as the stove exploded, Thor knew just what'd happened. He'd filled the stove with aviation gas from the plane. "You put gasoline in a stove?" one old-timer said in disbelief. He wandered off mumbling, "Dumb kids ought to know better." We decided not to tell him we were NASA flight controllers. I made sure to thank my guardian angel for watching out for me. If I hadn't turned away, I might have been badly burned or cut by debris. I even salvaged the hot dogs. We were extremely lucky. All we'd lost was our stove.

We took off (heading into the wind this time) and fueled up at Truth or Consequences, New Mexico. We planned our next stop to be the Grand Canyon. But again, the weather had other plans. As we flew into the sunset, this time instead of rain, we got snowed on! Worried about ice on the wings, we quickly decided to call it quits in Winslow, Arizona. No more sleeping next to the runway. We got a hotel room.

The next day, under beautiful clear blue skies, we finally arrived at Grand Canyon. We spent the night at the campgrounds. Because of our delays at Big Springs and Winslow, we only had about five hours to hike the canyon the next day. We needed to head back that night.

We reached Indian Gardens, 4.5 miles from the rim, and had lunch there. Afterwards, I sat on a ledge and let the serenity of the vista calm me to the core of my being. I was at peace here, sitting beside the love of my life, the wind and sun embracing us, his fingers curled over mine while viewing a majestic landscape that perfectly complimented the blue sky in the far distance. This canyon was a rough and rugged place, yet I spotted signs of life everywhere. Small plants stubbornly poked out of cracks in the rocks. Ants marched across the stones. If life could make it here, in this harsh desert, then Thor and I could conceive a child amidst the stress and pressure of our high-tech jobs. I leaned against his shoulder and breathed in a deep lungful of pine-scented air. Ah. Life was good.

The next week, I plunged back into planning STS-3. The biggest issue remained the electrical power usage. At a meeting in October, Cynthia Wells presented an analysis showing we'd run out of cryogenics a half day before the end of the mission. I reported, "The nose sun 80 hours requirement really eats up the cryo due to aft heater duty cycles. For comparison, PTC uses about 1000 Watts/day, and nose sun uses about 4700 Watts/day."

But STS-3's problems had to wait. *Columbia* was ready for its second flight, set for November 4. The *Roundup* reported, "STS-2 will be a five-day, four-hour mission. . .This time *Columbia* will be placed in a 137 nautical mile circular orbit, slightly lower than in STS-1. The vehicle also will be flown through a more ambitious set of entry maneuvers. This mission also features a scientific payload, the OSTA-1, a group of Earth Resources remote sensing experiments, and the first tests of the Remote Manipulator System, the 50-foot-long mechanical arm built in Canada."[4] Go *Columbia*!

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2. NASA, Space News Roundup, Sept. 1981.
3. Ibid, Oct. 1981.
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7

STS-2: President Reagan Visits Mission Control

On Wednesday, November 4, 1981, I got up before dawn and once again settled into my place in the FAO support room. The computers behaved themselves during the countdown this time.

But with just 31 seconds left in the count, EECOM Steve McClendon called a no-go. Two of the three shuttle Auxiliary Power Units displayed high-pressure readings. The KSC team discovered contaminants had clogged the APU filters. Filters were changed and launch was rescheduled for the following week. The NASA Comptroller estimated that our unexpected weekend off cost NASA $1.5–$2 million, mostly for overtime. [Data from STS-2 Transcript, available via UHCL Library, NASA Archive.]

The crew, Col. Joe Engle, USAF, and USN Capt. Dick Truly, flew their T-38 jets from Ellington to the Cape on Tuesday. That afternoon, the shuttle computers acted up. The problem was traced to one of 19 black boxes that collect data from sensors and prepare it for transmission to the ground. Two replacement units were shipped in from the next orbiter, *Challenger*, which was in production in California. The replacement delayed the launch from 7:30 a.m. to 10:00 a.m. Thursday. This wreaked havoc on the trajectory data in the checklists.

Slipping the launch a few days didn't change ground site coverage much. But slipping the launch time 2.5 hours later shifted all the day/night passes earlier. Activities that required orbital darkness, such as the crew optical alignment sight calibration (COAS—a telescope-like device used to align the IMUs); and those that required daylight, such as filming the first-time arm operations, had to be rescheduled. Sigh. Post Insertion would be interesting.

NASA wasn't the only one having timing issues. The day before launch, I met with Dr. Abbott. We discussed the results of my month-long temperature charting. I wrote, "My doctor told me I am OK. It's OK to ovulate late, it only makes it harder to time it." My ever-shifting schedule at work sure didn't help!

No one wanted any more delays, but storm clouds threatened to "blow out" our launch chances at KSC. So on Thursday, November 12, the KSC team presented Truly a cake for his 44th birthday in the shape of a space shuttle, complete with a trick candle that wouldn't blow out. The phrase, "let's light that candle!" referring to the boosters, was heard around the room.

M.J. Dyson, *A Passion for Space*, Springer Praxis Books,
DOI 10.1007/978-3-319-20258-7_7

During the T-9 hold, Hutchinson polled the MOCR. Everyone breathed a sigh of relief when DPS Darrell Stamper said he was "go." Though the sims had prepared us to deal with computer failures, we all remained a little unsettled about the glitches. So even though all the systems were "go," Launch Director George Page wasn't ready to resume the countdown. Instead, he gave everyone ten-minute to "catch their breath" and double-check everything.

As I waited the final few minutes, I clicked my government-issue black pen open/closed. Click. Click. "You guys ready?" I asked Marion and Chuck (Knarr) for the fourteenth time. They nodded and smiled. I had the log out and resisted doodling on it. Click. Click. I opened the PDP to the first page of Post Insertion. I'd already marked the earlier start of the day/night passes in pencil. The ten-minute additional slip wouldn't change it enough to bother redoing those pages. The countdown resumed. The bustle in the room quieted. I put my pen down.

At T-6 minutes, Truly began the APU prestart. Watching via displays, I saw APU 1, then APU 2, then APU 3 activate as planned. The oil change had worked. I sipped some cold coffee.

As the count moved past the T-31 seconds where it had halted the week before, PAO reported that a cheer went up at the press site. I exchanged smiles with Marion and Chuck.

I watched the small black and white image on my console. Then, moments after Booster John Kamman reported solid rocket start, like it had done on April 12th, a cloud of smoke billowed out and surrounded *Columbia*. Liftoff was at 9:10 a.m. That was some birthday candle!

I jotted down each ascent milestone in my log: Max Q, Negative seats, SRB separation ("Smooth as glass," Engle reported.), Negative return, Press to ATO (abort to orbit), Press to MECO, MECO (at 8 minutes 33 seconds), and finally external tank separation. For the first time in history, a spaceship had gone into space, returned, and been launched again.

Our rejoicing was brief, though. The Evap Out Temp high caution alarm sounded onboard and lit up on my console display. Truly reported, "we've got the Freon loop Evap Out Temp [warning], but we'll catch it perhaps as soon as we get the OMS burn off."

I caught my breath. Had the flash evaporator system failed? It hadn't run out of water yet—no leak was indicated. Was there a blockage? The fuel cells were at maximum output during ascent and producing a lot of heat. Cooling them was critical. I thought back to the summer's training schedule. It would be just like Sim Sup to fail the evaporator right on top of an OMS burn when the crew wouldn't be able to deal with it. But this wasn't a sim, and this crew had scant practice on the Loss of FES procedures or Launch Day Deorbit. I sure hoped we wouldn't have to exercise either of those today.

Capcom Dan Brandenstein said, "The Evap is shutdown. We'll need it cycled off and then back to Primary On." [Quotes are from the STS-2 Transcript, available from UHCL Library, NASA Archive. Future quotations from the STS-2 Transcript will not be individually cited.]

It was now 10 minutes 40 seconds MET. The crew reported a good OMS ignition and that guidance looked good. They were referring to the guidance system, not the position in the MOCR, but I immediately thought of Thor. He'd be sitting in the front room tomorrow—his first shift as a Guidance Officer. So I smiled to myself and thought, "Of course Guidance looks good!"

Then the crew asked, "you want the Freon loop cycled off and back on?"

Yikes, I thought. Didn't the crew realize that Dan had meant the FES controller when he said "it" earlier? It seemed obvious to me. But then, I wasn't distracted by my first time in space or monitoring an engine burn that was vital to keeping me in orbit.

Capcom calmly replied, "Negative, the Evap."

A few minutes later we saw the Evap Out temperature coming down. I exhaled the breath I'd been holding. Unlike a sim, simply cycling the controller actually worked.

When the engines shut off, the apogee was 120 nm. Perigee was still only 53 nm, but OMS 2 on the opposite side of Earth would take care of that. FDO Jay Greene reported to Flight that he was "go for OMS 2." Before Capcom could tell the crew, Truly reported another problem.

"Dan, we just got an APU 3 temp." Capcom acknowledged the warning as we went LOS.

This flight was feeling like a sim. What was going on with APU 3? Was there more contamination in the filters? I grabbed my Ascent Pocket Checklist. The APU tab was the first section. The procedure said to shut down the affected APU. That was standard procedure for after the OMS burn anyhow. I asked Chuck to be on the lookout for any switch list changes. He was keeping a master list to use in case we had an early entry.

When comm coverage resumed, Truly explained that the APU 3 oil temp was about 300 degrees. He'd shut it down, as we'd expected. But he'd done so before the main propulsion system fuel dump had been completed. This dump got rid of any excess fuel trapped in the main engines which were shut down at MECO. Like tapping the bottom of a ketchup bottle to get the last little bit out, the thrust of the OMS burn caused the propellants to "settle" instead of floating around in freefall. The APUs provided the mechanical power to open the valves through which this fuel escaped. But the other APUs had been on, so no one was overly concerned.

Capcom told the crew that they were go for OMS 2. Even though we'd be talking to them again before the burn (scheduled for 41 minutes 58 seconds MET), in case communications were lost or garbled, we wanted them to know it was okay to circularize the orbit at 120 nm. If this were a sim, some problem would happen now to cause us to cancel OMS 3 and 4 and not raise the orbit to 137 nm. I clicked my pen nervously. Why was I so worried?

EECOM McClendon recommended to Flight that the crew turn off one of the APU pump valve cooling systems. I looked in the back of the PDP where we had pictorials of all the panels. I found the switches A and B, APU FUEL PUMP/VLV COOL on R2, a panel next to Truly. Flight approved the change. Capcom told them to flip A to OFF and leave B in AUTO. Chuck marked up the switch list. So far, we were staying on top of everything.

The OMS 2 burn went fine. Next up was Post Insertion. I looked at my copy of the checklist. I hoped to simply check off activities like I'd done for STS-1.

The next item on the timeline was the computer transition, followed by seat egress, and then the maneuver to put the bay towards Earth prior to opening the doors. Engle would then move to the aft station, turn off a bunch of heaters, and get out the new wireless headsets. He'd turn on the bay lights and set up the cameras to record the door opening tests while Truly set up the theodolite, a device to accurately measure any warping in the doors.

All of these thing should be done when we got AOS about 1:30 MET. But Engle reported, “We are running a couple of minutes behind and just now bringing up the TV cameras.”

All of us quickly checked the displays for anything the crew had missed. PROP noticed a few of the APU heaters were still on. The switches were part of the “Aft Station Config” that Engle probably skipped because they were running late. Capcom reminded him about them and also told them we were waiting on the TV downlink.

But the color TV camera refused to work. The Instrumentation and Communications officer (INCO), Al “Gap” Pennington (1944–2013) commanded it on from the ground. It didn’t work for him, either. Oh well.

Ascent Guidance Will Presley sent a state vector update. Capcom told the crew. The onboard navigation would be good for hours now. Calculating those updates and sending them to the orbiter would be Thor’s job tomorrow. I thought it was pretty cool that he’d get to send a command to the orbiter in space.

Around 90 minutes into flight, Truly reported trouble with the theodolite. “Boy, it is so dark [in the bay] that you can barely pick up the targets. It’s going to take me a little while.”

We lost comm about 15 minutes later. With a half hour before the next AOS, the support room emptied out as everyone hit the restrooms.

I soon returned with a fresh cup of coffee in my STS-2 mug. It had the Mission Control emblem on one side with “Timeline” under it, and the STS-2 patch on the other with my name. Thor’s said “Guidance” on it. Tradition required us to use these souvenir mugs during the flight.

7.1 Flight controller Jerry Pfleeger arranged for all the controllers to get mugs with our names and the mission patch on one side, and positions and MCC patch on the other. We collected them for all flights we worked (Photo by the author)

Since Truly was running behind, I worked up a plan in case they didn’t get the COAS calibration done during the night pass (which had shifted 15 minutes earlier).

The plan was to slip the COAS calibration to the next orbit. The procedures for this were already on board in the Abort-to-Orbit timeline section just behind the nominal post insertion procedures. This simple fix had the crew do the IMU alignment as scheduled and then, when it was night again, the pilot would do the teleprinter activation instead of the commander, and the COAS calibration would be scheduled into that slot. The same attitude and star that Engle was used to from training would be available, so no pen-and-ink changes were necessary.

I recommended this plan to my FAO, Elvin. No sooner had he approved it than our section chief started arguing against it. Mr. Section Chief had been hovering behind me during the entire ascent. He said we'd lose 22 minutes from the timeline because we had to wait for the next night pass, and shouldn't invoke the ATO plan unless we were at least 10 minutes behind schedule. He insisted that we should start the IMU alignment early.

Elvin was in an awkward position. During flight, the FAO reported solely to the flight director. But our section chief was responsible for evaluating all of us as employees of NASA. Not that he would, but he had the power to block our promotions by giving us bad performance reviews. Most managers of flight controllers were former flight controllers themselves. It made sense for seasoned veterans to help out in the support room during a flight. But there'd only been one flight so far, and Elvin, as lead FAO for STS-1, was the most seasoned veteran we had. If Elvin said no, then our section chief would have to back down. I was relieved when Elvin said no, because the ATO plan was easier to implement. Would I have the nerve to say no when my time came?

But our section chief didn't take "no" for an answer and started in with ways to "improve" the ATO plan. He suggested we choose a different star for the COAS calibration in order to minimize the maneuver time. I objected, saying that in sim after sim, Hutchinson had insisted that all changes to the nominal timeline had to be absolutely necessary—and saving a few minutes wasn't critical.

But our section chief declared, "You're wrong." His "I know best" attitude really rubbed me the wrong way. But there wasn't anything I could do. It was Elvin's decision.

Elvin wasn't a confrontational kind of guy. Despite knowing that Flight would probably say no, Elvin agreed that saving a few minutes of maneuver time, and a little bit of fuel, was a good idea. So Elvin approved our section chief's recommendation. If the crew were behind or we just wanted a few extra minutes, instead of slipping the COAS cal to the next night pass, they'd use a new attitude for the IMU alignment and follow it with a COAS cal using a different star.

Our section chief didn't waste any time. He ordered our Pointer, Gregg Walding, to stop what he was working on and calculate a new attitude to shorten the maneuver time and provide an appropriate star. Gregg grudgingly made the computation and, working with our Pads operators, Dave Weisinger and Virginia Nester, created a teleprinter message for the crew.

It took about ten minutes to prepare the IMU/COAS data and message. Elvin then presented this plan to Hutchinson. Hutchinson barely took a breath before saying, "No." Just as I'd predicted, he considered it too much trouble to save a few minutes. Hutchinson was more concerned with APU 3 and how it might impact OMS 3 and 4 later.

The signal through Yarragadee crackled into my headset at 2:26 MET. If the crew were on schedule, they'd have just completed the payload bay door procedures. They should be maneuvering to the COAS calibration attitude so the upper window was pointing to space.

The attitude data showed that Engle had already done the maneuver and was in the midst of the calibration. The procedure required him to manually maneuver the orbiter until the selected star crossed the center of the reticle (crosshairs) in the eyepiece of the small telescope. At the instant of crossing, he would make a “mark” by depressing an attitude reference button. At the time of the mark, software stored the gimbal angles for the three IMUs.

So Engle had caught up with the timeline. We didn’t need to move the COAS cal after all. Gregg mumbled about our section chief having wasted his time.

But listening to the air-ground, concern grew that we may have bigger problems than being a few minutes behind. In between static, Truly said “fuel cell O_2 flow” and “pH, Papa Hotel, indication down arrow.” A hush fell over the room. Were we losing a fuel cell?

Also Truly reported that APU 1’s pump temperature was high. He’d changed the switches of both the A and B pump valves to Auto. He said that the temp high message first appeared after we’d asked him to change the position of the fuel line heater from Auto to Off. “Would you like me to change it?”

A rapid-fire technical discussion ensued between Flight and EECOM about the APU and with EGIL Bill Moon regarding the fuel cell. Capcom told Truly he’d let him know at the next pass in a few minutes. In the meantime, he asked for “a quick door status.”

Truly replied. “The doors are open, the rads are open. There was no problems at all with them.”

Marion, who was taking care of the as-flown timeline, checked off these activities in the timeline. My job was to keep an eye out for what was coming up next and prepare for potential impacts to those activities. In the next 10 minutes, Truly was scheduled to power up the arm, and Engle was to maneuver to the IMU attitude. When comm came back two minutes later, Engle reported, “Okay, Dan, I’ve got the COAS channel and seem to be having a problem with the light. . .we’ll be using the flashlight coming in through the back end of it. Okay?”

The COAS had a light inside to illuminate the cross hairs that were marked every one degree. I thought using a flashlight was a pretty ingenious solution. I marveled that he could fly the shuttle with one hand and hold a flashlight into the COAS with the other and still line up a star in the crosshairs. I was reminded that he’d been selected as commander of this mission based mostly on his piloting skill. I shouldn’t be surprised. But I was nevertheless impressed.

Truly said, “And while Joe messes around with the COAS, Dan, I’m going to be in bubble one on page 1–14 powering up the RMS [arm] to temp mode.”

They were only a few minutes behind schedule, but we suspected that they’d skipped some activities. INCO wanted to know if they’d switched to the wireless headsets as planned an hour ago. Truly said they hadn’t had time. Was that the reason the comm was so bad?

EGIL had just briefed Flight about troubleshooting the fuel cell problem. A copy of the Flight Note with the instructions for Dan to read to the crew was on its way in the p-tube. We were responsible for checking that the flight data file references were correct—sometimes controllers made mistakes incorporating the pen and ink changes—and we’d had a lot of these because of the launch delays. Robert Federman was staffing the Flight Data File position on our team. He verified to Elvin that the checklist callouts were correct in the review copy.

Anticipating the arrival of the final Flight Note via p-tube, I got up from my gray swivel chair. I soon heard the familiar swoosh and clunk as another p-tube arrived. When I opened the door, about five p-tube carriers tumbled down into my arms. Good grief! Who ordered all these copies? I rushed back to my console with the Flight Note as Dan read the instructions to the crew.

"On fuel cell 1, for the pH problem, we'd like you to do a MAL 7.3 Hotel on page 7–25," he said. "And on fuel cell 2, it looks good to us, and we just want to watch it for a little while."

The comm continued to be spotty. "Dan, say again the MAL number."

"Roger, MAL 7.3 Hotel," Dan repeated. "It's on page 7–25 in the MALF book."

I thought about how hard it would've been to read up the attitude numbers for our section chief's COAS plan. It might have taken longer to voice it up than we'd saved in maneuver time!

Hawaii was 15 minutes away. I looked ahead for activities that might need to be changed or moved. At 2:51 MET in the timeline, right when we were to get AOS with Hawaii, Truly was supposed to switch APU coolant systems. I was pretty sure that EECOM didn't want them to do that, so I brought it to Elvin's attention. He confirmed that it should be deleted and told Flight.

But more importantly, EGIL told Flight that we should have told the crew to only do the fuel cell malfunction procedure down to step four which required the crew to remove a middeck panel and take a water sample. As soon as we got AOS, Capcom told the crew to stop work on the procedure. To EGIL's relief, Truly said, "Good, because that's how far I'd gone."

Dan chuckled and said, "That's nice of you to cover for us." He then told them not to switch APU fuel pump coolant systems. Dan then explained that they'd determined that there was no correlation with the switching of the coolant systems and the temperatures going up on APU 1. That's why they had switched 1B back to Auto.

Huh? I was lost. I looked to Chuck who was tracking all the switch positions. He'd been listening to the backroom chatter on this topic and thought he had the gist of it. APU 1 had a high fuel pump temperature on the output side because of a heater problem. The confusion was why the flash evaporator cooling water hadn't immediately brought the temperature down.

After this was sorted out, Truly said, "Dan, since you don't have anything else to do, I'm having a little problem with one of the RMS panels, and I wonder if I can tell you a little bit about that. This is like a long sim, isn't it?"

"Yes, it sure is," Dan admitted. "Okay, go ahead."

"Okay, if you'll turn to 1 dash 14 in the PDP, bubble one. . . I think I have pushed in the circuit breakers downstairs. . ." and he proceeded to explain that the annunciator lights expected when he powered up the arm hadn't come on. There wasn't a power short, so he wondered if maybe some switch was out of position. We determined that some of the lights had popped out of the panel during launch and had to be reset. Our brand new arm was in the correct mode.

In the meantime, Engle had completed the COAS calibration and moved onto the IMU alignment. But the shutter to one of the star trackers kept shutting before it acquired the star. He ran out of night pass before he could solve the problem. He radioed down, "Looks like for the timeline we may need to alter the IMU alignment here and possibly stick in another couple of stars. Better wait till they get a little farther around on the dark side here. That may delay the ZLV POP attitude. If you concur, we'll just delay the alignment for a while."

So we were moving the IMU align to the next night pass after all. I sighed. Gregg, and Marion, who'd been watching the attitude and alignment activities, quickly told Elvin that they concurred with Joe's plan. Elvin and the GNC Officer Rick Fitts told Flight they agreed. Capcom told Joe, "We concur with that." GNC, in charge of the hardware, recommended that they cycle the shutters on the star trackers to help clear the problem. Comm kept going in and out while Dan told them this. After several minutes of "Dan, I'm sorry I can't quite read you," and "Dan, you're unreadable on UHF," Engle finally got the message to cycle the shutters. Thank goodness we weren't trying to read up a new set of attitude numbers! But he reported that the –Z tracker was pointed at the Earth and wasn't going to work until they moved around more in their orbit.

On the Flight loop, I heard EECOM say that the APU fuel pump coolant valves were in the wrong configuration. We'd deleted the switch change in the checklist that would have turned A to Off and B to Auto. A was supposed to be in Auto and B Off per previous calls to the crew. I glanced at Chuck who smiled and shrugged. Apparently the crew had done the checklist activity before we'd told them not to? I guess the crew were as confused as I'd been on this topic. Dan said, "*Columbia*, Houston, panel R2, we need APU fuel pump/valve cool Bravo to Off."

We were supposed to give the crew the go to stay in orbit at 3:15 MET, just a few minutes away. But they hadn't yet finished the IMU alignment or purged the fuel cells.

Ever since Truly had reported the pH problem, a discussion had raged among the experts about what was going on with fuel cell 1. EGIL had consulted the Spacecraft Analysis (SPAN) managers for an opinion, and they'd in turn called the contractor experts in the Mission Evaluation Room (MER). They agreed with EGIL not to purge fuel cell 1 until they knew more.

If we had less than three fuel cells, the flight rule required us to come home early. But we only needed two of them purged to give them the go to stay in space overnight.

Truly did the purges manually. 3:15 MET came and went. The purge on 2 completed, then 3. No problems. Capcom told him not to purge number 1.

The computers had transitioned, the doors had opened (and radiators deployed), and two of three fuel cells had been purged. The only thing left to satisfy the criteria for staying in orbit was the IMU alignment. GNC felt sure Joe would get it finished as soon as the orbiter passed back into darkness. So we gave them the "go" for orbit just as we lost comm at about 3:20 MET.

We had about 15 minutes to the next pass, but no one took any breaks. The control center was abuzz about fuel cell one potentially being shut down. The fuel cells produced water as a byproduct of combining hydrogen and oxygen for electrical power. This water was piped into a tank used for crew drinking water. Normally, this water is extremely pure and pH neutral. The fuel cell pH alarm indicated that something was either wrong with the sensor or that there was a contaminant in the water. The likely contaminant was potassium hydroxide (KOH), a fuel cell electrolyte that is commonly known as caustic potash. If KOH were escaping into the water, the pH would be high.

The earlier malfunction procedure isolated the tank that the fuel cell water flowed into. To confirm that there was KOH in the water, and also rule out a sensor failure, the experts had decided to have the crew test the pH of a sample of the water.

This was not a simple task. Because the water was used for drinking, before flowing into the water tank, it first went through a microbial filter that removed bacteria and contaminants. To test the water, they had to remove a panel in the middeck and disconnect this filter. They'd then use a strip from the urine test kit to test the pH. If the pH was high, KOH was escaping from the fuel cell. In that case, the fuel cell would have to be shut down (and the flight shortened).

While the EGIL support room worked on the details of the mal procedure, we wondered how long it was going to take. Truly was scheduled to do more theodolite tests and then turn off equipment that wouldn't be needed in orbit. Engle had to finish the IMU align and then do the delayed maneuver to –ZLV Y-POP. After that, he had his own list of switch changes to make. They both needed about a half hour to take off and pack their launch and entry suits. They also had to set up and activate the teleprinter in the middeck. We were anxious to have the teleprinter for detailed messages rather than depending on poor-quality voice updates.

I didn't see any way we'd stay on the timeline. Like Truly had said, it sure felt like a sim.

The chatter on the EECOM support loop focused on the supply water tanks. I remembered a switch change planned for that system in the "Config Controls for On-Orbit" which was scheduled for 3:22 MET, in other words, while we were LOS. Darn, I should've caught that earlier! Oh well, it wasn't like there wasn't a lot going on—and it was EECOM's system, not ours, to reconfigure. So I mentioned it to Elvin, saying I thought it might be a good idea to ask EECOM about it.

We were too late. When we got AOS, Dan told them to close the water crossover valve. "Okay, Dan," Engle said. "I did close it about a minute ago, but it's open now."

Oh well, at least we corrected the mistake. Then Dan told them to get out of their suits and continue with the fuel cell procedure. ". . .go down and do get a water sample and test it."

But the IMU alignment was still not done. The -Z star tracker hadn't picked up the target star. Engle asked, "Do you want us to just stay in this attitude and wait for this other star to come up, or do you want us to go to another attitude for a [new] pair of stars for the alignment?"

On the Flight loop, Prop said that we were over budget on our fuel use. He advised that we not go to another attitude. Pointing told FAO that the attitude wasn't the problem—it just wasn't dark yet. GNC agreed. Capcom told them not to change attitude.

After several "did you copy" and repeats, the crew confirmed they'd stay in attitude until they got the star and then go to -ZLV.

As Capcom and the crew then discussed some of the arm switches, Pointing quickly calculated a new set of stars in case the IMU alignment had to be repeated. The calculations were done and a Flight Note generated, approved, and sent to Capcom prior to the comm pass. Once again we had weak and scratchy com, but we were very happy to hear Engle's report, "We have a few stars in the table and a good IMU alignment. . .and we're gonna start the maneuver to ZLV."

With that problem solved, Capcom asked them to check the circuit breaker for the color camera that hadn't worked earlier. Back at the very beginning of Post Insertion, the last line of the very first bubble was "R15:E All cbs closed."

Truly said, "Houston, on row Echo, all of the camera circuit breakers are still open. It looks to me like that we might have missed them reconfiguring panel R15."

Capcom told them to close them all. He then asked if they were both out of their suits yet. Only Truly was. Engle hadn't had time. They also hadn't donned the wireless headsets.

We were supposed to have completed everything in Post Insertion by 4:00 MET. We were at least 20 minutes behind. Hutchinson regaled us with one of his trademark pep-talk/tongue-lashings. He started with "Listen up, people." The FAO support room got quiet for the first time since launch. He told us we were the best team ever, but we couldn't afford to be sloppy! This was not a sim. The crew were depending on us to watch their backs. We'd had some issues to work, but there was no excuse for taking nearly three hours to notice that the crew had missed pushing in a row of circuit breakers! What else had we missed during the rush through Post Insertion? The crew needed time to catch up, and we were going to give it to them even if that meant we had to cancel some things. Anything we could do to offload them, we should do. Our job during the next half hour was to makes sure all the orbiter systems were properly configured. He closed with "Okay, back to work, folks."

At Hawaii, Truly said, "You're hearing the first transmission from the wireless com. This makes all the difference in the world."

It sounded good at our end, too. I was glad they'd finally gotten rid of the bulky suits and headset cords. I bet they'd do everything faster now that they could move around more freely.

As part of Hutchinson's plan to offload the crew, INCO offered to do some camera work using ground controls. Capcom let them know this was to give them time to catch up.

Truly said, "We're going to catch up here in a few seconds." We all knew it'd be longer than that. They hadn't even started on the fuel cell water sample.

To make that task easier, Dan reminded them where the med kit and pH sticks were located. He also reminded them that the In-Flight Maintenance book had a photo of the microbial filter on page 88.

Someone piped up on the Flight loop and said, "That's 80, Flight, not 88."

Another little mistake had almost gotten through. Darn, why was it so hard for us to stay focused? Like Hutchinson said, the crew needed us to watch their backs. I wasn't even tired, but, as usual, I'd lost all sense of "real" time. I looked at my watch and found it hard to imagine it was 2 p.m. on a Thursday afternoon in November. It'd been dark when I'd arrived, and it'd be dark when I got off shift. I wondered what Thor was doing—probably monitoring the flight from Building 4. His first shift wasn't until tomorrow. We handed over to the Entry Team this time.

While we were still over Hawaii, the FES shut off. The doors were open with the radiators deployed, so this loss of cooling wasn't as serious as when the evaporator had shut off during ascent. But I didn't want to put my Loss of FES Deorbit Prep to the ultimate validation test. "*Columbia*, Houston, the evaporator kicked off, so we'd like you to go to Primary. Correction, we'd like you to go to Off, and then back to Primary A," Dan radioed up.

"Okay, Off and back to Primary A."

It wasn't a sim, so this reset worked. I exhaled in relief.

Gap (INCO) panned the now-restored color camera in the payload bay. "We're looking at some pictures coming from Camera Delta, and they're looking great," Dan told the crew.

Seeing the orbiter with Earth in the background reminded us all just what it was we were doing—testing a new spaceship. This was only our second shake-down cruise so to speak. We were finding a few things we'd need to improve on later flights, including our own performance in Mission Control. But wow, what an amazing thing we were doing! Hunched over a little black and white monitor, listening to discussions about temperature gradients and pressure values and navigation numbers, it was easy to get lost in the babble and forget that those crackly voices we heard in our headsets were coming from outer space. The men we knew as Joe and Dick were zipping around the planet at 17,500 mph witnessing 16 sunrises a day. I sat there for a moment with a silly smile on my face.

The air-to-ground loop was silent for a precious few minutes while we absorbed the view. Then Dan said, "As you go over the hill, we're seeing some fabulous pictures of the back end of the bus and the Earth..."

"Hey, great," the crew responded with their typical good humor. "So are we!"

Our reverie lasted about five minutes. As the data came down over the next set of ground sites, we found the FES had shut off yet again. In keeping with Huchinson's admonition to leave the crew alone while they closed out Post Insertion, Capcom told them not to take any action.

The EECOM's support room folks said the temperature of the Freon after passing through the radiators was hotter than it had been on STS-1. If the temperature got above 40 degrees, the FES would come out of standby and spray water on the Freon loops to cool them down. Because the temperature was hovering near this value, the FES kept turning on and off.

At 4:42 MET, the crew reported, "we're completed with the PDP if you want to take a quick scan and tell us if there is anything you see out of configuration. We're satisfied with it, with the exception of the teleprinter, and we're going to activate that pretty quick."

Marion jotted a note in the "As Flown" timeline that "TPR ACT" was now underway. So, they were 45 minutes behind now. I wondered how we'd make up the lost time. In the sims, we'd always either delayed or cancelled the OMS 3 and 4 burns. Would we do that for real?

Payloads reported that the SMIRR (shuttle multispectral infrared radiometer) first data take had gone well. SMIRR was an Earth-looking telescope that was part of the OSTA-1 payload in the cargo bay. Thank goodness it didn't require any crew activity other than being turned on and pointed at the ground. This small success provided some welcome good news for NASA Public Affairs to report in between downplaying all the systems issues we were having.

GNC reported that IMU 3 was drifting. Already? They'd just finished the alignment! Capcom told the crew that if it failed RM (Redundancy Management) that they should not do an IMU to IMU alignment on it. "We're going to babysit and keep an eye on it for a while," he told them. So now we were watching the FES and an IMU and a fuel cell, and had a suspect APU. If this were a sim, we'd have a computer problem now. Sure enough. . .

Truly reported a problem with the computer screen between the front seats. "As the DPS guy can see, we have gotten a number of poll failures on CRT 2, every time we either try to reassign or put it down to BFS. And it is also generated CRT BITE message four times in a row."

So now we had FES, IMU, APU, CRT, and fuel cell issues to add to being behind on the timeline. This flight was rapidly becoming more complicated than any sim.

MASTER ALARMS

As the mission clock ticked forward, I strained to follow the multiple conversations about all the equipment problems. The fuel cell problem was the most worrisome. Capcom sought to reassure the crew that we were on top of things. "*Columbia*, Houston," Dan called. "We've noticed a shift in the load sharing on fuel cell one. . . .we're keeping an eye on it."

"Roger, Dan," Truly acknowledged. But just moments later, he called, "Houston, *Columbia*, do you read?" In the background alarms blared just like we'd heard in sims. I pictured the red lights flashing on and off in rhythm with my heart rate.

EGIL reported that fuel cell one electrical output was steadily dropping. I called up the power system display on my little black and white monitor. Arrows appeared next to parameters whose limits had been breached. If Diane were there, I'd have squeezed her hand. But the only other woman around was Virginia, ten feet away at the Pads console. I clicked my pen.

Through static we heard, "Yes, Dan, we're getting a master alarm," Truly said. "We were getting a few master alarms. I think there was a cabin atmosphere caution and fuel [cell] warning light that was flickering on intermittently here. I know we show just a little over 15 psi."

Normal cabin pressure was 14.7 psi, so they apparently had an overpressure of the cabin. Was that causing the master alarm? A temperature spike could affect more than one system and thus set off more than one alarm—all causing the same light to flash and tone to sound. Yet master alarms were serious. Only major malfunctions set them off. The noise level in the support room rose to a low roar. Everyone was talking to somebody. I punched off some loops so I could focus on the fuel cell discussion on Flight's loop.

The fuel cell was now down to 26 percent of load sharing, compared to normal at 35–38 percent. EGIL recommended having the other two fuel cells take over its electrical load, and then disconnecting it from the "grid." This procedure is called a "bus tie." After all our training together, all Hutchinson had to say to Dan was "Capcom," which meant that Dan was to relay this order to the crew. He did.

I flipped open my Orbit Pocket Checklist to page 5–7 for "BUS TIE" to follow along while Truly performed the procedure in space. Three main circuits, or buses, carried power from the fuel cells to the equipment. These were labeled A, B, and C. Normally, fuel cell 1 powered bus A, cell 2 powered bus B, and cell 3 powered bus C. The procedure would first take fuel cell 1's "A" load and give it to fuel cell 2. Then fuel cell 1 would be on, but not providing power to anything. Truly said, "A and B are tied now. We have taken fuel cell 1 off of Main A."

It was now five hours into the second space shuttle flight. As we got AOS through Dakar on Orbit 4, the crew had some bad news. "We have just gotten a couple of SPEC 68 Fuel Cell messages, probably caused by open circuiting that fuel cell." He rattled off the volts and amps.

EGIL told Flight he wanted the crew to shut the fuel cell down. The final step in the procedure was to reduce the power load on the remaining two fuel cells. Chuck and I had already been looking at power down procedures in anticipation of this action. But the consensus was to hold off on the power down—EGIL wanted to keep the power level the same and see how the remaining fuel cells reacted. Also, we'd just gotten everything configured, and we didn't want the crew distracted further with the OMS 3 and 4 burns coming up on the next orbit.

Before Dan could relay Flight's instructions, Truly called down, "Houston, Dan, we just had a master alarm which we're unable to find out what it was that tripped it off."

Capcom said, "We'll take a look at that. What we'd like to do now is we'd like to do a fuel cell number 1 shutdown. There'll be no power down required . . .. And we still plan to do an OMS 3 and 4 going uphill. We just want to shut down this fuel cell while we think about it."

While we think about it? This statement at first seemed an attempt to downplay the seriousness of the action we were taking. But I knew Dan wouldn't be worried that the news media, who listened to the air-ground communications, would sensationalize the problem. No, Dan wasn't trying to trivialize the failure in any way. His job was to reassure the crew, his friends and fellow astronauts, that Mission Control had their backs. Telling them about the burns let them know that we were still planning to press on with the nominal timeline—that shutting down the fuel cell didn't necessarily mean they were coming home. At least not yet.

But reassurances aside, the big question on everyone's mind was *why* this fuel cell had quit working. Was it unique to this one fuel cell, or a generic problem? Were the other two fuel cells at risk? We were painfully aware that this was only our second flight.

What did the Flight Rules say? Did we want to bring them home on Orbit 5 or 6? The go/no go for Orbit 5 was 5:02 MET—right now—but Orbit 6 go/no go was 6:35 MET. So, if the situation worsened, we still had an option to come home today. Chuck passed me a copy of the Flight Rules. I flipped past the definitions of what it meant for a fuel cell to be declared failed. I unfolded the double-sized page with the go/no go criteria on it. Hundreds of hours of Flight Techniques meetings supported by analysis and simulations and management meetings had gone into these rules. The Flight Rules were sacrosanct. They weren't to be set aside in the heat of the moment to satisfy some political need to prove the program successful, or because our action would run up a big tab for NASA. The rules were there to protect the lives of the crew, and to bring them and the ship home safely.

The "go" for orbit ops, which we'd given them an orbit ago, required two of three fuel cells with demonstrated purge capability. But to continue past Day 2 required all three fuel cells. I also flipped to the Guidance and Navigation section and noted that three IMUs were needed to continue past Day 2. Though we weren't sure yet if IMU 3 would fail, it didn't look good. So, unless we recovered this fuel cell and verified IMU 3 could hold alignment, we were coming home a day early.

I wondered if management would swap our shift schedules around. We were supposed to hand over to the Entry Team who would hand over to the Orbit Team that Thor was on. But if the crew were to come home in the morning, would management decide to keep our team on console longer and not use the Orbit Team at all?

But I was getting ahead of myself. No decision had been made yet about coming home. However, a lot of managers had spilled over into our support room from the SPAN next door. People in the SPAN were busy analyzing the downlink data, and had probably shooed these guys out. They knew better than to bother the front room controllers, but they didn't seem to have much regard for the job that we "back room" folks were doing. So they stood there like a gaggle of teenagers caught in the eddies of the hallway traffic outside the players' locker room. Their loud male voices really grated at my already-tense nerves. At least I didn't have alarms going off.

I studied the timeline, thinking about what activities we'd missed and still had to do before crew sleep. We'd missed one of the navigation tests involving the TACANs, all of the TV events, some of the theodolite work, and we'd delayed the activation of the OSTA payload. The crew were supposed to be eating lunch now. I was pretty sure they had skipped that, too. (So had I, my growling stomach reminded me!) It was doubtful that we'd get OMS 3 and 4 off on time.

The comm continued to be garbled. Capcom repeated the page number for the shut down several times. Truly couldn't hear because the master alarm kept going off—like a very loud annoying alarm clock put on "sleep mode." He radioed down, "Okay, Dan. We got the master alarm again, and the cabin atmosphere [warning light] is flicking on intermittently."

On the Flight loop EECOM quickly explained the cause. Capcom relayed, "Roger, *Columbia*. On that cabin atmosphere, we believe it's the temperature probably getting a little warmer in there, and it's bumping the pressure high. If you are uncomfortable as far as temperature goes, you can go Flash Evap Primary B."

Truly replied, "Okay, understand that. We're not uncomfortable, Dan. So we'll just live with it for now."

EGIL told Flight he wanted the fuel cell reactant valves closed. Capcom told the crew. "Okay, fuel cell 1 is shutdown, and the reactant valves are closed," Truly said. "And Dan, now that we have done that, do you still want to continue with that sampling of the water?"

It had been more than an hour since we'd asked them to do that. "That's a negative, *Columbia*," Dan said. We knew that fuel cell was bad, so no use wasting more time on it.

Truly then reported that they were using CRTs 1, 3, and 4 now since CRT 2 wasn't working. He hadn't had time to go through the malfunction procedures on it. I'd almost forgotten about that problem. What a nuisance that must be for them. But we were running out of AOS and we hadn't sent up the OMS 3 burn data yet. The targets were to be copied onto cue cards that the crew stuck to the "dashboard" with Velcro. "*Columbia*, Houston, we have the rest of this pass and Botswana are our only two chances to get the Pads up for 3 Alpha and Bravo for your cue cards. So if you're not ready to copy those here, we'd like to give them a try at Ascension."

"Okay, we'll get the cards out, Dan."

But while the crew got ready to receive the data, there was a discussion raging on the Flight loop about how much electrical power the burns would require—maybe we should delay them an orbit to be sure the two remaining fuel cells could handle the load? Flight told Capcom to hold off on the burn data until the next pass which would give him another four minutes to think about this.

During the ensuing four minutes, Neil decided to postpone the burns.

"Hello *Columbia*, this is Houston.. . . we're going to delay OMS 3 Alpha and Bravo and OMS 4 for a rev here. We want to understand the power loads, and with the fuel cells out and stuff, before we try to pull off this burn."

So all those sims where we'd either canceled or postponed OMS 3 and 4 had been prescient after all. I wondered if the crew were relieved? Maybe they'd get a chance to eat.

EGIL told Flight they wanted to keep the power load constant, so they could tell if any changes in fuel cell output were the result of the fuel cells' performance and not because of equipment turned on or off. Dan told the crew we were canceling the navigation tests that required them to turn equipment on, and all TV cameras were to stay off.

Engle then radioed down to say that he was still in his suit! We thought he'd changed a half hour ago. "You agree I think, what we will do is go ahead and get our meal going here."

My stomach grumbled another reminder. We had about 13 minutes to the next pass, so I quickly ate my bologna, mustard, and lettuce sandwich. I chased it down with milk poured into the cap of my thermos. It was 2:30 p.m. It seemed as if hours had gone by since I'd checked my watch a half hour ago. I ate raisins while Pointing talked to FAO about the new burn targets.

Because we'd delayed or canceled the OMS 3 and 4 burns so many times in sims, Chuck had a plan prepared ahead of time to minimize the loss of activities. He rolled his chair around Marion's and we quickly went over it. I suggested to Elvin that we could write a Flight Note for him based on this case, but he said Neil wouldn't listen to any rescheduling. He said to focus on what we could do post OMS 4 to recapture some of the test objectives we'd missed.

The crew weren't catching any breaks during the 90-minute delay they'd been given. Truly summed it up for all of us, "Okay, the system won't seem to leave us alone here to get time to get squared away downstairs [in the middeck]. We have had several fuel stack temp messages since the fuel cell is cooling down. We've also had some S66 [caution and warning] water messages, and cannot find anything on the SPEC [display] that we see is wrong. We also kept getting cabin pressure warnings. So I went to the Ref [Reference Data] book and bumped the hardware caution and warning limit up to 15.4 psi on the cabin pressure.

"And just while I was talking, we got a couple of propellant thermal OMS messages on SPEC 89, and it's the same parameter. It's the right bulkhead mid-temp is indicating 49 degrees with a low arrow."

Dan voiced up a procedure to inhibit some of the warnings and switch some heaters.

Engle then got on the radio and said, "Dan, I know we haven't had time to talk about it, but every second that we've had just. . . we've really been having a lot of fun up here even though there sure are a lot of heady's [headaches] going on."

"Roger, *Columbia*, you cut out on some of that, but we did get the update that you're having a good time."

Engle said, "You bet, and we're both feeling real well."

Engle then read down some information on the COAS calibration and IMU alignment, but Dan interrupted him because we saw that they were getting yet another alarm.

"Break, break. Just a second, Joe," Dan said. "*Columbia*, Houston. To get rid of the water message, we'd like you to open the inlet on water tank C."

While Chuck noted the changes to the switch list and Marion jotted down the IMU and COAS information, I listened to all the chatter and kept trying to finish the message I was working on. But interruptions were constant for me, too, though obviously on a much smaller scale than what the crew had to deal with. I wrote afterwards, "I gave up on the message after three tries, turned to Chuck and gave him the activities and times for Post Insertion and asked him to put them into the CAPS [for the As Flown Timeline]. About then our section chief came over the loop and said, 'Elvin's stepped off a while, and I'm in command, so I'm going to make lots of changes. Ha.' It wasn't funny. Then he told Chuck to create some pages to cover the center of the timeline. Chuck objected, but I stepped in, told Chuck to keep working on the As Flown and told our section chief that what Chuck was doing was more important and (thank goodness) he agreed. Chuck said, 'You won!'

"But not for long. I was writing the Flight Note and our section chief showed up again. He stood behind our table with [Division Chiefs] John O'Neill (1946–2014), Pete Frank (1931–2005), and some others I didn't know and yakked like a bunch of gossipers. I turned around (after O'Neill left) and asked them to please keep their voices down. He said OK. Then I asked him if he could do something to get rid of some of the people. He came back at me with, 'Who would you have me get rid of?' I was so frustrated, I said, 'I don't know, just get the noise down.' He said something to me about not handling the pressure, and then I was fuming inside. I turned my back to him and concentrated on the message. I finished it, and sent it to Elvin."

In the meantime, the crew soldiered on. They replaced the CO_2 absorbers. Dan asked if they'd eaten lunch yet. Truly responded, "Dan, I ate the sandwich that was in my pressure suit this morning, and I think Joe is maybe getting something for himself now."

So the answer was "no." But Truly added, "I'm getting the TV set up, and I'll grab a sandwich as soon as I get in there." That is, unless something else interrupted him!

Wait, what TV set up? I flipped to the proper page in the Crew Activity Plan. I called Elvin and said that Truly didn't need to be setting up that TV. It was for a scene that was now scrubbed because the OMS burn had been scheduled into that time slot. So instead of getting his sandwich, he was busy setting up for something he didn't need to do. Sigh. And we were probably not going to tell him about this because there were more important items that were about to take his time from that anyway.

Sure enough, when we reacquired signal, Dan jumped immediately into telling them to reconfigure some APU heaters, again. Chuck marked up that panel of switches again, too.

Then, as the shuttle passed over the U.S., Dan read up the OMS target numbers. OMS 3 was being done in two parts, A and B, as part of a "restart" test on the left OMS engine. OMS 3A's burn lasted for 12 seconds and changed the velocity (called delta v) 10.4 ft/s. OMS 3B was four minutes later for 24 seconds and a delta v of 21 ft/s. The OMS 4 burn would follow about 45 minutes later and last 42 seconds to increase their orbit to about 140 nm. The OMS 4 burn included an important "crossfeed" test, pulling fuel from the right tank to burn in the left engine.

It took the full 15 minutes of AOS to get the numbers repeated and copied correctly. At the very end of the stateside pass, Dan said, "Roger, on page 4–5 in the PLT's column, that TV setup, you can delete that because that sets up for some scenes that would have been happening where we moved the OMS burn to."

Truly simply answered, “Okay. Copy that.” I wondered if he’d already done it.

The problem wasn’t that we didn’t have time to do things or to change plans, it was simply getting attention for any one thing amidst the flood of interruptions that required a response, whether it was a nuisance alarm onboard or a manager talking in the back room. In other words, we were so busy doing the urgent things that we had no time for the important ones.

So the post-OMS 4 plan was ready to go, but Hutchinson was embroiled in heated discussions about what to do with the fuel cell and how to respond to all the small stuff the crew had reported. He also had to balance the needs of the crew with those of the program. It was one thing to delay setting up the teleprinter (still not done), and quite another to cancel an OMS burn so the crew could eat. Generally, crew convenience took a back seat to flight objectives, payload tests took a back seat to orbiter tests, and everything took a back seat to any problem that threatened the safety of the vehicle or crew.

As a veteran flight director, Neil was able to handle all the technical stuff. But in sims, the “peanut gallery” behind the glass in the MOCR wasn’t full of VIPs. I only had my section chief to worry about—Neil had payload representatives, NASA management, contractor management, the news media, and the families of the crew staring holes in his back.

Mr. Kranz ran interference for him, fielding a lot of the questions and explaining why Neil was making the decisions he was—and standing up for his right to make those decisions without consulting *them*. But the pressure was intense. Some of the news media were already saying that the $10 billion-dollar shuttle had failed its reusability test.

So, about the time I sent the post OMS 4 plan to Elvin, Flight was deciding to shorten the flight because of the fuel cell, making himself the target of all the VIP’s frustrations and disappointments. But the SPAN and MER and EGIL backed him in his decision. They’d determined that the fuel cell wouldn’t be recovered. Dan told the crew to modify one of the Malfunction Book procedures to first isolate the contaminated water that might come out of the fuel cell, and then turn it on long enough to burn up all the reactants left inside it. Per the Flight Rules, the mission would now be 54 hours long, what we called the “Minimum Mission.” I wrote, “Elvin didn’t want to interrupt Flight. . . . Between OMS 3 and 4 we’d do the Fuel Cell Checkout and there was no plan for after OMS 4. . . .We wasted about 30 minutes of on-orbit time because there was no [comm] coverage, and no one had told them what [tests] to do. Chuck and I felt very bad about it.”

At least the OMS engines performed perfectly. And the crew got the fuel cell restarted and then shut down without any trouble. I worked on an updated timeline using the preflight-prepared “Minimum Mission.” PAO described it. “The 54-hour mission would not necessarily mean that we would automatically land in 54 hours, but move many of the critical flight plan items ahead into Day 1 and 2. . . the mission could be extended if things were looking well.”

The idea that we’d extend the mission later was merely wishful thinking. We all knew we were coming home, and that meant we had to shoehorn in every test we could fit into what remained of our 54 hours in space. Even though we’d missed one opportunity to accomplish more tests, Chuck and Marion and I were ready with a good solid plan to get us back on the timeline. But once again, our efforts were preempted. I recorded, “We drew up another plan. . .. The Entry Team had arrived by then, and drawn up their own plan without consulting any of us! Elvin was really angry about it, especially at Tucker, but they were all under the thumb of management. Even Neil was getting directed by Kranz et al. in the front room.”

Our shift’s last AOS was typically garbled, so Dan didn’t even get to bid them good night.

I gathered up my things and unplugged. Holmberg took my spot, and Mi-Mi took Chuck and Marion's place. She still hadn't told anyone that she was pregnant. I hoped her shift wouldn't be as stressful as mine had been. Would I want to work console if I were pregnant? Pearline had managed, and Mi-Mi was about to. I guess I'd have to cross that bridge when/if I came to it. At least her shift wouldn't be as long. I'd gotten there at 4:30 a.m., and it was 7 p.m. now. I walked out with Chuck. We met up with Elvin at the lockers. All of us were very frustrated about how the last few hours had gone. Elvin said we'd done a great job with the replanning, and it wasn't our fault that we were ignored. He said it was even worse in the front room. When systems are failing, no one cares about the timeline.

Thor was actually home when I got there. I was glad because I really needed a hug. And he even made dinner! It was my favorite Hamburger Helper, stroganoff flavor—with frozen peas which Thor added to everything he cooked. I explained how hard it was to hear the crew, and that the signal had kept going in and out. We agreed it would be better once we got the tracking data relay satellite up there. I laughed as I took a forkful of stroganoff. "But if we have almost continual com, the crew will never get to eat!"

Thor helped with the dishes, and then headed to the office to review some things before his first shift in the MOCR. He'd be on console when I arrived around 1 p.m. on Friday. I thought that shiny new green front-room badge looked great clipped to his pocket. I straightened his tie and gave him another long hug. Then I got ready for bed.

7.2 As a "front room" Guidance Officer for STS-2, Thor got to wear a coveted green badge versus my support room pink one. But I had an SMS badge in case I needed to check out a new procedure in the simulator (Photo by the author)

But despite having been up since 3 a.m., I wasn't sleepy. I kept hearing the voices of the crew and Hutchinson in my head. Was there anything I could have done differently that would have made Post Insertion easier for the crew? Would my job be any easier on the planning shift with Holloway, my mentor and a former FAO, as Flight Director? How was Mi-Mi doing? I buried my face into Jasper Kitty's fuzzy tummy, and drifted to sleep listening to him purr.

COLUMBIA COMING HOME EARLY

In the morning, the headline of the Houston Post read, "*Columbia* may come home early: Fuel cell on shuttle not working." The article, by Jim Maloney, said, "Flight controllers elected to cram the most important experimental tasks into the front end of the mission in the event the flight is shortened. In addition to the failed fuel cell, Hutchinson said flight controllers were carefully watching one of three auxiliary power units that was not cooling properly. . . .Jim Riley of the Johnson Space Center's Power and Propulsion Division, said the fuel cell problems were caused when tiny passages in some hydrogen lines became clogged. When this happened, water collected in the cell, and it was decided to shut it down. He speculated the line may have been clogged by flakes of material . . . or by particles lodged in the lines themselves. . . [or] perhaps were caused by aging or a manufacturing defect" [1].

Thor was on console. His shift had started around 5 a.m. Was it tense being in the front room? I'd been looking forward to my turn in a few flights, but this flight was dulling the shine of that goal a bit. The night's rest and a good breakfast had restored my optimism somewhat, but I was still upset about how our team's inputs to the timeline had been rejected out-of-hand. I vented in my journal, "One time I turned to my section chief and said, 'When do I get a raise?' He replied jokingly, 'You don't even get a cost of living raise!' I said laughing, 'OK, I quit.'"

Without the instant communications that we take for granted today, I didn't know that even while I was complaining about how the FAO seemed to be underappreciated, the Entry Team Flight Director, Don Puddy, had asked Tucker Pierce to accompany him to the change-of-shift press briefing to explain the changes to the timeline. Last night had been Tucker's first time in the front room as FAO, and already he was in front of the news cameras.

7.3 The Entry/Crimson Team for STS-2 was led by Don Puddy, fifth man from the *left* in the front row. The 10th guy from the *left* is Tucker Pierce, then Bill Holmberg, Mi-Mi Lau, Jay Penn with head turned, and Mark Brown. Two women in the second row are Sara Beck (Sim Prop) and Sandy Mangold (OREO). Liz Cheshire (Computer Command) is in the third row (NASA photo)

I soon arrived at work. As I rode up the elevator in Building 30, I felt a burst of pride that I was part of the Mission Control team. Even though we'd had a rough shift yesterday, I was confident we could handle whatever came at us today.

In the second floor hallway, I dialed my combination lock and took out my blue headset bag. With the shortened flight, this would be my last shift for STS-2. I was determined to prove to my section chief that I could handle the pressure. I'd be "Tough and Competent," just like Mr. Kranz!

A roar of voices blasted me as I entered the FAO support room. Shift change was underway. Mindful of how the noise had stressed me out last shift, I kept my voice down.

Carolynn said she really needed to talk to me—as soon as we had LOS. Orbit Team Capcom, Jim Buchli (1945–), was talking with the crew on Orbit 19. "We'd like you to cycle the primary B FES controller Off and back On at this time, please." That sounded unfortunately familiar.

While I reviewed the Timeline log for the hours I'd been off duty, Truly said he was going to cradle the arm and then go to primary jets. The reason they were doing that was to let the smaller Vernier jets cool off for 10 hours. We wanted to know if the heaters for the nose jets could compensate for heat loss in a cold attitude like tail-to-sun that was planned for STS-3. This test would show if the heaters were physically big enough. "Looks like we'll be operating a 10-degree deadband," Truly said. "Is that going to be sufficient for the SIR-A?"

The answer was no. Pointer Rolwes reminded FAO Ben Ferguson that the SIR-A (shuttle imaging radar), which was taking map-like images of the Earth's resources, needed a 0.5 degree deadband accuracy on its targets. Maintaining this tighter control on the shuttle's attitude required more frequent jet firings, and thus used more fuel. So it was only applied during SIR-A data passes. Carolynn reminded Ben that the deadband was five degrees otherwise, and that this information had been sent to the crew on teleprinter message 19. The information was passed to Flight Director Chuck Lewis and then to Capcom who relayed it to the crew.

After LOS, Carolynn looked around the room, checking for who was within earshot. Then she told me in a quiet, serious voice that our section chief had just about driven her mad! She said he'd been ordering her around the entire shift. I burst out laughing. "He did the exact same thing to me."

"Really?" she said, her mood brightening.

"Oh yeah, and when I asked him to keep the noise down, he said I wasn't handling the pressure well." I rolled my eyes. "I was actually doing fine until he said that. Then I was fuming!"

She laughed. "Exactly!" She grew serious again. "But I'm afraid he'll tell our branch chief I'm not ready to be FAO on STS-3."

"Don't worry," I said. "I'll be your Timeline, and we'll be fine." I really believed this. I'd built that STS-3 timeline from scratch, and no one knew the power-down cases better than she did. We'd be an unbeatable team!

She said she was glad I'd be her Timeline. Then we chatted about upcoming tests.

"What about deorbit tomorrow?" She said that John Bains, her Timeline 2, had the entry switch list updated, and that Team 4 had been called in to work through a Loss of 2 Fuel Cells Deorbit Prep in the simulator just in case. Astronaut Rick Hauck was doing the run.

7.4 Truly was overwhelmed with changes to the checklists for during STS-2, but he still thanked me for "sending up the morning mail." (NASA photo)

"Then that's one thing we don't have to worry about," I said. I trusted they'd do a thorough job checking all the procedures. If another fuel cell failed, they'd have something ready to go. "All" we had to do was keep up with the timeline and respond to any new problems.

It occurred to me that actually, what the Entry Team had done for us yesterday was similar to what Team 4 was doing now. So why had I been so resentful of them doing the planning versus being grateful for Team 4's help? Maybe it wasn't what they'd done, but the fact that no one had bothered to tell us they were doing it until after the fact?

But none of that mattered now. Yesterday had been tough, and we'd all done a pretty good job under the circumstances. We'd sort it out later. We had a flight to finish. Thankfully the crew were right on schedule. I asked what else had been added to the timeline.

"Oh, and you're not supposed to tell anyone, but the president will be calling the crew during a TV pass this afternoon," Carolynn said.

"The president? Reagan is coming to the MOCR?" She nodded. He'd wanted to be here for STS-1, but couldn't come because he'd been shot. Now he was here to show his support. It meant the world to us to have him do this. Despite the issues we were having with the orbiter, he was giving us his vote of confidence. Carolynn said we weren't allowed to discuss this over the loop—that not even everyone in the support room knew about this yet. The news media only knew that the crew would be sending down live TV. We were to refer to the activity only as a crew TV event. For security reasons, the president's schedule was protected.

I couldn't call anyone, anyhow. I'd have to go home to use the phone. (No cell phones yet.) The console's black phone for calling was strictly for official business. It was actually illegal to use it for personal calls. Mom would probably see the coverage on the evening news, anyway. I wish I could see it, too—I'd enjoy hearing what the reporters would say about us—but I wouldn't be home until 1 o'clock in the morning. (Home video recorders didn't exist yet.)

The "event" was scheduled for 9:05 MET, about five hours away, during TV coverage through Buckhorn. This time slot had been carefully negotiated, and it was considered the highest priority. In other words, no matter what the crew were doing when that time came, they would stop doing it, and talk to the president.

Carolynn left around 1 p.m., and me and Marion and Chuck settled into our routine. Our Capcom for this shift was Terry (TJ) Hart (1946–). Tommy Holloway took his first shift as Flight.

During LOS, I'd heard EECOM explaining to Flight that they thought they'd figured out what was causing the FES problems. It had to do with what is called the beta angle which is the angle the sun makes with the plane of the orbit. In November, because the north pole of the Earth is tilted toward the sun, the orbiter was getting sunlight underneath one of the radiators on the day side of its orbit. So the radiators weren't cooling the Freon as much. EECOM wanted them to get out their PDP and do a "SINGLE RAD OPS" procedure on page 3–20.

So TJ explained this to the crew. "We're thinking that by closing the radiator, but not latching it, using this procedure and opening the starboard radiator circuit breakers, it will be able to stabilize the loops a little better."

"And it's the port radiator that you want to be closed?" Joe asked.

"That's affirmative. Stow but do not latch."

Then Truly, who was in the midst of his suit donning and doffing exercise, added, "Okay, let us read this procedure real quick, and we'll see if we have any questions."

Comm was once again garbled. Then one of the crew said, "TJ, I presume that you want to, at the top of the procedure, would you like to leave the Flash Evap Primary B as the active, leave it On and A Off?"

I realized he was starting at the beginning of the procedure that had him configure the FES for entry—and that's not what we wanted him to do. "Tell him to start at the STOW RADIATORS subtitle," I said to Elvin. But TJ had already realized that.

"We'd like you to enter the procedure under STOW RADIATORS."

I thought the procedure was clear now, but the crew called down again. "Let me make sure I understand this," one of them said. "What you want me to do, TJ, you want us to go ahead and stow both radiators and reopen only the starboard per this procedure. Is that correct?"

"Negative," TJ responded.

I sighed. This was why it was so important to write clear Flight Notes. I dreamed of the day we'd have two-way video and could just show them what we meant.

They got the radiator stowed, and not latched, during the next ground pass. Realtime ops continued with the usual reminders about upcoming procedures that had been added such as switching to the 0.5 deadband for SIR-A operations. I listened with one ear while I studied the upcoming timeline. I paused for a moment and smiled. Like Joe had reported on the last shift, in between all the "heady's" I realized I was really enjoying this job.

Over Buckhorn, TJ did a communications test. He said, "*Columbia*, Houston, radio check on this transmitter."

"Well, it's not quite as loud... readable though," they replied.

"Roger, *Columbia*, and we need one more. We're setting up for later this afternoon. How's this?"

I noted he carefully hadn't said we were setting up for the president's call. They replied, "Ah, that's great. Check you loud and clear."

Immediately after this comm check, TJ asked them to once again cycle FES B to Off and then back to On again. I wondered if that meant the radiator stowing hadn't worked?

The crew suit donning and doffing exercise was underway. Per Young's comments from STS-1, the two men did the exercise in series so one of them could "answer the phone" and respond to any anomalies. Assuming there were none, TJ suggested that, time permitting, the non-suiting crewmember do a noise level survey, and a window observation. These tests weren't high priority, but they were still important for evaluating the ship's performance.

Next up was a private crew medical conference (PMC). During those, the air-to-ground was blocked for everyone but the Flight Surgeon. This allowed the crew some privacy in discussing whatever ailed them. I wondered if they were at all nervous about the upcoming call from the president? Did they even know yet? Maybe this PMC included a covert announcement?

Truly reported that he'd inadvertently put CRT 1 in standby, causing an input/output (IO) error. "I've turned the power back on, and so far I have not got a picture on it."

A quick discussion followed between DPS and Flight. CRT 2 had already been shut down with problems. They needed at least two of the three CRTs in the front for entry tomorrow. There was a procedure to recover a CRT in the Malfunction Book.

Capcom radioed up, "*Columbia* Houston... we recommend that you run MAL 5.4 Foxtrot. It's on page 5–40 for CRT 1 to regain it. Over."

Truly said, "Wilco," which was short for "will comply."

About ten minutes later, Truly said, "Houston, PLT. We need to talk about CRT number 1. We have been through the malfunction procedure and cycled power on it several times. ...when we bring it back On, the CRT still is blank." TJ told them to leave it off.

I confirmed with someone in the DPS support room that there was a spare CRT onboard.

Meanwhile, the Payloads Officer had reported that the FILE (feature identification and location experiment) science team was requesting a change in the vehicle attitude to improve their sensor resolution. Instead of the usual roll, pitch, yaw coordinates, TJ read up the new attitude using roll, pitch, and omicron. I turned to Marion and asked, "What's omicron again?"

He explained that it is basically the negative of the angular momentum vector. Um, okay. I still wasn't sure what it meant for omicron to be 205. Marion promised to give me a more thorough briefing about it after the flight. I suggested he do a little class for me and Carolynn and Mi-Mi, so we'd know what our Pointers were talking about when we were FAOs.

EECOM reported that stowing the radiator had worked. The FES was holding steady.

The presidential visit was coming up in a half hour. Time for a quick restroom break.

Since STS-1, another restroom had been converted to a ladies room on "our" side of the building, opposite from the elevator we used to reach the second floor. The restroom was practically outside our door, very convenient. I used the facilities, combed my hair, and refreshed my makeup. Ready to once again tackle the world, I emerged from the rest room.

When I stepped into the hall, I was stopped by a big hunk of a man. One look at him and I froze in place like the proverbial deer in the headlights. I knew immediately he was secret service. His dark suit did nothing to hide his bulging muscles or the dead serious look on his smooth face. "This area is off limits," he announced. He was "parked" in front of the freight elevator that was beside the rest room. I'd never seen it with the doors open before. Another agent was inside, patting down the quilted padding on the walls. Looking for bugs?

I blinked and muttered, "Oh? Um, I, a, I just went to the ladies room." Dummy! He obviously saw me come out of there! I sounded more like a mouse than a flight controller.

"Anyone else in there?" he asked.

"No," I said. I didn't need to explain that there weren't many women on the flight control team. He probably assumed I was a secretary.

"I need to get back to my console," I managed to explain. I pointed to the door which was only about 10 feet down the hall. "Through there."

He studied me, taking into account my various badges and that I had indeed just emerged from the restroom. His walkie talkie squealed. The elevator doors were closing. "Go!" he commanded, nodding his head toward our door.

"Yes, sir!" I said, as I nearly tripped over my feet to get out of there. The president was coming up the freight elevator, and I'd almost gotten myself locked out of the support room! I wondered why he was coming up that way? This windowless building was built to handle an atomic blast. Certainly he should feel secure here of all places. But maybe there was a crowd of reporters at the other door, and this way, he could sneak in quietly?

My heart still beat a little fast as I donned my headset and plugged in. "The president is coming up the freight elevator!" I told Elvin. "The hall is blocked off." Chuck had switched our monitor to a camera in the MOCR. The place was full of VIPs jostling for their turn in the limelight. None of my immediate managers made the cut. The only representative of our group was Elvin, seated at his console right next to Dan and TJ, our team's Capcoms.

The president would have to sit at the Capcom console to talk to the crew. Elvin would be on TV! "Hey Elvin, you'd better clear off your desk! Company's coming!"

"Yeah, yeah," he said with a silly grin on his face. He said they'd already been told to clean up the usual stack of flight notes, ashtrays (though Elvin didn't smoke, other controllers did), and various checklists. He only had his log and the CAP out. "Looking good!" I said. I bet he was glad he'd worn a nice crisp-looking white shirt today.

What an exciting thing this was for all of us, to have the president come on our shift! FAOs were really getting some attention this flight. Tucker got to be on the news, and now Elvin got to sit a few feet from the president of the United States. How cool was that?!

The secret service brought a drug-sniffing dog into the MOCR. I don't know what they expected to find, but the German shepherd seemed to somehow know which console was "his," in other words, the FDO's console! Guidance Will Presley, who sat next to FDO, said he thought the dog was literally going to eat his lunch!

Elvin whispered, "They told us all to scoot in close to our console. The president's coming now!"

The JSC Center Director, Chris Kraft, Jr., escorted President Reagan into the room—passing right behind Elvin. "Hey Elvin," I said on the FAO support room loop, "Smile, you're on TV!" Everyone in the support room laughed when he looked up with a sheepish grin.

Lots of folks were there to shake the president's hand, including the STS-1 crew of Young and Crippen, and the on-duty flight directors Hutchinson and Holloway. TJ stood up as Reagan settled into his chair next to Brandenstein at the Capcom console. Instead of a headset, they gave him a regular black phone handset (with a cord). He looked at it incredulously and said something like, "I can really talk to space with this?" Brandenstein assured him that "yes sir" he certainly could.

On Orbit 23, we came up on Buckhorn. TJ said, "Dan and I are proud to say that we have a visiting Capcom here with us today, and he's asked to speak to the crew of *Columbia*, America's Pride. And with your permission, we'll turn this pass over to him." Reagan smiled like a kid at Christmas.

"Joe, Dick. This is Ronald Reagan."

"Hello, Mr. President," they said.

"Hello. I just want to make a request. I just wondered if when you go over Washington before your landing at Edwards Air Force Base, could you pick me up and take me out? I haven't been to California since last August."

The MOCR and support room erupted in laughter, drowning out most of the crew's reply except for, "We'll be proud to sir."

"Okay, thank you very much. Let me just say, I'm sure you know how proud everyone down here is, and how this whole nation, I'm sure the world, but certainly America, has got its eyes and its heart on you."

"Well thank you very much Mr. President. We're awfully honored that we've got the opportunity to take part in this, and I'm sure that we're very glad that you're getting a chance to meet all the people there in Houston that are making it happen."

Maybe not all of them, I thought to myself.

"Well, I've enjoyed meeting them," he said. "I told them when I came in this was a rare experience for an old horse cavalry officer."

"Well, Mr. President, we certainly do appreciate you taking the trouble to show all the people working on the space shuttle how much you care, and it makes us mighty proud."

"Well, I care, and again, God bless you both, and from all of us here [who] are watching with great pride."

7.5 President Reagan talked to the crew from the MOCR during STS-2. *Left* to *Right*, Terry Hart, Dan Brandenstein (seated), Hans Mark (NASA Deputy Administrator), President Reagan, James Beggs (NASA Administrator), Chris Kraft, Jr. (Center Director), Tommy Holloway (seated). Gene Kranz is in the background behind the president (NASA photo)

The whole conversation had taken less than two minutes even though this "highest priority" event was allotted four minutes. So TJ got back on the loop, and immediately back to business, discussing a hydraulic circulation pump and upcoming OSTA data take.

The camera in the MOCR followed Reagan as he greeted Truly's family and headed out of the room. Someone poked their head out to confirm he was taking that freight elevator again.

Now that the president was gone, the chatter on the loop instantly resumed, with the primary topic being CRT 1. At the next pass, TJ told the crew, "We're convinced that the power supply has failed, and we're discussing a possible change out procedure for CRT 1. . ."

"Well we'll sure be glad to do it, and as a matter of fact, we would probably have some time this evening to get on it. I guess it sure would be nice to have that CRT for entry."

The advertised time to do a change-out was supposedly 30 minutes, but I was pretty sure it would take longer than that. We had a nice block of time after their meal. They'd had a very long day and little sleep the night before (alarms had gone off all night), so I didn't think we'd want to keep them up late the night before entry.

TJ asked them about their meal prep. "Well, Terry. . . the food is tasting good, and we're getting a lot less air in our water today. We got quite a bit of air in our water yesterday."

The air in the water was the result of the fuel cell shutdown. Air bubbles had gotten into the water lines and reduced the efficiency of their water "gun." They used this gun to rehydrate their food and drink mixes (yes, Tang was one of them!). I heard post flight that the flow rate was so reduced, and their time so oversubscribed, that they had gotten very little to eat or drink.

Astronauts get dehydrated in space anyway because of space adaptation syndrome. In freefall, excess fluid accumulates in the upper body because the heart is designed to pump "uphill," and the design of the blood vessels prevents "backflow." The face gets puffy, the nose gets stuffy, and fluid presses on the brain. (This effect can be felt on Earth by simply bending over and staying that way for several minutes.) The brain then triggers the body to lower this pressure by reducing blood volume, which is mostly water. The body gets rid of water through sweating, urinating, and sometimes, vomiting. Once the blood is reduced, the heart doesn't have to work as hard, and shrinks. After about three weeks in space, it reaches a new normal.

Space adaptation poses a problem for entry. As weight returns, fluid in the upper body sinks back down. The brain suddenly doesn't have enough blood. (This effect can also be felt on Earth by bending over for a few minutes, and then standing up straight.) Heart rate increases, but can't totally compensate for the lower blood volume. If the brain doesn't get enough blood, the person faints. Fainting usually results in collapse so that the head is level—making it easier for the heart to get blood to the brain, restoring consciousness. Needless to say, space shuttle re-entry is not a good time to faint!

This was only our second flight, so we didn't, or at least I didn't, fully appreciate how potentially hazardous the reduced fluid intake of the crew might be. Not only were they undergoing space adaptation, but they weren't drinking enough liquid to replace normal losses. Their lack of eating and especially drinking was exacerbating their risk of fainting during entry.

Capcom responded, "Roger, we're glad you're drinking that good water. . .and don't let us interrupt your meal periods there with too much work."

Mission Control was making it clear to the crew and the managers who were listening that crew health trumped all other priorities. So if the decision was to change out CRT 1, that time was going to have to come from something other than the crew meal.

Crippen, who'd been in the MOCR for Reagan's visit, dropped by our support room. He let us know he was heading over to the simulator to do a CRT 1 change out. I asked him how long he thought it would take. "At least an hour," he said. I passed this along to Elvin who told Holloway. We wanted to be sure folks knew how much time to set aside—and consider which activities that had been shoehorned in must be sacrificed to make room.

I'd been on console for eight hours now, and I was once again feeling frustrated, though not as much as the day before. The issue that frustrated me was that Engle had said he wanted to change out the CRT. We'd found a spot for it in the timeline. But an hour had dragged on with no decision because DPS wasn't sure it would work. The longer the decision was postponed though, the more likely it was that the crew were going to lose part of their sleep period.

Finally, on Orbit 23, Capcom said, "Richard, you have a GO for the CRT number 1 change out. . . . However, we are not a hundred percent confident that it will work. We're afraid that the problem may be due to an RPC interfering with the power flow."

We kept our fingers crossed that Engle would be successful moving CRT 4 from the aft flight deck to the center panel next to his seat.

An alarm sounded on board. This one had been anticipated—one of the nose jets that was getting chilled to test the heaters had gotten so cold that the system thought it might have a leak. They had Truly reselect it and continue with other tests.

Only a few short passes remained before crew sleep. TJ was inundated with Flight Notes for the crew, while they were in the midst of the first ever CRT change out in space. At AOS, TJ said, "We have a couple of reminders for you, Richard, when you have a second to listen."

"Okay, please hold off just a second while I (garble) reconfigure (garble)," he said. "This RCS jet test is complete. Hang on just a second."

A few minutes later, he said, "The forward CRT, CRT 1 is loose. We haven't pulled it out yet, and we're going back to get to the aft one right now." Truly then asked if any of the tests in his checklist could be deleted. "My book doesn't have any of it deleted."

Capcom told him he was go for all the tests. I don't think this is what Truly was hoping to hear. He needed to help Joe with the CRT change out, but we hadn't cleared his schedule. No one was willing to accept responsibility for cancelling any of the tests. Management had directed us to cram everything in, and then added in the president's visit and a CRT changeout, too. But we'd lost three days of tests by shortening the flight, and the reputation of the shuttle was at stake. So the crew were going to get it all done, even if it meant they stayed up half the night. At least Surgeon had managed, with support from the Capcoms, to protect their meal.

But I wondered how much more the crew could take. After only a few hours of constantly interrupted sleep last night, they'd been going nonstop since 5:30 a.m. I checked my watch—it was 10 p.m. now, and they still had to do more jet tests, an IMU alignment, an hour-long water dump, change out the CO_2 absorbers, test the star trackers, and oh yeah, have a chance to use the toilet. All this after they got the CRT swapped and tested—which was not exactly a simple thing to do in freefall. (It took them 90 minutes.) I wondered if they were at least snatching moments to peak outside at the glorious view of Earth. I shook my head. Engle and Truly had been waiting for this flight since NASA hired them in 1966 and 1969, respectively. No sir. I'm sure they considered it an honor and privilege, even if we worked them to exhaustion.

Truly soon reported that he'd accomplished all the tests and was purging the fuel cells, per the timeline. Engle had interrupted the CRT change out to do the IMU alignment and reported that the –Y star tracker was pointing toward the sun. "I was a little reluctant to force the shutter open," he said. "Could I double check that attitude with you?"

He read down the roll, pitch, yaw numbers, and they matched what Capcom had. There had been some confusion on when the alignment would be started. But within a matter of minutes Pointing had a new set of numbers to FAO who passed them to Capcom who read them up. We saw them maneuvering into the new attitude as they went "over the hill."

Phew, that was a close one. We only had one more comm pass, six minutes long, before crew sleep. Holloway polled the room for last-minute items.

At AOS, the crew said, "Hello there, Dan, and we've got some good news. The CRT 1 is working now. We swapped it out with 4, and it's working."

Dan said, "Alright, you get the golden wrench award."

Dan then explained that this was the last pass of the night, and it would be 90 minutes until the next one, but we didn't intend to call them again. The crew suggested that we look to see if two CRTs were still powered up. If they were, then they were up and we could call them. This was a good plan, though we all hoped they'd be asleep an hour and a half from now.

Then Joe, apparently buoyed by his success with the CRT, offered to go fix the fuel cell and extend the flight to five days. Dan ignored this comment—he still had to squeeze in all the last-minute messages. He told them we'd pick up the flight plan for Day 6 in the morning.

While they were talking, Pointing noted they still didn't have the IMU alignment done, and the stars would be setting shortly. FAO told Flight, and Capcom told the crew. "Roger, it's in work," they said. A moment later they added, "Okay, Dan, the stars are in the table."

Another close call! Dan said, "Roger, *Columbia*. . ., and once again a reminder to terminate the water dump . . .The Silver Team will not be working any more this flight. So we really enjoyed getting you up there and wish we could have worked with you a little more."

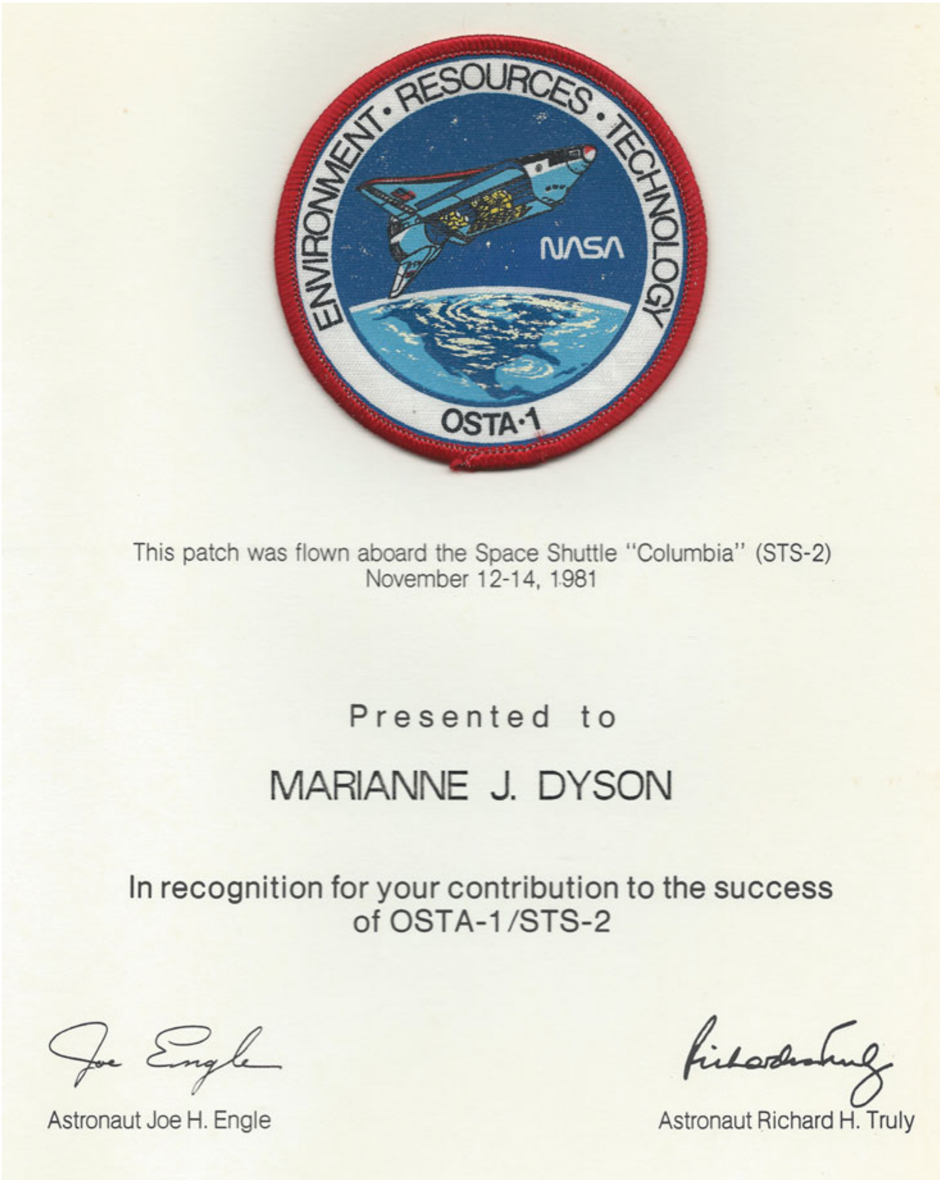
The crew were off to bed now, but we still had three more hours of our shift before the Entry Team took over. While we typed up the flight plan changes and prepared a teleprinter message, the Ground Controller James Brandenburg replayed the launch from a video tape. The front room controllers hadn't been allowed to watch in realtime like I had. So this was the first and probably only time they'd see it because there was no Internet or home recorders.

November 14, 1981 was a lovely sunny Saturday. The front page headline read, "Troubled *Columbia* to return today: Goals put at 90 percent complete." Kraft said he thought coming home early was "the prudent thing to do in this phase of the test program" [2].

I enjoyed their version of the President's visit. It said, "With as much pomp and ceremony as they could muster, NASA employees Friday slipped on their suit jackets, turned up the lights and opened the doors as if readying for a movie shot" [3]. Huh? TJ was the only one with a jacket!

I read that Air Force One had landed at Ellington. "Meanwhile, the "peanut gallery" overlooking Mission Control was beginning to fill. . .. Accepting lapel pins and charms bearing the likeness of the shuttle and provided by Rockwell International, the spectators took their seats."

I hadn't heard about these pins and charms. I wondered if they'd give any to the flight controllers? After STS-1 we'd each gotten a piece of a tile flown in space encased in plexiglass with our name in it. I had it next to my bed. That was a lot cooler than any pin, but I doubted they'd do something that special again. (We got flags and patches flown on the flight.)



7.6 After STS-2, team members received American flags and OAST-1 patches (shown) that had flown on Columbia (Photo by the author)

REFERENCES

1. Maloney, Jim. "Columbia may come home early." Houston Post, 11 November, 1981.
2. Maloney, Jim. "Troubled Columbia to return today." Houston Post, November 14, 1981.
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8

Preparation for STS-3

Thor and I watched the landing on TV and headed to Ellington around 6 p.m. to greet the crew. The Houston Post summarized the return. "'Joe and I really had a lot of fun,' Truly told a crowd of some 250 people, including many co-workers from the Johnson Space Center. He apologized, however, for returning home 2½ days ahead of schedule" [1].

STS-2 shared the front page with an article about the race for mayor, just days away. On Tuesday, Kathy Whitmire (1946–) made history as the first woman to be elected mayor of Houston.

On the heels of Reagan's visit, Vice President Bush visited JSC. He ate breakfast with the STS-1 and STS-2 crews at the Gilruth Recreation Center on site. It was the first ever back-to-back visit of the nation's two highest officials to JSC. Boy were we popular!

"This nation," the Post quoted Bush saying, "owes a great debt of gratitude to all of those at NASA who express the best in professional competence and integrity. It is essential that this center, this national treasure, be preserved and it will be" [2]. Wow, I was part of a national treasure!

However, this unit of national treasure was back at work the next day, preparing "lessons learned" and getting ready for STS-3 scheduled for mid-March 1982.

A handwritten note entitled "Timeliners Debriefing Comments—STS-2" was compiled and circulated by Holmberg. He summarized the experience saying, "STS-2 was a taxing test of realtime replanning and timeline support. The minimum mission plan was essential. . . .We have two major concerns: management assistance and future training."

Under "Training," he wrote: "Everyone said the flight was like a bad sim which indicated the necessity of simulation training."

Under "Management Help," he wrote: "Timeliners received direction from management that conflicted with their own judgement [sic] and the understood direction of the FAO. Some of these directions were perceived as causing disruption of the T/L tasks, disorder in the chain of command, difficulty in hearing during AOS and concern that outputs from directed tasks were eventually ignored. This problem was not, however, consistent. Timeliners did receive valuable direction, encouragement, and assistant [sic] from management."

I read this and thought how deftly Bill had softened the message that Carolynn and I had been micromanaged. I didn't blame him, though. Either because he was a man or a

M.J. Dyson, *A Passion for Space*, Springer Praxis Books,
DOI 10.1007/978-3-319-20258-7_8

contractor or simply that he was on console when the offending managers were sleeping, he hadn't had the same experience that Carolynn and I'd had.

Another handwritten note "STS-2 Comments," circulated by the Ascent Team Pads (Dave Weissinger and Virginia Nestor) console operators, was much more blunt. The first header was "Micro Management," and stated, "The biggest problem encountered during the flight was micromanagement, and there were *too many managers*! It seemed as though everyone was trying to take over the Pads operation to get their message completed."

Our griping about micro management had little effect. At least our section chief didn't take offense, and even encouraged discussions of the topic. I was relieved when Carolynn was confirmed as Ascent FAO for STS-3 with me as her Timeliner.

The management "problem" evolved into not one of how to stop managers from interfering or interrupting operators during the missions, but how to reduce the crowding, noise level, and workload of the operators so that overall tensions were reduced.

We quickly identified one job that Timeline 2 no longer had to do, and that was to track the anomalies. The Operations Integration Officer was now officially in charge of that.

Another thing we could do was rearrange the support room. As the lead operator for the FAO support room for STS-3, I submitted a new console arrangement for consideration. It was not approved because the consoles were connected to data and electrical cables under the floors and very difficult (and hence expensive) to move. About the only thing we could move easily were the bookcases of documents—and the managers!

The more serious issues of the flight were discussed in meetings with the crew. On November 23, I attended a post flight debriefing with Engle and Truly and other flight controllers. Hutchinson was especially interested in why APU 3 had shut down during ascent. My notes say that the water spray boiler had frozen, so it wasn't cooling the unit properly. It thawed at about 24–26 minutes into the flight. Jack Knight pointed out that this meant that we wouldn't have had APU 3 if we'd done an abort. The STS-3 crew were going to be trained on this failure in case it happened again.

I listened carefully to the discussion of the flash evaporator operations in case I needed to update the Loss of FES Deorbit Prep. They reiterated that the high beta angle had probably caused the frequent shutdowns. However, no one knew what had caused the shutdown before the doors were open. Knight explained that the FES would come out of standby every time the control temperature had gotten greater than 40 degrees. He also admitted that stowing the radiator hadn't actually helped! Fortunately, the consensus was that because of the "cold" attitude profile for STS-3, and the lower beta angle in March, the FES "won't be a nuisance."

Engle said that though he tried the flashlight for the COAS calibration, he ended up using reflected sunlight in the cabin to see the crosshairs. He reported that he "could see stars with the sun out." So he hadn't been restricted to the night portion of the orbit after all. Software Release 19 would fix the Earth occultation software so that targets would be found more easily.

The temporary failure of CRT 2 was not understood, but a power cycle fixed it. I smiled. Wasn't that always the solution to a computer problem?

To avoid having to reprint the PDP when only one section changed, for STS-3, we'd publish three separate books: Post Insertion, Nominal Deorbit Prep, and Contingency Deorbit Prep. I was still responsible for Post Insertion, Launch Day Deorbit, Loss of FES, Loss of 2 Freon Loops, and BFS Deorbit, as well as sharing responsibility with Bob for the

STS-3 Crew Activity Plan. Having Post Insertion in its own book meant the acronym PDP now stood for one of the STS-3 payloads: the Plasma Detection Package.

The list of changes to Post Insertion grew so long by the second week in December that I wrote, “Good Grief—some ‘stable’ timeline!” To save power, two of the five computers would be powered off for orbit. To save fuel, instead of pointing the bay at the Earth (-ZLV), we’d go to PTC after door opening which would be done in the faster Auto mode. The IMU alignment was no longer required for the go for orbit, and was moved to the CAP.

However, Flight Techniques put a hold on changing the flight documents until all the other documents affected had been identified. The attempt to keep the books in sync was admirable, but logistically impossible because the books had to be printed in serial. “If no book can be changed until all other books are changed, then *no* book can go to print... *Please* do something!!” I pleaded to management in my activity report.

One thing they could do was increase the staff to handle the workload. Thus, in early December, I escorted two Timeline recruits, Bob Schaf (who’d worked EVA support for STS-2) and new-hire Mark Maschoff, on a tour of the FAO support room. Like John Wegener had done for me almost three years ago, I went over the use of the equipment, sim support, and explained what Timeliners do. That same week, I also briefed the FAOs and Timeliners on the objectives for STS-3. With two flights under my belt, I felt like an old hand now at age 26.

WORK IS WORK

Never sure of our schedule more than a week in advance, Thor and I volunteered to organize the family holiday reunion. We rented a beach house in Galveston to sleep all 14 of us As soon as everyone had arrived, Thor’s cousin Martha announced that she and Mike (the man she’d met at the South Pole) would be married in June.

I took a long walk on the beach in the moonlight with Cousin Ruthie Kane, discussing her decision to change careers even though she’d just turned 30. She loved to cook, and had been working as a chef, but had decided to study psychology and become a counselor. She and her mother Anne had sought counseling to improve and strengthen all their relationships. The experience had been so positive, she wanted to learn how to help others solve their problems and lead happier lives. (She finished her Ph.D. and landed a job as a counselor at Harvard.) “You just wouldn’t believe the difference this has made in my life–knowing what I want and where I’m going,” she said during our walk. The passion and the excitement in her voice reminded me of the way I’d felt when I’d first joined NASA three years prior.

I realized that though I still had a passion for space, some of the fun had gone out of the job. What had happened?

8.1 As the flight rate increased, a new generation of Flight Dynamics and Guidance Officers took their places in Mission Control. *Left* to *Right*, Phil Burley, Terry Burleson, Ed Gonzales, Rick Wray, Alan Keisner, Thor Dyson, Greg Oliver, and Brad Sweet (NASA photo)

Two weeks after the holidays, I wrote in my diary, "I've been unhappy at work. It's not as satisfying as it used to be. It's just hard grinding work and hardly any reward. After STS-4, I really want to change jobs. Part of the reason is the way my section and branch chiefs have been treating Mi-Mi being pregnant. They took away her assignments (mine, too), and said it was for her own 'welfare!' They want to take my checklist away because I'm a 'single-point failure' as if everyone isn't—it's because I'm a woman. Even if I do get pregnant this year, I'll still make it through Flight 4, and then I can bow out to a new job."

The "even if I do get pregnant" part of this entry weighed heavily on me. In my diary's list of highlights of 1981, I'd included STS-1 and 2, trips with friends to San Antonio and Kerrville, our trip to Grand Canyon, the family visit for Christmas, and a list of all the babies born or expected soon. I wrote, "It was a fast, furious, and frustrating year. I look at my beautiful husband and feel like I don't deserve him, esp. since I can't seem to have a child."

I listed all our new furnishings that our promotions and raises had bought. "The half-done airplane and the redone garage are the biggest changes. And we also bought a new car—our Subaru." Then I lamented, "I'm almost tired of all the money. It seems wrong to have it and not children. I wonder if the Lord hears my prayers? Here's hoping for a better year, 1982."

1982: STS-3 PAYLOADS AND TESTS

As the year began, STS-2's payload data was released. The IECM's results showed that the humidity levels remained low in the cargo bay during ascent and descent. Almost no particles larger than 5 micrometers appeared in the data, but particles smaller than that were more abundant than expected. Data showed that jet firings and water dumps did create temporary "clouds" of particles, though water boiled off rapidly in the vacuum of space.

The IECM would also fly on STS-3 and 4 and Spacelab 1 and 2 to further assess contamination levels that may be experienced by future payloads. IECM had faced Earth during STS-2, but on STS-3, it'd face the Sun. Scientists were curious to see if the extra heat caused materials in the bay to release chemicals, a process called "outgassing."

Another STS-2 experiment, the Heflex Bioengineering Test, would be repeated on STS-3. It was designed to see how tall plants grew given different amounts of soil moisture. This data would inform the final preparations for a plant growth experiment planned for Spacelab 1 (STS-9). STS-2 had been too short a duration for the plants to grow.

A small experiment package called a Get-Away-Special (GAS) was added to STS-3. About the size of a large round trash can, it was attached in the far back right-hand corner of the cargo bay. Goddard was in charge of these small payloads that took advantage of cargo space that would otherwise not be used. The GAS's were self-contained, didn't require any external power, telemetry, or crew interaction. This first one was flying empty as a check of the container's environment.

STS-3's primary payload was OSS-1 whose eight experiments I'd learned about last summer in Florida. The previously scheduled middeck experiments also remained on the list: the MLR to create perfect spheres; and the Electrophoresis to separate blood using electricity.

Although I was mostly concerned that I schedule the Electrophoresis tests to avoid crew exercise and teleprinter operations, NASA management was touting this little experiment as a first step toward a factory in space. NASA had signed an agreement with McDonnell Douglas of St. Louis and Johnson and Johnson's Ortho Pharmaceutical division to fly continuous flow electrophoresis (CFES) units on six shuttle flights to investigate the potential for commercial processing of new drugs.

In all the hassle with the documentation of the test equipment, no one had really emphasized to me that this particular test was so important in terms of public relations. NASA was selling continuation of the Shuttle Program and its own future growth as an enabler of a new industrial base. The headline of the January 22 *Roundup* promoted NASA's plan to build the Space Operations Center (SOC) in Earth orbit. "Initial traffic estimates call for a SOC which could accommodate a crew of two to four persons. As more habitation command and servicing modules are brought into orbit by shuttles, the crew complement could grow to 20 by the year 2000. . . . The SOC concept is seen as providing the United States with a marshaling yard in space, capable of handling large and complex payloads, servicing and storage of orbital transfer vehicles, and maintenance of satellites" [3].

This theme of the shuttle facilitating private industry was echoed in the lead stories of every issue throughout the spring. An interview of veteran newscaster Walter Cronkite included his comments about the manufacturing of perfect ball bearings in space. He said we "couldn't make enough of them to speed railroad transport." Asked if permanently manned space platforms were the next step, he said, "I don't think there's any question about it. . . .I'm confident that we'll prove through the shuttle that some of these manufacturing processes, healing processes even, whatever, are feasible, . . .and when we do, it's logical to build the platform to do it on a regular basis with commercial and private investments" [4].

Reading the *Roundup*, I learned that the latex beads that the MLR would produce "could function as internal standards for electron and optical microscopes, for filter calibration, for aerosol-counting equipment and for the calibration of blood cell counters." I also noted that "Beads grown on STS-3 will be flown again on STS-4 to increase their size, and so on through STS-6." Like Mr. Cronkite, I had no doubt that these products were just the beginning of our inevitable expansion into space. Once we had the shuttle operational, we'd build the SOC, a solar power satellite utility to run it, and an O'Neill colony to house all the space workers. I wondered how our kids (and cats!) would like living in space?

Back in the present, all the activities in the timeline were vying for attention. One criticism of the "minimum mission" we'd flown on STS-2 was that there'd been no priority list for scheduling. We'd ended up overloading the crew to the point where their health, and thus their safety, had been compromised. Rumor had it that if Engle hadn't been "a pilot's pilot" able to land the shuttle in his sleep, we could've lost the orbiter during entry. Word came down from "on high" that this'd never happen again. So the program office assigned every detailed test objective a priority. The attitude profile of tail-to-sun for 30 hours followed by passive thermal control was given the top priority of 86. This was followed by nose-to-sun attitude at 85. The next group involved arm tests and deploying, grappling, and berthing one of the payloads.

Despite their importance to NASA's future plans, the payload tests were the lowest priority as a group. Parts of OSS-1 were the highest at 62, IECM at 54, and the Electrophoresis at 51. Surprisingly, a student middeck experiment affectionately called the "bug box," at 38, ranked higher than the Get Away Special at 37, and the MLR at 34. After the student talked about his research at a press conference in February, it was obvious why this experiment was ranked higher: the earnest 18-year-old scientist and his live moths had huge public relations appeal. NASA hoped to recruit more young scientists like him to build those future space factories.

My friends and family didn't hear much about this third flight that so consumed my every waking hour. My mother wrote, "I can't believe how busy you are with the shuttle. Do you know there hasn't been one word of publicity about it? I don't even know the scheduled liftoff date." She also worried about how the stress was affecting me. I'd told her I was spending some time each night reading what I called 'mindless novels' to relax.

"The pressure really sounds bad," she said. "just do the best you can each day and try not to take it home with you. I think your 'mindless novels' are a good idea. Are you taking your iron? Love, Mom."

I didn't think the pressure was all that unusual or especially bad. Unlike my college friend Tom Alspaugh who reported that his new job at IBM wasn't "intellectually challenging," or Tom Burkhalter, who was working at a restaurant while writing a novel, at least my job was meaningful. But my brother Jeff, now a hot criminal lawyer, noted, "I make mistakes all the time, but in law, unlike science, close counts." And as long as his client was satisfied that he'd gotten his day in court, he was also well rewarded for his efforts. He reported earning $800/week, twice what I was making. Still single, he bought a shiny new Camaro saying, "You only live once and all that!"

I needed to remind myself of that fact every day. After all, the Toms and my brother and my friend Marilyn were all still single. I was extremely lucky to have found Thor, and I did enjoy our life together. We met with Cindy and John (and Johnny) every Sunday for dinner, went out to movies, and joined folks from work on outings. In addition to working on the Long-EZ, Thor continued flying lessons. I sewed and did embroidery, making a lot of baby shower gifts.

Pregnant women were everywhere. Besides Mi-Mi, my next door neighbor and the neighbor across the street and Thor's flight instructor Mitch Polt and his wife Sharon were expecting. At least one weekend a month, I was at a baby shower.

So being busy was a two-edged sword. The weird hours of the sims disrupted my cycle, but the work kept me from obsessing about babies every waking minute.

EVERYTHING THAT CAN GO WRONG...

Knowing that we had only one or two long-duration sims, Carolynn came up with a creative training tool. In a memo dated January 28, 1982, she wrote, "In preparation for STS-3, the FAOs and Timelines have lots to learn in a short amount of time. To facilitate this and to produce useful guides to be used real-time, the following two projects should be done: (a) Scheduling Constraints Document, [and] (b) Contingency Notebook." She assigned specific contingency cases to everyone on the STS-3 team except me and Bob. She assigned herself the "minimum mission" which management had renamed the "high priority mission."

The first week of February, we put our new knowledge to the test during our first long-duration (57-hour) sim for STS-3. The sim started during the crew morning with the Orbit Team, Bob as FAO and Mi-Mi as Timeline 1. They'd hand over to Carolynn and me on the Ascent Team. Our first shift was 14 hours long, from two hours before crew sleep to an hour after wakeup. Our task was to take into account all the failures during the orbit shift, and make necessary changes to the next day's timeline. We'd then hand over to the Entry Team of Tucker as FAO and Marion as Timeline 1. Jerry Shinkle, who'd been Pads for STS-2, was my Timeline 2, and the two "new guys," Bob Schaf and Mark Maschoff, were Timeline 2 for orbit and entry.

8.2 Thor is fifth from the *left* in the second row in this photo of the STS-3 Orbit Team MOCR operators. His flight director was John Cox, fifth from the *right* in the first row. FAO Bob Nute is in a dark suit at the far *right* in the front row (NASA photo)

As I wrote in my post-sim report entitled, "Everything That Can Go Wrong. . . or What Caused the CAP Update Message to be late," the sim proved that even two flights of experience weren't enough to prevent Murphy's Law (what can go wrong will go wrong) from taking charge. Our major product is the timeline update message, and it hadn't gotten done before crew wakeup. Both Carolynn and I were painfully aware of how bad this looked. The first women-led team had failed miserably during our first test. I was tasked with explaining why.

I had plenty of excuses. We started with a power down during the confusion of shift handover. This delayed operators coming up to speed and approval for changes while options were discussed. I also blamed an ice cream party that "occupied the Capcom for the better part of two hours right when the CAP Update draft was ready for review." Equipment failures (Pads terminal and pen plotter crashes) and poor communications rounded out my list.

But one reason we'd performed badly was that I'd let myself get distracted by systems issues instead of focusing on planning. I needed more practice, but no more sims were scheduled. Carolynn arranged for us to join the crew on a walkthrough of all the TV scenes in the 1-g trainer in Building 9. We learned what they were looking for in a scene and how long it took the crew to set up and stow the equipment. This session helped, but flight was only six weeks away! I stayed late almost every day and came in on the weekends to study. I had plenty of company.

8.3 What we called the "1-g trainer" was a full-scale orbiter, seen here from the visitor walkway of Building 9 at JSC in 2011 before it was moved to its new home in Seattle (Photo by the author)

Our branch chief noted, "A lot of people have been working nights and weekends to meet the STS-3 due dates and respond to the numerous changes. Your efforts really are appreciated and you should feel a sense of accomplishment that you are contributing in a direct and real way to the success of the STS-3 planning effort! Jack and Gordon's thanks are enclosed."

He'd included a copy of one "ATTABOY" certificate to each of us. It said, "One thousand 'ATTABOYS' qualifies you to be Leader of Men, to Work Overtime with a Smile, Explain assorted Problems to Management, and be looked upon as a local Hero, without a raise in Pay." At the bottom was a Note. "One 'AWSHIT' wipes the board clean and you have to start all over again."

Our third anniversary was the week before the launch. All we did was wear green (for St. Patrick's Day) and go out to dinner. As Thor's father wrote, "I'm sure there is much to do and get done in a short time and your pace is getting frantic. Let's hope all goes well and there are no more 31-second holds or evaporation malfunctions to contend with."

I hoped so, too. I didn't need any more AWSHITs like I'd earned during the sim. I'd do my best to earn Carolynn an "Atta Girl" for her being the first woman FAO.

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2. Ibid.
3. NASA, Space News Roundup, Jan. 8, 1982.
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9

STS-3: Realtime Flight Planning

With all the delays and countdown scrubs prior to STS-1 and 2, I didn't expect that we'd actually launch as planned on March 22. Miraculously, the launch date remained firm.

However, the stable launch date had done little to stem the tide of changes to the checklists. The week before launch, we had 66 updates just to avoid "nuisance" alarms. These generated page-change notices to the CAP, Post Insertion, Deorbit Prep, Entry, and many of the other flight documents. No one wanted to enforce an absolute cutoff on making changes because it was easier to hand-write a change into the book before launch than in space.

The "Final" editions of all the main books were therefore final in name only. The Final STS-3 CAP was dated February 15, 1982. The page change notices (PCNs) were dated, March 1, March 8, and March 10. Post Insertion and Entry each had three PCNs, and Deorbit Prep Sections 3–12 had five. I spent hours hand marking all the copies we'd use on console.

On March 18, NASA declared that White Sands would be the official landing site because Edwards AFB in California was flooded by spring rains. Delaying the flight would reportedly cost $3 million a day. We were also told that NASA wanted to demonstrate to future commercial customers that bad weather wouldn't force a schedule slip. So they moved shuttle processing equipment to White Sands where, hopefully, we'd land on March 29.

On Monday March 22, I arrived on console bright and early at 4:30 a.m. A very pregnant Mi-Mi (due in May), who'd been on shift since Sunday night, handed the log to me. I wrote, "We are delayed launch by 1 hour due to a heater failure just prior to ET tanking." At 6 a.m. I wrote, "Crew eating breakfast. Liftoff at 10 a.m. CST." My breakfast wasn't nearly as fancy: a donut and coffee.

M.J. Dyson, *A Passion for Space*, Springer Praxis Books,
DOI 10.1007/978-3-319-20258-7_9

9.1 A very pregnant Mi-Mi is first in the front in this photo of the STS-3 Orbit Team. The other women beside her are (*Left* to *Right*), Linda Patterson, Janet Clark, Mary Ann Austin, and Karen Johnson (NASA photo)

The crew were in their seats by 8 a.m. The tension level rose as liftoff time approached. I checked the kilowatts, monitored the purge of the newly-installed fuel cell (that replaced the one that failed on STS-2), and listened to the loop chatter.

PAO fed quotes and statistics to the press, such as that it took 97 working days after the last flight to get *Columbia* ready to go again as opposed to 187 between STS-1 and 2. Also, only 471 tiles had to be replaced compared to 1800 after the first flight. It still seemed unlikely to me that we'd launch each orbiter once/month any time soon, but we were making progress.

Hutchinson was quoted saying, "Our biggest objectives are to subject the vehicle to various thermal conditions, seeing if it is able to operate for long periods in orientations where one side of the vehicle gets very warm and the other gets very cold." PAO said this would be accomplished by pointing the nose, then the cargo bay, and later, the tail, at the Sun.

The robotic arm tests were also highlighted by public affairs, starting with the Shuttle's Pilot, Gordon Fullerton, exercising it on Day 2. "The third day, one of the busiest, will be devoted to more robot arm flexing, including practice with the arm grappling payload packages and extending one set of sensors out over the sides of the cargo bay. . . .On the fourth and fifth days, more testing of the robot arm will be combined with more thermal testing maneuvers and brief ignitions of the shuttle's maneuvering rockets. The rocket firings are to check how well they perform after being extremely cold." [Quotes are from crew from STS-3 Transcript, available at the UHCL NASA JSC Archive. Future quotes from this source will not be individually cited.]

These tests and their constraints and requirements were etched in my brain from three years of planning. Today, my head spun with details like when I'd crammed for a final in college. I couldn't afford to fail this "test!" Neither could NASA. After the shortened second flight, many in Congress were looking for an excuse to cut the program despite the president's support.

Ivory (Ascent) Team Flight Director Holloway asked each operator if they were "go" for launch. I looked up and down the row of consoles in the support room. One other woman was on shift with me, a young redhead named Karen Ehlers who was rapidly becoming a top expert on the payload deployment and retrieval system. I smiled at everyone and was met with thumbs up and return smiles all around. "We're all go back here," I told Carolynn. I felt a burst of pride when she responded to Holloway's roll call with, "FAO is go, Flight."

The countdown continued. At L-4 minutes, I recorded "small bubble in APU 3, but we're go." I also noted the backup mission operations computer wouldn't be ready by liftoff.

Liftoff! I wrote, "No TV!" All the channels were taken up with data, and we no longer had our portable TV. I vowed someday I'd go see a launch with my own eyes.

About a minute and a half into flight, FDO Ron Epps said we were a "little depressed" meaning the shuttle wasn't flying as fast and high as expected. A few seconds later Ron reported this depression was the result of a head wind. Thor and I often joked that every time we flew, we had a head wind that slowed us down. So why should STS-3 be any different?!

Two problems we'd seen on STS-2 cropped up again: a Freon Loop Evap Out Temp exceeding the caution and warning limit, and APU 3's temperature climbing. Commander Lousma also reported a blizzard of flakes passing by the window. He said the flakes were light blue. I wondered if there were more or less ice as a result of leaving the tank orange versus painting it white like they'd done for STS-1 and 2.

APU 3's temperature continued to climb. After the call for "single-engine-press-to-MECO," Capcom told them to "secure APU 3."

"Okay," Lousma said. "Shutdown APU 3."

I noted in my log that failure of an APU was a priority mission case. My heart sank. Not again! But maybe they'd be able to recover it later?

The OMS 1 burn to circularize the orbit went fine except that an oxygen tank heater seemed to have either a sensor or instrumentation failure. EECOM Steve McClendon said if a reset didn't fix the problem, we'd run on heater B for tanks 3 and 4. While he was talking, one of the details I'd memorized popped into my head: that heater was configured on page 1–17 of Post Insertion. I made a note to remind Carolynn later.

I followed the discussions on the loops about the APU. It was cooling off quickly. That was the good news. The bad news is that we didn't understand why it had gotten so hot.

We did the OMS 2 burn during AOS. I saw the kilowatts jump from 20 to 22, answering the question I'd wondered about during STS-2 about how much extra power a burn required. But while following the burn, I discovered I'd goofed up one of the updates to the books. I wrote, "I had an old page in Orb Ops Checklist! Bad. Bad." Considering the flood of preflight changes, I wondered if the crew copies had similar mistakes.

Fullerton reported a problem with the backup computer. He said, "BFS went to stand alone." We were over Yarragadee (Australia) and only had voice, no data. DPS Randy Stone asked the crew to confirm that all the strings had transferred in the primary computers. Fullerton said yes. So we told them to reset the backup. Unlike the sims, this reset worked. If the backup system had failed, that was a reason to shorten the flight.

We expected to talk to the crew at Dakar at 1:55 MET, but the elevation angle was bad. So we had about 35 minutes of no comm. Flight asked for a status around the room, including FAO. Carolynn reported that the crew were 10 minutes behind, Pads had the test message ready, and that orbit sunrises and stars for the IMU and COAS alignments would be 4 minutes early.

By the next comm pass, the crew had fallen 20–25 minutes behind schedule.

This crew was definitely more talkative than Engle and Truly on STS-2. When the orbiter passed over the flooded, previously dry lake bed at Edwards, Lousma remarked what a good decision it'd been to change landing sites to New Mexico. Later, seeing snow over his native state, he said, "Things look a little chilly in Michigan today." I imagined Thor's mother, an elementary school principal in Mason, Michigan, donning gloves to check on the kids at recess.

Once the computers were transitioned, the fuel cells purged, and the doors opened, we were go for orbit. All was going well.

We sent up our teleprinter test message at 3:12 MET. The crew reported that they got some gibberish, but they received all 66 lines of the actual test message. So the FAO team was all set for the replanning shift. I hoped they'd get the message done before the crew got up.

Capcom Terry Hart said goodbye for the Ascent Team over Hawaii on Orbit 4. Lousma replied jokingly, "Okay, Terry, to you and all the rest of those troops, we have enjoyed training with you, too. This is one of the best training sims we've ever had with you guys and you got us off to a super start." The support room filled with laughter. We really were off to a "super start" on STS-3. I handed over to Mi-Mi who'd had only had a few hours of sleep. Carolynn handed over to Bob. I wasn't due back until about two hours before crew sleep tomorrow—27 hours away.

Leaving Mission Control and returning to the "real" world, even just to drive home, was always kind of a shock. It didn't help that once again, the Ascent Team was doing a circadian flip-flop. I'd gotten up at 3:00 a.m. I'd be ready to fall into bed as soon as my caffeine buzz wore off. My next shift started at 7 p.m. and ran until 8 a.m. If I slept now, I'd have to stay up 24 hours. Maybe I'd just sleep until Thor came home at 1 a.m.? Then I could go back to bed around 8 and sleep at least until noon. Maybe. Sigh. No wonder my ovulation cycle was so messed up!

SPACE SICK CREW

After my patchwork sleep cycle, I arrived on console Tuesday night and wondered how I'd stay awake until 8 a.m. Wednesday. I'd soon learn that the crew were in even worse shape.

The remainder of the first flight day had gone well. But static over the airwaves had kept Lousma up all night. He indicated that it sounded like radar tracking them as they passed over Iran, the Soviet Union, and China. Mi-Mi said that we were recording their comm overnight to try and find the source of the interference. But in worse news, Lousma told the flight surgeon that he'd been sick the day before, like he'd been on Skylab. As a result, he'd eaten hardly anything and had cancelled the suit donning exercise. Mi-Mi explained that we weren't supposed to discuss the crew's health over the loops.

Fullerton hadn't been bothered by the noise because he'd been in the middeck, but he'd been bothered by the uncomfortable cabin temperatures. The cabin had started out in the 1980s, and he'd reported stripping down to his underwear. Then the temperature had dropped into the 1960s, and he'd been so cold, even in his sleeping bag, that he'd had to dress and also put on his jacket. I hadn't slept all that well, but at least I'd been in my own bed.

As I reviewed the as-flown CAP, I was surprised to see that we'd stopped the tail-to-Sun test early and gone to top Sun, followed by PTC which we were in now (as planned for the sleep period). The tail-to-Sun test was our number one priority. Mi-Mi said that one of the port payload bay door latches had gotten hung up so the door wouldn't close. The doors had to be closed for entry, so this was important to fix. But preflight, in meeting after meeting, we'd discussed what we'd do in this case. The answer had always been to check the doors with the theodolite and then go to PTC for two orbits. Only if PTC didn't work, *then* we'd go to top Sun. I couldn't believe they'd not followed this carefully crafted plan. It wasn't until post flight that I learned that Tommy Taylor, the lead thermal guy, had approved the change to speed up the door recovery, which also got the crew to bed on time. EECOM reported that the temperature of the longerons in the bay had gone up 30 degrees almost instantly after the sun hit them. And just after handover, the crew reported the port door had responded to the top sun warming, and closed fine.

The thermal test had been a success. We'd learned that the orbiter couldn't do long periods in tail-to-sun, and we'd also learned that top sun quickly fixed warping of the doors.

One run of the Electrophoresis had been dropped while the crew inspected some missing tiles on the nose using the arm. Team 4 had been called in to sim and prepare the arm procedures for this action. It worked great though, unfortunately, the wrist camera had failed on the arm. The elbow camera had also briefly failed, but was recovered and provided good video of the nose. Tom Moser reported at the press conference that about 25 tiles were missing with none in any areas critical for entry. After the flight, I recommended in my report that a tile inspection with the arm become a regularly scheduled activity on Flight Day 2. My supervisor wrote an emphatic "NO" in all caps next to this suggestion. (It wasn't until after the *Columbia* was lost because of tile damage in 2003 that NASA implemented regular tile inspections upon reaching orbit.)

The IECM hadn't been picked up by the arm as planned because of a failure of a key aft camera in the cargo bay. Fullerton said that he felt he could grapple and deploy the PDP without that camera, and the payload folks were discussing whether or not they'd approve it.

I'd just bid farewell to Mi-Mi (who'd be off only 11 hours—it was their team's turn to flip their circadian) when Carolynn got on the loop and dropped a planning shift bombshell into our laps: we were going to "swap" Flight Day 3 (FD3), tomorrow, for FD4 in the CAP.

"What? Why?" I stuttered in disbelief.

Carolynn said that FD3 was our busiest day (as PAO had noted before flight), and that with the crew not feeling well, we were going to give them a lighter load by executing FD4 instead. I resisted doing this. Why not just cancel or postpone a few of the arm tests? She carefully explained that this decision was not up for discussion. Kranz had talked to Surgeon and Flight and this was *his* decision.

Oh.

No one argued with Mr. Kranz. He'd decided, and it was our job to execute the decision.

I understood the concern. We'd worn out the STS-2 crew and barely avoided a disaster during entry. No one would risk that again.

While I sat there thinking about which tests had to be done in order and which ones could actually be "swapped," Capcom Dave Griggs told the crew, "The plan is for tomorrow that we're gonna let you sleep in. You call us. We won't call you, and the plan is that we're gonna build a new Flight Day 3 for you tomorrow that will get thoroughly relaxed."

Lousma protested that it wasn't necessary for them to sleep in. Capcom reiterated the "order." "It is our definite plan not to start until an hour later tomorrow." Capcom then joked, "The Silver Team says they need an extra hour's sleep, and that's the reason why, Jack. We're gonna give it to you, too at least."

If the Silver Team was getting an extra hour, that meant our Ivory Team would be extended. That would be good for Mi-Mi. I worried about her getting overly tired at seven months pregnant. And I was glad that at least we weren't moving their shift early like they'd done to me on STS-1 (when I'd ended up coming in late).

But now I had to stay alert until 9 a.m. versus 8. Yawn! I wrapped my hand around my coffee cup and inhaled, hoping for an extra infusion of caffeine. Well, at least we'd have more time to get the CAP Update message done before crew wake up. We were going to need it!

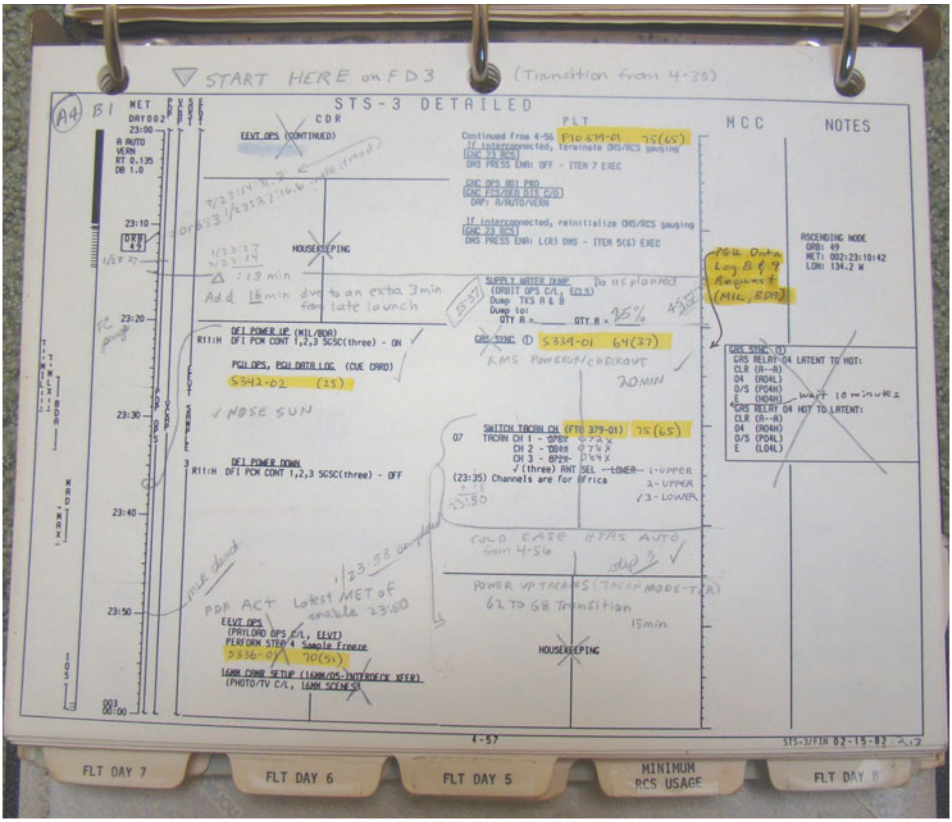
The main problem wasn't in generating the directions to the crew, but in preparing a timeline with the proper trajectory on it. The CAPS system had one trajectory loaded that came to us via a tape from MPAD. We couldn't even shift the day/nights to account for the late launch.

As I reported post flight, "The problem was that FD3's morning was used twice, once on FD3 and once on FD4 with two different trajectories."

Fortunately, my Timeline 2, Gerry Shinkle, had been involved with CAPS since 1980. Along with me, Mi-Mi, and John Bains, he'd written sections of the *CAPS User's Guide*. Gerry and I decided we needed to call in our own version of "Team 4," one of the CAPS programmers, to help us. Ramesh Khatri answered our call. Gerry reported post flight, "We had a lot of problems with trajectories when we flip flopped FD3 and 4. The ability to assign only one trajectory at a time was the limiting factor. However, Ramesh showed me a program already resident in CAPS whereby a trajectory composed of up to 15 separate segments can be built and assigned."

While Gerry and Ramesh wrestled with the software, Carolynn gathered inputs from the controllers and fed the changes to me. Chuck Knarr took care of changes that would impact entry.

I needn't have worried about getting sleepy on this shift. I barely remembered to stop pacing and sit down. We planned to have the CAPS Update message ready by normal crew wakeup time. But just like the long sim, we didn't get it done. At normal wakeup time, we were still putting final touches on the revised plan. We finally got it approved and uplinked about an hour later. We'd needed that extra hour more than they had.



9.2 Swapping Flight Day 4 for Flight Day 3 required us to completely redo the timeline as shown here in my console copy (Photo by the author)

Using the FD4 timeline on the real FD3 caused no end of confusion. It would've been a lot easier to reschedule all the arm tests than to "swap" days. I worried that I hadn't caught all the activities related to the thermal attitude tests such as a FES water test that required 24 hours of Nose-to-Sun. Carolynn had really done a good thing by having our team prepare that constraints document. We had each other's backs.

DPS said someone was up and had punched up a CRT. But we'd promised the crew we'd wait for them to call us. But an hour and a half past their scheduled wakeup time, they still hadn't called. Were they both sick now? Flight decided to call at 7:30 a.m. The Orbit Team had arrived an hour earlier, but we were told to stay until after the crew had finished the initial items in the checklist in case they had questions. Capcom Griggs explained why we called: "We just couldn't wait any longer."

It turned out to be a somewhat prescient choice of words. Lousma replied that they'd slept a little better but weren't totally ready to go yet. "One other malfunction we've had is the commode stopped working while it was being used. The motor quit running."

Uh oh. The waste control system was a crew system, and therefore fell under the purview of the FAO. D. Brooks and M. Cohen were working the Crew Systems console on our team. I didn't envy them having to work this issue in full view of the press. Even though this was a serious problem, NASA would soon be the "butt" of jokes about its malfunctioning toilet.

9.3 The shuttle toilet broke during STS-3, making NASA the "butt" of many jokes (NASA photo)

But I felt truly sorry for the crew. Like all FAO candidates, I'd been required to take a "practical" class on the use of the WCS. It was one of the most memorable of all my classes.

I'd tromped over to the test toilet in Building 5 along with Mi-Mi and Tucker and a guy from Crew Systems to take our "practical." The shuttle toilet is basically a vacuum cleaner. The instructor demonstrated how to turn the toilet fan on by releasing a clamp across the top of the seat. I covered my ears. It sounded like a jet taking off! He pointed to holes around the edge of the seat where air flowed into the transport tube below. The lid lifts up and to the back, uncovering a central hole. I learned that (yuck!) solid waste tends to curl and stick to the body in weightlessness. To get enough air flow to pull it free, the commode used a hole of only four inches. (This was enlarged in 1993.) The transport tube took the place of the bowl of water. The tube is eight inches wide and is lined with a disposable bag. The open end of the bag is held in place by the seat. The instructor put a fresh bag over the hole. He explained that putting the seat down locked the bag in place. The fan wouldn't turn off until the lid was down. I smiled. The guys couldn't leave the lid up in space!

During use, the bag is kept inflated by the air flowing through the holes around the seat. Air passes through the bag, but wet wipes and solids are trapped inside. When done, instead of flushing, the crewmember lifts the lid and puts a plastic cover over the bag. Then the compactor is placed over the hole and rammed down through the transport tube into a canister underneath. He showed us what this looked like and said it could hold 25 flattened "cow patties."

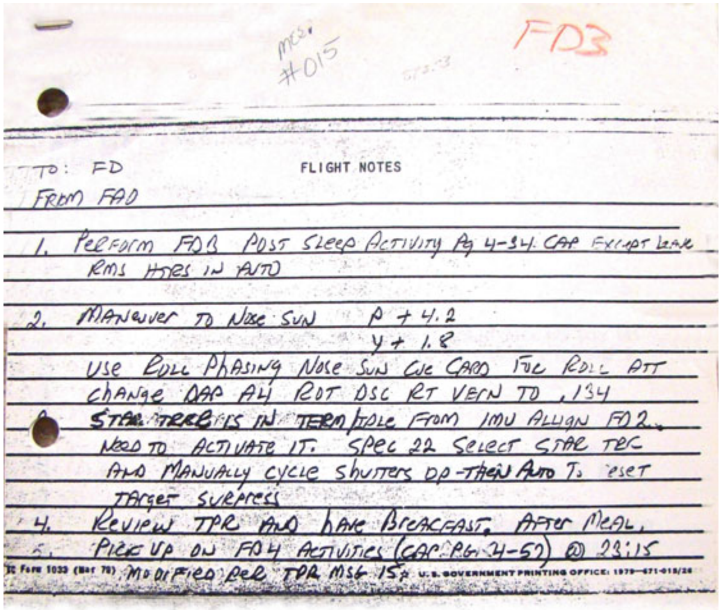
He noted that waste never touches the tube, so it remains clean, important for a reusable shuttle. The urinal was a separate unit that could run at the same time as the commode or by itself. It looked almost exactly like a vacuum cleaner attachment. The urinal fan turns on when the hose is pulled from its holder. The water was removed from the urine through a centrifuge. The crew had chemicals to "flush" down the urinal to keep bacteria from growing. I asked how it'd be different for women, and he said they'd just have a differently-shaped attachment.

The instructor then calmly explained that because the opening of the commode was so small, it took some practice to line up so that the waste went into the bag. To help us determine the best position, a camera had been placed in the center looking up out of the hole. He placed his fist over the opening and we saw it appear on a little monitor mounted beside the seat. With a perfectly straight face, he then invited each of us to take a turn on the seat!

I exchanged a wide-eyed look with Mi-Mi. Was he serious? No way was I going to expose myself in front of these guys! If that meant I flunked the class, then so be it. The guys seemed equally embarrassed by the whole idea. They shifted awkwardly from foot to foot, and no one offered to be first. The instructor seemed puzzled. Then a smile slowly spread across his face. "Oh!" he said and chuckled. "Obviously since this is a mixed class, you don't have to disrobe. You can go ahead and try it with your clothes on!"

Back on console, I thought about what it meant that the motor had stopped working while the commode was "in use." Without air flow to suck the waste into the bag, it had very likely hit the bottom of the bag and bounced right back out. Good old Newton's Law: action-reaction. Yuck! No wonder they hadn't called us. They'd been cleaning up a mess. And whoever the unlucky guy was that hadn't finished his turn had been forced to stick a bag to his rear with the equivalent of Dentu-Cream. Just thinking about it made me nauseous, and I wasn't space sick.

Because the crew were getting a late start and hadn't read the teleprinter message yet, Carolynn wrote a Flight Note for Capcom to voice up instructions for initial activities. We told them to do the FD3 post sleep activities with a few exceptions, maneuver to nose sun, have breakfast, and go to FD4 page 4–57 in the CAP, as modified by our teleprinter message.



MSG #015
STS-3
FD3

TO: FD
FLIGHT NOTES
FROM FAO

1. PERFORM FD3 POST SLEEP ACTIVITY PG 4-34 CAP EXCEPT LEAVE RMS HTRS IN AUTO
2. MANEUVER TO NOSE SUN P + 4.2
Y + 1.8
USE ROLL PHASING NOSE SUN CUE CARD FOR ROLL ATT CHANGE DAP A4 ROT DSC RT VERN TO .134
3. STAR TRACKERS IN TERM/IDLE FROM IMU ALIGN FD2. NEED TO ACTIVATE IT. SPEC 22 SELECT STAR TRK AND MANUALLY CYCLE SHUTTERS OP - THEN AUTO TO RESET TARGET SUPPRESS
4. REVIEW TPR AND HAVE BREAKFAST. AFTER MEAL,
5. PICK UP ON FD4 ACTIVITIES (CAP PG 4-57) @ 23:15 MODIFIED PER TPR MSG 15
JSC Form 1033 (Mar 78) U.S. GOVERNMENT PRINTING OFFICE: 1979—671-018/26

9.4 Controllers wrote instructions for the crew on Flight Notes that were approved by the Flight Director and read up by the Capcoms. This is one that FAO Carolynn Conley prepared on the morning of the third day of STS-3 (Photo by the author)

Jack said he hoped this wasn't going to "mess up the total output of the mission."

Capcom said, "We don't see anything wrong with swapping these around, and it's just a minor change as far as we're concerned."

Minor change?! I rolled my eyes at Gerry, busy walking Bob Schaf through the CAPS program mess.

Lousma asked if he could reset the circuit breaker on the commode. Capcom asked, "Do you need it?" I logged "(!!)"

Crew Systems told FAO to tell them it was okay to reset the circuit breaker. But by the time Capcom relayed the message, Lousma said he'd do it later. What he wanted now was a roll angle and a start time for the IMU alignment. Pointer Greg Walding recited the numbers to Carolynn who read them to Flight. Capcom then read them to the crew. Way to go FAO team! We were going to earn our AttaBoys and AttaGirls.

During LOS, I tried to explain everything we'd done to Mi-Mi. I was so tired, I wondered what I might have missed (besides Thor who was now in the front room). We'd marked up a CAP using the teleprinter message so it would match what the crew had on board. We hoped.

At the next site, we did some troubleshooting on the toilet. It worked for a few minutes, and then quit again. I was glad to be going home to a working toilet.

When I left the building, the bright Sun nearly blinded me. Because I'd arrived at work at sundown the night before, I'd forgotten my sunglasses again.

I'd just worked a 14-hour shift. I had to be back in nine hours—that didn't even include my travel time. Even if I fell into bed instantly, I couldn't get eight hours of sleep. And right now, I needed about ten. Oh, the joys of being a hot-shot flight controller! What would I do when the flights were twice a month? I shut the dark navy blue drapes and set my alarm for 4 p.m.

It seemed I'd only slept a few minutes when that alarm sounded. I dragged myself into the shower, telling myself that it was only for a few more days. If Mi-Mi, being seven months pregnant, could work these crazy shifts, what did I have to complain about? Jasper Kitty followed me from room to room. Had I fed him this morning? Had Thor? His dish was indeed empty. "Poor baby!" I said, picking him up for a quick snuggle. I filled his dish, ate a bowl of Cheerios, and headed back to the maelstrom of flight planning.

MORE 14-HOUR PLANNING SHIFTS

When I arrived with the rest of the Ivory Team, the crew were in the midst of their evening meal. They reportedly felt much better. It was now 2 days and 8 hours MET, the end of FD3. The vehicle was performing well. Even the toilet had been partially recovered.

The cold-soak attitude had some unexpected effects. The crew cabin got so chilly that the windows fogged. The condensation interfered with TV images of the bay. Some creative folks used the 1-g trainer in Building 9 to invent a sort of funnel out of the plastic cover of the world atlas and (of course) duct tape to direct air from a vent to clear the aft windows.

Lousma reported a stowaway fruit fly in the cabin. The principal investigator of the Plant Growth Unit, Carol Peterson, asked him to keep the fly off the mung beans. Lousma said, "He was getting pretty good at flying around here. That's probably where he is. So far those plants growing haven't pushed the lockers up or anything like that."

I chuckled. I could just see the headline: Jack and the bean stalk "fly" in space!

The bugs taken to space intentionally, including moths, flies, and honeybees, were surviving in their "Bug Box." PAO reported, "in their television appearance, they were not exactly buzzing with energy. Most clung to the inside walls of the case, except when shaken." Lousma reported that the moths had adapted better than the bees and were getting around without flapping their wings much.

The day swap had apparently gone smoothly except for the Get Away Special. Mi-Mi logged, "Whole sequence is messed up." Lousma blamed this problem on a last-minute change to the procedure. One of the pen and ink changes was to "Wait 10 minutes" before doing the second part. Lousma had paused and then gotten distracted. He said, "And that's a write in, of course, and that's what we were saying before flight about all these last-minute changes."

I thought of all those PCNs and the missing page I'd discovered in the Orbit Ops Checklist. Mistakes like these were inevitable.

Mi-Mi went home, and I settled in for the night. I'd arrived around 6 p.m. I'd be on console until 8 a.m., out of sync with the rest of the working world, and my husband, too.

I watched the power levels drop during the crew's "presleep" activities which included putting up window shades and turning off lights and CRTs. The nose-to-sun attitude had increased the cabin temperature to 81 degrees. Someone joked that they shouldn't mind since it was about the same temperature in Houston. I had no idea what it was like outside. My world had narrowed to the support room where the air conditioning made my teeth chatter.

Crew went to bed around 10 p.m. As usual, our job was to prepare the flight plan for the next day while they slept. The crew were only going to get eight hours of sleep this time, so we wouldn't have the luxury of that extra hour of planning. I looked at the FD3 morning timeline and shook my head. We were using the same physical pages twice. We'd be making mark ups on top of mark ups. Commander Lousma would not be happy.

Four hours later, we were almost done with the summary level timeline, but still had a myriad of details to work out. I logged that PAO had requested that the payload activity, especially the beaming experiment which was being recorded and supposed to be cool to watch, be downloaded for them to release to the press. I wanted to see that too, and I hoped I'd get a chance eventually—but I never did. It seemed ironic that I'd been involved in planning this flight for three years and wouldn't get to see any of it. I wished that I were on the Orbit shift with Thor!

The timeline update was on hold while we discussed how to do the robotic arm activities without breaking the cameras. We'd been in nose-to-sun attitude for 18 hours now, and the cameras were frozen. Once the arm lifted up out of the payload bay, the cameras would be exposed to sunlight. After 30 minutes of Sun, the cameras should be warm enough to turn on safely. Unfortunately, nothing was ever that easy. The timeline sequence in the plan the crew had onboard had them starting the procedure during orbital darkness.

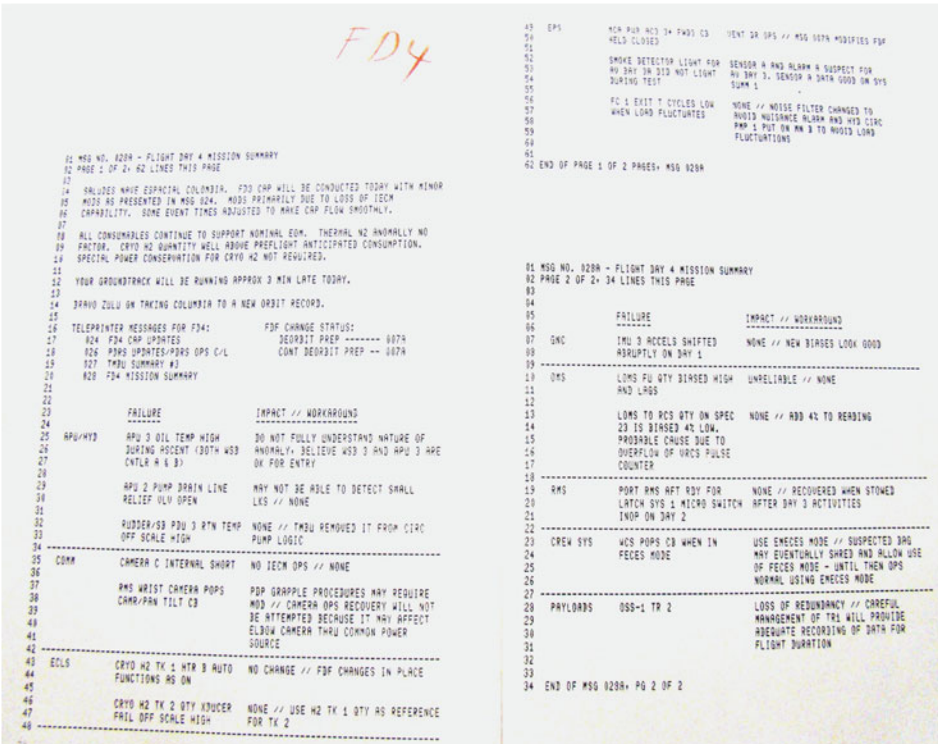
The simple answer was to just extend the test to allow the cameras to warm up. That required another set of instructions added to the CAP Update which was already so long it would take two comm passes to uplink it all. But Flight didn't have time to talk about it. He was busy with the debate about whether or not it was safe to leave the PDP on the arm overnight.

The original plan had been to stow the PDP while the crew slept, and then deploy it again the next day. But the camera warm up would shorten the time the PDP would actually operate in space. The scientists had already missed a whole day of data because of the crew being sick. They wanted as much data as possible to make up for it and argued hotly for approval.

How difficult it was for the crew to grab or grapple the PDP? We didn't know. If that procedure proved difficult and time-consuming, then not having to repeat it the next day would save time and be a real benefit. But the Flight Rules pretty much nixed that idea. If there were a need for an emergency deorbit, we didn't want the crew to have to stow a payload in a rush. If it got "stuck" part way in, a real possibility with the cargo bay warped from the cold, the doors couldn't be closed to come home. But Dale Moore, speaking from a shuttle safety perspective, said it might actually be safer to leave the PDP on the arm. Then it could be simply jettisoned overboard along with the arm. Needless to say, the scientists didn't like this line of reasoning!

The debate about the PDP carried over to the IECM's planned use to test "loads" on the arm. The decision was to leave the IECM in the bay and use the PDP instead. This got the scientists some more data, so they were happy. However, the loss of the wrist camera changed the PDP grapple procedures, requiring another teleprinter message. It would be crew lunch time before we got all these messages up!

Pads also had to prepare a two-part message summarizing the status of the vehicle systems. This "Mission Summary" included the good news that the APU that had shut down during launch was good for entry. The only failed equipment were the arm cameras and the toilet.



FD4

MSG NO. 028A - FLIGHT DAY 4 MISSION SUMMARY
PAGE 1 OF 2, 62 LINES THIS PAGE

SALUDES NAVE ESPACIAL COLOMBIA. FD3 CAP WILL BE CONDUCTED TODAY WITH MINOR MODS AS PRESENTED IN MSG 024. MODS PRIMARILY DUE TO LOSS OF IECM CAPABILITY. SOME EVENT TIMES ADJUSTED TO MAKE CAP FLOW SMOOTHLY.

ALL CONSUMABLES CONTINUE TO SUPPORT NOMINAL EOM. THERMAL N2 ANOMALLY NO FACTOR. CRYO H2 QUANTITY WELL ABOVE PREFLIGHT ANTICIPATED CONSUMPTION. SPECIAL POWER CONSERVATION FOR CRYO H2 NOT REQUIRED.

YOUR GROUNDTRACK WILL BE RUNNING APPROX 3 MIN LATE TODAY.

BRAVO ZULU ON TAKING COLUMBIA TO A NEW ORBIT RECORD.

TELEPRINTER MESSAGES FOR FD4:
024 FD4 CAP UPDATES
026 PDRS UPDATES/PDRS OPS C/L
027 TMBU SUMMARY #3
028 FD4 MISSION SUMMARY

FDF CHANGE STATUS:
DEORBIT PREP ------- 007A
CONT DEORBIT PREP -- 007A

	FAILURE	IMPACT // WORKAROUND
APU/HYD	APU 3 OIL TEMP HIGH DURING ASCENT (BOTH WSB CNTLR A & B)	DO NOT FULLY UNDERSTAND NATURE OF ANOMALY, BELIEVE WSB 3 AND APU 3 ARE OK FOR ENTRY
	APU 2 PUMP DRAIN LINE RELIEF VLV OPEN	MAY NOT BE ABLE TO DETECT SMALL LKS // NONE
	RUDDER/SB PDU 3 RTN TEMP OFF SCALE HIGH	NONE // TMBU REMOVED IT FROM CIRC PUMP LOGIC
COMM	CAMERA C INTERNAL SHORT	NO IECM OPS // NONE
	RMS WRIST CAMERA POPS CAMR/PAN TILT CB	PDP GRAPPLE PROCEDURES MAY REQUIRE MOD // CAMERA OPS RECOVERY WILL NOT BE ATTEMPTED BECAUSE IT MAY AFFECT ELBOW CAMERA THRU COMMON POWER SOURCE
ECLS	CRYO H2 TK 1 HTR B AUTO FUNCTIONS AS ON	NO CHANGE // FDF CHANGES IN PLACE
	CRYO H2 TK 2 QTY XDUCER FAIL OFF SCALE HIGH	NONE // USE H2 TK 1 QTY AS REFERENCE FOR TK 2
EPS	MCA PWR AC3 3φ FWD3 CB HELD CLOSED	VENT DR SPS // MSG 007A MODIFIES FDF
	SMOKE DETECTOR LIGHT FOR AV BAY 3A DID NOT LIGHT DURING TEST	SENSOR A AND ALARM A SUSPECT FOR AV BAY 3. SENSOR A DATA GOOD ON SYS SUMM 1
	FC 1 EXIT T CYCLES LOW WHEN LOAD FLUCTUATES	NONE // NOISE FILTER CHANGED TO AVOID NUISANCE ALARM AND HYD CIRC PMP 1 PUT ON MN B TO AVOID LOAD FLUCTUATIONS

END OF PAGE 1 OF 2 PAGES, MSG 028A

MSG NO. 028A - FLIGHT DAY 4 MISSION SUMMARY
PAGE 2 OF 2, 34 LINES THIS PAGE

	FAILURE	IMPACT // WORKAROUND
GNC	IMU 3 ACCELS SHIFTED ABRUPTLY ON DAY 1	NONE // NEW BIASES LOOK GOOD
OMS	LOMS FU QTY BIASED HIGH AND LAGS	UNRELIABLE // NONE
	LOMS TO RCS QTY ON SPEC 23 IS BIASED 4% LOW. PROBABLE CAUSE DUE TO OVERFLOW OF VRCS PULSE COUNTER	NONE // ADD 4% TO READING
RMS	PORT RMS AFT RDY FOR LATCH SYS 1 MICRO SWITCH INOP ON DAY 2	NONE // RECOVERED WHEN STOWED AFTER DAY 3 ACTIVITIES
CREW SYS	WCS POPS CB WHEN IN FECES MODE	USE EMECES MODE // SUSPECTED BAG MAY EVENTUALLY SHRED AND ALLOW USE OF FECES MODE - UNTIL THEN OPS NORMAL USING EMECES MODE
PAYLOADS	OSS-1 TR 2	LOSS OF REDUNDANCY // CAREFUL MANAGEMENT OF TR1 WILL PROVIDE ADEQUATE RECORDING OF DATA FOR FLIGHT DURATION

END OF MSG 028A, PG 2 OF 2

9.5 Each night the Flight Controllers prepared a Mission Summary, like the Flight Day 4 message shown here, to send the crew in the morning (Photo by the author)

Once the messages were on their way to the crew, I marked up my copy of the Crew Activity Plan during hand over to the Orbit Team, and timed myself. I then noted in the log, "crew will need about 20 minutes to do pen and ink to CAP. Note to post flight: leave time for P&I at front of morning." After the mission, the crew would heartily agree with this suggestion. Teleprinter review time would become a permanent part of all future flight plans.

As the crew reviewed the messages, Gordo congratulated the team for adjusting the Table Maintenance Buffer Update (TMBU, pronounced tim-boo) so that no alarms woke them during the night. This was the first time in the shuttle program that no "nuisance" alarms had gone off. We were finally getting to know the systems well enough to set the temperatures and pressure values to avoid triggering alarms. Capcom had no sooner said, "I understand no alerts during the night," when an alarm sounded in the cockpit. Everyone laughed. Capcom joked, "*Columbia*, Houston, we didn't want to pass up the opportunity, the payloads data and retrieval system alerts—you can disregard." Although the alert wasn't important, it illustrated that we still had a lot to learn about the arm. We'd get some good data during the tests with the PDP today.

Lousma commented about all the messages we'd sent, saying "Looks like you guys have really done a lot of the planning, a lot of hard work."

We appreciated them acknowledging our work on the open loop like that.

Just before I left, Orbit Team Capcom Sally Ride asked the crew how the temperature was in the cabin overnight. Lousma reported that he'd been a little too warm on the flight deck, so had taken off his jacket. He said, "I did notice that when I went down the stairs this morning that it seemed colder downstairs than up."

Ride replied, "Okay, Jack. Our theory down here is that that's because heat rises."

Not being able to see Ride's face to know for sure that she was joking, everyone in the room exchanged puzzled looks. Hot air weighs the same as cold air in space—nothing. So hot air does *not* rise. Also, there is no upstairs or downstairs in space, the flight deck is "up" and the middeck is "down" only in the simulators. Then Lousma replied, "You thought you were going to get me on that one, didn't you?" Sally reported the upcoming LOS. Lousma kept talking. "To be frank about it, you almost did." Then we heard him tell Gordo, "There's a little hot air coming up on the uplink."

Just as they "went over the hill" and we lost comm, Ride quipped, "I heard that."

9.6 Sally Ride joked with the STS-3 crew during her shift as Capcom. Next to her is Capcom George Nelson, FAO Bob Nute, and standing, FAO Carolynn Conley, arriving for handover (NASA photo)

Yep, the crew were definitely feeling better today. I handed over to Mi-Mi and headed home again. I had to be back in less than 10 hours.

All I had time to do was eat and sleep. When my alarm went off, I wondered what day it was—or rather what night. The newspaper said it was Thursday. The sun was setting. Sigh. Had Thor taken out the trash? Nope. Oh well, he probably didn't know what day it was, either. I went to get breakfast and discovered we were out of milk. Maybe Thor could get some on his way home? At least I'd thought to stock up on cat food. Poor Jasper was getting matted. I really needed to brush him, but when? I barely had enough time to sleep six hours.

I went into the closet and blinked my eyes to focus on my clothes in the dim light of the single bulb in the ceiling. How many more shifts did I have? They didn't land until Monday—so tonight plus Friday, Saturday, and Sunday. Hmph. Could I wear that brown skirt again with a different shirt? The guys could get away with wearing the same suit over and over, but women were expected to be "fresh" every day. Carolynn said it was really important to look professional. But I sure was getting tired of stockings. I'd run another pair yesterday. And it was so darn cold in the support room! What I needed were dressy pants suits, but they were really hard to find.

When I got back to work, Mi-Mi said that her shift had gone well. The crew had successfully accomplished the first ever grapple, unberth, and stowing of a payload with the robotic arm. All that TV planning had paid off, too. They'd seen some cool images of the PDP being hoisted up and out of the bay, and then held steady while they'd fired the big primary jets. The small stuff had gone pretty well, too. The Electrophoresis blood samples had separated electrically as planned and been frozen. The payload bay was so cold from the nose-to-sun attitude that the radiators provided all the cooling. The FES had been shut off to save power.

One funny thing that'd happened was that one of the crew had bumped the flight control "stick" and engaged the manual system by mistake. They'd drifted out of nose-to-sun quite a bit before we'd had a comm pass where Pointing had discovered the roll rate was wrong. He'd quickly calculated the correct roll rate for FAO who gave it to Capcom for reading up to the crew. Lousma was embarrassed for not noticing he was out of attitude sooner. They'd been out of ground contact eating their meal in the middeck immediately after it happened. I wondered how he could have possibly known they were out of attitude without the usual clues of acceleration? Sheesh, I wasn't even in freefall, just in the windowless Building 30, and I barely knew what day it was. I'd be completely "lost" in space.

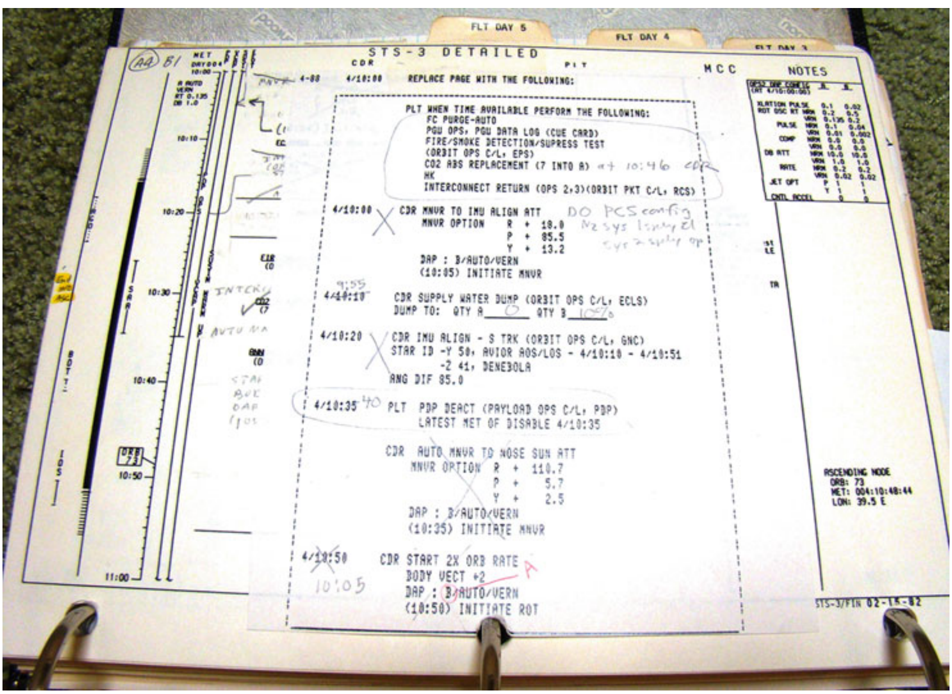
The Silver Team said their good night to the crew and told them the next pass would be reserved for a medical conference. Then just a minute before we lost com, the active onboard transponder quit working. This kept us from getting any voice or data from the orbiter. The only way we had to talk to them was via UHF, and the next ground site coming up didn't have UHF. So Capcom had asked the crew to cycle the communication settings, but either they forgot to do it or it hadn't worked because we didn't hear anything at the next pass. If they didn't hear from us, the malfunction procedure would have them switch to the other transponder. We all sat listening intently for a signal on the air-to-ground. As if it would make any difference, we kept our voices to whispers. The support room was as silent as it ever gets for those long five and a half minutes. But we didn't even hear the usual static. I logged simply, "Quiet."

Had they even missed us? Maybe they were enjoying the silence and the captivating view. I suspected that with the timeline all messed up (they were still following FD3 even though it was FD4), they were wondering if they were on the right page or had the time wrong. My suspicion was confirmed when Capcom Griggs called them at Botswana (a UHF only site) and Jack didn't even mention the lost pass. Griggs read up the new switch configuration, and we got data at the next pass, but no voice.

On the Flight loop, INCO Pennington suggested that we just stay on the good transponder overnight and worry about regaining redundancy in the morning. Troubleshooting it now wasn't worth keeping the crew up past their bed time.

The crew went to bed, and we went to work planning their fifth day in space. Every planning shift for the past two flights and simulations, we had built a teleprinter message using the format of "Page/CAP Time/Activity." The crew and flight control teams would then mark their books with the changes. But our books were almost unreadable now because of all the preflight changes plus the need to shift the day/night and ground coverage for the late launch. So we decided to replace the center of some of the CAP pages. This would allow the crew to execute the timeline from the TPR message taped into the book.

The only problem with this approach was that we couldn't match the format of the CAP. The teleprinter was like a typewriter, only capable of one font size and spacing between lines. We couldn't line up the activities with the time ticks. If the crew taped the message into their book, it covered up ground site information on the left and stuck out of the bottom. Pads Jay Penn came up with an idea for a new format, a box that could be cut out and taped into the book. We created the FD5 Cap Update message using this new format. I logged, "We should find out post flight how the crew felt about this format and standardize it for every flight."



9.7 Pointing Jay Penn created a new format for the Cap Update that could be cut out and taped it into the book as shown here in my console copy (Photo by the author)

We had the draft plan ready for review four and a half hours before the crew was scheduled to wake up. It got approved, retyped, and sent to "Repro" for copies to distribute for final review an hour and 40 minutes before wake up. We finally had this job figured out!

Around 5 a.m., Crippen showed up in our support room and passed out OSS-1 buttons to all of us. I proudly pinned one on my shirt collar.

About a half hour before the crew was supposed to get up, a payload alarm woke them up. Payloads Officer Tandy Bruce sheepishly said he'd thought that parameter had been disabled. Oh well, one more TMBU to reset tomorrow night. Even though we knew the crew were up, we pretended they were still asleep. They'd need the extra time to read the five messages we'd sent.

Holloway informed us that handover would be delayed so that we could make sure the crew had time to review the plan and ask questions before we left. Why hadn't they thought of this last night when it would have made a difference to the Entry Team? They were probably already on their way in. Shoot, some of the team had already arrived. But I didn't feel too badly for them. After all, they hadn't even been on console since Tuesday! But now we wouldn't get off duty until 8 a.m. and had to be back by 7:30 tonight. "Why is the Ascent Team getting the shaft?" I complained in my log. I wondered just how many days in a row I was supposed to follow this 13-hours-on, 11-hours-off schedule and still perform my best work?

I left Building 30 on this Friday morning wondering what I was going to eat for dinner. None of the fast food places were open this early, and I was pretty sure Thor hadn't gone to the store. Wait! He was home! The Orbit Team had the day off.

I hurried across the parking lot as most center employees were arriving for the day. I hadn't even seen Thor since the launch. Thoughts of dinner and sleep fled from my mind as I shifted the Subaru's manual transmission into fourth gear, anxious to get home.

His car was still in the driveway. I hoped to surprise him in bed, but he was already up and dressed, reading the paper. In fact, he was about to leave. "Do we have anything left in the house to eat?" I asked, wandering into the kitchen. Jasper pushed his soft self up against my legs. I picked him up. "Are you hungry, too?" I asked as I rubbed the side of his head. Thor joined us in the kitchen for a "three-way" hug. "Hmm," I mumbled sleepily. "I've missed you."

I put Jasper down and opened the refrigerator door. I stared at its meager offerings: a half-empty can of cat food. A plastic pitcher of tea. A glass jar of Smucker's strawberry jam and a jar of Kosher dills. I frowned at the limp-looking lettuce in a plastic wrapper that hadn't been closed, some dried up looking whole carrots, and something fuzzy that may have once been a zucchini that was rapidly evolving into an alien life form in the vegetable drawer. "No milk?"

Thor shrugged. "I'll get some on the way home tonight," he promised. "But hey, I saved you some dinner from last night!" He pointed to the old steel saucepan with matching lid that sat on the bottom shelf. Dare I look?

I pulled it out by its aging wooden handle and lifted the lid: hot dogs and mushroom soup with noodles and peas: Thor's favorite "bachelor chow." It was barely better than that evolving alien vegetable.

I kissed Thor on the cheek. "Thanks," I said. I turned on the burner to warm up my dinner. Thor didn't know it yet, but he was getting a microwave for his birthday in June!

Thor left for work, and I sat down to eat and look over the paper. The flight was still front-page news. The electrical potential experiment had provided some really cool photos!

SLEEP SHIFTING

Once again I fell into bed and woke with a start when my alarm went off. I took a shower to revive myself and then nearly fainted from fright when Thor said hello from the other side of the shower curtain. "What are you doing home?" I said, my mind still fuzzy with sleep.

"I'm not due in until noon tomorrow, remember?"

No I hadn't. I didn't even know what day it was. Friday? "Did you get milk?" I finally managed to ask.

"Yes, and bread, too. I made macaroni and cheese for dinner—you want some?"

"Not for breakfast!" I said. "Toast would be great. And orange juice if we have any."

"I got some of that, too," he said.

Was I married to an angel or what? I sure wished I had time to crawl back into bed with him. But I barely had time to get dressed before I had to leave. I was going to miss "Wall Street Week" with Louis Rukeyser. "See you, um, Sunday? Monday?" I said at the door.

"You'd better take your coat," Thor advised. He explained that a cool front had come through while I'd slept. I slipped on my new pale blue trench coat, grabbed my briefcase, and dashed out. It was overcast and getting dark already at just after 7. The air was thick with the smells of damp grass with a hint of honeysuckle. I eyed my front garden wistfully, hoping the cool weather lasted until after the flight. I had a lot of gardening to do.

This time of night, I had my choice of parking spots. The Entry Team had been there when we'd left, and they were there when we got back. They'd had a long shift and had to be back again to relieve us in the morning—but they didn't get any sympathy from us: that's what we'd been doing all week with the Orbit Team. At least they were sleeping when it was dark out.

I settled in at my console and read Marion's neatly printed log. I appreciated what a good job he'd done. He'd only recorded conversations that were pertinent to the timeline (whereas I recorded all sorts of extraneous chatter). The day had gone well. One test that they tried hadn't been on any official manifest: a method for removing bubbles from their drinking water.

In freefall, bubbles don't automatically rise to the top—there is no top. So when an astronaut squirts water into a bag of drink mix, any air bubbles in the water stay embedded. Dr. Billy Thornton (an MD and astronaut hired in 1967 who would finally fly on STS-6), suggested simply spinning the bag around: using centrifugal force to push denser water to the "outside" end where the straw was inserted. The crew did the experiment during lunch and reported it during Orbit 68: "We used the bag that had the colored, strawberry color in it, and slung it around a few times and all the water went to the drinking end, and all the air went to the opposite end. So it looks like Bills' little invention is one that really works, and our hats are off to him."

The transponder hadn't been recovered. So we only had data downlink through transponder 1 in high power mode. At a press conference, Kranz assured the public that we still had enough redundancy in the communications to continue the nominal flight.

Still, this was a serious problem. We were one failure away from having to come home. So our planning shift included looking at that as well as planning a "normal" day.

Our Ivory Team Capcom Griggs greeted the crew. Lousma said, "Hello to your team," and, apparently noting how few hours had elapsed since we were on duty earlier in their day, added, "You guys sure drew straws for the bad duties."

Dave answered for all of us when he said, "we're glad to be here, Jack."

Despite being tired and not knowing what day it was (Gerry, what day is it? "Flight Day 5." No, what day of the week is it? "Heck if I know!"), I was indeed glad to be here in Mission Control. I just wished that management would divide up the shifts in a more equitable manner.

We read up a new configuration for the comm system and then said goodnight.

Their morning, and ours, would come even earlier than usual tomorrow. Because of the way the Earth "rolled out from under" the shuttle, the times when it passed over the landing site at Northrop came earlier each day. Their wake-up time shifted two hours earlier during the flight. Thus, the crew (and the Entry Team!) were only scheduled for seven hours of sleep tonight. Then tomorrow night, they'd go to bed an hour early and get up eight hours later. Sunday night, they'd go to bed at the same time as Saturday, sleep seven hours, and be up an hour early again. If we had to come home on Sunday, we'd have to make the whole two-hour shift in 24 hours.

Anyone who has ever tried to go to sleep hours early knows how hard it is to actually sleep. How many of us drag around for days after we "fall back" from daylight savings time or travel to eastern time zones? It seemed obvious to me now that the shift should have come sooner in the flight. We needed them well rested for entry. Yet during the three years I'd worked on the STS-3 timeline, no one, including Lousma and Fullerton, had expressed any concern about shortening two sleep periods near the end of the mission. The crews of STS-1 and 2 hadn't complained, and both had less than eight-hour sleep periods. In fact, Young and Crippen both said that six hours would've been sufficient. Engle and Truly had suffered from fatigue, but that had been blamed on the incessant interruptions of alarms, not short sleep periods.

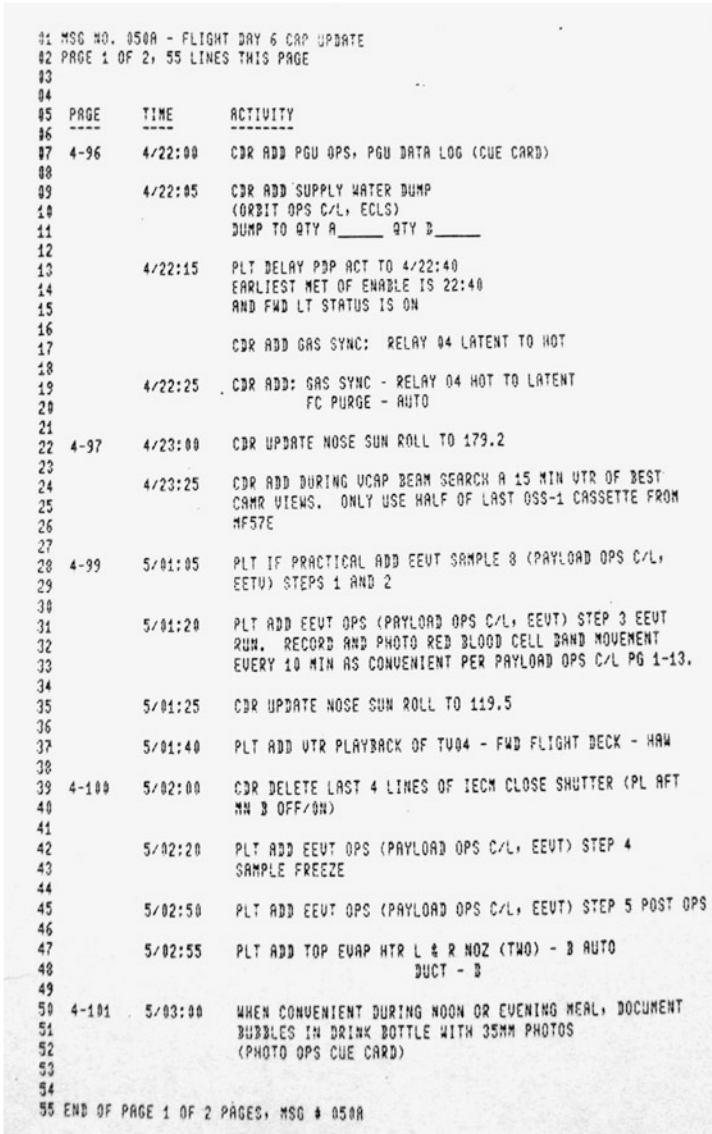
But this flight forever changed the way NASA handled crew sleep. I logged: "Note for STS-4 and subs: all sleep periods must be eight hrs long. No 7-hr sleep periods." I dearly hoped that this new awareness of the importance of sleep would be applied to flight controllers, too!

The issue of sleep was especially pertinent this night in light of the possibility that we were one failure away from coming home early.

If they had to come home Sunday versus Monday, not only would they have to get by on less sleep, they might not get to land at Northrop. High winds were kicking up the white gypsum dust there, and Edwards remained flooded. Our only option Sunday was the as-yet never used concrete runway at KSC. With only two landings under our belts, we wanted the extra margin the desert offered. We didn't want to plunk our multi-billion-dollar shuttle into a Florida swamp!

So the transponder failure haunted us. The INCOs had done all the troubleshooting they could think of, and still had no idea what had caused the failure. Multiple hardware failures seemed unlikely, but software updates hadn't done any good. So the Ivory Team studied what we'd do if another failure caused us to return on Sunday.

Though we weren't swapping days, the changes to the Flight Day 6 timeline were extensive. This was the day that we concluded the 80-hour cold soak test and maneuvered to a "hot soak" of top-to-sun. Before we made that transition, we wanted to check what effects the cold had on the ability to close the payload bay doors and also to fire the OMS engines. We also cancelled the IECM payload activities because of the camera failures.



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MSG NO. 050A - FLIGHT DAY 6 CAP UPDATE
PAGE 1 OF 2, 55 LINES THIS PAGE


PAGE    TIME      ACTIVITY
----    ----      --------
4-96    4/22:00   CDR ADD PGU OPS, PGU DATA LOG (CUE CARD)

        4/22:05   CDR ADD SUPPLY WATER DUMP
                  (ORBIT OPS C/L, ECLS)
                  DUMP TO QTY A_____ QTY B_____

        4/22:15   PLT DELAY PDP ACT TO 4/22:40
                  EARLIEST MET OF ENABLE IS 22:40
                  AND FWD LT STATUS IS ON

                  CDR ADD GAS SYNC:  RELAY 04 LATENT TO HOT

        4/22:25   CDR ADD: GAS SYNC - RELAY 04 HOT TO LATENT
                           FC PURGE - AUTO

4-97    4/23:00   CDR UPDATE NOSE SUN ROLL TO 179.2

        4/23:25   CDR ADD DURING UCAP BEAM SEARCH A 15 MIN VTR OF BEST
                  CAMR VIEWS.  ONLY USE HALF OF LAST OSS-1 CASSETTE FROM
                  MF57E

4-99    5/01:05   PLT IF PRACTICAL ADD EEVT SAMPLE 8 (PAYLOAD OPS C/L,
                  EETU) STEPS 1 AND 2

        5/01:20   PLT ADD EEVT OPS (PAYLOAD OPS C/L, EEVT) STEP 3 EEVT
                  RUN.  RECORD AND PHOTO RED BLOOD CELL BAND MOVEMENT
                  EVERY 10 MIN AS CONVENIENT PER PAYLOAD OPS C/L PG 1-13.

        5/01:25   CDR UPDATE NOSE SUN ROLL TO 119.5

        5/01:40   PLT ADD VTR PLAYBACK OF TV04 - FWD FLIGHT DECK - HAW

4-100   5/02:00   CDR DELETE LAST 4 LINES OF IECM CLOSE SHUTTER (PL AFT
                  MN B OFF/ON)

        5/02:20   PLT ADD EEVT OPS (PAYLOAD OPS C/L, EEVT) STEP 4
                  SAMPLE FREEZE

        5/02:50   PLT ADD EEVT OPS (PAYLOAD OPS C/L, EEVT) STEP 5 POST OPS

        5/02:55   PLT ADD TOP EVAP HTR L & R NOZ (TWO) - B AUTO
                                          DUCT - B

4-101   5/03:00   WHEN CONVENIENT DURING NOON OR EVENING MEAL, DOCUMENT
                  BUBBLES IN DRINK BOTTLE WITH 35MM PHOTOS
                  (PHOTO OPS CUE CARD)


END OF PAGE 1 OF 2 PAGES, MSG # 050A
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9.8 Changes to the Flight Day 6 timeline required a 2-page message uplinked to the crew. Page 1 of 2 shown (Photo by the author)

Once we had the nominal plan figured out, we turned to the "what if we come home Sunday" plan. One thing we had to add in that case was the entry rehearsal, a.k.a., the Flight Control System (FCS) Checkout. The Checkout normally took about 35 minutes, but we needed 20 more minutes to test APU 3 that had overheated during ascent. Our challenge was to find 55 minutes that wouldn't compromise the high priority thermal tests.

Scheduling this Checkout depended on when the decision was made to cut the flight short. We had two high priority tests in the normal timeline: the door cycling, and an OMS burn. The OMS burn was higher priority than the door tests. So if we made the decision early, we'd do the FCS Checkout in place of the door tests. But if we made the decision *after* we'd done the door tests—we'd do the Checkout during the time scheduled for the OMS burn.

If we didn't make the decision until after we'd already completed both the door and engine tests, we'd perturb the payload data in the top sun attitude, and keep the crew up late. We all hoped we wouldn't need to exercise any of these options.

While discussing the Mission Summary message that listed all the failed equipment, Crew Systems told FAO that if the commode quit working completely, we should tell the crew not to use the "fecal" bags onboard. I noted in the log, "Tell crew those bags don't work as advertised, and to use Apollo bags instead." These were sandwich-sized plastic bags that attached to the buttocks. Apollo astronauts ate a low fiber diet specifically to minimize the need to use these bags. However, the Crew Systems folks assured us these bags were still preferable to the new ones. Supposedly "tests" had been done comparing the two. I didn't press for details.

The crew's seven-hour sleep period went by in a blur. PAO noted that STS-3's duration had now surpassed the combined length of STS-1 and 2. I logged, "CAP Update and 12-hour distributed by crew awake minus 30." We'd almost been late, but had squeaked in under the wire. Carolynn should get her Atta-girl now.

But Carolynn and I hadn't finished our "what if we come home Sunday" plan. So we'd do our handover and then meet at a table in the support room and finish laying it out.

While Marion and I did our handover, the crew were greeted by a taped message from their families. Lousma's 13-year-old daughter asked how he'd slept. Completely deadpan, Lousma said, "With my eyes closed." I groaned along with others listening in the support room.

Fullerton remarked that just after they removed the window shades, the shuttle passed into darkness, and that made him want to "roll over and go back to bed."

Capcom said lightheartedly, "You might want to after you read the CAP Update."

These were the longest messages we'd ever sent. Fullerton said, "I'm reading my morning newspaper here. I noticed that it gets longer and longer to read it these days."

We sent them the weather updates at the next pass and told them we were handing over to the Entry Team. The crew replied, "We see more paper coming....Thank you for sticking with it all night and for making a good plan, and we're looking forward to carrying it out."

Capcom said, "Okay, and we'll try to reduce the paperwork tomorrow morning."

The crew said, "No problem. I was just kidding you a little bit."

I glanced over at Marion, shaking my head. Yeah, right. Just kidding. We knew from all those sims how much they just *loved* getting updates. And Capcom's comment was purely wishful thinking. As long as we had tests to do and equipment (and crew!) that didn't work as expected, we'd have a long list of changes to the preflight plan.

Marion and I finished handover by 5:30 a.m., and I met up with Carolynn. We gathered our checklists and notepads, and drafted a detailed plan for what to do if another failure required us to come home today or tomorrow. We even drafted the teleprinter messages.

I hand printed the detailed changes to the pages of a CAP and brief explanations for each step. Carolynn and I made copies for ourselves and the Entry Team. I placed mine in the console log book so that Marion would have it, and Mi-Mi would see it later as well. Future Flight Director John Cox (d. 2012) and Crippen, who were part of the "Team 4" gang that always kept abreast of any and all contingency plans, came by and thanked us for this extra work.

Carolynn and I had stayed two hours past our shift. So it was now 7:30 a.m. on Saturday morning. I headed out to my car in the gray dawn, tired, but happy. I wondered if Thor was still home? He wasn't due on console until around noon, and he had a nice short afternoon shift. On the other hand, as tempting as it would be to spend time with him, I had to be back by 5:30 p.m.

Thor was up and dressed and was finishing breakfast when I arrived. He sat with me while I had yesterday's mac and cheese for dinner. Picking up a stack of unopened mail, I complained about not having any time off to catch up on my sleep, or anything else. When was I supposed to do the laundry?! We were both down to our last pair of underwear. Thor said he'd start a load before he left if I sorted out what I wanted in it. I could put it in the dryer when I got up. That sounded like a plan.

I crawled into bed. Jasper curled up beside me. I glanced at the clock: it was almost 11 a.m. already! I cleared my mind, tried to think about anything other than the flight. But that wasn't possible. I'd been living and breathing STS-3 for almost a week now. I drifted off with voices chattering away on the loops in my head.

What was that alarm? Had something failed? Oh, that's my clock! Like Gordo, I wanted to roll over and go back to sleep. Thankfully, Jasper, who once again hadn't been fed on any kind of schedule, took over where the alarm left off. I sat up and groggily apologized to his meowing highness for neglecting my duties. I thanked him for getting me up, and buried my face in his soft fur while I carried him to the kitchen. Was it really almost 4 o'clock in the afternoon? It was dark and stormy outside, so it seemed later. Or earlier? It just didn't seem like the time of day to be getting up, and of course it wasn't. I spooned some food into Jasper's dish, and then remembered about the laundry. I was supposed to start a load.

But I didn't want the washer to hog all the hot water. I'd take my shower first, and then start it afterwards. I was half way to work before I realized I'd forgotten to turn it on. Darn, I'd have to wash something in the sink if I wanted clean underwear tomorrow.

I needed my umbrella on the way in, and felt badly dripping it all over the shiny clean floors. When did the janitors come, I wondered? Did they work on the weekends? I didn't think so. But we sure did. The crew most of all. I hoped they'd had a good day in space.

When I arrived, Mi-Mi was talking on the loop with Bob, discussing the CO_2 absorber change-out. Well, that was good news. They probably weren't coming home early, then.

A quick glance at the timeline confirmed that all the big tests had been done as planned. At the end of the cold soak nose-to-Sun attitude, they'd checked that the doors would close, fired the OMS engines, and gone to the top-to-Sun attitude. Now they were wrapping up normal crew activities like changing the filters that absorbed carbon dioxide.

After the LOS, Mi-Mi handed me the logbook to catch up on the details. Her day off (while the Entry Team worked) had done her good—she looked rested, though she admitted she was still tired. As I gulped down some bitter black brew, I remarked that I didn't know how she managed to stay awake—she'd given up coffee for the duration of her pregnancy. She said she drank hot water instead, and considered it an improvement. I laughed. The coffee really was pretty awful. I always put a ton of sugar in it. (No one had heard of Sweet and Low yet.)

The Mission Management Team had just let out—and they'd decided we were landing Monday, as originally planned. The weather looked good. The transponder hadn't gotten any worse. Even though this meant my extra work (and Carolynn's) wouldn't be used, I was glad to hear this. "One more shift to go," Mi-Mi noted with a smile.

I had tonight and Sunday night to work yet. Somehow, I'd manage. I just needed to remember to turn on the washer when I got home. Maybe Thor would notice? Normally, I could leave a message with his secretary, but it was Saturday—no one was there. Maybe he'd notice when he opened his underwear drawer?

While scanning the log, I saw that the crew had done the Electrophoresis with the primary jets active per our instructions. But "we're going to be in our normal jets and that's a no-no for electrophoresis," Gordo had noted. I wasn't surprised by their surprise. In meeting after meeting, the scientists had stressed how important it was to have no vibrations disturb the blood separation. They'd complained about being too close to the teleprinter. They didn't want the crew exercising. They certainly didn't want the big jets shaking them from here to next Tuesday. (The crew said that even one small jet firing "makes your legs swing from side to side.")

They'd held onto their idealistic perfect conditions during endless iterations of the PIP Annex. Then, a few days of flight experience had convinced them that it was better to get imperfect results than no results because their scheduling constraints were too rigid. I was glad they'd allowed us to schedule a run with the primary jets on, and also with the crew exercising on their spiffy new treadmill.

The astronauts jogged in place while strapped to the treadmill with bungie cords across their shoulders to push against. Accelerometers on board proved that exercise was a significant source of vibration—more than the teleprinter. Gordo reported that Jack was "shaking the whole cockpit." With all this shaking, it'd be interesting to see if Electrophoresis sample 8 was different from the rest. We'd have to wait until after they brought the frozen samples back to find out.

There was just one more sample left—number 7. They'd skipped that one on purpose. It was an "extra" one that it seemed we'd have time for now. I found a perfectly "calm" spot to schedule the run in between maneuvers.

9.9 Jack Lousma is shown here with the Electrophoresis Verification Test which used electricity to separate blood into its component parts. The test was unfortunately destined to fail in a rather strange way (NASA photo)

Another thing I noted was a report of a "beverage container" failure when Marion had been on shift. Marion had written "it was a bit of a mess" and "3rd beverage container that has broken in flight." Why hadn't anyone noted this before? Oh wait! Could they actually be talking about the fecal bags, and not want the news media to catch on?

Hmm. I wondered about this until after flight. But the transcript made it clear they'd been talking about an actual beverage container. Gordo said the failure happened near the valve, and added some comments about the chilled water actually being lukewarm.

Preparing the list of changes for the next day's timeline was routine now. We reviewed the CAP Update a full three hours and 11 minutes prior to crew awake time.

We'd make good on our decision to not have any more 7-hour sleep periods. We cancelled or moved everything after the evening meal. I wished I could have an extra hour, too!

Then, about an hour and a half before crew wakeup, the pen plotter failed. We always printed out a "fresh" as-planned timeline for the team using this "sunken table" that took up as much floor space as a large desk. Pens were suspended above the plot area and shifted into place by computer X-Y position commands. I'd stand beside this table and watch (impatiently) as it drew each line in black ink on large sheets of thick white paper. When people talk about a process being "drawn out" this precise, but painstakingly slow pen plotter is what I think of!

Once a plot was done, we'd pull the paper out, and send it to "Repro." The original had to be reduced to a normal 8.5 × 11-inch size that we could copy and distribute. After one page was done, we'd queue up the next plot and wait while it drew each line like a ghostly robotic sketch artist. From start to finish, it took about 30 minutes to plot each page.

Our first try to print at wakeup minus two hours had resulted in a batch of pages that were shifted like someone had bumped the table in the middle of the run—though no one had touched it. We reset and started the job over. We got about one in four pages to plot correctly. It took (whir, scratch scratch, whir, scratch scratch) f o r e v e r!

The managers who wandered in at the beginning of the day expected us to have these timelines. The controllers used them. The media used them. They were displayed under the TV camera in our support room and "broadcast" to everyone. My section chief was not happy that we didn't have them ready. But the plotter didn't discriminate. It ignored his pacing just as it had mine.

My handover to Marion was complete at 5:05 a.m. For once, it was still dark out when I left Building 30. When I got home, Thor was still in bed. I was extra quiet opening the door, though Jasper came to greet me. I was too tired to eat, so just left my clothes on the bathroom floor and crawled into bed.

FIRST EXTENDED MISSION

When my alarm went off, I didn't remember Thor getting up. It was 6 p.m., and I had to be on console in an hour. By not taking time to eat, I'd gotten eight hours of sleep, but I was still tired. Oh well, this was my last shift! Planning for entry day was always easier than other days. They were scheduled to land around 1:30 p.m. Houston time on Monday.

I took my shower, washed my long hair, and headed into the bedroom wrapped in a towel. Oh no! The laundry! I'd forgotten all about it. Well, it was too late now. I felt around in the back of my nearly empty underwear drawer and pulled out some black lace "fancy pants" that I wore on special occasions. As I modeled these in front of the mirror, I imagined Thor's surprise when I slipped into bed with him tomorrow morning after my last shift. Something to look forward to!

The crew had wrapped up the mission with a string of accomplishments. The main one was the fact of just staying in space for almost a week. We'd now passed the 100th orbit. The cold soak test was done, and the hot soak would be finished up just after handover. So we now knew that we could depend on vehicle systems under extreme thermal conditions.

The OSS-1 payload rep, Dr. Werner Neuberg, briefed the media in the afternoon before I arrived, and a typed summary from Mission Manager Kenneth Kissin was delivered to the support room. The Fast Pulse Electron Generator beam "was directed along Earth's magnetic field lines to detectors on other satellites up to 6000 km (3728 mi) away." This experiment became the "media darling" because a glowing beam rising out of the shuttle was just plain cool.

I was pleased to read that the science team reported "operations between the POCC and MCC went reasonably well and much better than in the early simulations." Three years of meetings had paid off. The shuttle was proving itself a good platform for science.

The usual crop of systems issues occurred while I'd been off duty. The port door radiator had taken twice as long to close as it was supposed to take. EECOM Charlie Dumis decided it might be a loose microswitch versus a motor, and devised a test to find out. He had the crew stow the radiators. If they stowed in their normal time, that meant the motor was okay, and a loose switch had caused the problem. If the stow time was twice as long again, then one of the two motors had failed. In that event, we'd keep that radiator stowed because if the second motor failed, the radiator couldn't be stowed for entry—and that would prevent the door from closing. So this was a potentially serious issue. The crew ran the test and both motors worked. So thankfully we dodged that bullet, and another one, too.

The commander's keyboard had quit working. The Orbit Team decided the most likely cause was that the "SPEC" key had worn out. So they had Gordo pull that key out, and replace it with an identical key from the aft station. But the astronauts figured out an improvement: they covered the hole with duct tape so nothing would float in there.

Our shuffling of activities to recover that extra hour of sleep had almost compromised our high priority thermal test. I overheard Pointing tell Carolynn that they were out of attitude—they'd started the IMU align maneuver an hour early. Mi-Mi flipped to the checklist page. They'd been supposed to enter the numbers into the autopilot at 7:52, but not start the maneuver until 8:52. The reason the list of numbers were on the page before the actual maneuver was because the crew's meal was there—and we hadn't wanted to interrupt their meal to do the alignment.

The actual maneuver had been carefully scheduled to occur during orbital darkness so as not to upset the final orbit of Top-to-Sun attitude which we'd already shortened so they could get that extra hour of sleep. Oh well, Pointing caught the mistake right away, and word was relayed to Capcom who quickly told them, "go back to Top Sun now."

9.10 First woman FAO, Carolynn Conley, called Flight to tell him the shuttle was out of attitude during our shift on Flight Day 9 (NASA photo)

I discovered the crew had already done Electrophoresis 7 the night before. I need not have wasted time finding a perfect "no maneuvers" slot for it. I reported post flight, "We should require a quick voice status of all activities at the end of each flight day. . . . A few words from the crew can save us *hours* of effort!" (My boss penned in "end of day status by crew" as a good idea. This got implemented on later flights.)

As we finished handover, Capcom George "Pinky" Nelson (1950–) signed off for the Silver Team, saying, "This is going to be the last pass of the evening . . . We think you did a super job, and we appreciate the opportunity to work on your flight."

After a few platitudes, alluding to all the sims going back to pre-STS-1, the crew joked, "Well, how long will it take Neil [Hutchinson] to debrief this one?"

Capcom opened the mike so the crew could hear everyone laughing over the air-to-ground. "And *Columbia*, rest assured the Ivory Team is going to be coming on to relieve us. Know you haven't heard much from them yet, but they're not too bad. They're reasonably confident. And they wanted me to tell you to get a good sleep because they will."

We continued laughing, knowing we had another long sleepless night ahead.

The crew then paid a very public compliment to the FAO team, saying, "I tell you, they put up a super job in the morning . . . I have to compliment you on your messages, the contents, the form, and so forth."

Mi-Mi unplugged her headset with a smile and a sigh. This was her last shift for a long time. She wasn't working STS-4 because the baby was due in May. "Maybe I'll see you at the post-landing party," I said. "If I'm awake!"

She laughed. "I think I could sleep for days."

The main (big) change to the Entry Day timeline was the deletion of the Checkout. Because it had gone so well today, the team decided it didn't need repeating. If we'd known about this earlier, we could've let the crew sleep in a little more instead of shifting their to-bed time early. Post flight, we decided to permanently move the Checkout to the day before entry.

At 12:20 a.m. on Monday morning, about half way through our shift, the CAPS crashed. I logged, "Hard failure of the main power supply." Argh! We lost five hours' worth of work.

Heedless of the time of night, we immediately called in our CAPS experts to help us recover the system. In the meantime, we had to do the replanning job by hand. Pads got the messages typed in record time, and we were even ready early.

But without CAPS, we couldn't plot the As-Flown timeline showing what the crew/vehicle had done and when. Especially on this final day of the flight, the managers were keen to have this timeline to toot our success to the news media. The CAPS contractors were well aware of this and really worked hard to get the system back online. They got the hardware working by 1:30 a.m., and then loaded the keep tape. To our tremendous relief, with Gerry's help, they recovered the data we'd assumed lost. We still had to wait on the plotter—but thanks to some great teamwork, we got the messages and the timelines and mission reports all done and distributed by the end of our last shift.

Carolynn was really proud of us, and I was proud of her. Our first woman FAO had done well. I hoped I'd be able to manage our roomful of geniuses and juggle management's often conflicting demands as well as she had.

We'd had a little fun, too. Carolynn created a mock "Real Time Crew Procedure Change Request" to the FAO Console Handbook. The detailed change in exact wording said, "Denny's 6/18:30 MET, Ascent Team FAO support personnel meet for meal prep/meal/close kinship development. This is to be followed by a much needed rest period."

Under the "Technical Rationale" it said, "Due to the last 7 days of inattention to the needs of his people . . .it is deemed necessary that [our branch chief] invite all of his beloved Ascent Team folks to a gathering place of the Team's choice for the purpose of renewing that close kinship that existed prior to this flight. Secondly, it is only fitting that he take care of all expenses since the Team looks to him as a 'God' father figure."

She got this signed by the managers in the SPAN and the Program Office and our section chief during the night. We all had a good chuckle over it, helping to reduce the tension and some of the resentment the Ascent Team had for the grueling shift schedule. There was no intention of actually meeting at Denny's at 4:30 a.m. on Monday. I don't think they were even open. But our branch chief got the "change request" later and took it all in good humor.

Thor was asleep when I got home. I slipped into bed without waking him, set the alarm, and snuggled up beside him. I'd planned to sleep four hours and get up to watch the deorbit burn around noon. But at 11:30 a.m., Thor came in and woke me up. "They waved off," he said.

"Huh? What?" I mumbled, totally out of it.

"The winds were too high at Northrop," he explained. "I'm heading in now—they haven't updated the recording yet, but I assume your team will relieve mine tonight."

Still trying to process all this, I blinked as he bent down and kissed me on the forehead. "Gotta run. See ya," he said.

I padded into the bathroom. Would this flight never end? I saw my pale reflection in the mirror. The circles under my eyes were so dark, I could easily play a zombie in a horror movie. What was I supposed to be doing? Oh yeah, sleeping. Better reset the alarm. My shift had started at 7:30 p.m. last night. I reset the clock for 5, figuring that would give me enough time to get ready. I lay back down and wondered if Thor had thought to start the laundry.

The phone ringing startled me awake about 1 p.m. I fumbled for the phone by the bed.

One of the secretaries from work informed me that I was to be on console at 6:30 p.m. She didn't know what time the shift would end. "Okay," I said. What time had I set my alarm for?

"Meow!"

"Oh hello, Jasper," I said, scratching his chin. Had Thor fed him this morning? I carried him to the kitchen. "There's food in your dish," I pointed out. I sat him down and headed back to the bedroom. But he continued to squeak. He was trying to tell me something. "Your box!" I hadn't changed it since before the flight. I took the box to the garage and dumped it into a bag. (We didn't have scoopable cat litter yet.) I filled it with new litter and took it back in. A grateful kitty immediately jumped in.

Now that I was awake, I was hungry. Stupid dumb schedule! I'd been looking forward to finally being able to do more than sleep next to my husband for a few hours. I'd never get pregnant this way! My mood didn't improve when I opened the refrigerator to discover we were once again out of milk. Bread and water. Yum. Oh well, I'd survive. It was only one more day.

After the flight, I'd submit my opinion on the shift schedule: "Ridiculous. Everyone worried about the crew health, how about the Ascent Team? It is very upsetting to work days then shift to nites [sic] 14 hours long! There is no excuse for working people to death."

I got up at 5 p.m. and turned on the TV. To my surprise, the change-of shift briefing was on! Had I missed my shift? Hadn't the secretary said to be there at 6:30? I ran to the phone and called the number. It said 6:30. I wasn't late. Apparently, it was the briefing that was late. Because the Entry Team had to be back on console tonight at 1 a.m., Draughon had gone home and Mr. Kranz had stepped in to do it. He said that we were still planning to land at Northrop, but that KSC was available if we needed it. He emphasized that the extended mission, the first one in human spaceflight history, posed no danger to the crew. *Columbia* had plenty of fuel and supplies. The ship's systems are "in excellent shape," Kranz said. The landing would be earlier in the day to avoid the winds—they hoped to land at 10:07 a.m. CST. If I wanted to watch it, I'd barely have time for a nap when I got home.

Bad weather had delayed the landing and was also threatening the local area. Rain poured in sheets outside. I got soaked getting to the car. I heard on the car radio that high tide and flood warnings were in effect for nearby Seabrook and Kemah. Marion lived in Seabrook.

The earlier landing opportunity meant that the crew had to be up two hours earlier than the day before. So we told them to go to bed two hours early. But they couldn't go to sleep early. Lousma asked if he could go to a better attitude for photographing Earth. He couldn't. The BBQ mode used the least amount of fuel. Power constraints likewise kept them from adding any payload operations. We also shut down some equipment so power levels were around 10–11 KW all night. We finally had proof our power down procedures worked.

Because of the crew's shifted sleep period, we only had about six hours to prepare all the messages. I wrote, "Crew awake minus 1:25. Deorbit Prep Update not even close to done yet." Carolynn's Atta-girl was in jeopardy. We created and plotted a new summary timeline for the new FD9 with the trajectory and activities. I'd suggest adding an extended mission summary timeline to the CAP for STS-4, and management would agree.

The storm continued to rage outside, but Marion showed up right on time at 1 a.m. We were done with handover by 2 a.m. Holloway wouldn't release us. He wanted our team to have several passes with the crew to answer any questions. We were stuck there until almost 3:30 a.m.

We (mostly the Pads team) made up a silly rhyming message we asked to send the crew, but Holloway said no. Copies made their way around though, and everyone got a good laugh. The bad poetry captured our "slap-happy" feelings at the end of this seemingly endless flight.

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MSG NO. 999Z - ASCENT TEAM REQUEST REAL TIME RELIEF
PAGE 1 OF 1, 25 LINES THIS PAGE


 COLUMBIA, COLUMBIA, PLEASE COME BACK.
 I NEED A DAY OFF BEFORE I CRACK.
 I NEED A GOOD BATH AND I'M FIGHTING SLEEP,
 OUR MATES HAVE ALL LEFT US AND WE'RE STARTING TO WEEP.
 WE'VE SPENT ALL OUR OVERTIME ON DRINKING AND DRUGS,
 OUR KITCHENS ARE DIRTY AND WE'RE SEEING LITTLE BUGS.
 YOUR RADIO IS BROKE,
 AND YOUR TOILET IS A JOKE,
 COME BACK NOW LIKE DESCENT FOLK.
 ANTICIPATION IS TOO MUCH TO TAKE,
 OUR KIDS HAVE FORGOTTEN US,
 AND WE'VE GAINED TOO MUCH WEIGHT.
 THE BILLS ARE LATE, HAVEN'T READ MY MAIL,
 LOOKS LIKE BAD CHECKS...THEY'RE GONNA TAKE ME TO JAIL.
 SO HURRY COLUMBIA HURRY PLEASE,
 YOU'VE GOT ALL THE OPERATORS DOWN ON THEIR KNEES.


 **************** THE ASCENT TEAM *********************

 END OF MESSAGE 999Z
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9.11 The FAO team prepared a silly poem to uplink to the STS-3 crew, but the Flight Director wouldn't allow it (Photo by the author)

Post-flight, the crew said it would have been perfectly fine to send it the night before entry. Their positive comments circulated as quickly as the original message and guaranteed the FAO support room would create more silly messages in the future.

The winds died down at Northrop. Crews were out all night clearing the white sand off the runway to increase visibility.

I got home around 4 a.m. and went straight to bed. Thor was sound asleep. I set the alarm for 8:30 a.m. When I got up, Thor already had the TV on. He'd been in touch with folks at the office and they were definitely coming home today. Hurrah!

They landed at Northrop on Tuesday, March 30. The winds were actually so calm that they couldn't do the crosswind landing test. We'd have to pick up that test on the next flight so that we could start landing at KSC. The official duration was 8 days, 4 hours and 48 seconds. The astronauts were welcomed by their families and big crowds at White Sands. Lousma said, *Columbia* "performed magnificently."

The crew flew home to Ellington that afternoon. The rain had stopped, but the sky was still white with clouds. Thor and I went to greet them. I don't think either of us were wearing underwear.

9.12 At the STS-3 Welcome Home, Thor snapped a photo of STS-1 pilot Bob Crippen and me. Astronaut John Fabian is in the background (Photo by the author)

10

Secret Preparations and Discrete Discrimination

I only got one day off after STS-3. We had as-flown timelines to publish, lessons learned to write and review, and checklists to update, all of them seemingly due yesterday.

So starting April 1, I gathered and summarized the reports from all the support room controllers. The chief complaint was, big surprise, the shift schedule. Our complaints about this, like our complaints about micromanagement on STS-2, mostly fell on deaf ears.

We did get some pretty cool tokens of appreciation, though. The crew signed a photo for me saying, “With special thanks for the professional touch and patient effort you gave to the timeline for a near perfect mission!” I’d gotten my OSS-1 pin during the flight, but afterwards, I was surprised when they presented me with a certificate and a patch that had flown on *Columbia*. The certificate read, “This emblem, flown aboard STS-3, March 22 through 30, 1982, is presented to you in recognition of the significant contribution you made to the success of the OSS-1 mission.” They even personalized the certificate with my name. These patches didn’t go to everyone—Thor didn’t get one even though he’d been a front room operator. I was honored and touched by this recognition.

The *Roundup* headline read, “Another for the books: STS-3 doubles airframe time, stirs scientists with experiments.” With a wry smile, I read that “it was the longest space flight since 1975.” At times it’d felt like it had been ongoing SINCE 1975! [1]

Another news report was rather unsettling, and seen from the far future, a sort of ominous premonition. “The biggest surprise was losing almost 40 tiles on ascent from two locations: on the nose of *Columbia* just above the forward reaction control system, and on the body flap at the extreme aft end of the spacecraft. . .speculation is that the culprit was either ice flying off the external tank or heavy aero-acoustic loads on ascent. . .. As many as a thousand tiles may be pulled off and densified before STS-4” [2]. Some 30 years later, we’d still be replacing tiles instead of preventing ice from impacting them during launch. The fact that we’d survived the damage on this flight and others to follow would lead to a sense of complacency that would contribute to the loss of the vehicle and crew in 2003.

M.J. Dyson, *A Passion for Space*, Springer Praxis Books,
DOI 10.1007/978-3-319-20258-7_10

10.1 The Office of Space Science gifted me this very special memento that included a patch flown in space on STS-3 (Photo by the author)

The *Roundup* didn't mention the little Electrophoresis test whose requirements document had gone through so many tribulations. Had the blood separation technique worked? Had their placement next to the teleprinter been a problem? I was especially curious about sample #8 that had been jolted by primary jets and crew exercise. When I inquired, I discovered some sad news.

The test tubes containing the separated blood had been frozen and placed in a freezer on the shuttle. The tubes had been transferred off *Columbia* at Northrop and sent to a lab. Liquid nitrogen was supposed to keep the samples frozen, but it had either been used up too quickly or had leaked out. The precious samples, representing millions of dollars in ground and crew time, melted. All separation data was lost. The only consolation was that the next electrophoresis unit was already scheduled for STS-4.

HITTING THE GLASS CEILING

Amidst celebrating our success on STS-3, management dropped a bomb on Carolynn, me, and Mi-Mi. On the Monday after the flight, a memo appeared in my inbox: "FAO MCC Preliminary Staffing Projection." I eagerly flipped to the list of positions and personnel assigned to flights 5 through 8. "This can't be right!" I exclaimed.

All of the women FAOs had been removed from their lead positions. All those positions were now assigned to men. Also, a non-civil servant (Bill) was being given a plum assignment ahead of two women civil servants with more experience. What was going on?

My disbelief turned to indignation the more I thought about this. I didn't begrudge Bill becoming an FAO. But no contractor had yet been promoted to a front room position. Wasn't that why Diane, who had years more experience than any of us, hadn't been promoted to FAO?

The only change that made sense was holding Mi-Mi at Timeline for one more flight (STS-5) and slipping her debut as FAO to STS-6 in case she needed to extend her maternity leave. But removing her as lead of STS-8, more than a year away, seemed punitive.

Carolynn, Mi-Mi, Marion, and I got to together over lunch to discuss the situation. We reviewed the qualifications and experience required to be a lead FAO. Based on Elvin's old memo about training FAOs, we agreed on two basic guidelines. Rule 1 was that a person had to be a Timeline twice before becoming an FAO. This rule only had one exception and that was for Tucker on STS-2. There'd only been one previous flight, so that explained this exception. Or did it? Carolynn and Diane had also been Timeline on STS-1. Did Tucker's military experience prior to coming to NASA give him "seniority" over Carolynn? We assumed Diane hadn't been chosen because of being a contractor. But considering Bill, who worked for the same company, was now slated to be an FAO, we were left wondering why he'd been chosen over Diane.

The second rule was that a person couldn't be an FAO on the flight prior to or immediately after being a lead FAO. This was the "workload" rule. This was why Elvin, lead on STS-4, hadn't worked STS-3 and wouldn't work STS-5. It was also why Bob, lead on STS-3, wouldn't work STS-4. But the new assignments had Ben as FAO on STS-5 and lead on STS-6. I wasn't assigned to STS-5 or 6, but my lead assignment on STS-7 had been given to Bill anyway. In fact, I had no assignments at all after STS-4!

Carolynn hadn't been assigned to STS-5, and had been removed as lead, and even as FAO, from STS-6.

Obviously, the rules were being applied differently for the men than the women.

Diane had been assigned to take over as lead Timeline for STS-4 because Wayne Huning was being promoted inside MacDac. Yet despite this being her second time as lead Timeline, she wasn't in the running for FAO. She was still assigned as lead Timeline on STS-7—we'd done some preliminary work on it together. But now she'd be working for Bill instead of me. She mentioned that Bill was being groomed to take Wayne's place as her boss. Was that why he was being given this assignment?

As I slid into my gray vinyl chair, I pondered the situation further. Had Carolynn and I done something wrong during STS-3 to trigger this? Our branch chief had taken the mock change notice with good humor. I hadn't heard any complaints from our flight directors.

Unfortunately, there was only one logical conclusion which I wrote at the bottom of my analysis. "The reshuffling of assignments was not driven by training requirements or experience. The new assignments show favoritism and discrimination."

We owed it to the women coming after us to speak up, even though we were all nervous about what it might cost us personally. Carolynn contacted the Federal Women's Program manager, Virginia Hughes. She also said that she'd talk privately with a manager in the Training Division, Jim Bilodeau, who knew all of us and would provide a neutral perspective. She'd then arrange a meeting with our Directorate Chief, John O'Neill.

So the three of us, with Virginia and the manager from Training acting as observers, met with O'Neill on Thursday, April 8. We reviewed the assignments and the guidelines we felt had been applied differently to the women in our branch. We noted that we didn't know if the source of the discrimination, was our section, branch, or division chief, so we felt we had to come to him. (O'Neill was the next level up. He reported to Mr. Kranz.) He took our concerns seriously, thanked us for bringing it to his attention, and promised to schedule a follow-up meeting with us after he'd further reviewed the situation.

A SECURE JOB?

STS-4 was rapidly coming on the heels of STS-3, and I was still on tap to be an FAO for the first time regardless of having no downstream assignments. With the future of all women flight controllers, at least women FAOs, being evaluated by all levels of management, I had more reason than ever to prove that I could do this job as well as, or better than, any man.

I was still in charge of Post Insertion, but I'd handed over my Launch Day Deorbits and the contingency deorbit procedures to others to free me to focus on STS-3, and, I'd thought, planning STS-7. Instead, my only new assignment was to create and oversee the STS-4 Twenty-Four-Hour Late and the Extended Mission timelines. These timelines addressed procedural changes if we slipped the launch like on STS-1 or stayed in space longer like STS-3.

Carolynn and I had attended some STS-4 briefings with Elvin, the lead FAO for the flight. With STS-3 behind us, we attended our first classified briefing with the Air Force personnel who'd be working the flight from their control center in Sunnyvale, California.

The meeting was in the same windowless room in Building 1 where we held the crew flight data file reviews during the "prime contact" weeks before flight. A security guard was stationed outside the door. He checked my red badge, which showed I had a secret clearance, and also checked that my name was on the "need to know" list to attend this briefing.

The first thing we did was confirm that everyone had received and reviewed the *DOD 82-1 Security Ground Rules* (Document PA-CWP-002-82, January 19, 1982). I'd received the list of "ten commandments" in a memo from Acting Manager of STS Operations, Jerry Bostick, in January. Basically, all STS-4 flight planning was unclassified as long as "the DOD payload is not identified as the source of any operational requirement." We were not to reveal, on penalty of treason, the name, the attitude requirements, the external view (it was to be represented as a 14-foot diameter cylinder), or whether or not the payload was deployable. During simulations and flight, only people with secret clearances would be permitted access to the MOCR just in case someone slipped up and left a document open or spoke the payload name. Only the people, of which I was one, who were cleared to know the requirements, would be permitted access to a special room on the third floor that had a secure voice line to the Air Force facility in Sunnyvale. If the payload had a problem, the fact that it had a problem was not classified, but the details were classified.

This all seemed straightforward enough. However, management stressed that this flight was a test of NASA's ability to keep our "dang civilian mouths" shut as well as to implement the classified requirements. If anyone asked about information in *Aviation Week* (a.k.a. Aviation Leak) magazine, I was to reply, "I can neither confirm nor deny that information is correct."

So, even though Thor had a secret clearance and was working STS-4 as a guidance officer, I couldn't tell him anything about DOD-82-1. He didn't have a need to know.

We were warned that Russian spies could be, right this minute, on a boat out on Clear Lake videotaping us as we talked on the phone, eavesdropping on our conversations by reading our lips or measuring the faint vibrations of our voices on the windows. Therefore, all discussions involving the STS-4 payload had to be conducted in person and in rooms without windows. We could only remove the checklists and requirements documents (kept in a safe) if they were concealed inside a lockable briefcase, and that briefcase never left our touch or sight. The timelines were unclassified, though. Copies of the Post Insertion, CAP, and Deorbit Prep were available to the public. The timelines had no mention at all of DOD-82-1 in them.

Although the briefers had warned against Russian agents prying secrets from us after getting us drunk in a bar (yeah, right!), I was completely sober when my ability to protect government secrets was tested. My desk phone rang. The secretary said it was *Aviation Week* reporter Craig Covault. He had a few questions about STS-4. Would I take the call?

I'd talked with Covault about STS-3, and I'd been impressed with his level of understanding and subsequent articles about the flight. I loved that he included details about the people as well as the equipment. He provided a perspective that, being as close as I was to the flight, reminded me that what we were doing was historical and of interest to people around the world. I loved seeing the photos of the orbiter and equipment during processing at the Cape. Subscriptions were pricey, but both Thor and I considered *Aviation Week* a must-read publication.

I picked up the black handset of my phone and pushed the blinking button. “Hello,” I answered. He didn’t come right out and ask me if DOD-82-1 was deployable or not—a question I knew not to answer. Instead, he asked questions about how long various activities took and what the attitude requirements were for them. After I’d explained how the robotic arm and thermal tests were different from STS-3, I realized what he was doing. He seemed to already know I couldn’t tell him if any maneuvers were required to support DOD-82-1. But knowing how long it took the crew to do other activities, he could look for blocks of time in the schedule where a deploy might be scheduled—or not.

I answered all his questions honestly, but I was careful not to elaborate like I’d done for STS-3. After I hung up it occurred to me that even if I hadn’t been briefed about the payload’s requirements, I could’ve figured out most of them using the “Covault” elimination method. I shared my thoughts on this with Elvin who said that Covault had also called him. He reassured me that I’d handled things properly. I was reminded that we were not to disclose who was on the need-to-know list or give out the names of any of the Air Force personnel. Elvin said that if Couvalt had the roster, he could, and probably would, call them all and use our collective answers to figure out what none of us would tell him directly.

EMERGENCY IN A SMALL PLANE

Finally, the reports were filed, the debriefings debriefed, and though I hadn’t heard back from O’Neill yet about our discrimination complaint, Thor and I decided to take a vacation while we could. He rented a Piper Cherokee to finally take that trip to California to see my brother that we hadn’t had time for in the fall. We’d stop at Grand Canyon for more than one day this time. We’d also visit my Aunt Fran in Los Angeles and do Disneyland. I hoped that the time away from my stressful job would be just what I needed to finally get pregnant. We’d been trying for more than a year now. So on April 17, 1982, we headed out to the Houston Gulf airport.

We loaded our gear into the Cherokee and Thor settled into the pilot’s seat. Because of the shuttle, I thought of the left seat as the “commander’s” seat. But that would make *me* the pilot, and I certainly wasn’t. I joked that he was both Commander AND pilot for this flight. I lifted a grocery bag of snacks and suggested I’d be the stewardess. “I like that idea,” he said.

Houston Gulf was a small single strip airport. Like most small airports, it didn’t have a tower or any air traffic controllers. So at the end of the runway, Thor gracefully spun the plane in a pirouette while he and I checked for any aircraft or birds over us. Then Thor spoke into the radio, “Houston Gulf traffic, this is Piper three zero one two delta taking off from runway one three.” And off we went.

We climbed to about 2000 feet and headed southwest. We skirted the busy controlled airspace around Houston’s big Intercontinental (now Bush) airport. We were flying Visual Flight Rules (VFR), which meant we didn’t have to file a flight plan or report our position. But air traffic control at airports would see us on their radar if we came into range.

In these days before GPS and electronic maps, navigating was a big part of flying. As pilot, Thor had to fly the plane (control the speed, altitude, and attitude) and keep it heading in the direction we wanted to go. He used a compass, a paper map, and a set of very-high frequency omni-directional radios (VOR). The VORs receive signals from dish antennas on the ground—all medium to large airports have them. Pilots navigate from one VOR to another on "Victor airways" that are like interstate highways in the sky. Pilots can use these or map their own VOR-to-VOR paths to their destinations.

I was happy to leave the navigating to Thor while I lost myself in the view. As we got farther from Houston, the freeways gave way to recently plowed fields and grassy pastures. The noise prevented conversation, and so I let my mind wander. I hadn't seen Tommy since that trip to the space conference where Thor and I had fallen in love. Patrick would be eight in June, Paul was six, Christine had turned two in February. Would Thor and I ever have a family like that? I glanced over at my "commander" with one hand on the yoke, and one hand holding a clipboard. I smiled. It was going to happen. Maybe we'd even get started tonight!

About 100 miles from Houston, the engine lost its rhythm like an instrument suddenly going off key. The plane rattled and shook. "What's going on?" I hollered over the racket.

Thor didn't answer. He was following a memorized procedure for a failing engine. He pushed the black throttle knob all the way in to increase the power. He pushed in the red fuel mixture knob. The engine roared and choked like a dragon with a spear down its gullet.

Maybe something was wrong with the fuel? He switched gas tanks. The plane lurched when he switched tanks. But then it continued to shake rather violently. I chewed my lip. Something was definitely wrong.

"Montgomery Center, this is Piper three zero one two delta," Thor said loudly, but calmly, into the mike. The only sign of tension was his tight grip on the yoke. "Engine is running rough. We're losing altitude."

I looked down. The ground was getting closer. Oh my God! We were going to crash!

We were out of range of their radar. Thor read off the VOR direction and the distance so they'd know where we were. *So they'd know where to find the wreck!*

The propeller blades spun and then stuck, like a mixer trying to turn against a lump of hard butter. Normally, the prop blades spun so fast, I could see the sky through them. But now they appeared like ugly black smears staining the pretty white clouds.

Our one and only engine was failing, and we were dropping out of the sky as fast as the space shuttle. Thor pitched the nose up to stretch out our glide. But we were so low that we had two, maybe three minutes before we'd hit the ground.

On the overhead speaker, I heard our guy at Flight Service tell another pilot to clear this frequency, he was working an emergency. He was talking about us! I searched the area below hoping to see a farmhouse, a tractor, some sign of civilization.

"A dirt road!" I said pointing. Thor nodded. He'd already spotted it. It didn't look like it had been used lately. Grass had reclaimed parts of it. Was that a fence there at the end?

I imagined the gear catching in the soft mud, the prop flying apart and hitting a wing: *the plane bursting into flames*. How would I get the door open? How would I get Thor out if there were a fire? Would we even survive the crash? For someone who wrote procedures to help the astronauts through a crisis, I was ill-prepared for what to do during an engine failure. Why hadn't I asked him more questions before we took off on this trip?

I touched Thor's arm and put on my bravest face. "Is there anything I can do?" I asked.

"No," he said, unwrapping the handheld radio from around the yoke. He had tied it there to help keep the plane flying level. Because he weighed more than me, it tended to tilt in his direction. But now it was in the way. I could use that to call for help if he got knocked out.

"Okay if I pray?" I asked.

"Yeah," he said. "That might help." I noticed he didn't say not to worry, or try to assure me we'd be fine. The seriousness of the situation was clear to us both. We were going down.

I squeezed my eyes shut. "Lord," I prayed. "I've never needed you like I need you now. Please don't let us crash! I know I'm asking for a miracle, but I believe you can save us. And when you do, I promise to give you all the credit! Amen."

Instantly, the vibrations eased. "Thank you Lord!"

Thor flashed a tight smile my way. He told the guy on the radio, "Engine smoothed out. We're holding at about 200 feet."

Yikes. Two hundred feet! If the engine hadn't smoothed, we'd have been on the ground in seconds!

The guy replied, "Eagle Lake is directly south of your position. Advise you head in that direction. Call us when you're on the ground."

"Roger, heading south to Eagle Lake," Thor answered, while yawing the plane until the compass said South. The cows had scattered under us, running in terror from our big metal bird.

We weren't on the ground yet, but I was no longer terrified. Having cheated death by seconds, I now had hope. God had answered my prayer. We'd survive. But that didn't mean we'd get out of this unscathed. I snatched a pillow from the back seat and hugged it to my front. If we ended up in the field short of the runway, it might keep me from hitting my head on the dashboard. I didn't want to get knocked out and block the door. The only exit was on my side.

The airport! A runway never looked more beautiful than on that day. Thor tried calling Flight Service to tell them he had the airport in sight, but we heard only static. We'd dropped out of range and were on our own now.

Eagle Lake had two runways making a narrow X. I expected us to glide straight in from the top right because it was the closest one. But I was in for a surprise. Thor had spotted the wind sock and decided to land the opposite way. He banked around in a loop and came in from the bottom of the X instead.

But after the turn, he didn't something really strange. He'd worked so hard to maintain altitude that we were now too high. If we didn't lose altitude fast, we'd go off the end of the runway. He put the flaps down—and the plane jerked and started falling faster. I caught my breath. But we were still too high. So he yawed the plane to put the right wing forward, placing the body of the plane into the wind and slowing us down more. I had no idea what he was doing—I felt I was on some poorly designed carnival ride, falling out of the sky sideways!

When the wheels hit the pavement, I barely felt a thing. I didn't need the pillow at all. But we were really close to the end of the runway, and there was a fence there! Thor quickly pulled back on the throttle and swung the tail around. We were down! And all in one piece! I was amazed at how calm and professional Thor was as we taxied back the way we'd come and onto the apron. I glowed with pride. This man I'd married was a rock I could count on in any kind of emergency. He'd stayed focused on the task at hand and brought us down safely. Even though my heart was pounding, I hadn't lost it either. I hadn't screamed and turned into jelly. My biggest frustration was that I hadn't been able to help. That was something I was going to correct soon.

We taxied to the small airport station. Thor pulled the throttle all the way back, and the engine sputtered to a stop. The propellers froze in place. I popped the window, letting the wind whistle through the cockpit in appreciation.

"We made it!" I said, leaning over to plant a wet kiss on his forehead.

"Yeah," he said, taking a deep cleansing breath.

A line boy came trotting up to the pilot's side as I struggled to get the door unlatched. I didn't seem to have any strength in my arms.

Thor reached over and popped it open for me. (Later he said he should have told me to unlatch it while we were coming down. If we'd crashed, we might have been trapped with the door shut.) The line boy hollered, "That engine didn't sound too good."

"No kidding!" Thor said, sarcastically.

I laughed. I felt a little light-headed and giddy. The blue sky had never looked so blue, the grass never as green as in that moment.

Thor told this teen that the engine had failed and then mysteriously smoothed out just as he was preparing to land in a pasture. I said, "It wasn't mysterious. God answered my prayer!"

Thor agreed that was about as good an explanation as any.

I crawled out onto the wing. I shakily slid off the wing and to the pavement. With my feet once again on solid ground, I looked skyward and said, "Thank you, Lord. Thank you."

Thor asked the boy if there were a pay phone he could use. He explained that he needed to call Flight Service right away, or they'd assume we'd crashed and come looking for us. The phone was in the pilot's lounge inside.

Anxious to make that call, Thor quickly followed me out. But when he tried to stand up on the wing, his knees gave out. "Whoa!" he said with a laugh, lowering himself to sit on the wing. "Now I know what they mean by weak-kneed!"

We were both a little bit in shock after our ordeal. But it only took a few minutes for our youthful hearts to slow to a more normal pace.

Thor dug some change from his pocket and called Flight Service to report our safe landing. Then he called one of the aircraft mechanics who was in the Bay Area Aero Club that we'd rented the plane from. A guy named Larry Birdwell offered to fly out in a Cessna 172 with some tools. He'd look at the Piper and either fix it or fly us back to Houston in the Cessna.

We both had an abundance of nervous energy, so we took a walk while we waited for Larry. Dewberries were ripe and ready for picking all along the runway apron. We plucked the juicy berries and fed them to each other, savoring the sweetness and special joy of being alive and in love on a spring day. I wondered if this were somewhat like how Engle and Truly had felt coming back to their families after STS-2's shortened flight?

It was late afternoon before Larry got there with the Cessna 172. He opened up the Piper engine and declared it a total loss. I remember him saying it was a miracle that the engine put out any power at all after it "swallowed a gasket" and had only two working cylinders.

We unloaded our bags and my banjo from the Piper and transferred them to the Cessna. In addition to being a mechanic, Larry was a flight instructor. So Thor flew the Cessna back to Houston under his instruction. He was then cleared to fly it to California, if we still wanted to go.

Thor asked if that was okay with me. I said, "Of course."

My answer surprised Larry. "You're a lucky man. Most wives would refuse to get back on another plane after what just happened!"

Thor squeezed my hand and said, "Yeah, I married the right girl."

"That's right, you did," I said with a wink. "Besides, you know what they say about lightning not striking twice in the same place? We've had our turn, so we should be safe now."

I was right about that. But there would be more challenges ahead on this trip.

CALIFORNIA, CANYONS, AND COWBOYS

We flew to Fort Stockton, Texas on Monday. Thor made sure I knew how to use the radio, and who to call if anything should happen to him. I also insisted on learning how to use the VORs to tell where we were.

I was no longer content to be an ignorant passenger. I was a flight controller, for heaven's sake. I knew the space shuttle systems inside and out—how they could fail, what we'd do when they did. If I wanted to know how this plane worked and what to do when it didn't, there was an obvious solution. When we got back to Houston, I'd sign up for flying lessons. Thor enthusiastically endorsed this idea.

We continued west Tuesday. As we headed across New Mexico and Arizona, I made a game of locating landmarks and checking them off on the map. Previously, I'd been nervous when we flew above about 5000 feet. Now I realized that the higher we flew, the more time we'd have to choose a landing place.

Then we came to the mountains between us and Los Angeles.

We had gradually risen to 8500 feet in altitude, heading almost due west. I'd never been this high in a small plane. The lower oxygen level had given me a headache, and my nose felt kind of numb, so I wasn't anxious to go any higher. It also burned more gas to go higher, and that meant it cost more money. Then I looked at the map. "Thor, that mountain out your window is 8700 feet tall! We have to go higher!"

"No we don't," he said calmly. "We're not flying over the peak. We're going through a pass."

I checked the map again. "What pass? The peak on my side is 11,200 feet!" The mountains were so close, I felt I could almost dangle a foot out the door and nab a pine cone.

He shook his head and said, "Trust me."

I reminded myself that he'd known what to do in an emergency. He never took unnecessary chances. Shoot, he never even broke the speed limit when driving. So I bit my tongue. But I whispered a quick prayer as we headed straight for one of the towering behemoths.

As one peak rose some three thousand feet in front of us and another several hundred feet on the left, a valley appeared to the south between them. A road snaked through it thousands of feet below us, trucks and cars looking like tiny Matchbox toys. We flew west, then dodged south, then north, then west again. I hadn't been able to see the pass until we were in it.

About the time my heart rate returned to normal, we were over Los Angeles, the second largest city in the United States. Thor had trained me to find airports by looking for their beacons flashing white then green then white again. I saw beacons everywhere! Which one was the little airport at Torrance that my aunt said was closest to her house?

Thor stayed high while we flew over all these airports' traffic patterns. In a big city like this, there were planes taking off and landing and sorting themselves out every minute in those first few thousand feet. He didn't want to be down there until he had to. But it took time to drop down from 8500 feet to sea level. Torrance was near the coast. A white bank of fog had formed along the shore already and was rapidly rolling in.

Suddenly, the plane spun around and went into a dive. "What's going on?" I hollered.

"I'm spiraling down," he said. "Shh, I need to listen to the radio!"

Oh. That made sense now that he explained it. My poor stomach still didn't appreciate the "elevator dropping" feeling, but at least I knew what was going on. I sure was getting tired of all these surprise maneuvers. I was definitely signing up for those flying lessons.

We beat the fog by maybe 15 minutes. Aunt Fran, my father's only sister, and Uncle Jim Farinet picked us up and took us to their luxurious home (it had a swimming pool!) that was just a few blocks from the ocean. My cousins joined us, and we enjoyed a fabulous dinner at a private club restaurant in a high rise with an amazing view of the city. I think my heart would've stopped if I'd seen the bill. But generous Uncle Jim picked up the tab.

The next day, Aunt Fran loaned us her car to drive to Disneyland. We were amazed at the number of lanes going each direction on the freeway—eight! We got there without incident and enjoyed the rides, especially the "people mover" that was purported to be the way we'd all travel in the future. I imagined riding a gondola across a deep lunar crater with the Earth high in my sky. If all went well with the shuttle, we'd be building an orbital station, and then cities on the Moon. I daydreamed about taking our children to a Lunar Disneyland.

The next day we flew up the coast of California. Many of the flower farms were awash in colorful spring blooms. We landed at Buchanan. Thor took our nephews on their first trip in a small plane, while I visited with my sister-in-law Martine and my first niece, Christine.

After another overnight in LA on the way back, we got to Grand Canyon on Monday, April 26. We took a bus to the campground. I'd camped in the winter before, in the mountains of North Carolina. But I'd had a school tent, a down sleeping bag, and wool socks. All I had now was a cheap sleeping bag and a thin nylon tent. My teeth chattered so loudly that night that I feared I might chip a tooth. I lost the feeling in my toes. Our breath condensed on the inside of the tent and pelted me with little ice crystals every time I turned over on the stone hard ground. Eagle Scout Thor, who'd spent every summer camping, slept like a hibernating bear.

I wasn't amused when he cheerfully woke me with, "Hey, it snowed last night!"

All I wanted was hot coffee. But we hadn't replaced the stove we'd exploded last fall. I couldn't even sip water: our jug had frozen solid.

I got my coffee at a small restaurant at the trail head. Not wanting to freeze another night, I suggested, with a wink at Thor, that maybe we'd have more fun if we got a hotel room that night. He liked that idea. They had a vacancy at the Bright Angel Lodge. Did we want it? Yes!

But to stay at the hotel, we'd have to hike all the way to the bottom and back in one day. The day was young, and we were both in excellent shape. Mr. Eagle Scout thought he could do it. Could I? I was tired of being a wimp. "Sure. Let's go!"

This plan was about as ambitious as the Shuttle Program's plan to fly twice a month. But we were still planning to do that. And I was determined to prove that women could do everything men could do. So if Thor could do it, I could, too! I practically skipped down the Bright Angel Trail to Indian Garden, about 4.6 miles from the rim. I wasn't tired at all, and the view was fantastic. We filled our water bottles with icy spring water that tasted divine. The weather was perfect—clear and cool. "Guidance, are you go?" I asked.

"I'm go," he said. "How about you, FAO?"

"I'm go!" So we set off on our quest to reach the bottom. It was only three more miles.

We covered those three miles in less than an hour, passing very few people. April was a perfect time to make this hike, after spring break and before school let out. We felt like we had the whole world to ourselves. I imagined that we were explorers on a strange planet in a galaxy far, far away, the first to see alien life—Look! There's a lizard sunning itself on a rock.

We made it to the bottom and clomped out on to the bridge. The Colorado River seemed to thunder its applause of our accomplishment.

But it was well past noon now, and we knew it'd take at least twice as long to go up as it had to come down. So we didn't linger. I picked up a small pink rock to remember the moment. I hid it from Thor. Mr. Boy Scout was a firm believer in "take only photos, leave only footprints." But explorers always took rock samples to prove they'd been somewhere new and different. I slipped my pretty pink pebble into my backpack. It'd be perfect for my "Mars" fish tank scenery.

Then we climbed back up the trail we'd just come down. Up and up some more. It hadn't seemed this steep before. It's 4 o'clock already?! What time will it be getting dark? Yes, we should pick up the pace. Sorry, I can't really go any faster.

By the time we arrived back at Indian Gardens, only an hour of daylight remained. No, I didn't bring a flashlight. Did you? I thought Boy Scouts were always prepared? We laughed at the fact that neither of us had planned for this contingency. Fortunately, the Moon was first quarter phase, so we had enough light to find the trail. The wind was chilly. But the sky was clear. No snow tonight!

Darkness and cold weren't the real problems, however. We were worn out. We'd already hiked more than 10 miles, and we had another 4.6 to go! It was like the morning of the STS-3 wave off. I had to push myself to move despite how tired I was.

My other choice was to sit down and await rescue. I imagined the embarrassing headline: “NASA Woman Gives Up—Needs Rescue.” Thinking of my branch chief reading that, I winced. Failure was not an option, especially for *women* flight controllers.

All I had to do was to lift one foot and put it in front of the other. One more step. You can do it. There’s a hot shower waiting for you at the lodge! “Ouch!” I squeaked. Rocks are hard to see in the dark.

“You okay?” Thor asked.

“Yep,” I answered. One more step. “You?”

“Fine.” He shuffled along behind me.

A light! Were we near the top?!

“Howdy folks!” the park ranger said shining his flashlight on us. “You doing okay?”

“Where’s the elevator?” I asked.

He laughed at my attempt at humor. “You’re almost there,” he said cheerfully.

I wondered at his definition of “almost.” But I wasn’t going to ask. I had an embarrassing headline to avoid. We shuffled upward.

Finally, about 8 p.m., we reached the top. Three 9-inch steps remained to the parking lot to get to the lodge. “I can’t lift my leg that high,” I stated, matter-of-factly.

“I can’t either,” Thor admitted.

Like a couple of zombies from some B-movie, we stiffly dragged our dead-weight feet over to the wheelchair ramp, and shuffled the final yards to the lodge. The dining room was closed. We got some candy bars from the vending machine for dinner, rode the elevator to our room. Stripped off our dusty clothes, rinsed off in the shower, and fell into bed. So much for our romantic evening. We both felt like we’d been tumbled in a stone polisher.

I’d wanted to prove myself. All I’d proven was that I was more stupid than I’d imagined! Hike 15.2 miles in one day? What had I been thinking!

The next day, my feet were too swollen for my hiking boots. I bought a pair of soft moccasins at the gift shop. We also got several Navaho hand-painted flower vases—one for us and one for Thor’s cousin Martha whose wedding to Mike was the first week of June.

Wednesday morning, we gingerly made our way to the airplane. I’d learned a good lesson here. Challenges were good, but knowing your limits is good, too.

I couldn’t help but wonder if maybe asking for my STS-7 lead assignment back was asking for more challenge than I could handle. Maybe I should have thanked them for the reduced workload? No. Even if it was kind of a dumb idea, I’d actually hiked all the way down and back out of the Grand Canyon in one day. How many people could say they’d done that? And why shouldn’t I also have a chance to see if I had the “right stuff” to be a lead FAO? I might get a few blisters along the way, but I liked being able to say, “I did it!”

I was anxious to find out what O’Neill had to say after investigating our complaint. I also had my first sim as FAO coming up on Monday. It was time to fly home.

Unfortunately, the weather had other plans. We only made it to Socorro, New Mexico on Thursday. The next day we flew eastward into Texas. Clouds pressed down from above. Thor remarked that if he had his instrument rating, we’d just fly up and over the clouds.

We didn't get very far Friday. We ended up at Van Horn, Texas, still 600 miles west of Houston. We parked the plane and walked to the local Fixed Base Operator (FBO)'s station.

FBOs are like gas stations for airplanes, a place to get fuel, snacks, and use the restroom. This one was especially nice: it had air conditioning! I plopped onto the sofa and picked up an issue of *Aviation Week*, all about STS-3. Thor immediately used the pilot's phone to call Flight Service for a weather report. The news wasn't good. Because of the nearby mountains, no planes could take off unless the ceiling was at least 2100 feet above the ground. They didn't expect it to clear until tomorrow at the earliest. But I had a sim Monday!

Thor had to stay with the plane, but maybe I could get a bus back to Houston? While the FBO attendant dug through a phone book for the bus station's number, we were distracted by a lot of chatter on the radio. Was more than one plane trying to land at once? Curious, I walked to the window. I watched in amazement while five green helicopters descended from the solid cloud bank like grasshopper puppets on invisible strings. The clouds and mist muffled the whop-whop sound and made their appearance almost a bit magical. They landed in a neat row. Helmeted men in green flight suits emerged and made their way to the station.

They were army choppers that had been on maneuvers. One pilot joked that he'd gotten so low that, "I was a danger to the fences 'round here." Ground visibility was a few hundred feet.

As soon as the ceiling rose, these guys were heading out. As a VFR pilot, Thor could fly only if he didn't have to fly through a cloud. All he needed was a hole big enough to fly up through to that clear sky above. And so we waited.

The FBO attendant said there wasn't any bus. Could I rent a car? Sorry, they didn't have a car rental place in Van Horn. But he'd be happy to give us a ride to the hotel.

I slumped into a chair. We should've cancelled the trip after the engine failure. Or not gone to Disneyland. Or skipped Grand Canyon. Or something. This whole trip reminded me of STS-3 with its scrambled beginning and delayed end.

Time passed. The ceiling outside was as stubbornly white as the one above my head in the lounge.

The FBO attendant recommended the El Capitan hotel which he joked was the only hotel. He said their restaurant was also the only one in town. Then he added with a laugh, "Fortunately, it is a good one!" I asked if there were a movie theater. Nope. Any places to go hear music? Nope. A bookstore? Nope. "You could go hiking!" the man helpfully suggested. I glanced down at my Grand Canyon moccasins, and said no thanks.

Saturday morning, we headed out to the airport at first light. We hoped the clouds would clear enough for us to punch our way out. The choppers had made it out. So we had hope. We loaded up and took off, but we couldn't find a hole. We landed back at Van Horn. Again.

I told Thor that I thought an instrument rating would pay for itself by saving us from all these hotel and restaurant bills. He agreed. I read the *Aviation Week* about STS-3 again. I wondered what Covault would write about STS-4?

Over the radio, we heard a pilot with a thick drawl announce his intention to land shortly. Did that mean we could leave? Thor shook his head. That's a corporate jet, he said. They're flying instrument flight rules.

A little later, a stereotypical Texan, complete with business suit, string tie, cowboy hat, and boots, sauntered into the FBO station and tipped his hat at me. "Howdy there little lady," he said. He was soon joined by three similarly-dressed middle-aged executives, one smoking a cigar.

The pilot chatted with Thor about the winds and clouds. He said he was taking these guys to El Paso for a quick meeting, and then heading back to Houston. He expected to be back in Houston before dinner. Did I want to join them?

Really? How much would it cost?

He laughed. "It's my pleasure to help a lady." Besides, he said, the company was paying for the jet—it really didn't cost them anything to add another passenger.

I wouldn't have to miss the sim!

Thor pulled me aside and asked me if I was sure I wanted to do this. We didn't know anything about these "cowboys." But I wasn't that worried. I decided to go.

I went up the stairs of the Cessna Citation and into the cabin. I'd expected rows of seats like in other planes. But the interior looked like a hippy party room, complete with bar. Even though it was morning, two men were smoking, drinking, and playing cards at a small table. Oh my. What had I gotten myself into? They paused their game, and scanned me up and down mischievously. My cheeks burned. "Um, your pilot offered me a ride to Houston. . ." I stammered.

"Well, come on in, sweetheart, and make yourself comfortable!" one man said. He patted the seat beside him. "You want a smoke?"

"No, no thank you," I blurted. Nervously, I stuck my hand in the pocket of my pants. What should I do? Reminded of the guy in Nashville, I realized that once they shut that door, I'd have no escape. What if they decided to party in El Paso? Would I even make it to Houston?

My fingers closed around a key in my pocket. I pulled it out. The key to the Cessna! I'd pulled my bag out of the luggage and forgotten about the key. Thor couldn't start the plane without it. "Oh!" I said. "I can't go with you after all! How silly of me," I rattled. "I have the key to the plane. I have to give it back to my husband." This explanation didn't make any sense to them, or to me for that matter. I just needed some excuse to get out of there before they got their hands on me. I backed toward the door. "Thanks for offering to give me a ride! But I've changed my mind. It wouldn't be right for me to leave my husband here all alone."

The men shot me a puzzled look. "Your husband's here?" I'm sure they'd thought I was some bimbo the pilot picked up to entertain him in El Paso. "Bye! Have a good trip!"

Feeling like the fool that I was, I scampered back down the stairs. I walked as fast as I could without running back to the station. I found Thor in the pilot's lounge.

I wrapped my arms around him. "I thought you left with those cowboys," he muttered.

"A lady reserves the right to change her mind." I held up the Cessna key. "Besides, look what I found in my pocket!" I proceeded to tell him about the bar and the drunks.

He shook his head. "You should have listened to me," he said. I very sheepishly agreed.

We spent Saturday night at the El Capitan again. We ate the same thing for dinner at the same restaurant. But I was content. I might miss the sim. I might even miss the meeting with my managers, but I'd learned a valuable lesson: safety is more important than schedule! It was one we'd learn the hard way at NASA.

We made it home on Sunday, May 2. While we were still at the airport, Thor made arrangements to start training for his instrument rating. It'd take him a year and a half, but it was worth it to not worry about being at the mercy of the weather, or a bunch of drunk cowboys.

FEDERAL WOMEN'S WEEK

I hadn't missed the sim. My STS-4 flight director was Harold Draughon, who had adopted the nickname "Dragon" Flight because of the spelling of his name, even though it was pronounced "drawn." I was the only woman on the team, so I became "Dragon lady." But only a few of my friends jokingly called me that because, after all, I was Thor's lady (a Valkarie!).

I sat next to Capcom Brewster Shaw, an Air Force pilot who'd been officially assigned as pilot for STS-9 a few weeks ago in April. He'd been one of my best crewmembers for procedure verification runs. He was only the third pilot of the 1978 class to be assigned to a flight. This showed his management's confidence in him—at least that's how those of us outside of the Astronaut Office viewed it. I wondered if the astronauts paid any attention to flight controller assignments? Did any of them know I'd been removed as STS-7 lead FAO?

Ironically, while I'd been in California, NASA had officially announced crew assignments for STS-7, 8, and 9. The big news was that Sally Ride was on STS-7. She'd be the first American woman to fly in space. This news made my removal as lead sting just a little more.

All of these early flights were historic in some way. STS-4 would carry the first classified payload. STS-5 would deploy the first commercial satellites. STS-6 would loft the first Tracking Data Relay Satellite. STS-8 would feature the first black astronaut and night launch and landing.

Was I really going to miss all of those flights? Would they restore my STS-7 job?

While I'd been out, O'Neill had finished his review. In a memo dated April 21, 1982, he said he'd talked to those involved and invited them and us to a meeting. We also invited Virginia Hughes. So we gathered in O'Neill's corner office on the third floor of Building 4.

Our section chief seemed a bit amused by the whole affair. Our division chief seemed unconcerned as well.

As we settled around the rectangular wooden table, my branch chief wouldn't look at me. I followed his gaze out the window. Trees were blooming around the duck pond. How I longed to be out there listening to the birds instead of testing the strength of my deodorant in this suddenly stuffy office.

Carolynn had suggested that we not all sit on one side of the table in an "us versus them" manner. So she sat in the middle of the table on one side, and Mi-Mi and I sat across from her. O'Neill sat at the head of the table with Hughes beside him.

O'Neill reported that in his discussion with those involved, he hadn't uncovered any intent to discriminate against women. However, he agreed that regardless of the intention, the new assignments had given the appearance of discrimination.

Carolynn reviewed the details of the memo and the "qualifications" and "workload" guidelines we felt had been unequally applied.

Hughes asked how long Mi-Mi expected to be on maternity leave. Mi-Mi replied that she planned to work until the baby was born. Then she'd take six weeks off unless she had a c-section. In that case, she'd take eight weeks off. She'd already arranged child care with her sister-in-law, so there shouldn't be any issue with her return. With only one set of simulators, no STS-5 sims were planned until after STS-4. If the baby were late, Mi-Mi might miss a few weeks training at most. Delaying her first time as FAO one flight was not the prime issue here, though. We wanted to know the reasoning behind removing her from STS-8, scheduled for July, 1983.

O'Neill then said something to the effect that NASA was committed to treating men and women equally in the workplace, and he personally shared that commitment, along with Mr. Kranz. He then intimated that many factors were involved in personnel assignments, and that he usually left those decisions up to the managers who, like the flight directors during a mission, were closest to the work and thus in the best position to judge how to balance the needs of the mission with the talents and skills of the workers.

Huh? Was he saying that he supported our managers' decision to remove our assignments?

I expressed my concern that if the new assignments were to stand, that it'd send a message to all the women coming up through the ranks that no matter how they performed, they wouldn't be considered for leadership roles—that even male contractors would be promoted ahead of them. My section chief said I shouldn't concern myself with contractors—but I said I had to because Holmberg had been assigned to take my lead FAO spot, even ahead of Carolynn. I wondered if he had suggested Bill to take my place?

I also said that I wanted to be treated as an individual—that if I did or didn't perform well, it shouldn't be attributed to my being a woman, but just to my being me. I recall Carolynn and Mi-Mi nodding in agreement with this sentiment.

O'Neill assured us that management recognized that we each had unique talents and skills, and that all of us were valuable assets to NASA. In fact our varied backgrounds (mine in astrophysics, Carolynn's in biology, and Mi-Mi's in computer science) would definitely play a role in our future assignments.

What was that supposed to mean? That I had to wait for a flight that had a telescope or physics experiment as its primary payload in order to be lead FAO? This kind of thinking had not been evident previously. How had my astronomy background qualified me to write contingency procedures for thermal systems?

Finally came a sort of apology for the "insensitive" way the reassignments had been handled. The three of us had obviously been caught by surprise, and without the benefit of discussions with our managers ahead of time (he glanced at our branch chief) we'd drawn conclusions based on incomplete information. In the future, care would be taken to inform employees privately if changes could impact the perceived standing of women in the organization.

In summary, better communications would solve all our problems.

Our branch chief fumed. Perhaps he thought he was being blamed for making our directorate look bad in its handling of female employees? His name had been on the memo, but surely our division chief and maybe even O'Neill had signed off on it? Kranz was a strong advocate for women at NASA. Especially with the media's attention about Ride's assignment and NASA touting its advancement of professional women, I could almost hear him chewing out all of them for letting this situation develop. I never had the nerve to ask Mr. Kranz, so I don't really know.

But it didn't look like we'd get our assignments back. No one was admitting to doing anything wrong. We'd had a communications issue, that's all. It wasn't that they'd taken away our positions, it was that they hadn't been clear about their right to do whatever they wanted.

I had a queasy feeling we'd pay for our complaint. If my assignments were restored, my managers could easily give me a bad performance rating on my next evaluation, proving they'd been right to hold me back. Or, they could not give me any assignments, and wait for me to quit out of frustration or boredom—showing that I hadn't been committed to the job, and proving I didn't deserve a leadership role. And who would know the truth?

In the April 12 memo announcing this meeting, O'Neill had said, "I feel that any subsequent discussions that might be required will most probably be on an individual basis. I find the situation is clearly one involving individual job assignment circumstances, and the scheduling of any further discussions should allow for whatever privacy the employee chooses." So, whatever happened, it'd be done behind closed doors without any observer like Hughes present.

Hughes noted that if our "situation" escalated, we could file a formal complaint with the Equal Opportunity Office. We weren't ready to do that. We hoped that by voicing our concerns privately with our managers, everyone could save face and continue working together. So the three of us women didn't discuss the issue with anyone else at work or elsewhere (until I wrote this book more than 30 years later).

I walked to the elevator with Mi-Mi, discussing the baby shower at my house for her that weekend. I'd invited everyone in the branch. We didn't expect any reps from management to show up now, though.

Our branch chief took the next few days off. Carolynn suspected he'd been so angry after the meeting that he'd needed some time to cool off. We both worried what this might portend for us. A week went by, and then another. No new memos were forthcoming. The stony silence from our management sent a clear message: we weren't getting our lead assignments back.

I wrote of my disappointment to my mother who was dealing with discrimination at her job, too. She wrote, "I don't understand why you three women are being treated the way you are. Your Federal Woman's Director did absolutely nothing to help any of you as far as I can see. She just passed the buck back to your section chiefs? And let them do what they wanted. . . . The women here [at her store] who have had babies have returned to find their jobs taken over by someone else. . . . The company does just enough to comply with the law but the woman is not at all considered as to what she would like. It's disgusting."

I agreed, but there wasn't much else we could do. We thought that filing a lawsuit would only bring embarrassment to NASA and make it even harder for more women to be hired or promoted. So I focused my attention on doing the best job I could on STS-4.

10.2 The annual Flight Operations' Chili Cookoff helped with team building and stress relief. Mr. Kranz, shown here delivering the "10 Commandments" headed the event (Photo by the author)

Mi-Mi had her baby in May. I went to see her and baby Andrew in the hospital. About two weeks later, I was back at the hospital again to welcome another baby. Thor's flight instructor Mitch and his wife Sharon had a baby girl.

June was incredibly busy for us. Not only were we training for STS-4, but we took off for a long weekend to attend Thor's cousin Martha's wedding to Mike Savage in New Jersey. We presented them with the Navajo vase we'd picked out at Grand Canyon. The wedding reception included a square dance that was incredibly fun. All too soon we had to be back at work.

NASA was anxious to convince the world (and especially Congress) that everything was on track for the shuttle to become "operational" and "routine" and thus, it was hoped, allow room in the budget for the station. NASA Administrator James Beggs (1926–) was quoted in June saying, "We think that such a station could be built and placed in orbit by 1990. It would be small at first, assembled in orbit with modules carried to space by the Shuttle" [3].

The Soviets had launched the Salyut 7 space station back in April. We wanted one of our own. So, we were all looking for ways to simplify and automate our jobs to reduce costs and make station approval more likely. Could we consolidate Flight Data File with Pads, Pointing with GNC? How about combining ascent and entry procedures with Guidance? (This eventually created the Guidance Procedures Officer.)

A June *Roundup* article proudly proclaimed, "MOCR positions being streamlined." It said, "With the STS-4 countdown underway and the United States on the verge of space shuttle operations, flight control has matured to the point where some streamlining will be evident in the Mission Operations Control Room." The article explained that the electrical power system would now be overseen by the EECOM versus having EGIL as a separate console [4].

But there wouldn't actually be fewer positions. Some of EECOM's mechanical systems were being combined with the arm operator in a new position called RMU ("U" for upper stages). Because there weren't any arm activities on STS-5 or 6, those two flights would have fewer MOCR operators. But the EGIL folks simply moved their chair from the front room to a support room, and RMS moved from the back to the front. Only Public Affairs would call this "streamlining," and attribute it to maturity of the program.

But in June of 1982, we truly believed we were headed toward airline-type operations in space. And our family and friends were cheering us on. "I imagine you're all eyebrow deep in preparations for the space shot," Thor's father wrote. "I hope everything goes well for you, and there aren't too many glitches in your computers, or the Astros don't get air sick. (We'd told him about STS-3.) This will be one with arm time which actually puts stuff out in space, isn't it? (I could neither confirm nor deny that statement!)" In reference to my discrimination issue, he added, "Don't let the big guys bug you, Marianne. Just be persistent and don't lose your cool. It'll work out for you, I'm sure."

My friend Tom Burkhalter wrote, "Ah so, honorable Dragon Lady! If you need luck, all the good vibes I can think of are heading your way. I mean to be watching STS-4 GO next Sunday. I'll be in NC with [friends], and we will *definitely* be looking for you . . . next to the Flight Director. I couldn't do that job. But still, to be *that close*. I envy you and Thor both."

Gulp. I hoped I was ready!

REFERENCES

1. Ibid, April, 1982
2. Ibid.
3. Ibid, June 25, 1982
4. Ibid.

11

STS-4 Flight Activities Officer

June 25 was a lovely Friday night for a young couple to go out to dinner, attend a party at a friend's house, or take in a show. (*Star Trek II* and *Blade Runner* were playing.) [1] But Thor and I were far from a normal young couple. After a day split between the office and Mission Control, we were glued to the news, wondering if storms at Kennedy would delay the launch, scheduled for 11:00 a.m. EDT Sunday.

The crew had flown their T-38 s to Kennedy that afternoon. Navy Capt. Thomas K. (TK) Mattingly, who had rather famously been scrubbed from *Apollo 13* because of a last-minute exposure to measles and then flown *Apollo 16*; and Henry (Hank) Hartsfield (1933–2014), who was making his first flight, had reportedly circled around for an hour, dodging thunderstorms and heavy rain. They'd finally landed on the shuttle runway at KSC instead of Patrick Air Force Base as planned.

But the countdown was still on schedule. NASA Public Affairs additionally reported that the MLR and CFES payloads were installed in the middeck, and the IECM and GAS were in the cargo bay along with "a collection of Defense Department instruments."

Then they reported that the Air Force payload "is generally known to include infrared and ultraviolet sensors being tested for future surveillance and early warning satellites of the Air Force. Details of the instruments were described last year in testimony to Congress by Air Force officials who acted before it was decided that all military payloads riding the shuttle would be classified secret."

What did he just say? Then, they nonchalantly added that technicians at Launch Pad 39A had worked "through much of the night checking out the secret payload and supplying one of the instruments, the infrared sensor, with super-cold helium necessary for its operations." [STS-4 Transcript, available via UHCL Library, NASA Archive. Future quotations from this source will not be individually cited.]

I sucked in a breath. All operational details of the payload were classified. And here was NASA Public Affairs shouting to the world that technicians had loaded helium?! Gee, I guess I knew why no Russian spies had bought me drinks or been seen boating on Clear Lake. Why go to so much trouble when Public Affairs supplied everything but the name!

As if to highlight their mistake, or maybe to explain why they didn't go ahead and also broadcast a photo of DOD 82-1, they quoted Brig. Gen. Richard F. Abel, the Air Force director of public affairs, reiterating that no information would be released.

M.J. Dyson, *A Passion for Space*, Springer Praxis Books,
DOI 10.1007/978-3-319-20258-7_11

Well, on penalty of treason, I would neither confirm nor deny anything NASA Public Affairs said. No sir. This "dang" civilian mouth was shut, sir.

This incident was just the first of many communication goofs that would surround this mission. Not all of them would have to do with our secret payload. We needed to learn the difference between operating the shuttle systems (understanding how fast and far the car can go) versus using the shuttle systems to perform operations for customers (getting the pizza to the right place while it's still hot).

Thor and I took our turns on console Saturday. He worked the afternoon, and I worked until the wee hours of Sunday morning.

During my preflight shift, Entry Team Capcom Brewster Shaw showed me and Flight Director Draughon what he called TK and Hank's "shopping list." The crew would like to have these activities scheduled if time became available. This was the first time either Draughon or I had seen them! The most complex one was an indoor demonstration test of the space suits. I could certainly see the value in a don and doff and communication exercise. But why had the crew, and Capcoms, waited until we were literally hours from launch to discuss this with the FAO and Flight Director? I wondered if the list were a result of the STS-3 crew having had an extra day?

Timeline 1, Bill Holmberg, put a summary up on the FAO TV channel. Public Affairs used this to highlight all the "firsts" of this flight. STS-4 was the first to launch due east from Kennedy. The shuttle would fly over everything on the Earth's surface between 28.5 degrees north (KSC's latitude) and south. Notably, this band didn't include the Soviet Union. The media speculated that we'd chosen this inclination to avoid political repercussions of having a secret military payload on board.

Another first for STS-4 was the altitude which would be the highest to date at 197 miles (172 nm). While I could neither confirm nor deny that the inclination or altitude had anything to do with the payload, it was well known that most satellites preferred orbits closer to the equator and of higher altitude than demonstrated on the first three flights.

Another mission first that NASA Public Affairs didn't mention was that STS-4 was the first flight to have a husband and wife both working consoles in the MOCR. Thor was Orbit Guidance, and I was Entry FAO. Other women had worked in the MOCR before me, and some had also worked in support rooms, like I had, who had husbands in the front room. But we were the first couple to be assigned to front room positions for the same flight. I mentioned this to the NASA photographer, Pat Patnesky, who graciously took a photo of the two of us on landing day.

And of course for me, the most important first was that I was FAO, the second woman ever to hold this position, and the first woman to be an FAO on the Entry Team. I was also the only female front-room console operator on the Entry Team. Carolynn was FAO on the Ascent/Planning Team. The only other women with front room positions on STS-4 were Janis Plesums as Payloads on the same shift with Carolynn, and one of the Flight Surgeons, Ellen Schulman. (Plesums and Anngienetta [sic] Johnson had both been Payloads Officers on STS-2. Johnson was also the first black woman in Mission Control.)

11.1 This green badge gave me access to the MOCR, the only woman on the STS-4 Entry Team (Photo by the author)

Early Sunday morning, the countdown clock still counted down. No computers had acted up. All the systems looked good, and the weather, too. We handed over to Holloway's Ascent Team. Carolynn arrived "bright-eyed and bushy tailed" as we were fond of saying, meaning she was wide awake and ready to go. I'd be back for my next shift at 11 p.m. that night.

As I made my way out to the car in the predawn hours, I thought about how we both had a lot riding on this flight. O'Neill had said that better communications would solve everything, but there had been no further discussions of assignments since that meeting. I felt that they were waiting to see how well I performed technically and as a member of the team before assigning me to be FAO again. I was okay with that. With three flights under my belt, and years of working the details of deorbit, I was pretty confident in my technical abilities.

Maybe it was my imagination, but I also felt that my coworkers actually liked me. It helped that, even though the (all-male) controllers in the FAO support room reported to me, I wasn't their boss. I didn't sign Bill Holmberg's paycheck, and I'd not write his performance evaluation. Likewise, my flight director wouldn't be deciding my future assignments as FAO.

I saw the launch on TV at home. STS-4 got to chalk up another first: on-time launch. Maybe we really were ready for operations! I headed off to bed.

ISSUES WITH DOD-82-1

I arrived a little early for my shift and was surprised to discover that the crew, who were supposed to be three hours into their sleep period, were still awake. They'd fallen behind the timeline and hadn't even eaten dinner yet.

Just about all the experiments had issues. The crew had activated the MLR late, hadn't been able to activate the Get Away Special at all, and had a problem activating DOD 82-1. The biggest immediate change to the timeline, though, was a result of their orbit burns.

The shuttle had used more fuel than expected during ascent, so the burns had been shortened, and the orbit consequently lowered about five miles from the original plan. This lower altitude took about 10 seconds less time to complete one revolution around Earth than the higher orbit. These 10-second intervals accumulated, so that times for the ground sites listed in the timelines shifted earlier—10 seconds the first rev, 20 seconds the next rev, then 30 seconds, etc. With 16 orbits a day, the ground track shifted more than two minutes a day. For all previous flights, we'd had to shift the ground track because we'd launched on a different day or at a different time. Those shifts had been relatively easy to implement: just add x number of minutes to everything. This change was different for each orbit! Argh.

Every single page of the timeline had to be checked for items that were tagged to ground or day/night coverage, and all of those items, such as live TV and Night Optical Survey of Lightning (NOSL), had to be rescheduled.

We'd also changed the attitude. We'd planned to be in an attitude with the payload-bay-to-Earth and one wing "forward" (called –ZLV XPOP) during crew sleep. But because the thunderstorms had soaked the vehicle, we'd gone to bottom sun to "bake out" the wet tiles. We hadn't planned to go to bottom sun until Flight Day 6. We were supposed to do top sun, then tail sun, and bottom sun last. Jet firings and payload bay door activities were associated with each of these thermal test periods. All of them had to be shifted around now.

Basically, the preflight plan was useless. I'd be hard-pressed to earn my Atta-girl for getting the timeline replanned before crew wakeup in a few hours. But before I could get started, I had to head up to the third floor communications room for a status briefing on DOD 82-1.

Because only a handful of controllers had a "need-to-know," we couldn't discuss DOD 82-1 over the loops. Carolynn and I held a whispered conversation of the status during handover, but I had to go to the third floor to a locked room and use an old-fashioned cord telephone with a handset to talk to the Air Force controllers in Sunnyvale, California.

The Air Force hadn't anticipated much need to discuss classified materials with us during the flight. Their controllers were monitoring the air-to-ground and flight director communications, and their Capcom, called Paycom, was available to answer all crew questions. We had a classified document onboard called simply the "Operations Checklist" with lettered tabs for various procedures. We'd only had a couple of sims, and their understanding was that any problems could be handled by voicing up instructions.

There wasn't even a rep from the Air Force in Houston, and no rep from NASA was at Sunnyvale, either. Management considered this exchange of personnel too costly. We were going operational—we wanted a space station—we had to keep costs low!

So when a problem occurred around six hours into the flight, the Houston Capcom simply handed over to the Paycom. But the controllers at Sunnyvale had no experience with human space flight. They didn't have pre-planned procedures for what-to-do-if cases like we did. So they basically repeated the same procedure over and over, and continued to get the same unsatisfactory results. Even though the conversation was rather cryptic to eavesdroppers without a copy of the checklist, by nine hours into the flight, it was clear that something was wrong.

PAYCOM: "The first step is for you to perform experiments C power on select. And then verify that the ON LED is ON."

MATTINGLY: "Verified."

PAYCOM: "Roger, Columbia. *The second step is select cover open and then verify that the open LED is ON."*

MATTINGLY: "Okay, that's no joy, and no visual joy either."

PAYCOM: "Roger, Columbia. *. . .Now step 3, we'd like you to select cover closed. . ."*

MATTINGLY: "Okay, that's been done. Both the opened and the closed are OFF."

PAYCOM: "Roger, Columbia. *Now we would like you to select cover open, and then cover closed one more time. . . ."*

MATTINGLY: "Okay, we've completed your second try with no joy."

Mission Control has one of the best, if not *the* best, team of technical problem solvers in the world. We were anxious to help our Air Force friends. From the conversation, it was clear what wasn't working. Some creative ideas were bandied about (off the loops) to address the "cover" problem. But before we could act, we needed to discuss our ideas with the Air Force.

Carolynn told me during handover that she'd gone up to the third floor to use the secure phone with Sunnyvale. But she couldn't get through. The phone was busy!

"Busy?" I said, incredulous. "Who the heck are they talking to that is more important than us?"

"You're not going to believe this," she said. After numerous failed attempts, she called them on an "open" non-secured line to report the problem. They told her that our one-and-only secure line was shared with all other DOD operations. A training exercise was tying up the line.

"It's a party line?" I said.

"Told you that you wouldn't believe it," Carolynn said.

"You'd think a billion-dollar space shuttle flight might warrant a dedicated line," I said. We shrugged at yet another example of the government being penny-wise and pound foolish.

Anyway, they'd suggested we just keep calling until we got through. Then don't hang up! To keep the line open, Carolynn had taken turns manning the phone with Payloads, Timeline 1 (Diane), and Pointing (Mark Brown). Currently Brown was "holding the line" for the team.

We couldn't just leave the phone off the hook, "live" and unattended. One of those Russian spies (who may have missed the Public Affairs announcements) might find a way to get onsite (the gates were guarded) sneak past building security (who checked your special badge), know which floor and room to go to (this was not documented anywhere), and get someone on the other end of the phone (all Air Force officers) to give up the deep dark secrets of the payload. Yeah, right. But even if this "don't leave it off the hook" policy didn't make any practical sense, this civilian wasn't going to break the rules. No, sir.

I told Holmberg to get a green badge and report to the MOCR. He'd be acting FAO while I went upstairs. I asked our Pointer, Tom Vollrath, to come with me. I was especially happy to have Tom's help. Being an Air Force officer, he immediately understood the sometimes "colorful" terms they used to describe their situation. Brown, Carolynn's Pointer, was also a blue suiter. He and Tom did their own handover while I chatted with my counterpart in Sunnyvale.

They said they were planning to try one more procedure in the morning, but they didn't hold out much hope for experiment "Charlie." We discussed one rather complicated option that we all agreed was crazy enough that it might actually work. I said I'd talk this over with Flight and get back with them. Mark went home, and I left Tom to babysit the phone and headed back downstairs to talk with Draughon and Payloads Officer John E. Hoover.

We all liked the "crazy" option because not only was it rather ingenious, it offered the best chance for success. But it also required some significant crew time and shuttle resources, so before we suggested it, we needed astronauts and flight controllers to test it out in our training facilities. Draughon checked with Mr. Kranz, and the next thing we knew, Team 4 was coming in to take charge of making that happen. So in the wee hours before dawn on Monday, Bob Nute, the Team 4 FAO, Marion, serving as Timeline, and Mark Riggio, as Pointer, got called in.

Despite all these things going on, the end-of-shift press conference was cancelled for lack of interest. It probably didn't help that it was after midnight, nothing had blown up, and we weren't going to tell them what "no joy" on the secret payload actually meant. It was only the fourth flight, but we were already a victim of our own PR campaign to make shuttle flights "routine" which translated to "boring" as far as reporters were concerned.

But my job was anything but boring. We had to document the As-Flown timeline from the previous shift, get the flight plan ready for the morning, and then oversee most of the second day of the flight while the Ascent Team did their usual flip flop from working days to working nights. Our shift was scheduled to last about 13 hours.

I settled into my chair in the MOCR with a fresh cup of coffee. I hardly had time to think about where I was and what I was doing. The big screens with the map showing the position of the shuttle were just background. The air smelled of coffee and cigarettes. My thin nylons did little to keep the chill off my legs. I warmed my hands over the lighted phone line buttons.

Every time we had AOS, I'd dial up the EECOM or EGIL displays and watch for the telltale signs of the crew being up. The pattern of jet firings showed that something was venting, probably ice vaporizing off the orbiter. Mattingly had reported seeing a lot of debris following them in orbit which we assumed was water and exhaust from jet firings. Lousma had reported a similar cloud around them during STS-3. One of the STS-4 experiments called "Glow" had been added to this flight to investigate this "halo" effect.

During the night the CAPS crashed. In another not-very-smart cost-saving measure, we no longer had someone on call to come and fix it. Timeline 2 Mark Maschoff ended up doing the As-Flown timeline by hand. He did an excellent job, and Flight was pleased. We distributed copies hours before the crew got up. I might earn an Atta-girl after all!

We'd really come to depend on the CAPS for replanning, though. After the flip-flopping of days on STS-3, we'd updated the software so it could generate new trajectories in realtime. This capability was incredibly useful for seeing how the ground sites and day/night bands shifted in relation to the pre-planned activities. Post flight, Mark Fletchel of the Air Force said that they were impressed with this capability and planned to add a similar system to their control center. CAPS was a cutting-edge computer tool. I was proud of the small part I'd played in testing and "deploying" its capabilities.

Amazingly enough, the CAP Update teleprinter message was ready 30 minutes before crew wake-up. My creative Pads operator, Jay Penn, had devised a new format for the message with columns showing the time and activity. We hoped the crew would like this, and they did.

The crew only slept five hours that first night. The Orbit Team had offered to let them sleep in, but they didn't want to start the day behind schedule. We left them alone for an extra half hour though, and then played the wake up song: Up Up and Away (in my beautiful balloon).

They reported some bubbles in the lines of the first batch of Electrophoresis samples, but otherwise, the experiment appeared to be functioning well. Hartsfield said, "it steadied out to a very pretty flow." The team breathed a collective sigh of relief. NASA had touted it as a perfect example of the potential commercial uses of space, and a justification for why a space station was needed. The MLR experiment to make perfect spheres for use in industry was also part of this PR campaign to "sell" space to the public (and Congress). The shuttle was the truck to build the station that would incubate and facilitate these new business opportunities. Space was no longer about political prestige, exploration, or science. It was all about business.

Unfortunately, the crew's attempts to videotape the experiments failed. Mattingly fussed with the video recorder for hours, trying different settings and cassettes to no avail. The Crew Systems experts who handled this system were in the FAO support room, so the responsibility for this system fell to me. I felt unprepared to deal with this. I'd had a class in TV/VTR systems and gone through some minimal training in the Building 9 mockups, but that was a far cry from knowing what to do to fix it during flight. Fortunately, the Crew Systems team knew what to do. They prepared a troubleshooting procedure which we voiced up to the crew.

Within an hour after crew wakeup, Sunnyvale's Paycom had the crew repeat the same procedure they'd tried the night before. Mattingly reported some battery currents, but no change in position. A few minutes after this report, the crew got an onboard alert, "RPM at 1791." Not knowing what this meant, Flight asked me to use the secure line to find out more. So once again I had Bill come to the front room, and I went to the third floor. We'd hung up the phone for a few hours because we didn't need it during crew sleep, and there was no one to spare with clearance to babysit it. Now I couldn't even get a busy signal.

I reported this problem to Sunnyvale, and after some troubleshooting at their end, we determined that the line had hard failed. So our inadequate communication system became completely useless. We didn't have any backup. This convinced our management that the only way to deal with these payloads in the future was to have someone on site to advise us in person. For the rest of this flight, we were stuck exchanging cryptic messages over an open loop.

All we knew for sure was the problem from the day before persisted. Team 4 continued work on our "crazy" idea and expected to have it checked out by the end of the crew day.

The "faster" orbits shifting the night passes earlier almost led to ruining a camera used in the Glow experiment. The camera took 400-second exposures of the space surrounding the orbiter to check for light produced by vented gases, water dumps, jet firings, and interactions of the vehicle with particles in space [2]. Mattingly set the camera up in the aft flight deck window looking out into the payload bay. The vehicle was in a top Sun attitude, so at sunrise, which came a few minutes earlier than he'd expected, the Sun shined directly into the bay.

At around 10:30 a.m., Elvin arrived for handover. My first shift as FAO had come and gone. We'd composed and sent nine teleprinter messages, got the CAP updates and As-Flown timelines done, and coordinated with Team 4 and Sunnyvale on a solution to their problem. Overall, I thought we'd done a good job.

Like before, it surprised me that it was daylight outside at the end of my shift. It'd been the dead of night when I'd arrived more than 12 hours ago. The crew had reported seeing some menacing clouds out in the Gulf heading our way, but they hadn't arrived yet. Whether it was sunny, raining, day or night, didn't much matter to me, though. For the next week, I was living on "Mission" time. The Orbit Team would hand over to the Ascent/Planning Team, and then my team would pick up just after crew wakeup around 3 a.m. If anyone had asked me what day it was, I would've had to think hard to remember that it was still Monday, June 28.

SECRET COMMUNICATIONS

When I reported for my second shift, Surgeon let us know that Hartsfield had reported a headache and some queasiness. Surgeon blamed this on the fact that he'd had little sleep the night before and had skipped lunch. He'd taken aspirin and some anti-nausea meds and gotten to bed on time, so we all expected he'd be feeling better today. Remembering the STS-3 scheduling nightmare caused by the crew not feeling well, the FAO team was determined to protect crew meals and the new 15-minute "Housekeeping" (potty break) times.

But we had a busy day planned. Mattingly had requested that we not distract them with a lot of small things. The "big stuff" for today included the arm checkout followed by two IECM surveys. The surveys required the crew to pluck the IECM out of the payload bay and move it to various positions where it would take samples of contamination with and without jet firings. This data was important to future satellites that carried sensitive optics.

Currently, we were in bottom sun attitude, continuing the bake out of the tiles. TK had used his binoculars to inspect the OMS pods and reported they were clean—no missing tiles.

DOD 82-1 still had problems. Paycom basically gave the crew carte blanche to try anything they thought might help.

The line to Sunnyvale was still down. The Team 4 procedure was ready to send to the crew. Flight, Payloads, the Capcoms, and I huddled around a draft of this procedure, whispering our comments off loop. Someone had slapped a "Secret" cover over a diagram of the payload.

Though there was no one from Sunnyvale at JSC with detailed knowledge of payload operations, there was a representative of the DOD in the MOCR. The DOD console was immediately behind mine, in what we called the "back" row. This morning, a general was staffing that console. (He may have been Lt. Gen. James Abrahamson who was the Associate Administrator for the Shuttle Program at the time and later the director of Reagan's "Star Wars" program.) As the discussion group broke up, I stood by my chair with the two teleprinter messages, numbers 17 and 18. Flight had just told me they were now approved to send to the crew. The general said, "Excuse me, FAO."

Surprised, I turned to him. "Yes?"

"I believe those messages are misclassified," he said

"Excuse me?" I asked, my blood pressure rising.

"Could I see them, please?"

I handed him the two messages. What had I done wrong? Should I have checked his credentials before handing them to him? I told myself that was silly. He was a general for heaven's sake! He lifted the covers and glanced at the procedures. Then he met my gaze. "These are going to be sent to the crew using the teleprinter?"

"Yes, sir," I said.

"The teleprinter is not a secure means of communication," he noted. "Therefore these messages cannot be classified Secret." He handed them back to me.

I admitted being confused. I thought all operational data about the payload was classified Secret. He said that was true, but then he explained that if the messages were classified Secret, and sent over an unsecured line, then we'd be guilty of transmitting classified material.

Gulp. I didn't think going to jail for treason would look too good on my performance review. "What should I do?" I asked. Were my hands shaking?

Seeing my reaction, he smiled kindly at me. "Take the Secret covers off."

"Oh," I replied dumbly. "Yes, sir," I added. "But what cover should I put on them?" I couldn't just leave them on the console for anyone to see. Could I?

No. He suggested that until the messages were actually sent, they should be treated as "Sensitive" which basically meant that we'd continue to limit the distribution to those people who had a need to know. Once the messages were transmitted, then they'd be filed officially as unclassified, but sensitive. So we'd control the distribution as we had been doing, but anyone on the outside who had figured out how to translate our teleprinter signals into readable messages would have this information. I wondered if the Russians could do that?

I thanked the general for saving me from going to jail for mishandling classified or rather, unclassified, data. I put a nice purple-striped "management" cover on the messages.

We sent messages 17 and 18 to the crew shortly after that.

Throughout all of this, it must have been obvious to anyone in the room, including the public affairs officer who was tucked away in the back corner and not on the need-to-know list, that something was going on. But what could it be? What was that payload doing in the payload bay, anyway? Could it be spying on the Russian Salyut space station as it crossed paths with the shuttle? (PAO speculated about this early in the flight.) Was it testing a new space laser? Taking super-high resolution images of ground targets? What did it need that prelaunch helium for? The crew and Paycom had discussed a cover being open or closed, and reported fluctuating voltage levels. This thing was not just some passive blob. And something wasn't working properly. What had that Team 4 group been doing over in the simulator? It must involve the crew because that general was talking to the FAO. . .

The mystery surrounding DOD 82-1 continued to generate speculation and caused one of the most memorable miscommunications of the flight. It happened shortly after my "education" about classification levels. The crew were in the midst of their morning meal. Trying to follow Mattingly's request to minimize discussion of small stuff, the Capcoms were purposefully just calling out the start of the ground passes and then standing by. So when Mattingly called down with a report, we were all a bit surprised. He said, "Hey, just a note for those people that were worried about the little laser and how it would work. That thing works like a champ."

A hush fell over the MOCR. Did he just say laser?!

Capcom Shaw replied, "Okay, I'll be sure to pass that along to the appropriate individual." He glanced in my direction.

The appropriate individual? I could almost hear everyone wondering whose identity he was trying to protect.

Smiling at everyone's ability to jump to conclusions, I called over the loop to the FAO support room, "Crew Systems, did you copy that report?"

He responded that he'd be sure to pass along the good news that the new crew battery-powered *razor* worked well.

The news soon spread that what TK had really said was razor, not laser. And before long, everyone was repeating a modified version of the jingle of a popular commercial for Remington shavers that claimed the electric shaver shaved "closer than any blade." Our new version was, "New space laser, shaves closer than any blade!"

I know it was totally unprofessional of me, but after all the public affairs "announcements" and the breakdown of the so-called "secure" line, and the whispered discussions about the "crazy" procedure, and the tension over the misclassification of the messages, the laser/razor comments struck me as so funny I could hardly stop laughing. And when some controllers suggested that those of us "in the know" were trying to cover up a mistake by the crew, we just smiled and rather pompously said we could "neither confirm nor deny" whether or not there was a laser on board! Post-flight, someone printed the "razer" slogan in big letters and hung it in the hallway of Building 4 as part of the Welcome Home decorations for the crew. Interestingly enough, the official STS-4 transcript had the word "laser," not razor.

You'll have to ask Mattingly what he really said. I'm not telling. No sir.

The first major activity of the morning was checkout of the arm. Hartsfield couldn't get the talkbacks to match what was in the checklist. He went through a procedure in the Malfunction Book and decided a microswitch had failed. But the indications didn't quite match. After checking with our RMU officer, Al Ong, he went ahead and captured the IECM and hoisted it out of the payload bay.

After some discussion, we realized that the arm was working properly—it was the procedure that was wrong! This mistake had just cost us about a half hour of expensive crew time. If we'd had more simulations, we'd probably have caught this before flight. With flights coming closer and closer together, it just wasn't possible to practice every part of a week-long flight. I filled out a form 482 to get it corrected before the next flight (STS-7) that had an arm.

Because of the problem getting the arm checked out, the IECM Survey started late and ran into their meal. Surgeon J. S. Logan reported that Hank was feeling fine today, but we didn't want him to miss lunch. But despite Capcom Shaw encouraging them to take a break, the crew just grabbed some coffee and kept working.

While they were still in the midst of the IECM Contamination Survey, Capcom told the crew, "You have a GO to implement TPR message 17 Charlie at the published time." This was the mystery procedure that Team 4 had prepared. I wondered if the Russians, or more likely Craig Covault at *Av Week*, had decoded the message and now knew what we were doing with the payload? About two hours after I got off shift, the crew reported they'd performed the procedure a couple of times. "And we had no success."

On the published "As Flown" timeline, the time period between 3/03:30 and 04:05 hours is labeled "RMS EXP OPS" which with the acronyms decoded says Remote Manipulator System Experiment Operations. The footnote adds, "Recovery Procedure." Therefore, the information that the "recovery procedure" involved the remote manipulator system was considered public knowledge. But if you want to know *how* they used it, you'll have to wait until someone declassifies the information and/or ask the Russians or Craig Covault. (While writing this book, I filed a Freedom-of-Information Request with the Air Force to discover if the payload had been declassified, as expected, after 25 years. Unfortunately, no information could be found.)

At the Orbit Team press conference, public affairs said, "As for problems with the DOD payload, the Department was, of course, saying nothing. But several conversations between Mattingly and the AFSCF [Air Force Satellite Control Facility] at Sunnyvale indicated some difficulties with scanning mechanisms and something called Payload C. For what is known of the secret payload, three of the military instruments presumably involve scanning technologies."

Don't ask me to define what they meant by "scanning technologies." Printer-type scanners were not yet invented as far as I know back in 1982. So I don't know what they were referring to, and, of course, I could neither confirm nor deny that DOD 82-1 had anything to do with them. But if I had to advise PAO on providing the media with an interesting story, I'd suggest that the "laser shaver" had some real potential!

GUIDANCE FROM APOLLO

Because of orbital mechanics, every flight had to shift the crew wake up time earlier. STS-4 had the biggest shift yet: six hours. As on previous flights, the time shifts caught up with me in the middle of the flight. I'd gotten off console around 11 a.m. on Wednesday. I took a nap, and then Jasper Kitty reminded me that *he* was still on a normal schedule, and someone should please get up NOW and feed him. I fed my "baby," had breakfast for dinner, and watched the news with Jasper. (Thor was on console.) With the blackout of the payload bay, the media didn't have much to work with. Coverage consisted of a few minutes of Hank with the Electrophoresis, and quotes from managers saying everything was going smoothly. *That* was news to me!

When my alarm rang just before midnight, I questioned why I thought being a flight controller was such a glorious job? At least there was no traffic at 1 a.m. on a Thursday morning.

I savored the sugary sweetness of a glazed delight while I climbed up the wide blue-carpeted steps to my console. I waved a greeting at Thor's office mate and one of his mentors, J. T. Chapman, who was Entry Guidance. He'd be taking over from the Ascent Guidance, Will Presley, another of Thor's mentors. Will was wearing one of his usual short-sleeved white shirts, a carry-over from his days as an Apollo flight controller. He and J. T., both ten or more years older than Thor and I, referred to us as "the kids." We in turn called them the "old guys."

Many "old guys" Apollo-era flight controllers were still working in Mission Control during STS-4. Ed Fendell, the Entry INCO, had famously controlled the cameras on the Apollo rovers on the Moon. The blackout of images from the payload bay on this flight must have been somewhat frustrating for him. But I never heard him complain. Whenever I caught his eye—he was at the opposite end of the row of consoles from me—he'd wink at me and smile. In Flight Techniques meetings, he was always happy to indulge my questions with very thorough answers. Thanks to him (and Gap, another Apollo-era INCO), I had a reasonably good idea of how the communications system worked, and a deep appreciation for how well they handled that system.

I never felt as if any of these "old guys" had anything but respect for me as a flight controller. We'd sat through endless hours of meetings and sims and briefings. We were a big family, all of us "housed" in Building 4 and working here in Building 30. I didn't know my "cousins" in the Systems Division as well as my "brothers and sisters" in Flight Activities, but everyone on the team was at least "familiar."

11.2 In 1982, the Systems Directorate occupied the first floor of Building 4 and contained Apollo "oldtimers" as well as young new-hires, including my husband (center 4th row, behind Debra White in green). Pearline Collector is in that row also, on the right next to Greg Oliver wearing a green tie. The tall man in the center of the last row is Jim Oberg who became a Russian space program expert, author, and NBC's space correspondent (NASA photo. See www.mdyson.com for a list of all 101 names)

I took my place next to Carolynn and began the shift the way I usually did, by reviewing the console log. Carolynn said the crew had been up in the middle of the night, though they hadn't called the ground. I wondered if a stowaway cat on board had gotten hungry?

She mentioned that it had taken three hours to stabilize the PTC attitude before the crew had gone to bed. I made a note and later asked my Pointer, Tom Vollrath, why it had taken so long. Didn't they just have to maneuver so that the x-axis pointed where they wanted, and start the BBQ roll? He said, "A [normal] PTC attitude would take about three minutes. This PTC attitude maximized antenna/site coverage which requires the evaluation of 144 site passes." This information reminded me that I always had something new to learn, even in an area that was the domain of the FAO. I sure appreciated the expertise of the people in the support room. I made sure to acknowledge Tom's good work in my post-flight report.

Carolynn said that the CAP Update message would be uplinked at the first site after crew wakeup. (We didn't want the noisy teleprinter to wake them.) She unplugged and headed home. She'd just done a flip-flop from days to nights, so wasn't sure if she'd be able to sleep. I nodded in sympathy. Did we really want to work more of these flights?!

The crew wakeup included a taped message to Hank from his two daughters and his wife on his 25th wedding anniversary. Thor and I had been married three years now. I wondered if one of us would be in space for our 25th anniversary? (No, but we did go to Taiwan!)

The crew hadn't even had time to finish reading the CAP Update before we made changes to it: the fuel cell purge could be auto versus manual as specified in the message. I shook my head. Was it even possible for a flight plan to remain stable for five minutes?

The first major experiment of the day was a release of a mixture of neon and hydrogen gas from the IECM in the payload bay. *Columbia* was maneuvered during and after the release while the IECM took readings. Scientists were investigating how movement of the orbiter changed the concentration and distribution of gases. Though it wasn't clear what went wrong, I logged that "the gas release got fouled up." I blamed it on the timeline being too crowded. We'd scheduled this important experiment right on top of their morning meal.

And looking at the timeline for the afternoon, we realized we had another potential bottleneck of activities that could lead to another foul up. So we decided to have the crew start a bunch of payload bay door tests a full hour earlier. New Capcom, Roy Bridges, Jr. (1943–), voiced up this rather big change to the CAP Update.

The test included deploying the radiators four hours prior to the cycling of the doors, closing and opening the doors several times, and then stowing the radiators again. No sooner had Capcom finished voicing up the change to the crew than we got a call from Sunnyvale.

Even though the Planning Team had explained the test to the Air Force, and they hadn't objected or even commented on it, now that we'd put it on the timeline and doubled the time for the test, they called to tell us it was a problem. It was too late now to unschedule or move the test. We were sorry that they hadn't understood that the test required the bay doors to close, thus cutting off communications with their payload. I reported post flight that "They lost three sites."

But we got one thing very right in the payload department. At 02/20:23 MET, the crew reported, "We owe somebody down there a great big cheer. Your little fix for the first try on fixing up the GAS, and we got the relay 02 and 00 systems from latent to hot."

I let out a little "Woo-hoo!" and there was some actual cheering in the support room. We'd had the crew use some jumper cables to "hot wire" the control panel. Wayne Boncyk in Payloads support was quoted saying, "Lo and behold, everything worked fine."

R. Gilbert Moore, a Utah businessman who paid $10,000 for the students to fly this experiment said, "To be honest, I didn't think it was going to turn on. We're thrilled to pieces."

The students told the crew, "The get-away gang says thanks for the good work. One small switch for NASA, a giant turn-on for us." We all groaned at that!

We had another success on our shift. Penn suggested that he could create a simple teleprinter format to use as an overview of the day. He, Holmberg, and Maschoff pulled it together and Flight and Capcom approved sending it. The crew liked it, and thus we established a new tradition of sending an overview/summary with the details in another message later.

But the onboard video tape recorder wouldn't rewind. We'd been using one tape to record, then "dumping" the recording to the ground to make a copy of it. Then the crew would tape over that content and dump it again. But without the rewind, it could only record until it hit the end of the tape. To save sufficient tape for entry, all orbit TV would have to be live. INCO Fendell and I worked up a schedule of opportunities for live TV. Public Affairs was anxious for content. Another end-of-shift press briefing had been cancelled for lack of interest last night.

Fendell suggested that we point one of the payload bay cameras straight up, zoom it out, and just turn it on. We could watch the United States go past, as seen live from space. But Mattingly didn't like this plan. He wanted to do commentary. So he set up a camera in the overhead window. We had three minutes of TV coverage over the U.S. It was an impressive sight, looking at the Earth out the window of the shuttle.

At this point in my life, I still considered it a real possibility that I'd get the chance to look down on the Earth one day with my own eyes. Maybe Thor and I'd rent a ship, and he could fly us up there. We could try hiking some canyons on the Moon! If I wanted to go into space, I'd need to become an astronaut. That meant I'd need to go back to school and get a Ph.D. In what?

While I was daydreaming about flying in space, the TV pass of Earth ended, and I was jerked back into the here and now of the MOCR. TK was taking us on a tour of the middeck. "This is what every kid always wanted," he said. "It's a 3-dimensional room, so he doesn't have to pick his toys up." I smiled. Thor would love that. His idea of organizing was to stack things in piles on his desk or the floor. Living in space with him would be like living in a fishbowl of floating papers!

The crew started their meal as the Orbit Team arrived for handover. Thor wasn't allowed to come up to my row—the back two rows were off limits to those not cleared for the payload. Since we were LOS, I unplugged and went down to the trench to say hello. He took my hand and gave it a squeeze while he said "Good morning." I could hardly believe it was only 9 a.m.

As I made my way back to my console, I said good morning to the incoming EECOM, J. Milt Heflin. He was taking over from Paul Joyce. Milt and I often ended up in meetings together because of my work with the contingency cases. He'd later become a flight director. Elvin, wearing a fresh white shirt, arrived, coffee in hand, to begin our handover.

He asked if there'd been any changes to the TACAN test considering we were in a different attitude than planned. I didn't know of any changes. Vollrath said that we could "tweak" the attitude to point the antennas more toward Earth, but no one had even discussed doing that.

I hadn't paid much attention to the TACAN test, but Thor had. As a pilot, and as a guidance officer, this test interested him. TACANs are military radio beacons that help pilots figure out their location, like we used the radios in planes. The shuttle didn't have a way to determine its location relative to Earth's surface. (The star trackers told it which way it was pointed, like a compass gives direction, but not location.) The guidance officer's job was to tell the onboard computers where the shuttle was relative to Earth. This information, called the state vector, was fed into a program that calculated, based on orbital models, where the shuttle would be in the future. The state vector "decayed" or became less accurate as time passed, so it was updated regularly. If there were an onboard emergency such as the Loss of 2 Freon Loops, requiring the crew to come home immediately, and the state vector wasn't accurate, the orbiter could calculate the wrong burn targets and end up in the ocean.

The question the TACAN test hoped to answer was whether or not the signal was strong enough in space for the shuttle to use it to update its own state vector. Vollrath said that the test was planned to be repeated on Flight Day 7, so we could tweak the attitude for that one if this test didn't get good results. I learned afterwards that the test worked, but the program didn't have the money to update the onboard software to incorporate the data. I guess it was cheaper to train guidance officers? But why had they bothered to do the test?

Just after 10 a.m., I went home. It'd been a good shift overall. I was proud of the work we'd done creating the summary timeline format, recovering the GAS, giving the crew more time for their door test, and making sure they got lunch.

DOORS AND KEYHOLES

When I got up for the evening news, there were no inspirational views of Earth from space. Instead, I puzzled over a zoom image of the doors that even having seen the real thing at KSC, was hard to decipher. But the story was clear: the doors had warped and the latches wouldn't latch. I immediately thought about the similar problem we'd had on STS-3 when we'd put the tail to the Sun. Apparently, the bottom Sun "bake-out" also warped the doors.

I shook my head and sighed. Why had we left a two-billion dollar space shuttle unprotected on the launch pad in a thunderstorm? How expensive could it be to cover it with a plastic tarp? Instead we risked that water freezing on orbit and heating during entry, popping off the tiles, causing the underside to melt, and leading to loss of the vehicle and crew (that happened in 2003, albeit from ice hitting the tiles during launch). The bottom sun attitude had worked to bake the soaked tiles. However, it had also bent the airframe so much that the doors might not close.

I hoped Top Sun would fix the doors—though it was sure to exhaust the flight control team and crew by requiring a total rewrite of the flight plan—again! But if an attitude change didn't get the doors fixed, the crew might have to do a spacewalk and manually latch the doors shut. We had a procedure for that. But we'd not done an EVA on the shuttle yet. We hadn't even tested the suits! How had upper management allowed us to end up in this situation when protecting the vehicle could have prevented it? That question was definitely above my pay grade.

The TV reporter said that the video had been screened by the DOD and cleared for release after they determined that it didn't "compromise the security of the Department of Defense payload." Huh? The video came down over the unsecured air-to-ground link. Surely the Russians already had the unedited version. So if they had it, why hide it from the public who would have no idea what they were looking at anyway? This keeping secrets stuff didn't make a whole lot of sense to me. Again: above my pay grade.

When I arrived in the MOCR, I learned that the whole timeline had been redone, just as I'd expected, because of the need to change attitudes and add in more door tests. Not surprisingly, the CAP Update wasn't ready to uplink to the crew yet. Carolynn said she'd tried her best to move things along, but her flight director, John Cox, had put a priority on the summary versus the detailed data needed to execute it. As everyone knows, the devil is in the details, so discussions rattled on and on. But the Planning Team handed over a good summary, and we got the rest polished and ready before the crew got up at 1 a.m.

Our first order of business was to uplink the CAP Update. Unfortunately, the shuttle was in that part of its orbit when it didn't pass over the U.S. After Dakar, Senegal (in Africa), we'd have no communication for 90 minutes. The CAP Update message was the highest priority. They'd need to read it during that 90-minute time to be ready to do all the activities planned. Penn estimated the five-page message would take six minutes to transmit—a tight fit into the Dakar pass. As soon as the AOS call came, the message began transmitting.

But when Capcom Shaw said, "*Columbia*, Houston, Over," there was no answer.

Fendell reported a keyhole, a short time when the signal dropped out.

Capcom continued calling, "*Columbia*, Houston on air-to-ground 2. Over."

Penn told me over the FAO loop that he hadn't known about any keyhole. If he'd known, he would've waited to start the transmission. We'd probably need to send the message again.

I reported this to Flight. I wrote post flight that "INCO called and was very rude, and said our people knew about the keyhole." But Capcom hadn't known about it, either.

Flight wasn't interested in assigning blame, though. It wasn't the first or last time communications got messed up during flight. All he cared about was making sure the crew had the information they needed to do the activities between now and the next orbit. He told Capcom to ask the crew about the message once they came out of the keyhole. There'd be no wake-up music, none of the usual chit chat. We had work to do.

Capcom called, "Good morning, TK. Is your teleprinter running?" Mattingly said it was.

"Okay," Shaw said. "We're trying to get a new Flight Day 5 up to you. We hope it gets onboard. If not, we'll get it to you the next pass at Dakar. In the meantime, there's nothing all that critical unless you could start a maneuver for us at 16:08."

He then read up the roll, pitch, and yaw for the maneuver and told them to have a good breakfast. I was very impressed at the way Shaw handled that pass. He deserved some sort of Capcom Atta-boy.

A full orbit later, we got to talk with the crew again. Capcom said, "By your configuration, we see that the teleprinter message did get onboard."

Hartsfield replied, "I want to talk to you about that. . . . Lines 15 through 17 are pretty garbled, and I think you're going to have to retransmit to us pages 3, 4, and 5 of the CAP."

We had the message ready to go, but the pass wasn't long enough. It took another orbit to get it up. What a mess. But Shaw got what the crew needed to know down to a few sentences. "The previous thermal attitudes have wiped out a lot of the tests we were going to do today," he explained. "So the main activity today is to make sure the doors are healthy for entry."

Then Shaw added something that took me by surprise. "And one thing for TK. He'd been promised sometime today to do his EMU exercise, and unfortunately, that got wiped out by the payload bay door problems. But we're going to promise it to him again for tomorrow. We hope to have the time between breakfast and lunch all open for him to do that."

Promised it to him? Capcom hadn't mentioned the space suit demo since our first preflight shift. Carolynn hadn't said anything about it. I asked the backroom if they had any notes about it. Nope. I called Crew Systems who were the experts on EVA. Did they have a procedure for this demo? Nope. Anyone know how long it is supposed to take? Nope. Great. We were now obligated to make time for a procedure no one had and that took an undefined chunk of time to schedule. Sigh. Next time we had a long LOS, I needed to get the Capcoms together with the Crew Systems people to sort this out.

As the time for the door test approached, we were nervously optimistic that time in PTC had corrected the problem. We watched the downlink data from the orbiter, alert for telltale signs of problems.

On Orbit 62, Mattingly commanded the doors to close. He reported, "I have all normal indications for the doors." We collectively breathed a sigh of relief.

Next up was a TV pass. The crew took us on a tour of the flight deck. I found the tour about as exciting as an academic lecture: "over here is the control panel from which we control the mechanical arm, the RMS. . . .over here is the panel which we use to drive the arm up and down." Maybe the public would like it, but I preferred INCO's idea of watching Earth.

As the time for the end of the shift approached, I decided to ask Flight about our handover schedule for the last day. We'd decided before launch that the landing would slip one revolution. Because of that change, we'd also extend the crew's sleep period. So why not also extend ours? I floated this idea to Draughan. He wanted the crew and the Entry Team well rested for the high speed entry phase. Change approved! It occurred to me that none of the "macho" male controllers would ever have asked this boon of the flight director. I smiled to myself. I bet they were all glad their "Dragon Lady" had brought it up.

SPACE WALK PREVIEW

I once again got up in time for the evening news. The crew had made a live call to the World's Fair in Knoxville, TN. They told the thousands listening over the PA system that they expected to land on the 4th of July and declare the "space transportation system is operational," and "celebrate the ushering in of a new era, just as our forefathers ushered an era of democracy for the whole world over 200 years ago on the same date." They also said that we'd "exploit space" and "make it pay off like it never has before." I hoped we'd be able to keep that promise. President Reagan planned to be at the landing, and the reporter speculated that he might make a new space policy statement there.

While I'd slept, the crew had also done an OMS burn to raise their orbit to 195 by 186 mi (170 by 162 nm). This slowed them down relative to the Earth, shifting the ground coverage yet again. The advantage of the slightly higher orbit was to give them more distance to fall through during entry, and thus increase the amount of error that could be tolerated in their trajectory north or south, i.e. the cross range.

On Friday, July 2, the wake-up music "Chariots of Fire" played during the Dakar pass at 1:20 a.m. We sent the teleprinter message without any keyholes. But we had another teleprinter goof that would show up later.

Bob Crippen, who listened to the download of the crew's intercom, heard the crew complaining about two lines we'd thought had been deleted from Message 50. He and I went over the content of the messages, and discovered that we'd sent version 50B instead of 50C as intended. Fortunately, the two lines hadn't caused any serious consequences. But Penn was given the action to review our uplink procedures to see how this mistake could've been prevented. When we fessed up to the crew later, Mattingly wasn't upset. In fact, he paid us a compliment. "These little one-page timelines you folks are putting together . . .those things are really helpful. Turns out that we use one of those as our master log to keep track of where we are . . . they really work out slick. Whoever put that together is doing a good job on that stuff."

Score one for the FAO team! I congratulated the backroom and said they should be sure to pass that compliment along to the Planning Team. I couldn't wait to tell Carolynn!

Overall, the schedule was a pretty light but for some reason, the crew still felt rushed. They kept trying to "get ahead" on the timeline. First thing in the morning, Hartsfield asked, "Is it okay if we go ahead and get the water dump now, or is that going to interfere with something down the line?"

That system belonged to EECOM, and he said that was fine with him. They could dump tank A to 90 percent and B to zero. Capcom was about to tell the crew, but I said, "Flight, FAO."

"Go, FAO."

"Stand by one," Capcom said to Hartsfield.

I continued. "I recommend we keep the water dump where it is. It could interfere with the Backup Nav test. The stars are low magnitude, and the -Y star tracker's been having problems." He understood that frozen water drops could easily confuse the star tracker.

"Flight, EECOM, how long will the dump take?"

"We estimate 40 minutes, Flight."

The Backup Nav test wasn't for an hour. So Flight let them go ahead and do it early.

Shaw said, "Henry, in response to your question about the water dump. You have about an hour before you get into the Backup Nav test, and the stars are rather low magnitude. But other than that concern, you can go ahead and do it, and we think it will take about 40 minutes."

"Okay," Hartsfield said. "I'll get it going right now then."

GNC Dave Whittle then told Flight that he shared my concern about water crystals affecting the star trackers. So at the next site, Capcom said, "Henry, people are worried about the star trackers and the water dump. We'd like you to stop the water dump at this pass, and then continue it again after the Backup Nav test and use the same numbers I gave you earlier."

"Okay, stopping the dump now," Hartsfield replied.

Trying to "get ahead" hadn't saved them any time at all. Post flight, I lamented that "We would have preferred they trusted us not to overcrowd the timeline and therefore do things as scheduled. There should be no need to get ahead." But often, like with the DOD issues on the first few days, and the door tests yesterday, they'd needed extra time. Today, they wanted to do the space suit test. So who could blame them, really? At least they'd asked first.

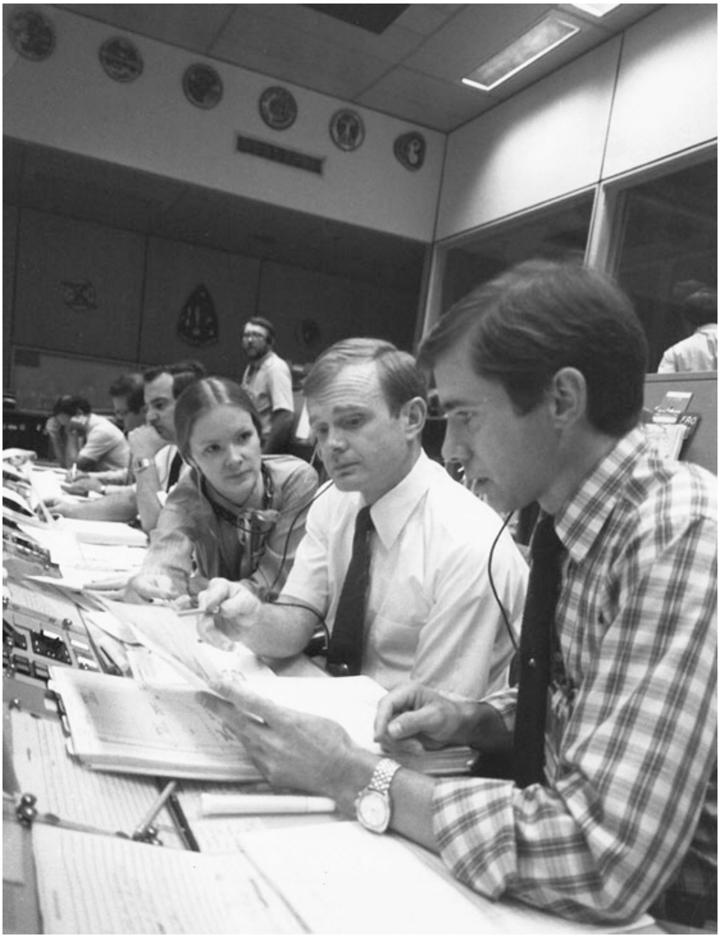
The big event for the morning was the space suit demo that Mattingly had requested. The Planning shift had cleared his morning to give him two and a half hours for it. I asked to see the procedure and discovered that Crew Systems hadn't been involved. Where did it come from? Apparently, this procedure had been banging around in the Astronaut Office since STS-2. I even overheard PAO saying that it had been planned to be done if we had a mission extension. What?! I'd written the one-day extension timeline, and no one had ever mentioned scheduling this. STS-5 had a test spacewalk under consideration. But it also had two satellites to deploy. If something went wrong, the crew might have to do more than a test spacewalk. Shoot, if the doors hadn't closed, they'd have had to do a spacewalk on this flight! And we didn't even have a procedure ready for a demo? I was glad the crew had found a way to get it added to the timeline. We'd all benefit from this "training" exercise.

PAO was more excited about something else, though. NORAD had discovered that a Russian Intercosmos 14 upper stage in space since 1975 would pass within eight miles of the shuttle. Would the crew see it? Would the mysterious DOD "laser" take a pot shot at it?

The booster was three by 12 feet. Seeing something that size from eight miles away was only possible if it reflected sunlight toward the shuttle. Draughon said at the press conference that the astronauts, "would have had to be looking at exactly the right place at exactly the right time and not have blinked." They didn't see it.

Mattingly started his space suit demo around 4 a.m. He asked, "Could you have someone verify the EVA flight assemblies and the fit check on the helmets that are in the airlock?"

Capcom looked at me, while he said, "Roger, we'll check."



11.3 Elvin Pippert (far *left*) arrived early for his shift and listened while the Capcoms, Roy Bridges and Brewster Shaw, and I tried to support Mattingly's impromptu suit demo (NASA photo)

"Crew Systems—do you have an answer for that?" I wasn't even sure what "EVA flight assemblies" were!

Fortunately, Terry Neal was in the support room, and he did. "Tell them yes," he said.

I told Flight. He had Capcom tell the crew.

The next pass, TK said they were going to try and set up some TV of the demo at the next Mila pass in about a half hour. I really wished we'd simmed this activity. Well, we had a half hour before the pass—Flight said he'd appreciate even a quick briefing. I knew I would.

I called the back room. "Hey Terry, please grab a green badge and come on out to the MOCR. Flight and I have some questions for you about this demo."

When the TV pass came up, we had video, but couldn't hear TK. The crew were talking to each other using the space suit's ultra-high-frequency (UHF) radios. We hadn't been expecting this. Hartsfield said, "Are you reading TK?"

"Negative," Roy said. "We're getting no voice."

"We're in EVA configuration on UHF, so you might want to reconfigure UHF so you can hear him," Hartsfield suggested. "And also, he would like for the docs to check and see if they're getting biomed on him."

Surgeon looked up, startled. He didn't know he was supposed to be involved in this test. INCO wasn't prepared either. Terry joined him at his console, and together they came up with a suggested new configuration. Flight told Capcom to pass these along to Hartsfield. That worked so we could hear TK, but Hartsfield couldn't hear him. So they switched configurations again. Finally, Capcom admitted, "We don't have enough time left in the TV pass to reconfigure."

We did get some video showing suit parts and equipment floating every which way. Hartsfield said, "When you get that extra suit out of the locker and get everything out of the way, there's quite a bit of junk in the middeck." I thought of the way Thor left his shorts and shirts draped over chairs. In space, our bedroom would look like the inside of a dryer on tumble!

Bridges said, "Roger… we were afraid somebody had an accident there for a few minutes."

Everyone burst out laughing, including Hartsfield. I thought this video should make PAO very happy, and make up for the Soviet satellite "dud." Even without the sound it was way better than the lecture on what switch controlled what.

Surgeon couldn't get the biomed. Capcom told them, "We're getting negative on the biomed." So, was the biomed not working or was the radio in the wrong configuration? It reminded me of the old simulator verification runs I'd done two years ago. Was the sequence or the configuration or the equipment at fault? At least they didn't have to deal with the simulator crashing! They did some troubleshooting on the next few passes, and finally got some data.

But all the changes to the communication system had some unanticipated consequences, typical of activities added without being coordinated ahead of time. For example, we missed one whole communications pass because they hadn't reset the switches for the right UHF band. Also, no one had considered what impact these changes might have on the DOD payload.

In the midst of the demo, I got a call from Sunnyvale. Because Terry didn't have a "need to know," I had to ask him to return to the back room while Flight and I discussed the issues. I reported post flight that, "Terry was most understanding. He handled the whole EMU demo in a most professional way. INCO was not up to speed, and they worked together real time to straighten out the communications." His support helped make the demo a real time success.

BETTER IS THE ENEMY OF GOOD

On my way home Friday morning around 9 a.m., I wondered what "normal" people were planning to do this weekend. I picked up a copy of our free local paper, the "Citizen," and put it on the table while I warmed up some leftover tuna and noodle casserole. I spread it on the table. "Oh my God, Jasper!" I exclaimed to the cat. "That's *me* on the front page!" Jasper wasn't impressed. He was way more interested in the casserole.

The front page story, "Shuttle passes main tests," by Jacquie Harbour said that the crew had "settled into a more relaxed work schedule today" [3]. I certainly hoped that would hold true for the rest of the day. Only two more shifts, and I'd have survived my first flight as FAO.

As I shooed Jasper out of my tuna and noodles, I focused on the second headline, "Women's leaders vow to battle legislative enemies of ERA," by Mary McFadin. Elaine Kimzey, Chair for the Texas NOW [National Organization for Women] Equal Rights Amendment Task Force was quoted saying that "We can no longer rely on political parties to work for women's issues. After all, we were not born Democrats, Republicans, or yesterday." She went on to note that only 46 percent of male legislators had supported ERA and that they were focusing on getting more supportive individuals elected [4]. Hmm. Maybe if things went sour at NASA, I should run for Congress.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News Roundup

Court rules against pornography

WASHINGTON — The Supreme Court, acting to curb the "serious national problem" of the abuse of children in lewd films and photographs, ruled 9-0 today that child pornography can be banned, even if it is not legally obscene. The decision upholds laws in 20 states that are waging an all-out war against material depicting children engaged in explicitly sexual conduct.

Thatcher counters Reagan

LONDON — Prime Minister Margaret Thatcher condemned President Reagan's attempt to hinder West European help in building a Soviet pipeline and moved to prevent him from applying U.S. law on American affiliates in Britain. "The question is whether one very powerful nation can prevent existing contracts from being fulfilled," she told the House of Commons. "I think it is wrong to do that."

Student pleads innocent

SAN DIEGO — Benjamin Sasway, the first American since Vietnam War to be accused of failing to register for the draft, has pleaded innocent to the felony charge amid nationwide support from anti-draft demonstrations. "I don't want to be a martyr," Sasway said Thursday ...

Coming down Sunday

Shuttle passes main tests

By JACQUIE HARBOUR
Staff Writer

JSC — Passing test flight objectives with nearly flying colors, the crew of the space shuttle Columbia settled into a more relaxed work schedule today as preparations are being made for the return of the reasuable space truck to Earth.

Columbia will celebrate Fourth of July Sunday streaking to a landing at Edwards Air Force Base in California for the fourth time around 11:09 a.m. Houston time.

Mission Control at JSC reported early this morning that Columbia passed within 8 miles of a derelict Soviet rocket. Astronauts T.K. Mattingly and Henry Hartsfield apparently did not see the burned-out upper stage from Russia's 1975 Intercosmos 14. The space debris was headed roughly toward the Columbia at about 6,400 mph as the shuttle passed over north-central Australia on its 75th orbit.

Major accomplishments of the Columbia's fourth mission have proved "We (can) have a high degree of confidence in our vehicle," said Lead Flight Director Charles Lewis. "We have met the test flight requirements and have a mature vehicle."

Asking the press to keep in mind the total view of this mission's accomplishments, Lewis said, "We don't have any significant problems. We are going to close the doors on the Fourth of July and come home."

He listed the two major accomplishments of the mission as getting the thermal testing done, and fullscale testing of the capability of the Canadian-built robot arm.

Completion of these tests provide verification of data which was previously an unknown or limited in confirmation by earthbound simulation.

On Thursday, Mattingly and Hartsfield beamed a message to Earth to people attending the World's Fair in Knoxville, Tenn.

"It's kind of fitting that we land on July 4 and celebrate the ushering in of a new era," Hartsfield said, "just as our forefathers ushered in an era of democracy for the whole world over 200 years ago on the same date."

The message was transmitted directly from Columbia, located about 166 miles above the Earth, through special radio hookups.

Women's leaders vow to battle legislative enemies of ERA

See picture, page 4A
By MARY McFADIN
Citizen Correspondent

HOUSTON — A panel of four women leaders in the Houston effort to get the Equal Rights Amendment ratified met Thursday at the Houston Area Women's Center with representatives ...

... Saletan said. She cited the fact polls show that 63 percent of the public are in favor of ERA and more than 80 percent approve of the text of the amendment when it is read to them.

Kimzey told the audience of about fifty people women have learned much during the long ten year campaign for equal rights ...

... committed to equality," Stevens said referring to the advantage of having a voting bloc and money now available. Stevens said last year the political action committee for ERA raised more money that the National Democratic Party. Recently, two North Carolina senators were defeated in the primary ...

FLIGHT OFFICER: Marianne J. Dyson, Clear Lake, views a monitor in the mission operations control room at Johnson Space Center. Dyson, 27, is a flight activities officer on the entry team working with mission four of the space shuttle Columbia. Dyson, who married to a flight guidance officer, Ted Dyson, says she believes they are the only man and wife team working in mission control. Columbia is due to land at Edwards Air Force Base in California July 4. (NASA photo)

Bass, Heard could be ousted

HOUSTON (UPI) — Five Harris ... Allison said that barring further ...

11.4 I was surprised to find a photo of me on the front page of our local paper (Photo by the author)

Flipping to the Entertainment section to see what I'd miss tonight, I noted that *Star Trek—the Motion Picture* was on at 8:30. The description read, "To prevent Earth's destruction, the USS Enterprise must challenge an alien force that is sweeping through outer space." The alien force was a silly-looking cornucopia that mindlessly sucked everything inside. In the movie, they speculate that this artifact is a weapon of mass destruction left from some forgotten war. After working this flight, I knew they had it all wrong. It wasn't a weapon at all, but a giant vacuum cleaner to get rid of all the floating space suit parts, dirty socks, and burned out Soviet upper stages. Hey, maybe DOD 82-1 was a prototype space vacuum cleaner!

The mess I walked into when I arrived on console on Saturday morning just after midnight needed more than a space sweeper to straighten it out. Post flight, I wrote, "The handover was pure chaos. The CAP Update was not close to being complete. [Flight Director] Cox would not hand over. FAO could not handover and continued to review and rewrite CAP Update. I could not brief my Flight Director."

The CAPS had crashed during the night again, and as Murphy's Law dictates, at the worst possible time. Carolynn's team had tried in vain to resurrect it. Diane had ended up doing the As Planned timeline by hand—cutting and pasting a CAP and penciling in the new items like we'd done back on STS-1.

Carolynn apologized for not having anything ready to handover. I tried to stay out of her way and absorb the state of affairs by looking over the log from Elvin's shift. The thermal attitude tests continued. One impact that hadn't been anticipated was the effect the shuttle's orientation had on the crew. Mattingly said that unless the allowed error (called the "deadband") in pointing the tail at the Sun was less than one degree, the sun peaked over the tail and right into the aft windows the crew were using. With no atmosphere to filter it, the sun could cause eye damage in just a few seconds. However, maintaining a tight deadband required the jets to fire more often, using more propellant than a "loose" deadband. Thus we had a new set of constraints to think about when scheduling robotic arm and observational activities.

I was happier to read how the team had come up with a creative solution to a nagging "operational" problem. Every morning, we used electrical data from the food warmer or the toilet fan to tell if the crew were up yet. Someone finally realized that electrical signals could also be used to mark the beginning and end of the crew's recorded messages that were embedded in the downlinked data. The crew did the recordings after contact with the ground was done for the day, and often stayed up hours past their scheduled sleep time. Thus we had hours of data to sort through. The team had told the crew to "tag" the start time by turning off a CRT (which they did every night), and turn off a second CRT when they stopped. Hartsfield said, "Okay, very clever." We weren't "operational" yet, but bit by bit, we were finding ways to make our jobs easier.

But considering the roar of chaos in the MOCR right now, we still had a lot to learn! Handover was delayed by a full hour, and I still didn't have a copy of the CAP Update to show Draughon. I gave him a quick overview of the day's plan. Shaw would have to read up the instructions for the first part of the morning because the message wouldn't be onboard in time.

Holmberg, wrestling with the CAPS in the support room, commented post flight that, "Because of CAPS crashes we did two summary timelines practically by hand." With his usual wry sense of humor, he concluded, “Suggestion to return the CAPS to its former status as a PACMAN machine are probably extreme.”

Making matters worse, the CAP Update message was a record ten pages long. We had to break it up into parts to send to the crew over the short ground passes. But even before we had the first few pages onboard, Mattingly was rescheduling the TV. He wanted to narrate a daylight pass across the U.S. Holmberg commented post flight, “Since the crew is uninterested in following the CAP for TV, photo, housekeeping, exercise, etc. why do we waste the effort to carefully schedule this stuff? Could we schedule a block of time each day for crew overhead activities and let them do their own thing?” This was exactly what we’d do for later flights.

The real problem wasn’t that the crew wanted to do their own thing, or that we’d wasted our time planning. We did our best to support these guys who had, after all, put their lives on the line for this flight. If they wanted to have a little fun with the TV, and it didn’t interfere with the primary objectives, then we’d find a way to help them do it. As soon as Ken mentioned wanting a daylight pass over the United States, Pointing got busy calculating the sites while Timeline looked for an open space in the schedule.

The problem was with the nature of flight control. On these short flights where every minute was worth tens of millions of dollars, there was a lot of pressure to find the optimal way to do everything—from which attitudes to use to minimize fuel to how to mark crew logs to find them on the downlink. We didn’t have anyone around with the authority to say, “enough!” With the rush to make spaceflight as “operational” as airline flights, we were actually encouraged to optimize every detail of every activity in space and on the ground. As Mattingly would say post flight, “better is the enemy of good.”

Thus I found myself in a friendly, yet heated argument with the Capcoms over the wording of a message. The sentence was something like “Data is not supporting the crosswind test.” Shaw said that data was plural, so “is” should be changed to “are.” I favored “is” because I considered data a collective noun like family. Unable to agree, we solicited the opinion of Flight who outranked us both. Instead of choosing grammatical sides, Draughon picked “is” simply because it was shorter!

(Thirty years later, I found a discussion in Grammar Girl’s *101 Troublesome Words*. She says, “data is a skunked term, meaning you can’t win—whether you treat it as singular or plural, you’ll get in trouble.” She added that “data as a mass noun. . .can be singular [my argument]; however, in scientific writing, always treat data as plural [the Capcoms’ argument]” [5]. Is a teleprinter message scientific writing? I say not! Besides, the Flight’s decision is always final.)

Despite our nitpicking natures, we did finally finish wordsmithing all the messages and uplinked them to the crew. Mattingly called down, “We have a picture we’ll bring back and, we’re not sure who to dedicate it to, but if it comes out, it’s a picture of Hank with today’s update floating through the middeck, and it makes a rather impressive roll of paper.”

Shaw replied, “Well, we figured that we had a hundred yards of paper, and we’re on about the 30 yard line and going in. . . .”

“I thought you were going to amend our summary at the end of the day,” Mattingly joked, “that we had enough consumables for the remainder of the flight plus extension, except we would have to be coming in early because we’d run out of teleprinter paper.”

Shaw replied, “That is a concern.”

I laughed along with everyone else, but we really needed to rein in this replanning stuff. It shouldn't take the crew longer to read the messages than to carry out their instructions. With flights getting longer and crew size doubling to four, we couldn't fly enough paper to continue to plan at this level of detail. Giving more control to the crew made sense. But it wasn't just the planning process that needed improvement. We also desperately needed better onboard tools for the crew to track and accept changes, especially to the trajectory. The test burns they'd done yesterday had once again changed their orbit. It was now 202 by 183 miles.

11.5 Hartsfield is seen here with the record 10-page-long CAP Update message the Planning Team sent on FD 7 (NASA photo)

Mr. Kranz monitored this exchange from the FOD console in the back row. After LOS, he asked me for a copy of all the teleprinter messages sent so far. Pads printed out a set for him. Then Crew Systems rolled them up and brought them out. Mr. Kranz nodded his approval. He indicated to me that this example would help him sell management on getting a new system.

Not only did the crew request changes to the 10-pages of updates, but we discovered enough errors in the details that I recommended to Flight that we just replace two of the pages. Most of the errors had to do with the FCS Checkout. The Entry Team wanted to see if the cold temperatures had caused any failures. These tests required real-time comm. Because the ground track had shifted (again), we had to start this test during the crew's meal.

All this shifting caused some "near misses" by the crew that could have had some serious consequences if the flight controllers hadn't caught them. In the middle of the TACAN test, the crew almost changed out the software in the computers needed to support the test. An alert DPS, Andy Algate, made sure they kept running the software called OPS 8.

Another near miss involved a test to see if the cryogenics (hydrogen and oxygen) for the fuel cells, settled out or "stratified," during orbit. The test required a power up of the tanks, then a "calm" time of two hours with no maneuvers, followed by a pitch up "shake-the-salad-dressing" maneuver. The Planning Team had accidentally scheduled a maneuver for something else right in the middle of the two-hour wait. Vollrath caught the error even before the EECOM folks.

But it almost got missed because Flight was focused on reviewing the proposed list of changes to the Entry timeline for tomorrow. I kept calling, "Flight, FAO," and he kept saying, "Stand by FAO," while he discussed the entry. The time was coming up where the crew were going to do the maneuver that would ruin the cryo test. We needed Flight's approval NOW. I alerted Capcom, and together we got Draughon's attention. He had Capcom voice up the change just in the nick of time.

During the crew's TV show, they praised the work of all the people on the ground who'd designed the shuttle and made it possible for them to fly it. Hartsfield said, "Probably the most important thing is that no technology can work without the people and proper planning cooperation." Speaking of planning, in the background, if you listened carefully, the teleprinter could be heard printing out Message 67B, another set of changes to the CAP.

Our handover to the Orbit Team went smoothly. If we didn't wave off, this would be Thor's last shift for STS-4. I gave him a kiss on my way out, looking forward to spending time with him after we landed this bird. His friends teased me about having my photo on the front page of the paper. I smiled, saying that Patnesky picked me because I was the prettiest girl on the Entry Team. Then I noted that I was also the *only* girl on the Entry Team, and they all laughed.

A FOURTH OF JULY TO REMEMBER

While getting dressed that night for my shift, I realized I didn't have anything red, white, and blue to wear. I had a pale gray suit. I pulled my hair up into a bun, the way I'd been wearing it throughout the flight. I didn't have time for anything fancy, and my hair wouldn't hold a curl anyway. But I wanted to look good because we'd be putting all the secret documents away prior to entry. I assumed there'd be television coverage of the MOCR for the landing. I made sure Mom and Grandma and Tom Burkhalter and everyone else knew where my console was—though being the only woman on the team, I should be pretty easy to spot!

The slip of crew sleep had given the Planning Team an extra hour to do their work. However, because of the chaos with the last shift, some of the Entry Team hadn't gotten the word to come in later and had shown up at the original time. Flight Director Cox wasn't happy to see these early birds. After yesterday's handover fiasco, he was determined to finish all the messages on time.

So I'd no sooner stepped to the console when I was "ordered" to leave the MOCR in no uncertain terms. I left Carolynn to finish the review, and padded to the support room. Even though it was just after midnight, the FAO support room was crowded. The high ceiling echoed the "gym full of hollering teenagers" roar of all the voices. The p-tube was backed up, as usual, and I unloaded the canisters and delivered the messages to Diane. On this last day of the flight, every console was piled high with checklists, messages, log books, clipboards, and empty doughnut boxes. The green metal trash cans had overflowed days ago, and people just piled stuff next to them. *This* is what operations looked like.

I rolled one of the spare chairs up to the FDF console and spent a productive half hour going over changes to the Entry Switch List with Dick Snyder and Mike Fossum (1957–), who would later become an astronaut. This was the first time the FDF console had handled the list, and we all agreed this new division of labor had worked well. (Timeline 2 was now dedicated to running the CAPS.)

The rest of "my" team arrived in the backroom. Someone passed out "bouquets" of small American flags. The atmosphere was festive, and for good reason. The flight had gone well. All the major objectives had been met, and the managers were happy. The FAO teams had gotten multiple kudos from the astronauts. Management, thanks to Kranz, was now more aware of the training and resources (including teleprinter paper!) required to do planning.

I made my way back to the front room where flags now sprouted from the sides of every inbox, poked out of shirt pockets, and reminded us all that we weren't just working for paychecks or for our managers: we were giving the American people a successful space mission to celebrate on our nation's birthday. President and Mrs. Reagan would be at Edwards to receive the gift. But first, we had some "wrapping" to do.

I read through the log from Elvin's shift. Wow! They'd done a test to collect data for my old Loss of FES case. I remembered my procedure-verification runs with Lousma and Shaw, and how neither the simulator nor analysis had been able to determine if the hydraulic circulation pumps could provide a heat sink during entry. Someone had decided to cycle them for a few hours and get some actual temperature data. I was no longer in charge of those procedures—I'd handed them off to (future astronaut) Mark Brown, currently serving as Carolynn's Pointer. I knew he'd do a good job making any necessary changes as a result of this new data. Capcom George (Pinky) Nelson said, "We're gonna try and get some real time data here to investigate the Loss of 2 FES case that we've got on the books."

I noted that the TACAN test that Thor had been responsible for tracking real time had gone well. Capcom told the crew, "We had all three TACANS locked on from 300 miles before the pass to 400 miles after, so we got real good data on that."

I laughed when I read another note Elvin had logged. Capcom said, "The flight directors have just reported to me that they plan on donating a dollar for every foot of teleprinter paper that we've used onboard. And our latest tally shows that we've used about 250 feet, and that will go towards the post-flight gathering we've got planned on Wednesday."

The crew replied with a hearty, "Outstanding."

11.6 STS-2 pilot Dick Truly stopped by my console to look over the latest teleprinter messages for the crew. Jay Green talks with Chuck Lewis (back to camera) behind us (NASA photo)

The Planning Team had hardly gotten out the door when EECOM reported a problem with a fuel cell. He didn't want the crew to do the purge scheduled just after wakeup. I reminded Flight of the crew's tendency to "get ahead," suggesting they might do it before our wake-up call. Flight decided to wake up the crew a half hour early to tell them not to purge fuel cell one.

The wake-up music was appropriately, the patriotic tune, "This is My Country."

Although the FAO team couldn't do much to provide the "stripes," we had the "stars" ready for this 4th of July. Vollrath suggested that we use "stars of opportunity" for the IMU alignment this morning. Rather than the crew maneuvering the orbiter to point the star trackers toward "guide" stars, we just let the star trackers sweep across the sky and pick up stars in passing. This saved propellant and crew time. This "star of opportunity" method was a definite step towards more efficient operations. I was proud of our Pointers "pointing" the way.

Two hours after wakeup, we finally got the teleprinter messages to them to update the Deorbit Preparation procedures and the Entry Checklist. Pads operator Penn was the book manager for the Deorbit Prep now, and he'd taken over my BFS Notes section, too. He'd done an excellent job typing up the changes. Knowing the flight directors were now paying by the foot of teleprinter paper, Capcom said, "They're not too extensive, and we think that's the end of it." So far we'd sent 77 messages.

With so many messages on board, and everything floating this way and that, it wasn't surprising that one got lost, though. Mattingly called down to say he couldn't find Message 6C that we'd sent the first day. Penn had it reloaded and sent in under five minutes, earning major kudos from the team (and costing Flight another dollar!).

We once again prepared a "silly" message for the crew that we entitled, "Post Mission CAP Extension." The description read, "This message outlines the STS-4 post mission party plan as follows: party at Gilruth Center, Outpost Tavern, and Quality Inn. Reception for crew at Ellington AFB. We included times and activities in appropriate format and made lots of inside jokes such as "INITIATE BODY MNVR TO –ZLV" which referred to being belly to the Earth. I asked Flight for approval, noting that the STS-3 crew had said post flight that they would've enjoyed it. I also noted that he was paying for all those long teleprinter messages that Cox had sent. There ought to be at least one from our team that Cox had to cover. To the FAO support room's delight, Draughon approved it. So the final teleprinter message of STS-4 was signed, "From your friends on the Entry Team."

The crew transitioned from the CAP to the Deorbit Prep. The clocks in the MOCR switched from counting up in MET to counting down to Time of Ignition (TIG) of the deorbit burn. They'd land about an hour after that.

The most critical of the deorbit procedures was the closing of the doors. Considering the warping of the port door earlier in the flight, we were relieved when it closed and latched.

The next big item was the transition of the computers from OPS 2 to 3 to support entry. I watched the attitude on my display in real-time as they did the transition. The error in attitude (top sun with a deadband of plus or minus 3.5 degrees) went from minus 2 degrees to plus 7.9 degrees. This error exceeded the deadband! The jets should have fired to line the Z axis back toward the sun. What was going on? I called GNC Dave Whittle, and he couldn't explain it. I called Prop Ron Dittemore to check if there had been a maneuver. He said there hadn't been one.

UPLINKED COPY

POST MISSION CAP EXTENSION
PAGE 1 OF 1, 44 LINES THIS PAGE

THIS MESSAGE OUTLINES THE STS-4 POST MISSION PARTY PLAN AS FOLLOWS:
- PARTY AT GILRUTH CENTER, OUTPOST TAVERN, AND QUALITY INN
- RECEPTION FOR CREW AT ELLINGTON AFB

RATIONALE: WHO NEEDS ONE? THERE IS NO POSSIBLE BETTER WAY TO CELEBRATE THE END OF A VERY SUCCESSFUL MISSION AND TO RELAX AFTER EIGHT LENGTHY AND EXCITING DAYS.

POST FLIGHT TIME		ACTIVITY
12:00(CST)	BOTH	CONSUME MASS QUANTITIES OF BEER & MUNCHIES(HI-SAMP MODE) (THIS IS A PAYLOAD SPONSORED ACTIVITY) INITIATE BODY MNVR TO -ZLV(ONCE AT GILRUTH CENTER) DAP: A/AUTO/NOT-SO-NORM
14:00(CST) -TILL?	BOTH	CONSUME ADDITIONAL MASS QUANTITIES OF BEER & MUNCHIES (SPONSORED BY FOD, USAF, MARTIN) (CONT-SAMP MODE) FIRE OMS ENGINES IN DIRECTION OF NASA 1 & EL CAMINO FOLLOW BY RCS ATT ADJUSTMENT TO OUTPOST TAVERN
16:00(CST) -TILL?	BOTH	CONSUME STILL MORE MASS QUANTITIES OF BEER & MUNCHIES (SPONSORED BY QUALITY INN OWNER) (HI-SAMP MODE) REQD MNVR:TRANSLATE ACROSS FROM JSC CENTER TO QUALITY INN
18:00(CST)	ALL	RECEPTION FOR CREW AT ELLINGTON ALCOHOL SOAKBACK(SOAK-IN) TIME
19:00(CST)	BOTH	RETURN TO PARTY OF YOUR CHOICE DAP: A/AUTO/ABNORMAL, ATT: FREE DRIFT PERFORM IMU ALIGN IF GRYOS ARE MISALIGNED WASTE WATER DUMP(AS REQD) DAP: A/AUTO/MINGLE

CAUTION- IMUS CAN NOT BE REALIGNED, GPCS SELF FAIL, AND COMM IS SLURRED: LET MISSION SPECIALIST DRIVE YOU TO YOUR DESTINATION)

FROM YOUR FRIENDS ON THE ENTRY TEAM

END OF MSG, PG 1 OF1

11.7 Flight Director Draughon approved sending this message created by the FAO team (Photo by the author)

Vollrath explained it post flight. Prior to and during the OPS 2 to 3 transition, the roll had been pegged to the port side of the deadband. So when the computers "landed" in the new software, the new "zero" point for the deadband was 3.5 degrees off center, causing an immediate error. Then the vehicle rolled to the "edge" of the new deadband, piling up the errors. This incident reminded me that there were always going to be quirky things like this that would come along to surprise us.

PAO reported that as of 6:30 a.m., there were 305,000 people at Edwards to see the landing. The crew were in their seats now. The CAP was stowed, the teleprinter turned off. The payloads, including DOD 82-1, all secured, and the doors were latched. We were all set to pen another entry into the history books.

I locked up all my Secret stuff, and tidied up the console. I fully expected that PAO would do some TV of the MOCR after the landing, but unknown to me, the cameras stayed off. All the support rooms had filled to capacity with managers. Thor was watching from his back room and would join me in the MOCR as soon as they opened the doors. They always blocked the doors for the final hour of entry. We didn't want to risk distracting anyone from catching a problem on the orbiter.

The crowd in California had grown to 403,000 people. Flying the shuttle training aircraft, John Young reported the winds were too calm for a crosswind landing test. So Flight decided to go for the first concrete runway landing by a space vehicle.

The burn went off as planned. The chase planes that would "escort" the orbiter took off, flown by Guy Gardner and Jerry Ross.

I sat on the edge of my chair, staring at the static display, waiting for blackout to end. Fourteen minutes dragged on. Then we got a report that radar contact had been established at 183,000 feet. Phew! We'd done it again.

PAO said the president and Mrs. Reagan were being accompanied to the landing by all the previous shuttle astronauts except John Young (who was flying approaches). So Crippen, Engle, Fullerton, and Lousma were there on the ground to hear the sonic booms as the shuttle descended through 32,000 feet. We were 4 minutes to touchdown.

At landing, we did a few seconds of cheering, then closed out the systems. A ladder was rolled up to the orbiter, and the Flight Surgeon went onboard to check the crew. When they emerged, we all stood and applauded.

11.8 The MOCR just after the landing of STS-4. *Left* to *Right*, Me, Roy Bridges, Brewster Shaw, Chuck Lewis, Harold Draughon, Gary Coen, Pete Frank. The woman behind Lewis is Jan Pacek, Kranz's assistant. Beside Kranz is Chris Kraft, Jr. and Neil Hutchinson (NASA photo)

TK and Hank came down the steps and shook hands with the president. The traditional walk-around inspection followed. I watched somewhat dumbfounded as Nancy Reagan reached up and touched the underside of *Columbia* with her finger. The vehicle had just come through Earth's atmosphere and reached more than 3000 degrees! Intellectually, I knew that the tiles wouldn't be hot, but psychologically, it just seemed too incredible to believe until she did that. What an amazing thing, a space ship parked on a concrete runway. I wished I could touch it, too.

11.9 President and Nancy Reagan with the STS-4 crew on July 4, 1982 at Edwards AFT, California (NASA photo)

In his speech, Reagan called the *Columbia* test program "the historical equivalent of the driving of the golden spike which completed the first transcontinental railroad."

We were disappointed Reagan didn't endorse a space station. He said "we must look aggressively to the future by demonstrating the potential of the shuttle and establishing a more permanent presence in space." Would STS-5 be demonstration enough to approve a station?

The shuttle was now declared operational. As if to underscore this declaration, Gordon Fullerton flew a 747 with the next space shuttle, *Challenger*, above and around the *Columbia* sitting on the runway. The *Challenger* stopped at Ellington later and spent the night with us in Houston atop its 747. Then it would be off to Kennedy to begin processing for its maiden flight in early 1983. Two shuttles didn't make a fleet, but we were getting there.

11.10 Patnetsky snapped a photo of me and Thor, the first married couple in Mission Control, just after landing of STS-4 (NASA photo)

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12

Welcome to Shuttle Operations

The headline of the July 14th *Roundup* declared, “July 4th spectacular marks end of orbital flight tests.” *Columbia* was now “a used spaceship with over 7 million miles on the airframe.” Of special note, “A second production spaceship has in the meantime been delivered under deadline and as advertised” [1].

Fighting to stay awake (I’d been up since 10 the night before,) I joined Thor in welcoming the crew home at Ellington the afternoon of July 4th. But I forgot my camera, and the only NASA photo shows the crowd from behind. Those of us who worked “behind the scenes” were destined to remain there.

After a fitful night’s sleep, we went back to Ellington in the morning to watch *Challenger* take off for Florida atop its 747 carrier (that would one day be part of Space Center Houston).

12.1 I snapped this photo of the brand new Challenger when it stopped at Ellington AFB in Houston enroute to Florida July 5, 1982 (Photo by the author)

M.J. Dyson, *A Passion for Space*, Springer Praxis Books,
DOI 10.1007/978-3-319-20258-7_12

The media had pretty much ignored STS-4. My friend Tom Burkhalter wrote, "I was disappointed (!!) in the media's coverage of the shuttle. CNN, as I understand it, did the best job and had full coverage starting 8 a.m. EDT. CBS had fifteen minutes. (The silence you hear is future generations of spacers refraining from spinning in their graves.) Well, it was a nice landing. But no one showed JSC! Alas, your moment of fame [went] unrecorded!"

Well, almost. I sent a copy of the photo of me that had appeared in the "Citizen" to my Grandmother Esther Canterbury in Canton, along with a short biography of me. She wrote that "they were happy to print it."

Flight Director Draughon called STS-4 "one of the cleanest flights yet." Our successes included resurrection of the Get Away Special, grappling of the desk-sized IECM, a demonstration of electrophoresis in space, lots of good photos for the Night Optical Survey of Lightning, and satisfaction of all thermal, jets, and robotic arm tests. Even though the news media hadn't covered us much, lots of people had followed the flight. The *Roundup* reported, "Amateur radio groups, including W5RRR at JSC, transmitted air-to-ground and mission commentary live to thousands, and the American Telephone and Telegraph Co. logged more than 1 million calls to its special 900 number which featured the same programming" [2].

One big disappointment was the loss of the two boosters in the Atlantic. An investigative panel showed that the main parachutes had failed [3]. Another disappointment was the apparent failure of the Monodisperse Latex Reactor which had worked well on STS-3.

In summing up the mission, Flight Director Lewis said, "We expanded our data base tremendously on STS-4. We are still learning how to use our vehicle and that'll never stop. After we land, we might change the oil, we'll change the crews and go again" [4].

It certainly seemed that we were at the beginning of a new era in space that would lead to the creation of a Space Operations Center (SOC) in orbit that would handle large payloads, service and store orbital transfer vehicles, and maintain satellites. This concept had been featured in the January 22, 1982 issue of the *Roundup*. The article noted that "Initial space traffic estimates call for a SOC which could accommodate a crew of two to four persons. As more habitation command and servicing modules are brought into orbit by shuttles, the crew complement could grow to 20 by the year 2000."

"SOC is the way to go," a Rockwell rep said. "It can save more than 200 shuttle flights over a 20-year SOC life, reduce flight rates by more than 20 percent, and reduce the orbiter fleet by at least one bird" [5].

Science fiction author Ben Bova (1932–) wrote an op-ed for the *New York Times* in January and was interviewed in the April *Roundup*. He said, "I would like to see the deployment of the Space Operations Center. I think that's the next logical step. . . . The L-5 Society wants to build colonies in space and solar power satellites. Other groups want to do other things in space. All these efforts involve that first step of putting a center in orbit that will be your point of operations" [6].

Thor and I were already members of the L-5 Society and the Planetary Society. We shared Bova's evolutionary view of the space program, and we hoped to help make it come to pass. "You can do a first step to a Space Operations Center with the shuttle as the primary lifting and hauling device," Bova said. "Eventually, you realize you are putting so much in orbit that it would be cheaper to put a few bulldozers on the Moon and start smelting the stuff and bringing it down to low Earth orbit. And on that happy day, we have assured the survival of the human race, no matter what happens on the planet Earth. People will be living out there" [7].

Yes! That's the dream we were pursuing, one flight at a time.

But what role would I play? At least part of the answer came soon after landing. I wrote to my mother, "Although my bosses have not officially evaluated my performance on STS-4, I know I did a fine job and received lots of compliments. My branch chief really surprised me last week though—he came blundering in when I was complaining about having nothing to do but read workbooks, and told me I'm FAO again on STS-5!

"I'm the Planning Team FAO on STS-5. It's definitely the hardest job. Carolynn did a good job on that team on STS-3 and 4, so I hope I can build on her experience.

"In addition to the STS-5 assignment, I'm also working on STS-11. That flight will have four crew, a deployed (let out into space) communication satellite, a test article, a large camera (they say the old camera could tell when [Russian leader] Krushchev lighted his cigar, and the this new one can read the brand…), and maybe a demonstration of the manned maneuvering unit. It's the Buck Rogers strap on jets backpack to move around in space with no tethers. Sounds fun!"

So I had my new marching orders, and I *would* get to be lead FAO, just not as quickly as originally planned. I told my mother that even though our original assignments hadn't been reinstated, Mi-Mi and I thought our meeting with management had worked in our favor.

But Carolynn's future remained cloudy. She wasn't back on the flight roster until STS-8, a full year away, and she wasn't lead (though she was later made lead). We remained cautiously optimistic that they had some management opportunity in mind for her, but I worried that Mi-Mi and I might be promoted at her expense: so someone could later point to our progress to show that whatever happened to Carolynn wasn't because she was a woman—using my "treat us as individuals" argument against us.

Mi-Mi had returned from maternity leave on schedule and was assigned as Timeline 1 on STS-5 as well as FAO on STS-6. During lunch with Marion one day, she admitted to feeling obligated to rush back to work after the minimum six weeks because of our complaint. If she had another baby in a few years (she did), she said she'd take off as long as she could afford. I remember her joking that it was more important that her tombstone read "Beloved Wife and Mother" than "Best FAO."

Becoming a mother was certainly at the top of my priority list. With the stress of the assignment uncertainty and the weird shifts for the sims and flight, my cycles remained irregular. Month after month nothing happened. It'd been a year and a half since we'd started trying. So the week after the flight, Thor and I underwent fertility testing. He was fine, and the doctor said my "plumbing" was in good shape—no obstructions. She advised that we try for at least two more cycles and then, if we didn't want to wait any longer, start a popular fertility drug.

My mother wrote that the drug option scared her. "Sometimes it causes multiple babies, and they are really tiny and don't make it." She urged me to reduce my stress level instead.

I tried. The weekend after the flight, we went camping at Canyon Lake with folks from work and our friend Maggie Harrison from Valhalla. I played my guitar while Thor volunteered as crew on in a sailing boat contest. The wind was dead calm, so the boats just sat on the water most of the day. Maggie and I relaxed on shore, eating our fill of cold chicken dipped in mustard.

The next weekend, my friend Cindy and I went stargazing with one of the guys I knew from work while Thor worked on the Long-EZ with Ed and Brian. I'd bought an Olympus OM10 camera, and I hooked this up to a Celestron 8 for some astrophotography. That weekend we also attended yet another baby shower, this one for our neighbors, Kelly and Gerald Trlica. Their daughter Gera was born the third week of July.

Wah! I wanted one of those adorable little babies!

The last week of July, we got some good news of another sort. Thor wrote to my mother, "Last Friday Mike Collins (my section head) asked me into his office for a 'closed door' session. He tried to make it sound serious but I have learned to read him pretty well and was not too surprised when he gave me the papers giving me a promotion. This promotion (to GS12) was not almost automatic like my/and Marianne's other ones. My management had to push a little to get it for me in the minimum time."

With the raise, we could afford more flying lessons. I'd had my first lesson with Mitch Polt in June, and Thor started work on his instrument rating. He wrote to my mother that "Marianne's flying has come along very well. She comes home frustrated when she can't do what she feels she should be able to do. However, she actually did a landing (with Mitch's help) last time and has started stalls. While not as fast as some people, she is doing just fine and making a lot of progress each week."

I'd expected flying to come more naturally. I wrote, "Maybe I have too high of expectations, but maybe I'm just as uncoordinated as I am! Last lesson left me feeling very disappointed when Mitch took over at flare out again saying I would have been too rough. At least I've somewhat overcome my fear since last April's [engine failing] trip."

My flight training was still "rough," but I got my "Atta-Girl" for STS-4 via a Recommendation for Official Recognition. The citation noted my work in preparing contingency timelines and my console work. It summarized with, "Ms. Dyson is very dedicated, dependable and has an excellent sense of priorities, maintains outstanding credibility and respect for her technical ability with her fellow workers and all levels of management."

Woo hoo! Now I just needed to repeat that performance on STS-5.

The main objective of the flight was to carry two satellites to orbit and (very precisely) toss them overboard. The technical name for this was "deployment." They'd then use their own boosters (payload assist modules or PAMs) to move from low-Earth-orbit to their position in geostationary orbit. The flight plan called for the first satellite to be deployed before crew sleep on the first day. The second satellite would be deployed the next day. The third day was set aside as a backup deploy day. My assignment for STS-5 was to prepare the timeline for this backup deploy day. Tucker Pierce, the lead FAO for STS-5, briefed me and Holmberg, who would be the Entry team FAO, on the deploy sequence and constraints.

By the end of July, I had the Flight Day 3 Deployment timeline loaded into the CAPS and was busy at work on the details even while we finished debriefing STS-4.

Our social calendar included attending the wedding of "Prop" flight controller Robert Castle, Jr. to Sharon Barnes. Soon they'd be another married couple in Mission Control because Sharon was training to be a payloads officer. We also attended a Branch party on the beach and a Treasure Hunt party at Tom and Sheryl Vollrath's in Taylor Lake Village.

I'd hoped keeping busy would help me relax, but I continued to feel stressed out. I mentioned this to my doctor during a checkup. He suggested that I gain weight. At first I thought he was joking. Then he explained that people burn more calories under stress—and at 105 pounds, I could stand to gain five to ten pounds. His prescription: eat Blue Bell ice cream every night! Well, that sounded much better than fertility drugs. I said I'd give it a try.

But the pressure at work was unrelenting. "Tomorrow I have to work (Saturday) because my data base needs updating before we can microfilm the Crew Activity Plan for STS-5. . . . In parallel, I'm working STS-11. . . I had to give briefings on it twice this week."

PLANNING FOR STS-11/MANNED MANEUVERING UNIT

As the newly-minted lead FAO for STS-11, I attended a meeting led by Jerry Kinney to discuss options for a demo of the manned maneuvering unit. This jet pack allowed an astronaut to fly short distances from the shuttle. If Congress approved, NASA would use this capability to retrieve and repair the Solar Maximum Mission satellite launched in 1980. This ambitious task was tentatively scheduled for STS-13 (41C) in April 1984. So a test of the backpack was planned for STS-11 (41B), "my" flight, currently set for January 1984 [8].

To simulate approaching the spinning satellite, the astronaut wearing the backpack would try to match rates (i.e. hover above the payload bay) while the orbiter rolled. To simulate a failed backpack, the astronaut would fly a distance away from the orbiter, and the commander would fly to him and "scoop" him up. I couldn't wait to see this!

However, this demo presented a problem for the Large Format Camera, also assigned to STS-11. The camera required the payload bay to "stare" at Earth to take photos. Rolling the vehicle put the camera out of commission.

Another possible addition to STS-11 was the Movable Foot Restraint test. This involved an astronaut "riding" on the end of the robotic arm controlled by an astronaut inside the shuttle. A Payload Flight Test Article would then provide the spacewalker with a simulated Solar Max satellite to "repair." Remembering how hard it'd been for Hartsfield to do the jet tests, talk to the ground, and monitor Mattingly's suit demo during STS-4, I suggested in my activity report that this test shouldn't be combined with the demo. "The concern is the IVA crewmember can't be watching both EVA crewmembers and operating the arm as well."

This concern led to discussions of adding a fifth crewmember. But a decision on that would wait until we assessed the impact of four crewmembers. Pilot Robert Overmyer (1936–1996) said, "We can see that preparing food for four people, versus two, in *Columbia* is going to be a chore. . . . We could really be up to our elbows if we're not careful" [9].

Workload was an issue for those of us on the ground as well. We all scrambled to keep up with all the iterations of flight plans. One suggestion was to fly a summary-level crew activity plan with five hours per page instead of one hour. On August 31, 1982, I expressed my thoughts to management. "As the Flight Data File becomes standardized and crews have repeat flights, less detail will be welcome and expected. Also, if the backroom is ever to be whittled down in the ops timeframe, the replanning job needs to be made easier." This new format was implemented within a year: another small step toward more efficient operations.

But we still had a long way to go, especially in the decision-making area. For example, STS-11 was supposed to fly in less than a year and a half, but I wrote on October 1 that we didn't even have a launch date or know for sure which orbiter we were flying. Whether I used a one-hour or five-hour format was not going to solve these problems.

During this period, the Flight Operations Directorate was reorganized. My branch changed from CG5 to CH4 and our offices moved to the 3rd floor of Building 4 where all the astronauts' offices were located. This move was supposed to facilitate interactions with the crews whose flights we were planning. My office faced Building 7 and was next to that of El Onizuka, one of the astronauts selected in 1978. He was scheduled to fly on STS-10, the first completely classified DOD flight, planned for launch in December, 1983.

I often heard him laughing in the office next door. Every time I saw him, he was smiling. He and his wife, Lorna, and their two daughters lived in Meadowgreen. Thor and I passed by the Onizuka's house on our nightly walks. I knew who he was, so I'd wave if I saw him outside. He usually waved back, but I didn't think he actually knew who I was until after the move.

Likewise with another astronaut who lived in Meadowgreen: Ron McNair (1950–1986). His house wasn't on our regular "route," so I didn't even realize he lived close until he was assigned to STS-11. But at least we got to say hello regularly on our way up and down the stairs.

On October 6, I met with Flight Director Pete Frank to discuss the implications of adding a rendezvous on STS-11. Looking at the available crew training resources, he didn't see how we could get a crew trained for it by STS-11. We noted that STS-13, which was to capture and repair Solar Max, required a rendezvous. It was scheduled for April, just a few months after STS-11 which would be sometime in January of 1984. So perhaps we could combine training for these two flights, maybe even fly the same mission specialists? But this decision wasn't up to us. Pete's conclusion was that if we added a rendezvous, we had to take something else out of the timeline. I wrote, "Getting rid of one EVA sounds good on the surface, but would not significantly reduce the complexity of the timeline. Crews have to learn EVA regardless." Then I added a question that no one could answer: "Aren't we avoiding the real issue? Are we saying we can't support the flight rate we're being given? If we have a problem with STS-11 and 13 training which should be very similar, how do we handle flights that are not only closer together time-wise, but very different task-wise? Are we saying a multiple-task flight is too much for the MOCR? For the crew? For the simulators?"

I recommended, "Let's go for a simplified rendezvous, add a day to the flight, and do our best to make it by next year. Let's stress the system to get the bugs out now."

Unfortunately, the stress on the system would take the lives of my two Meadowgreen neighbors a few years later when the *Challenger* exploded. Although I certainly wasn't alone in recognizing the schedule problem, I also wasn't alone in assuming we'd figure it out. We were the can-do team. But we were already making choices based on launch schedules instead of how long it really took to train a crew or controllers. Timelines, analyses, training, testing all took a back seat to proving to Congress that the shuttle could pay for itself via a high flight rate.

This priority was emphasized at the 29th annual meeting of the American Astronautical Society which I attended on October 25, 1982 in downtown Houston. One speaker, Dr. Victor Reis, the Deputy Director of the Office of Science and Technology Policy, said, our first priority is to have "cost effective access to space."

However, Col. Gilbert Rye, a Staff Member of the National Security Council, said that the space program's number one goal was national security. He rattled off some statistics comparing the U.S. program to Russia's, one of which was that "70 percent of their space use is military, and ours is 50 percent." He said, "We will proceed with an anti-satellite system. The shuttle is our primary launch vehicle."

The Deputy Director of Intelligence and Space Policy for the DOD noted that the U.S.S.R. has "More than 1000 military satellites and some are part of weapon systems. They also have a booster that lifts six or seven times what the shuttle carries." He said that the "hopes of demilitarizing space are slim." He added, "We do not intend to meet an unforgiving adversary on an unequal basis. Whoever controls space will control the surface of the Earth."

I noted in my report to NASA management that "That comment scares me!"

Another DOD speaker was Maj. Gen. Jack E. Kupla, Deputy Commander of Space Operations, representing the U.S. Space Division. He said that national security is related to national prestige. Basically, if we show ourselves confident and competent, others will think twice before challenging us. He added, "NASA has been a major contributor to our prestige overseas." It was good to know that my work at NASA was helping to keep the peace.

One of the most exciting speakers was Dr. Ray A. Williamson, Project Director of the Office of Technology Assessment in the U.S. Congress. He said that "Congress is generally supportive even of a large expensive space project if reasonable success can be assured." He defined that success by how much the project provided stimulus to private industry, and said that we were facing "strong competition" from the European Ariane, SPOT, Japan, and the U.S.S.R. They were looking at shifting remote sensing such as Landsat to the private sector (which was eventually done). "Attention is also being given to commercializing the shuttle."

Someone asked who was in charge of private launches and the answer elicited laughter because it was five different agencies: FAA, FCC, Import/Export, NASA, and DOD. The fact Conestoga had launched despite that "just increased our respect for their persistence!"

Considering that I was busy working on the rendezvous for STS-11 to facilitate the satellite repair planned for STS-13, I asked if capability to repair satellites via a space station would increase the lifetime of satellites and reduce the cost of communications. The answer was with technology advancing so fast, and the lifetime already 6–7 years for satellites, most companies would opt to replace rather than fix satellites. "It will be a long time before technology is settled enough to take advantage of that capability." So why were we knocking ourselves out to prove we could do this?

Then I asked about the proposed Space Operations Center. "Which would be better, a small, short-lived SOC, or a larger, long-lived one?"

The answer surprised me. The consensus was that a smaller, short-lived one would be better because it could take advantage of lessons learned. However, one panelist noted that it wouldn't give industry a "warm feeling" if the SOC were temporary. Dan Fink, representing a consulting firm, said, "What business hates the most is uncontrolled uncertainty. They'll put their resources elsewhere, especially in areas of regulation and foreign competition."

I left this conference wondering if the future I'd envisioned of me and Thor living on a space station or on the Moon was ever going to happen.

At the beginning of October, I'd received a promotion from GS-11 step 3 to step 4. I now made $28,282 a year [about $70,000 in 2014 dollars]. The citation that came with the promotion, signed by George Abbey, Director of Flight Operations, read, "For continuing high quality performance that substantially exceeds all requirements."

I decided to use some of my raise to treat my mother to a trip around North Carolina Thanksgiving week, which was the week after STS-5. Mom loved this idea, and planned a trip for us to the mountains. Jack wrote that a reporter friend of his wanted to interview me for the Durham newspaper while I was in town. She'd told him "Every girl wants to do what your daughter has done!" He said, "She's a nice lady and you can probably amaze her with your acronyms." I said I'd be happy to meet her, so he set up the interview for November 24.

To fulfill Thor's requirement for a cross-country flight using instruments, he decided to fly to the Confederate (now Commemorative) Air Show in Harlingen, Texas. He invited me along, and Thor's instructor, Mitch Polt brought along his wife Sharon and their five-month old daughter.

The next weekend, we joined our friends Cindy and John on a visit with their good friends, Linda and Bill Dresslin in San Antonio. We drank wine, laughed, watched silly movies, traded neck and back massages. As I ate my bowl of Blue Bell ice cream, I joked that if I had more weekends like this, I'd get pregnant for sure!

But after our restful weekend, came the STS-5 "dress rehearsal." I was on the Planning shift, so I worked 7 p.m. Tuesday to 4 a.m. Wednesday.

Every morning I took my temperature, watching for it to drop, signifying the start of my "window" of fertility. As Fate would have it, this happened at the beginning of the sim.

The sim involved an early deployment of the satellite on the first day because of a simulated failure of the sunshield that kept it cool. We scrambled to deal with the onslaught of changes. It was a very stressful, but necessary, good shakedown of the team.

Thor was home asleep when I got off shift in the middle of the night. He didn't mind me waking him up to take advantage of my "window," but I didn't have much hope that we'd ever become parents while working different shifts.

After the sim, Tucker, the lead FAO, issued a Note of Interest (November 5, 1982) detailing the effects of a failed open sunshield. A second note on November 8 dealt with the sunshield failed closed, requiring a spacewalk to open it manually. But the main challenge of both cases was that the satellites couldn't be in direct sun for more than six minutes per orbit.

The final two weeks before the flight therefore found me studying all the permutations to the timeline if either satellite had a problem with its sunshield. We needed these deployments to prove to the business community, and Congress, that the shuttle was indeed a good delivery "truck."

Ten days before the flight, I took my temperature as usual. Hmm. Was my period late or had I counted wrong? Had it really been two weeks since the long sim? I checked my previous charts and noted that I often started on Day 15 versus 14, so I figured it would start the next day. I went into work.

On Tuesday morning November 2, my temperature remained high. Could I possibly be pregnant? More likely the stress of the long sim had confused my cycle. As I religiously ate my bowl of Blue Bell that night, I wondered if the extra 5 pounds I'd gained would make a difference. Wednesday, my temperature remained high. I had to know! Cindy had given me a home pregnancy test. The result was negative. I wrote, "Oh well, I was too anxious." But the test wasn't advertised to work this early in the game. So I still had hope. I went to work—Thor was at the MOCR being Guidance during the last of our STS-5 sims. During a break, I whispered to him that my temp was still 98. He said, "Well, that's encouraging."

Waiting was exasperating! By Thursday, my breasts were a bit tender. Was I imagining this, or were they really? That Friday, I came down with a cold. Could that have raised my temp?

On Sunday, I took another Daisy 2 test. I wrote, "IT WAS POSITIVE! I'm PREGNANT!"

That night we told our best friends Cindy and John when they came over for Sunday dinner. But we swore them to secrecy until after I'd confirmed it with a doctor, just in case the test was a false positive. I made an appointment with my doctor for after the flight. Since I already had tickets to North Carolina, I'd wait and tell Mom in person.

But I could hardly contain my joy. I wrote in my diary, "I've already rearranged the closet to make room for the boxes from the sewing room (baby's room!). I am so happy!"

I was worried about the flight though. They'd added a day for the spacewalk. I wrote, "I've got to work STS-5 this week. I sure hope I keep feeling fine. I need to be able to work 10-hour shifts until 3 a.m. I'm not looking forward to it really. Then again, I'll be proud to tell our baby it was in Mission Control for STS-5. It's real and I can hardly believe it!"

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13

STS-5: Fire in Mission Control

Unlike the previous flights, STS-5 had to be launched within 33 minutes of its scheduled time of 06:19 a.m. CDT, Thursday, November 11, 1982. The short window was driven by the timing of the deployment of the two satellites and that it be daylight at the Day 1 contingency landing sites. If weather or computer issues delayed launch, we'd postpone 24 hours.

During the countdown on Monday, a leak developed in a regulator of one of the Vernier jets. The Flight Rules said this backup regulator was required for flight, so we expected a scrub. But the launch director, Stanley Gross, said the leak rate was low, so we'd fly with the leak. Though some people wondered if the rule was being ignored to save money and keep Congress happy, I was personally relieved the flight was still on track. Not only did I not want to redo all the timelines for a different launch date, I also didn't want to postpone my flight to North Carolina. I only had a three-day pad in my personal timeline.

The four astronauts, Vance Brand (1931–), Bob Overmyer, Bill Lenoir (1939–2010), and Joe Allen (1937–), arrived at KSC on Tuesday. At a press conference, Brand said, "We're all trained and ready. We know the ship is ready." They were anxious to fly, and so were we.

The two satellites were paying $17 million for the ride, the first payback on the cost of developing the shuttle. Each weighed (with their PAMs) about 7200 lbs. They were seven feet in diameter and nine feet tall. The satellites would be spun up and then ejected from the payload bay somewhat like a Jack-in-the-Box. Once clear of the orbiter, the satellites would "pop" out to their full height of about 21 feet tall. The PAMs would then boost them to their final orbits.

Hopefully, the satellites would deploy on Days 1 and 2, then we'd move on to the fun stuff: the spacewalk. PAO explained in commentary that "Lenoir is to practice removing from a mount an electronic box similar to one now flying aboard the crippled scientific spacecraft . . . launched in 1979. This is the Solar Maximum Mission satellite." [Quote is from the STS-5 Transcript, available from the UHCL NASA JSC Archive. Future quotes from this source will not be individually cited.]

Lenoir said, "We think Solar Max can be fixed. The work I do will involve mostly cutting wires and removing screws. It will help us evaluate exactly what has to be done."

M.J. Dyson, *A Passion for Space*, Springer Praxis Books,
DOI 10.1007/978-3-319-20258-7_13

My flight director was Gary Coen (~1942–2009) who had been a GNC during Apollo. In the tradition of flight directors, he chose a team color. I never asked him why he picked gray, but considering he was a chain smoker and that the Planning Team had evening shifts, it seemed appropriate. I wore a gray suit for our first shift. Holloway's Ivory Team took charge of the ascent and entry, and John Cox's Granite Team, which included Thor, had the orbit shift. Hmm, wasn't granite also gray?

As I looked around the MOCR during my preflight shift Wednesday, I noted I was once again the only woman in the room. All of my back room were also men including: Chuck Knarr as Timeline 1; Dave Weissinger as Timeline 2; Jay Penn as Pads (same as STS-4); Mike Veres as Pads 2; Dave Schurr as Pads 3; Mark Riggio as Pointing; Mike Fossum as Flight Data File (same as STS-4); and Tim Bogart and J. Wedergren as EVA/Crew Systems.

Mi-Mi was Orbit Team Timeline 1 with Tucker as FAO. I hadn't seen her since I'd taken the pregnancy test. I'd left a message on her desk that I had some good news, but we kept missing each other. After my preflight shift (and a quick kiss to my guy in the "trench"), I peeked into the FAO support room. The place was wall-to-wall managers. I'd have to catch Mi-Mi later.

LAUNCH DAY, NOVEMBER 11, 1982

Thor came home while I slept and we were both up for the launch at 6:19 a.m.

The PAO commentator filled the dead air time with the usual NASA "propaganda" about all the great things this shuttle flight would do first: First operational flight: First four-man crew: First satellite deployment: First shuttle spacewalk. They were really into "firsts." How about the first time to have a pregnant flight controller in the front room?! (Though maybe Pearline deserves that first because of her stint in the MOCR as a phase specialist during STS-3?)

One PAO story caught my attention though. He mentioned that there were three student experiments onboard as part of the Shuttle Student Involvement Program. Michelle Isel from Connecticut had an experiment about crystals, Aaron Gilett of Florida had one on sponge cells, and Scott Thomas from Johnstown, Pennsylvania (where my mother and stepfather had lived while I was in high school) was studying convection and surface tension. Hearing that name Scott Thomas reminded me of my high school friend Scott Holland. I mentioned to Thor how I liked both names Scott and Thomas. If we had a boy, I said, patting my tummy, maybe we could name him Scott or Thomas? Thor said if we named him Thomas Earl, then he'd have the same initials as he did, T. E. D. Considering my dad's name was Thomas, and this would be his first grandchild, that sounded like a great idea. If we had twins, or a second boy later, Scott would be a strong contender. Now, what about girls' names?

The countdown continued while I daydreamed about our baby. Would she have red hair like me? Would he have blue eyes like his dad?

The launch went off without a hitch. PAO announced, "Liftoff of the first operational space shuttle mission with two satellites onboard." We watched for about 15 minutes, when the news cut back to their regularly scheduled show. Would STS-6 even be shown live?

Thor headed into work. His team relieved the Ascent Team, and my team relieved his just before crew sleep, which was 5:19 p.m. in Houston. For the next week, we'd only see each other awake during handovers. I went back to bed.

I slept through the most important "first" for this flight: the deployment of the first commercial satellite. Thor told me all about it later. He'd been practicing his part in the deployment for months in simulations with the other members of the trench in Mission Control: Jim I'anson, the FDO who nicknamed Thor "Zeus;" and Trajectory Officer Ed Gonzales, who was his partner building the Long-EZ in our garage. During one sim a few weeks prior to launch, the Sim Supervisor Denny Holt had pulled out all the stops. Thor said, "He'd thrown one system failure after another at the team until we were in the contingency of having to do back-to-back deployments on the first day of the flight." Only one deployment, on Orbit 6, was scheduled for the first day. The second deployment was scheduled for Flight Day 2.

As the failures piled up during the sim, I'anson, Gonzales, and Thor as Guidance had to redo the orbital targets, compute the times and durations of the necessary burns to reach them, and prepare the upload to the shuttle. Each deploy required the shuttle to maneuver to point the payload bay in the proper direction, release the satellite at the exact time to put it in the plane of the Earth's equator, and then fire its OMS engines to move away from the satellite before the satellite blasted the shuttle with its booster plume. Calculating all these targets was quite a challenge for the computers in Mission Control that took up the entire first floor of the building. One mistake entering the data, and the whole cascade of calculations had to be done over. And because the second deployment's targets depended on when and where the first one occurred, any change to the first one required the second set to be redone, too.

To deal with the onslaught of shifting parameters, "I'anson worked out an assembly line," Thor recalled. "Jimmy worked out the burn targets and handed them to Ed to calculate the resulting trajectory which he'd then hand over to me to generate the guidance uplink to the shuttle." He added, "We'd finish one set and staple it together and start another set for a slightly different time or orientation. By the time we were through, we had a dozen different target sets."

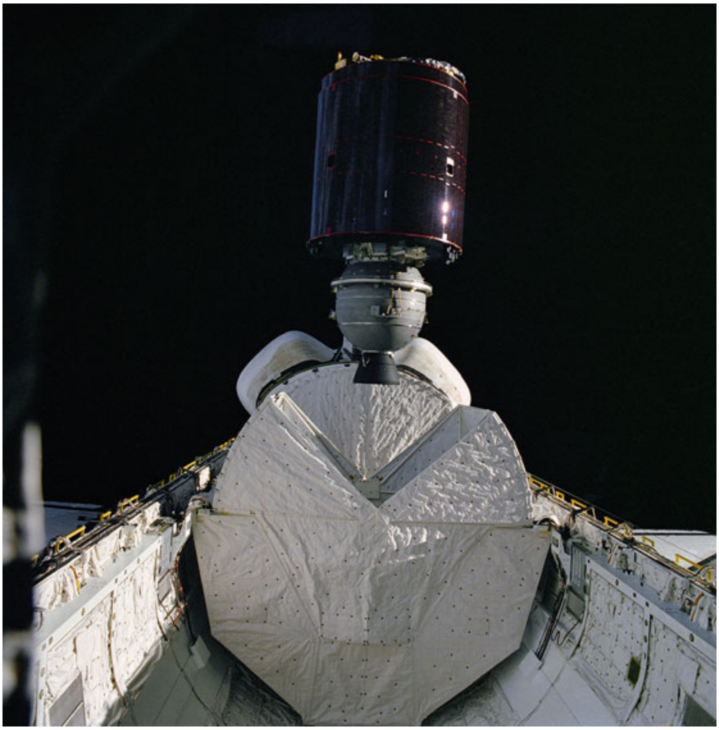
After the simulation, Sim Sup said, "Before we start this briefing, I want to congratulate I'anson and his team for keeping track of what targets went where."

Thor said the team gave I'anson a standing ovation. "He was well liked by everyone, and he totally deserved the credit," Thor said. "But I thought he was going to melt down!"

The team's practice paid off as the first deployment sequence went off like clockwork with the right targets, the exact timing, and the correct upload. The $30 million satellite, built by Hughes Aircraft Co. for Satellite Business Systems of McLean, Virginia, was now on its way. The company paid $8 million (an introductory half-price special) for the launch, a real bargain compared to $23 million it cost to use expendable Delta rockets.

One of the crew commented "We deliver," which the team picked up as a motto for the flight. NASA Deputy Director Hans Mark (1929–) who was there to watch this historic first, congratulated the team and shook hands with Cox and Capcom Mike Coats (1946–).

After the flight, Thor ordered a copy of the photo that astronaut Joe Allen took of the OMS separation burn whose target set Thor had uplinked to the shuttle. He hung it beside his desk to remind him of his part in the success of our first operational flight.



13.1 Thor Dyson was part of the team that calculated the targets for the first satellite deployed by the space shuttle (NASA photo)

The Sun was setting as I pulled into the parking lot beside Building 30. I flashed my badge at the guard, rode the elevator to the third floor, got my headset out of my locker, and took my personalized STS-5 mug to the coffee station just inside the door of the MOCR. Was coffee okay for the baby? I needed to ask Dr. Abbott—or Mi-Mi. I'd get just a half of a cup and to go easy on the refills until I knew more. (There was no such thing as decaf!)

I stopped by the trench on my way up the risers and planted a kiss on top of Thor's bald head. The way he was glowing with happiness at the successful deployment, you'd think he was the one who was pregnant! I congratulated him and Ed and Jim, and then made my way up to my console. The room hummed with happy chatter. Everywhere I looked, controllers were smiling.

I plugged my headset into the jack and flipped through the log. CRT 2 had failed during post insertion. (We might replace it on Flight Day 5.) The payload bay door sequence had gone fine. The sunshield had opened in the time expected. No thermal problems reported other than the usual slight overpressure of the cabin, and the good old flash evaporators setting off some nuisance alarms. The maneuvers and burns all went as planned—finally, a flight with a trajectory that matched the published timeline! Now that was a first worth celebrating.

President Reagan had called. The conversation was the usual "we're proud of you" "thank you, we're proud to serve" and, oh by the way, "we're proud, and God Bless America." But I thought it was important that the president had called. That meant he was still paying attention to the space program even if the public's interest was waning. Maybe with the success of this first operational flight, he'd finally get the space station approved?

The Surgeon, Ellen Shulman, had reported that the crew were feeling good—so far no STS-3 space sickness to deal with, thank goodness.

I leafed through the deployment sequence: the SBS sunshield had opened, it spun up like it was supposed to do, and then springs had pushed it out at about three feet per second. The deploy occurred on time. The shuttle separation maneuver that Thor had uplinked, moved the shuttle to a slightly higher orbit so that it was above and "behind" the satellite. The perigee kick motor on the SBS had fired about 45 minutes later, boosting its apogee to 22,300 nm. It'd be in an elliptical orbit for a few days (perigee at 160 nm) and then fire its boosters again to circularize in geosynchronous orbit.

All problems were minor. The front windows were fogged with salt spray from the Cape and smeared from engine firings, making COAS calibrations difficult. The GAS payload had been plugged into the wrong panel. Apparently, the crew had been plugging it in wrong in the simulator for months. No one noticed because the simulator switches weren't connected. Lenoir figured it out when the GAS didn't respond in orbit. He reported the issue to Capcom Coats who, being familiar with the limitations of the simulator, replied, "Roger that figures."

This was perhaps the easiest shift I'd ever had in the MOCR. With so few changes to the timeline for Flight Day 2, we had the update message done and approved more than three hours before crew wake up. Pads reported we'd used only 15 feet of teleprinter paper since launch.

With so little to do, some controllers tried to optimize some in-flight maintenance (IFM) procedures. I had Crew Systems contact the IFM book manager Frank Janes about the planned "improvements." He noted that the printed procedures were fully validated. I reported, "It seems that in real time everyone has a better idea." We didn't uplink the changes.

Around 10 or 11 p.m., the Capcoms, Dick Covey (1946–) and Jon McBride (1943–), suggested we order burritos and celebrate the successful first day. They collected orders and someone went to pick them up. When they sat the bags down beside me, I was repelled by the stink of greasy meat, peppers, and onions. What was the matter with me? I loved burritos. But tonight, the thought of eating one of those things was nauseating. And had it always been so smoky in here? Yuck!

Was it the pregnancy? Mi-Mi had told me that her sense of smell had been especially acute while she'd been pregnant. We thought it made sense that nature would enhance a mother's senses during this vulnerable time so she could better protect her unborn baby. But wow, I could hardly stand to stay here while the guys wolfed down those monstrosities. I asked Flight, puffing away on his Camel cigarette, for permission to be off console. I unplugged my headset and rapidly made my way to the relatively fresh air in the hallway.

When I reached the restroom, the artificial cherry scent seemed especially pungent. Pregnancy sure did some strange things! I combed my hair, sniffing it and noticing it smelled like smoke more than my favorite Clairol Herbal Essence. Oh well. I stopped by a drinking fountain and let the cold water settle my stomach. Then I padded back to my console, determined not to let the environment bother me. I wasn't ready for people to know I was pregnant. I needed to act normally. As I arrived back in the MOCR, Jon held out a burrito. "Want one?" he inquired sweetly. "We've got plenty!" I swallowed the bile that rose in my throat.

"Uh, no thanks," I stammered, "too spicy for me!"

He smiled. "Yeah, these are loaded with jalapenos," he said.

I turned my attention to the teleprinter messages. PAO announced that the press conference scheduled for 2:50 a.m. was cancelled. There wasn't any news to report.

Holmberg showed up around 1 a.m. Friday morning. Our team handed over to Holloway's without our Capcoms ever having talked to the crew.

Walking out in the dark parking lot at 2 a.m., I took a deep breath of cool November air and paused a moment to look up at Sirius, the star where I thought God lived as a child. The light that now winked at me had taken eight years to reach my eyes in that moment. I reflected how God had known back when I was 19 and struggling with my first physics course at UNC-G, that everything would work out. He knew I'd get through the classes, find my true love, land my dream job with NASA, and conceive a child. "Thank you!" I whispered, and blew God a kiss.

FRIDAY NIGHT AT THE MOCR

Just past noon, I awoke with Jasper Kitty curled up beside me. As I stroked his long silky fur, I wondered how he'd react to a baby in the house? In the shower, I patted my flat tummy. When would I need to start wearing maternity clothes? Mom would want to make some for me. I looked forward to picking out patterns and fabric with her while I was in North Carolina.

I needed to pack something for dinner unless I wanted burritos (yuck!). I cranked the manual can opener (no pop-top cans), and dumped some Campbell's Soup into a pot on the stove. I then poured the hot soup into my thermos. (No microwaves at work.)

I drove past the park near the Clear Lake Rec Center and saw children spinning on the merry-go-round, their moms watching and waving from a nearby bench. I smiled. Soon, I'd be one of those moms, soaking up some fresh air with the kids on a beautiful Friday afternoon.

I walked into Building 30, waved to the guard, and stepped into the elevator. The doors slid shut on the world of a sunny Friday afternoon, and opened into the windowless world of Mission Control preparing for Flight Day 3 of STS-5. Somehow, Thor and I were going to have to find a way to raise a family in these parallel worlds.

I stopped by Thor's console again—he said there was a party at Gilruth after the press conference today. The thought of drinking beer didn't appeal to me at all, so I was glad that I had to be on console. I told him to have fun. He noted the payload officers were buying, so of course he had to go. "By the way, the Roo is missing," he said of the payload team's mascot. I asked if he knew where it'd gone, and he said with a grin that if he did, he wasn't telling.

"I bet the Capcoms know where it is," I said.

"Or Ron Epps," he ventured. Ron was the Ascent/Entry FDO who loved pranks.

While I'd been off console, the crew had completed a full day of activities with the most important being the deployment of the ANIK satellite for the Canadians. They'd also done a head/eye tracking experiment that would eventually show that freefall changed the shape of the eyeball to be more spherical, and thus altered a person's vision. We were still planning to fix the broken CRT on Flight Day 5. Tomorrow's timeline had purposefully been kept open in case it was needed as a backup for one of the deployments. I expected the crew would add in some "shopping list" items. It seemed our shift would be pretty easy again tonight.

PAO reported that the change of shift press briefing had started in room 135 of Building 2. It was about 6 p.m. local time. Orbit Flight Director Cox happily showed the video of the ANIK spinning gracefully out of the payload bay and speeding on its way. Everyone kept repeating the motto, "We deliver." We really had. The space shuttle was making good on its promise to pay back, or at least offset, its cost by providing launch services. With the success of this flight, our future seemed bright. There'd be plenty of work for me after my maternity leave.

With no major problems to work such as STS-1's missing tiles, STS-2's fuel cell failure, STS-3's sick crew, or STS-4's broken secret payload, the most highly trained problem solving team in the world found itself examining every trivial little anomaly. Thus, we got embroiled in a long-winded, hours-long discussion of a loose tether on the starboard side of the payload bay. Could it get caught in the payload bay door mechanism? No, it wasn't long enough. Could it flap around during entry and damage something? Not really. Would it be a safety issue during the spacewalk? No. Didn't we have anything else to talk about? No, sorry, everything was fine!

I logged, "At first we were going to ask the crew to do some videotape of it [the tether] for us. Then we decided to just request a visual report. Then we watched a video playback of the s-band antenna test during which the tether was seen to 'flap in the breeze.' The Flight Director (eventually) decided it was a non-issue and not to ask the crew." My conclusion was thus, "The above is a good example of the time it takes (about 2 hours) for the ground to not ask the crew to do a two-minute task."

I did have one problem to work. As Murphy's Law dictated, CAPS crashed at the worst possible time, just as we were about to print out the As-Planned timeline at crew awake minus 2 hours. I reported that "Consequently, the Flight Day 3 Execute Package did not include the 12-hour timelines." But we got all the teleprinter messages onboard before the crew got up—which was the Gray Team's most important task to accomplish.

Our end-of-shift briefing, scheduled for 1:50 a.m., was once again cancelled for lack of any news. The crew wakeup music was "Cotton Eyed Joe," appropriately for Joe Allen.

I exited the smoky, burnt-coffee smelling room, and stepped into the elevator like the crew of Star Trek stepped onto their transporter pads. When the elevator doors opened, I was indeed "transported" to the world where most everyone was asleep in the dead of night. I don't know why I expected the world of Friday afternoon to hold still like an image on a videotape while I worked "onboard" my "Starship Mission Control," but it always seemed like it should.

FIRE IN MISSION CONTROL

As usual, the crew and flight controllers' sleep schedule shifted early to match up with the end-of-mission landing opportunities. So I had 12 hours off duty before I had to be back on console. Fortunately, with our landing in Florida instead of California, the total shift wasn't as great for this flight: only two and a half hours. But going to bed at 4 a.m., then 3, then 2 was still a far cry from normal. By this third shift, when the alarm went off, I had to think hard to remember if 12 was midnight or noon. (It was noon.) Well, if Mi-Mi could work weird shifts when she was seven months pregnant during the stressful third flight, I could certainly manage. This flight was a cake walk compared to all the previous ones.

But that was about to change. When I arrived for handover, I immediately sensed the tension in the MOCR. Something was up. I spotted Mr. Kranz in a huddle with the flight directors and flight surgeons. Uh oh. I didn't stop to chat with Thor, just flashed him a brief smile and climbed to my row. Tucker saw me looking at the managers. "Lenior's sick," he said.

I immediately understood the implication. "Is the spacewalk off?"

"Probably postponed to Monday." He then told me that as soon as Surgeon told him, he had Mi-Mi and Jim Feibleman (Timeline 2) pull together a swap of Flight Day 4 with 5. That's what Cox was talking with Mr. Kranz about.

Oh well, being busy was actually better than working some minor problem to death like we'd done last night. That lack of problems had turned into a good joke for everyone. I chuckled as I read Overmyer's report that he couldn't find any coffees with cream. He asked Capcom to find out from Rita Rapp (1928–1989), the crew nutrition specialist, how many were supposed to be onboard. He jokingly accused the other crewmembers of hiding them from him. Capcom Bob Stewart replied that "this lack of coffee with cream sounds like one of your major anomalies. We've got half the MOCR working on it right now."

13.2 Rita Rapp, shown here with Apollo 16 food packages, was NASA's lead dietician from Mercury through the Shuttle Program (NASA photo)

A few minutes later, Capcom told Overmyer that there were supposed to be twelve coffees with cream and which locker to look in. Overmyer said he'd looked there already, and they weren't there. He repeated his accusation that the crew had hidden them from him. Remembering that the Roo had gone missing here on the ground, having someone hide something onboard and pretend innocence fit well with Flight Operations tradition. About that time, the shift changed from the Entry to the Orbit Team. The Orbit Capcom Mike Coats then continued the banter, reporting to Overmyer that the MOCR team was now eating lunch (BBQ from Petey's) and "we've got plenty of coffee down here, so we're all fine."

Overmyer complained there were supposed to be 10 more coffees with cream. Coats then suggested that maybe the student experiment on sponges ate them. One sponge growth packet had gone missing the day before. Overmyer then said, "Roger, that's what I was thinking. We still haven't found that one sponge package."

I smiled at the imagined headline, "Mutant Sponge Steals Crew Coffee!"

Our work tonight was figuring out the detailed implications of swapping days. It looked to be a fairly straight-forward task. Tucker's team had given us a terrific head start with their plan. My Timeliners, Knarr and Weissinger, said the CAPS data base had already been updated for the swap. They had a good handle on the As-Flown, too.

But the elevator doors had hardly closed on the Orbit Team when a management decision changed everything. I reported post flight, "At handover everything looked great. The Orbit Team had built a plan for a non EVA on Flight Day 4. Just after they left, Kranz decided to let the crew sleep in and definitely not do the EVA. The Orbit Team plan fell apart."

Kranz decided to wake up the crew and tell them the news. (They'd already gone to sleep.) Then, because of waking them up, he decided to let them sleep in the next day. Shifting wakeup 40 minutes meant that we had to redo all the maneuvers to account for a different sun position; we had to move all portions of tests that required ground coverage; we basically had to redo the whole timeline just like we'd had to do when he made a similar decision on STS-3.

At least this time, the CAPS was able to swap trajectories. This made it a lot easier for us to see the conflicts and offer options to the team. Looking over the draft plan, I noticed that one test objective, a COAS calibration from the aft flight deck, could take the place of another lower priority test. I suggested this option to the SPAN managers (in charge of test objectives). They approved, and we put it on the timeline. Score one for the FAO team!

The Capcoms once again ordered burritos, and this time, ice cream. I steeled myself against the smell, even accepted a small tub of ice cream. I was eating this off a wooden spoon while Pointing Mark Riggio put the final touches on the attitude timeline. Spirits were high when suddenly all our television screens turned to "snow."

Coen swallowed his mouthful of burrito, and said, "GC, Flight, what's going on?"

Before the Ground Controller answered, Pointing told me, "The Mission Operations Computer is down!"

Knowing Mark needed the MOC to compute the shuttle's attitudes for the maneuvers, I asked "What's the status of the attitude timeline?"

"I just finished the calculations," he said. Well, that was good at least.

I assumed the MOC had just overloaded, and it'd be rebooted shortly. They always kept two units running. It was unusual for both to be down, but not completely unexpected.

The crew were asleep. We had an AOS coming up in a few minutes. Hopefully, the screens would come back by then. I finished my little tub of ice cream. The Capcoms wolfed down their burritos, crumpling up the papers noisily. I planned to take a console break after this next pass, wash my hands, and get out of the smoke. Coen always smoked after he ate: and before he ate, and in between.

Then GC reported a fire on the first floor!

"Listen up," Flight said. The room got quiet instantly. "Secure the room. We are in lock down until further notice."

Lockdown meant that we weren't allowed to leave our consoles. Of all the contingencies we'd planned for, a fire on the ground was not on the list. How long would it take for the smoke to reach us up on the third floor? There were no windows to climb out. No access to the roof for helicopter pickup. This place was built to withstand a nuclear attack! We were trapped in a bomb shelter with the exits blocked.

13.3 A fire on the first floor of the three-story windowless Building 30 (the five-story addition on the *left* was added in 1991), took Mission Control offline during STS-5 and threatened an emergency deorbit (NASA photo)

Patricia Mattingly was working in the GC's back room, also on the third floor where we were located, when she smelled smoke. She shared her experience with me via email in 2009. "We called the GC about the smoke, then we found out there was fire under the floor on the first floor where all the cables were. We knew that we could not leave if there was a problem while we were flying. We also knew they would get us out if it got real bad."

Maybe they would let the support teams go, but I doubted the front room folks would be allowed to leave. Even with Coen's chain smoking, my super-sensitive nose picked up the acrid smell of burning electronics. What would this smoke do to my baby?

The lights flickered and went out. I assumed the worst: the fire had spread! Fans whined to a stop. Emergency lights came on. I shivered, even though the room wasn't any colder than usual. The phone lines didn't require power, so we could still talk to one another through our headsets. But we were cut off from the crew.

"INCO, Flight" Coen called to Bob Castle, whose wedding to Sharon we'd attended last August. "What's our communications status with the orbiter?"

"We've lost all telemetry and command in the building, and the s-band voice as well," Castle said. However, there was a way to get a message to the crew as he explained to me later. "In those days, the voice actually went to the ground sites on analog lines, and the digital stream which went up to the Orbiter was generated at the site. So an operator at the site could talk on the link and listen to the crew without the Mission Control Center. So we could wake the crew and have the ground site pass on instructions and relay the crew's answers. The site could also record the telemetry and play it back when the MCC came back up."

Coen told him to investigate further and give him some options.

GC Norm Talbot reported that the A-1 power bus had failed. This bus provided power to the MOC and to the timing systems. This was why the clocks had stopped. Normally, the timing system was on another bus, but an earlier equipment failure had taken it offline. The MOC would be reassigned, but some equipment was being powered down to lessen the load. This could take several hours, depending on the severity of the damage caused by the fire. Security was preventing anyone from entering the building. Handover would have to wait.

"Flight, Guidance," Thor's office mate, J. T. Chapman called.

"Go, Guidance," Coen responded.

"We have an SPC (Stored Program Command) set to alert the crew if their state vector is getting stale. Without command capability, we can't clear it."

As the implication of this sunk in, I gasped. If we didn't refresh the state vector in the next few hours, the crew would have to do an emergency deorbit!

I studied the trajectory in the Crew Activity Plan. It'd be five 90-minute orbits until they were lined up over KSC, and six to Edwards. Their state vector would have deteriorated too much to wait for either of those. They'd have to land at a contingency site—probably in Africa.

We listened intently as INCO explained a way to clear the alarm: we could call the ground site on the phone and read them the hexadecimal code. Then the site operator would manually type it in and uplink it to the orbiter. Castle recalled in 2009 that "We were quite concerned about a typo going up to the orbiter, especially with the MCC not being available to help. I don't know if Gary would have actually done this, but we worked to give him the option."

Sitting there in the darkened MOCR, I tried not to let the stress overwhelm me. I'd waited so long for this baby. *Please, Lord, don't let anything happen to it!* The floors and even many of the walls in the building were hollow—they had cables and pipes and p-tubes running through and between them: miles and miles of wires to carry the flames, and miles of vents to spread the smoke. Was it my imagination or had the room become foggier than usual? My throat burned.

But the astronauts were counting on us. The safety of the vehicle and crew were the responsibility of Mission Control. Each console operator was asking themselves the same question: is there anything I can do to help?

"FAO, Pads," Jay Penn called.

My eyes popped open. "Go ahead, Pads," I said.

"I've got some good news for you," he said. He reported that he had just confirmed that we could send a teleprinter message all the way up to the crew!

"We don't need the MOC?"

"Nope!"

I happily shared this information with Flight. In the event we didn't get communications back, instead of relying on a ground site operator a world away, we'd send the crew a teleprinter message explaining what was going on. Though we still weren't out of the woods, I had renewed confidence that even a fire wasn't going to get in the way of the success of this flight.

Once the team realized the fire wasn't our problem to solve, we went back to our replanning task. We even built a message for Commander Brand for how to reset his personal communications. (He'd been using Joe's.) It helped to have something to take our minds off the blank screens, the unnatural quiet, and that we couldn't leave to use the restroom.

This third floor MOCR was the same room they'd used for Apollo, the missions I'd watched on TV from horseback-riding camp. Now I had a taste of how nail biting it was to wait without data like the controllers had to do when the command module fired its engines on the Far Side, out of touch with Earth. If the command module engine had failed, the crew would've been stranded in space. Was the shuttle still operating fine? We could only wait and hope for the best.

I was reminded of *Apollo 13*, also controlled from this MOCR, when an oxygen tank had exploded, crippling the command module. Kranz had been the flight director then and famously declared that "Failure is not an option." Through training, team work, and a dash of luck, they had returned safely.

I felt that the magic of Apollo still lingered in this room. No fire would melt our resolve. No smoke would smother our confidence. If we couldn't solve the problem with the MOC, we'd come up with a clever way around it. There was little doubt that we'd emerge from this darkness and declare that we'd known all along everything would be fine.

While we worked on planning the next day, people elsewhere worked feverishly to restore our power, computers, and communications. Castle prepared the hex code message in case Flight decided to risk it. Penn had a teleprinter message ready to go as well.

We frequently checked our watches as the minutes ticked by, and the shuttle approached the time when the onboard alarm would wake the crew. Sixty minutes remained until the scheduled time. The generators powering Mission Control were working fine, but the power load had to be reduced. We maintained minimum lighting. The MOCR grew chilly.

45 minutes to go. The fire had been contained, and workers were assessing the damage.

30 minutes left. The MOC would be moved to another electrical bus. We didn't know if the heat or smoke had damaged the computer.

15 minutes more. I really hadn't expected the power to be out this long. I wished I had something hot to drink. My soup was in the locker. At least the messages were ready. We waited.

The screens flickered and came on. The power was back! Would the MOC boot up like it should or were the crew going to be landing in Africa today?

About two minutes before AOS, the "snow" on the displays cleared, and our static overlays appeared, albeit with no data. The mission clock came on and started counting again. Everyone cheered. The old Apollo magic held. The MOC was up. We were back in business!

We "gulped" the data stream from *Columbia* like thirsty dogs. All onboard systems looked good. INCO sent the command to clear the onboard alarm. Guidance updated their state vector. Just in case the MOC should hiccup between now and the next pass, we went ahead and sent the highest priority teleprinter message. The crew, innocently sleeping through the whole emergency, wouldn't be landing in Africa today.

Mission Control was "down" altogether for an hour and fifteen minutes. We'd missed two ground stations. It may have been the most serious failure in Mission Control during the whole Shuttle Program.

Yet Public Affairs didn't release anything about the fire "accident" until the next day. Harold Stall, the director of Public Affairs, apologized to the media later, though he didn't offer any explanation. He said it was an anomaly and not a new policy to delay reporting.

At the time, I assumed the lack of coverage was because all the reporters took Saturday night off since we'd postponed the spacewalk to Monday. But even after NASA confessed, Public Affairs downplayed the fire so much that I wondered what they were trying to cover up. Did they think we'd handled it badly? Did they not want the Russians to know? Were they worried that Congress would lose confidence in our ability to sustain shuttle operations?

Maybe they simply didn't want to draw attention to the fact that we'd burned up one of our expensive computers, nearly cooked up a batch of flight controllers, and risked ditching the billion-dollar shuttle and four astronauts in Africa. No sir. We had everything under control, and "the crew were never in any danger." So though we controllers knew how serious the failure might have been, none of us were surprised by the official NASA statement. "If an emergency had developed, officials at JSC said, voice and data communications between the center and *Columbia* could have been channeled through tracking stations around the world." Um, wait a minute, someone forgot the "theoretically" in that statement!

It continued with: "Computers at the Goddard Space Flight Center, the nerve center for NASA's communications network, could have handled the processing of data and other procedures."

Huh? That was news to me! Maybe they were planning to fly Castle to Maryland to type in the hex codes?! But if GSFC had been able to process the data, why hadn't they done it? Why had they left us sitting there in the dark breathing smoke and endangering our health? Just to prove we had the right stuff?

But I didn't know any of this as my shift came to an end. All I knew was that I had cramps and a headache, and I felt a little nauseous, too. Was it my hormones, my nerves, exhaustion, the smoke? I didn't even consider asking the Capcoms if they'd suffered any ill effects from the smoke. These guys were military pilots. They had dropped bombs, avoided missiles, and downed burritos stuffed with jalapenos for breakfast. I was sure this little incident was beneath their notice.

Besides, I didn't want anyone to know about the pregnancy yet. The upcoming flight assignments hadn't been made. I didn't want to provide an excuse for them to remove me as lead on STS-11, either. Mi-Mi had endured STS-3 and rushed back to work after the minimal six weeks to prove that at least one woman didn't let child bearing interfere with her professional duties. I could deal with being locked in a bomb shelter with the only exit blocked by fire. No problem! I just needed some fresh air and a good night's sleep. I'd be fine.

But had the distraction of the fire affected my work? Had I overlooked something; a constraint, a conflict, an attitude change, that would subsequently cause a problem for the crew? I focused the last hour of my shift double-checking the flight plan.

The back room had been tracking the teleprinter paper usage, so I asked Penn for the status. Then I called Coen. "Flight, FAO." He told me to go ahead. "Pads reports that today's messages used up 12 feet of teleprinter paper for a total of 47 feet so far this flight." He flashed me a smile and thanked me for that report.

13.4 Overmyer reviews 12 pages of teleprinter messages we sent up. Kranz asked us to reduce this to one page the next day (NASA photo)

A little while later, I heard PAO happily repeat this statistic on the mission commentary. Good. Whoever was listening to the Flight loop would hear this shift's only female operator calmly making a consumable report. I'd helped NASA prove that everything was fine here in Mission Control. And it was. After all, every member of the team had shown they had the right stuff; from the people on the first floor who'd rerouted the electrical buses, to the hard-working INCO who put together a contingency command plan, to a secretly pregnant FAO who had finished the teleprinter messages for the next day on schedule. But, still feeling a bit nauseous, I was thankful no one asked me to eat jalapenos for breakfast!

The Entry Team arrived for handover not long after the AOS pass where power had been restored. Security had kept them waiting outside until the all-clear.

When I got home, I spent an extra-long time in the shower, letting the warm water wash the smoke and tension down the drain.

CHALLENGE FROM MR. KRANZ

The next day, the fire was ancient history, and the day had gone as we'd planned it. The crew had completed the FCS Checkout, medical and student experiments, engine tests, and recovered CRT2. Overmyer hadn't found his coffees, but the Roo had reappeared on top of Payloads' console. Maybe it had been "smoked" out of hiding?

13.5 The Payload console mascot was the Roo, seen here on top of their TV. Student investigator Scott Thomas is visiting the console with Payloads Officer Rob Kelso behind him and Bill Holmberg at the FAO console (NASA photo)

We learned a lot about living in space from crew reports during Flight Day 4. Apparently, the suction-cup shoes once popular in science fiction didn't work to hold them to the "floor" or walls, and the magnetic food trays were a flop, too. The magnets were too weak, and the trays detached and floated around. The astronauts said the best restraints were loops or handles that they could slip their toes under. Crowding was not an issue with four crewmembers. Joe Allen remarked that the “ceiling” in the middeck was a better “floor” than the floor, and was a great place to sleep. The only complaint, besides the missing coffees, was that it was difficult to secure packages inside the food warmer. Meal preparation took longer than expected.

As we started work on the plan for Flight Day 5, Mr. Kranz told me that I should keep the instructions for marking up the timeline to one page if possible. One page?! We’d needed 12 feet of paper, 12 pages, the previous night. Hmm. Immediately I discussed ways to consolidate the instructions with Chuck and Dave. There was no “if possible” in my mind. Mr. Kranz, the “failure is not an option” leader, had presented us with a challenge. We’d find a way to meet it! It helped that Coen was in agreement with Kranz that we didn’t want the crew fussing with marking up checklists on their last day—just get the spacewalk done and button up for entry. As Flight Director, he could keep the other controllers from requesting minor changes that weren’t absolutely necessary or could be handled by a quick call from Capcom instead.

But the old habit of optimizing everything was hard to break. As Mattingly had noted on STS-4, “Better is the enemy of good.” The list of delete/move/change instructions grew longer and longer. So by crew awake minus four hours, we still had nothing ready for Pads to turn into a message. How could we get all those directions onto one page? Could we tell them to delete all items from one time to another? Shift them all by some amount? What format could we use for the CAP Update? We had two hours to figure it out! We weren’t going to let Mr. Kranz down. I wrote in my shift report, “We adapted the Overview to be both an overview and include the details. This meant the crew would not have to do any pen and inks.”

Problem solved! But we still had to get approval. Like drawing a face with an etch-a-sketch, getting the draft directions exactly right using the clumsy teleprinter line-by-line formatting took all of our two-hour window. But we weren’t done yet. Castle still had to go over the TV plans for the spacewalk with Crew Systems. Chuck, with his “can-do” military mindset, got the constraints from both and helped forge a plan in the nick of time. The updates went through another approval cycle, and then Penn shoehorned them into the one-page format.

We almost missed our deadline. I wrote, “The final CAP was approved just four minutes before AOS!”

I felt really good about this shift, the next-to-last one of this flight for our team. We’d met Mr. Kranz’s challenge, created a one-page simplified format, and worked all the conflicting constraints to prepare the message on schedule. And best of all, the crew even voiced down that the Flight Plan “solution . . . is very pliable and a very easy thing to do.”

WHAT HAPPENED TO THE SPACEWALK?

I got up early hoping to catch some of the first historic shuttle spacewalk on TV. But there was nothing about it on any of the channels. Had the networks not covered it?

After I got to work, I learned that Allen’s suit fan had cycled on, then off, then failed. Crew Systems reported that the fans had worked fine when the suits had been checked twelve days before launch. Fan failures had been seen in tests when perspiration had built up in the suit. The crew removed the carbon dioxide filters and didn't find any evidence of water. They hooked up the vacuum hose and tried pushing air through the suit. No water came out. They switched the umbilicals. That didn't help. They tried running the fan with and without Joe in the suit. Nothing helped. The fan kept "motor-boating."

After an hour of troubleshooting, Lenoir suggested he do a solo "bare bones" EVA to test the suit and hatch. The team approved. He finished breathing pure oxygen and then depressed the airlock. But for safety reasons, he'd stay in the airlock.

But Lenoir's suit wouldn't hold pressure. Normal pressure (14.7 pounds per square inch) makes the suit hard to bend, like a stiff balloon. Space suits are therefore designed to operate at a lower pressure. But too low of a pressure meant the astronaut might not get sufficient oxygen.

Lenoir's suit would only maintain pressure at 3.6–3.8 psi instead of the planned 4.3 psi. He didn't find any leaks. They concluded that the pressure regulator wasn't working. Mission Control cancelled the spacewalk around 6:45 a.m. The crew took it pretty well, but all of us shared in their disappointment. Overmyer remarked, "This isn't our day for suits."

As I reviewed the log, I laughed at an air-to-ground exchange between Commander Brand and Capcom Bridges. With the EVA canceled, Holmberg had suggested the crew simply return to the nominal timeline with only one attitude change. Capcom said, "You realize that Bill is losing tremendous face with his fellow FAO's for coming up with such a wonderful plan."

Brand replied, "This is beautiful. It has simplicity, and we know right where to go to execute it."

Capcom said, "That's why Bill is going to be ostracized as an FAO."

My one-page update had been lauded, and Bill's real-time planning had been called beautiful. Tucker, the lead FAO had written the original plan, and it had worked really well. So the STS-5 FAO team had truly shined on this flight. This was Tucker's last shift, and I realized, that meant it was Mi-Mi's, too. And I still hadn't told her that I was pregnant! So, before handover ended, I made some excuse about donuts from the back room, and I went to find her.

I ran into her in the hallway. "Hey, Mi-Mi," I said softly, "Did you get my message that I have some good news?"

"Yes, but is it good news or *really* good news?" she whispered, her eyes searching my face. In other words, was it about a new assignment or being pregnant?

"The best," I said, my silly grin a sure-fire give away.

Her face lit up, and she smiled. "I was hoping you'd say that!" I whispered that I was going to our doctor Thursday to confirm. I didn't need to tell her to keep this news to herself. She understood. "Talk to you after I get back from North Carolina," I said. Then I went ahead and got a donut, said hello to some of the others on the team, and headed back to the FAO console for my shift.

While the crew slept, I worked on Entry changes with Fossum and Knarr. Penn continued to track the teleprinter paper. "We generated a 'Consumables' plot complete with a Mission Redline of 20 feet for a wave-off case," I reported post flight. "At end of flight we estimated we used about 85 feet of paper—less than one third of STS-4 usage!" This one was tangible measure of the "operational" readiness of the planning team.

I reported to Coen that we had plenty of paper onboard, and that with his permission, we'd really like to send one final message to congratulate the crew on the successful flight. He studied the message and saw the Capcoms nodding their approval. He said we could uplink it on the condition that all other messages had to be confirmed onboard first, and that the orbiter continued to perform normally. "Yes, sir! Thank you, sir!" I said, and happily informed my team.

The crew got up to one of my favorite songs, "Country Road" by John Denver. Capcom McBride had selected the song because both he and Coen were from West Virginia. (The lyrics include, "Take me home, country roads, to the place I belong, West Virginia. . .") It suddenly occurred to me that our baby would be a Texan!

We sent up our four usual messages, and the crew asked if we were done with the teleprinter—they were anxious to get it stowed. I reminded Flight about our special message. So Capcom said, "No, we'd like for you to hold off on that a while. We may have one more message to send up." McBride flashed me a grin. He said, "*Columbia*, we're going to uplink your entry summary here at Indian Ocean. Like for you to take a good look at that. See if you've got any questions."

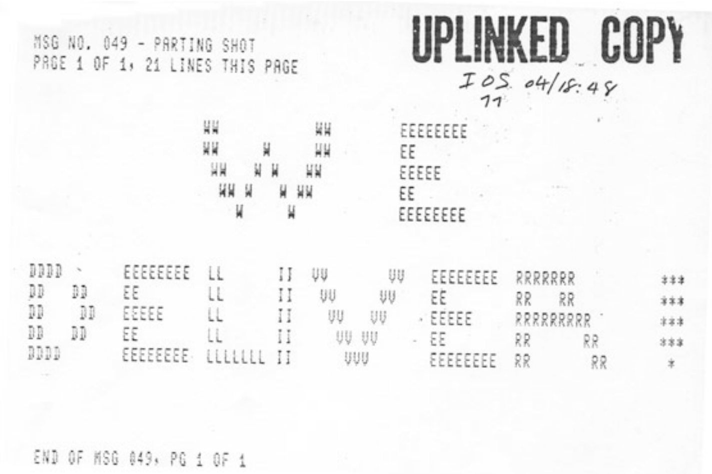
"Okay, Jon, understand you're going to send us up a summary?"

"That's affirmative. Your entry summary."

The crew were confused because we'd already sent them a message with the changes for entry, and we'd never sent them anything called an entry summary.

Some chatter up and down followed, and then Capcom said, "Yes, we just want to let you know that 49 was the Planning Team's parting shot."

"Okay, Jon. . . Outstanding message, Jon. Much obliged."



13.6 The final teleprinter message to the crew was "We Deliver," the motto of STS-5 (Photo by the author)

As I gathered up my things, I overheard another memorable air-to-ground conversation. The crew said, "We're sitting here reviewing the Deorbit Prep and noticing some of the humor."

Capcom Bob Stewart replied, “Anything to keep the troops entertained. We know you’re probably pretty bored up there this morning.”

Columbia replied, “Well, it isn’t too bad. You sent me up here a little while ago to see if I could see the equator. . . It’s dark out here.”

“With that 28.5 degree inclination,” Capcom said, tongue-in-cheek, “the equator’s painted on the water most of the way around, kind of washes out occasionally.”

The deadpan reply from space was, “I keep trying to look for that red line. All my maps have a red line, but it wasn’t there.” Ha ha! What a nice way to end my last shift.

I walked out of Building 30 into the dark of night at 1:30 a.m. Tucked in my briefcase the Entry Summary, #49, stamped UPLINKED COPY. It read simply, “WE DELIVER.”

STS-5 landed a few minutes after sunrise in California on Tuesday, November 16, 1982. Capcom Roy Bridges said, “It was beautiful, and you certainly lived up to your motto this flight.”

Columbia replied, “Yes sir, we deliver. We delivered.”

Watching the landing from home, I squeezed Thor’s hand. I hoped our personal “delivery” next summer would be as successful as STS-5.

13.7 STS-5 was the only shuttle flight to land at White Sands, NM. Columbia’s image is reflected in rainwater on the normally dry lakebed (NASA photo)

14

Combining Family and Flight Planning

Dr. Abbot confirmed my pregnancy. I could hardly wait to tell Mom! But as I packed for North Carolina, I felt worse and worse. I wrote in my diary, “The first time I was nauseous was my second to last shift of the flight. As long as I took it slowly, I was okay.” But this Friday morning, going slow wasn’t working. I felt awful. Thor took me to the airport.

During my layover in Atlanta (back before airport security), my friend Leslie Schworm that I’d lived with in DC, and college friend Tom Burkhalter joined me for lunch. I wrote that “Leslie is working for a cable TV firm and is up on satellite jargon. We talked about STS-5 deploying SBS and Anik, the first two ever.” Tom was working on a novel. My morning sickness faded while we had lunch and caught up on each other’s lives.

But by the end of my flight to Raleigh, NC, my lunch had all been “deposited” in the “motion sickness” bag.

I was pale as a ghost going down the steps of the plane and walking into the terminal (no jetways yet). I was anxious to rinse my mouth and fix my eye makeup in the ladies room.

In 1982, anyone could walk up to the gate and greet passengers. So before I had time to locate the restroom, my stepfather Jack parted the crowd and rushed up to me with another man close behind. Everyone stood aside to let the two suited gentlemen pass. I’d been focused on putting one foot in front of the other, and I looked up at Jack just as he announced in his best actor’s booming voice, “There she is!” I came to a cold stop. *No! Not now!* But Jack didn’t know I’d been sick on the plane. He mistook my reaction as simple surprise. He steered me by the elbow in front of none other than U.S. Senator from North Carolina, Jesse Helms (1921–2008).

“Senator, I’d like to introduce you to my daughter, a space shuttle Flight Controller from Houston!” Jack loudly declared. The crowd that had gathered around the famous senator went silent. All eyes were upon us as he warmly shook my hand and congratulated me on the success of STS-5. Jesse Helms was one of the leaders of the new Republican-run Senate. Luckily, my speakers’ bureau training kicked in, and I stumbled through some sort of thank you. I even answered some question about the space suit problems.

After this embarrassing encounter, I finally got to say hello to Mom, who’d stayed back behind the crowd. “Are you hungry?” she asked, as we headed toward Baggage Claim.

M.J. Dyson, *A Passion for Space*, Springer Praxis Books,
DOI 10.1007/978-3-319-20258-7_14

"Actually, I've been morning sick all day." As she digested what I'd said, her face lit up. She squealed like a little girl and enveloped me in her arms. Getting to see and feel that reaction in person made even the Jesse Helms' incident worth it.

The next day Mom and I left for our tour of western North Carolina. I especially liked visiting the Biltmore Estate in Asheville. Mom and I laughed that we wouldn't really want to live in such a mansion because it would require too much housework. The drive through the Appalachian Mountains afterwards was just what I needed to de-stress from NASA.

As planned, I met with Jack's friendly reporter, Betty Hodges, in his office at the courthouse for an interview. The article, "NASA: Durham Native Enjoys Work There" was published in the Durham Herald Style section on December 17, 1982.

In that time before the Internet, I didn't see it until Mom mailed a copy to me a week or so later. I was rather surprised by the title since I'd never lived in Durham! I'd lived in Charlotte and Greensboro, and Mom and Jack lived in Chapel Hill. This was my first exposure to "journalistic license." I was flattered that they wanted to claim me as one of their own.

But I decided I'd carefully write down all names for the next interview. The article had Wiley versus Wildey and Carolyn Connelley instead of Carolynn Conley.

I was pleased to be characterized as a "pretty but businesslike young redhead" who was only one of four women in my branch of 100. I'd gotten the point across that I felt we were at the beginning of a new era in space. "We're going to be going there and it's going to be an everyday thing," I was quoted saying [1].

We also touched on the fact that Ted and I were the first "man and wife team" working in Mission Control. She thought it was significant that we shared the housework and took "turns with everything." She also reported that I thought us working together was an asset to our marriage because we "speak the same language, know the same people and have a lot of the same friends, largely NASA workers" like ourselves [2].

Overall, I'd met my objective to portray NASA and women in the space program in a positive light. Public Affairs thanked me for taking time out of my vacation to get NASA some good press. Most STS-5 news reports focused on the space suit failures.

But some of my managers had a cool reaction to yet another mention of me in the newspaper. They thought I was "getting a big head." Considering that I was pregnant, I decided to avoid drawing attention to myself for a while. So in December when Boyd Mounce of Public Affairs asked me to speak to a Cub Scout Pack in Alvin, Texas, I wrote, "I think this is one case where a male speaker would be more appropriate. Please accept my declining this request."

I'd hoped the morning sickness would subside after North Carolina, but I was sick morning, noon, and night. I quickly lost all my "Blue Bell" weight. I was lucky to keep a few crackers down long enough to drive to work. Grandma and Mom had suffered this way, and I assumed it was just what I had to deal with.

But after I'd dashed out of a yet another briefing to throw up in the restroom and almost passed out from dizziness, I called my doctor. She prescribed an anti-nausea drug. If I didn't stop losing weight (I was down to 99 lbs.), she'd put me in the hospital.

Thankfully, the medicine worked. But I was concerned what the stress of working another flight would do to the baby. I wasn't working STS-6: Bob, Ben, and Mi-Mi were.

It was likely I'd be assigned to 7, 8, or 9 to keep my FAO skills fresh prior to being lead on 11. Did I want to be on console when I was six months pregnant? I thought of all the strange hours, and the fire, and the jalapeno burritos! No. There'd be plenty of shuttle flights after this baby was born.

My request to not work console until I returned from maternity leave was actually greeted with relief by my managers. They needed to push some new people into the front room to support the flight rate. I'd freed up at least two slots, STS-7 and 8.

On December 17, Thor and I headed to Ohio and Michigan for Christmas with family. We hadn't told my father or Thor's parents we were expecting their first grandchild. Like with my mother, we wanted to see their faces light up in person.

While we were in transit to Ohio, a hot fire test of the *Challenger*'s engines revealed a hydrogen leak. Even before NASA announced anything, Thor and I knew the launch of STS-6 would be postponed. We welcomed this delay. Except for Christmas break, he'd been scheduled for nonstop sims and working Saturdays to be ready for a January launch. Now he'd be home on weekends to help me convert the sewing room into Baby's room.

We flew (commercially) into Cleveland, Ohio and visited Thor's Aunt Lillian Moench and her son Bill's family. Despite the presence of five children in the house, there was no yelling or arguing. They treated each other with respect and spent a lot of time laughing. I marveled at how the boys said "yes ma'am" and "yes sir" to us, and cheerfully went about helping with dinner and dishes without being asked. I could only hope to have such a happy family.

I celebrated my 28th birthday in Canton. My Uncle Jack Jakmides, who had turned me on to science fiction, joined us for dinner at my dad's house. He was as excited to hear about the space program as my dad was about being told he'd soon be a grandpa. (When Jack died years later, his daughter Lisa would gift me his science fiction magazine collection.)

Our next stop was Thor's parents' house in Mason, Michigan where most of the Dyson-Kane extended family had gathered prior to a week of cross-country skiing. Because the family had grown as we "kids" married, Aunt Anne had instituted the "Cousin X" gift exchange. We'd all drawn names the previous year and promised not to spend more than $10 on a present. Anne was my Cousin X. In my card to her, I said something about her being a *Great* Aunt and needing to add another Cousin X to the list. She read it quietly, and then she started yelling "a baby!" and pumping her arms in the air and hooting while Thor and I laughed.

We also announced the pregnancy via Christmas cards to friends. My former boyfriend John wrote back that he was delighted, and shared his own good news: he was getting married!

My college roommate, Valerie Owens, whose son James was now three, wrote, "If you can swing it money wise—try to stay home with that baby as long as you can. Work will always be there, but children are only little once. . . . Mommy's work doesn't pay much—but it is the most rewarding."

Back at NASA, *Challenger* underwent another test on January 25, 1983, that found cracks in main engine 1. It was replaced, and the other two reinstalled. Launch was reset for April 4.

My focus was on STS-11 and 14. Both flights had Cargo Integration Reviews coming up.

The CIRs were held about a year before launch. It was a time to ferret out problems, assign actions, and make decisions to minimize time between flights.

In mid-December, we'd received trajectory tapes for STS-11. The orbit was planned to be lowered after deployment of Palapa so the Large Format Camera (LFC) could view Earth. But the lower altitude used more propellant and was "faster" so that we didn't have daylight landing opportunities by the end of the flight. We'd just begun addressing these issues when Shuttle Program Manager Lunney removed LFC (which would eventually slip to the 13th flight called STS-17/41-G) and added the Materials Experiment Assembly previously planned for STS-12, and a fifth crewmember. So it was back to the drawing board for STS-11.

The increase in crew size was driven by the lack of training facilities. With flights so close together, the simulators were almost entirely dedicated to training pilots for ascent and entry. The pool in Building 7 was likewise training crew for spacewalks, and the Building 9 mockup was dedicated to arm operations. The total number of astronauts training for each task had to be limited. So starting with STS-7, all flights had at least a crew of five.

We'd scheduled two "dry run" CIRs for STS-11. The first was February 1. I was to present the timeline. Unfortunately, by January 17, I still had no trajectory tape. I couldn't even schedule the crew sleep periods because the landing time kept changing—it depended on the launch date still under discussion. A week later, LFC was back on STS-11 and the Materials Experiment slipped to STS-12. The STS-11 CIR however, wasn't slipped.

So the last week of January, I met with other members of the STS-11 planning team: Rod Rose (1927–2014), Al Bishop, Ed Pavelka, and Richard Swalin (of MPAD). We prepared three options to deal with the propellant issue we'd uncovered earlier.

After another week's discussion, we decided to delay the orbit reduction from orbit 67 to orbit 83. This option fixed the end-of-mission lighting problem at the expense of the camera not getting the 48 hours of data at the lower altitude that they'd requested.

They weren't the only ones not getting exactly what they'd hoped for. I got a call from Boyd Mounce of the JSC Speakers Bureau. Would I speak to the South Texas Women's Forum of Corpus Christi in April? They'd asked for a woman astronaut, but with none available, he'd suggested me. I laughed, thinking my managers might think I was trying to draw attention to myself again. But I was merely Marianne the Substitute Women Astronaut Speaker. I said sure, if they didn't mind that by April my pregnancy would be rather obvious.

On Wednesday February 2, Thor and I used our lunch breaks to go to the doctor's for an ultrasound of our baby. A relatively new technology at the time, I was a little nervous. The doctor assured us it was safe and that, being an "older" mother (at 28!), it was a good to check for problems. That grainy image on the TV screen—our baby!—seemed more amazing to me than flying into space. The Polaroid "snapshot" was the first baby photo to appear on our refrigerator.

Though I didn't get to share my pregnancy with Mi-Mi, Kathy Abotteen and Sharon Conover, both in Crew Training, were expecting within weeks of me. Sharon and I had gone to KSC together and played on the volleyball team. I'd worked with Kathy on training materials.

Like me, Sharon went for an ultrasound in February. But she got more than a photo: she was told she was carrying, not one, not two, but three babies! She hadn't taken any fertility drugs. Multiple births ran in her family. She and her husband Doug were thrilled with the news.

14.1 Lots of women were pregnant at NASA in 1983. *Left* to *Right*, Sharon Conover, me, and Kathy Abotteen at Sharon's baby shower in April (Photo by the author)

Two days after my ultrasound, I was thinking about this when the secretary said a Dr. Colleen A. Walter was on the phone and wanted to speak to me. Who was that? Was there a problem with the baby, and Dr. Abbott had called in a specialist? Was I having triplets, too?!

I punched that blinking "Hold" button on with some trepidation. Dr. Walter quickly explained that she was with the South Texas Woman's Forum—the group who'd requested a female speaker. Oh! I relaxed. She then proceeded to pick my brain like Craig Couvalt trolling for secrets, only her topic was the inside scoop on being a woman in the space program. I didn't tell her about our protest over the assignments or my concerns about what would happen after maternity leave. I focused only on the positive: how women were making inroads in all major areas at NASA, including flight control. I told her a little about the first five flights.

She wrote to Boyd that she felt "quite satisfied with Marianne as a speaker." The Speakers Bureau granted her request for me to speak on April 28. I put it out of my mind because I had a more important speech to give first: my presentation to management at the CIR.

The STS-11 Dry Run CIR was held on February 8–9, 1983. I reported, "An hour before the meeting, MPAD admitted to a gross error in the deploy opportunities for Palapa. The result is that a Day 1 deploy is now available." I had to redo the timeline, again, before the CIR in March.

A rumor circulated at the meeting that LFC was likely to move to STS-14 because Westar (another deployable payload) was being offered its spot in the payload bay. We ignored the payload "musical chairs," and proceeded as if LFC were still assigned.

The STS-11 CIR was held in Building 1 on March 10, 1983. One of the few other women at this meeting was Linda Godwin who was working on the payload constraints for the Palapa satellite. Two years older than me, she had a Ph.D. in physics and had joined NASA in 1980. She impressed me as a thoughtful and dedicated professional. I wasn't surprised when she was selected as an astronaut in 1985. She married astronaut Steve Nagel (1946–2014).

But Linda and Steve weren't the first married pair of astronauts. The first woman in space, Valentina Tereshkova (1930–) married cosmonaut Andrian Nikolayev (1929–2004) in 1963. The first American couple had to wait until women astronauts were hired in 1978. In 1980 Anna's husband Bill Fisher (1946–) was selected. (They later divorced.) Rhea Seddon was next when she married Robert "Hoot" Gibson (1946–) in 1981, and then Sally Ride and Steve Hawley (1951–) married in 1982 (and divorced in 1987). Gibson was at the CIR because he'd just been assigned as the pilot for STS-11.

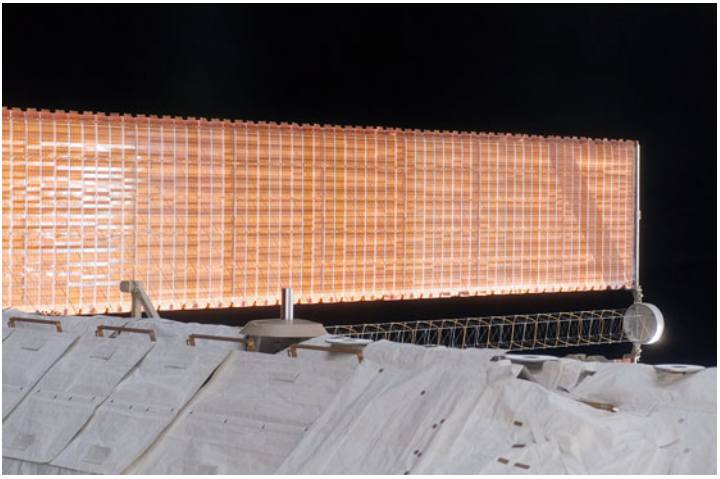
Most of the questions raised at the CIR had to do with what would happen to the payloads if there were a launch delay. The camera required fresh film after 45 days, and the spacesuit backpack's batteries wouldn't last long. STS-5 crewmember and newly assigned Commander of STS-11, Vance Brand, asked that the backpack be loaded as late as possible.

The week after this meeting, Tucker Pierce replaced me as STS-11 lead FAO.

This time management warned me before announcing the change. They'd asked me how long I planned to be on leave. I said about four months (which was my accumulated sick and vacation time). I also didn't want to be pressured to rush back in the minimum time, like Mi-Mi had. The baby was due July 8, and I planned to return by mid-October, three months before STS-11 launched in January. I agreed that Tucker was actually the perfect person to get all the documents ready. He'd just finished being lead on STS-5, and he had a good working relationship with STS-11 Commander Brand.

With my STS-11 work handed over to Tucker, I focused on STS-14. Back in January, I'd attended a week-long payload operations working group meeting for the Office of Aeronautics and Space Technology's first experiment (OAST-1). OAST-1 was a 13-foot wide, 100-foot long solar array, a test article for the arrays planned for the space station. The designers had placed tight constraints on the lighting, restricting their tests to just 7.5 minutes either side of orbital noon and requiring all extension and retractions done in orbital daylight. I reported, "If that were not difficult enough, they have limited the maneuver rate to 0.1 degree per second and require good attitude accuracy after 20 minutes in gravity gradient." (Something we considered rather impossible because the engines are off during gravity gradient.)

But our Pointers loved a challenge, and this payload offered a good orbital dynamics and lighting problem for them. We looked at allowing time for oscillations to damp out between tests, using payload bay lighting and earthshine to ease lighting constraints, and increasing maneuver rates to save time between tests.



14.2 Planning for the deployment of the OAST 100-foot solar array provided an interesting challenge for the FAO team (NASA photo)

The biggest challenge wasn't meeting the OAST-1 requirements though, it was scheduling their tests so as not to interfere with the "paying customers," the deployable satellites: Syncom IV and Telesat (a.k.a. Anik). OAST-1 required ten orbits of top sun attitude which was too hot for the satellites. Telesat representatives said five orbits was the maximum for them, if followed by five orbits of the payload bay toward Earth to cool down.

But no one knew much about Syncom's constraints. A series of these satellites had been designed specifically for launch from the shuttle, and this was the debut flight. At 14-feet in diameter and weighing around seven tons when loaded with fuel, Syncom took up about 45 percent of the payload bay. Syncom didn't have a sunshield like the satellites on STS-5.

A month later, I found someone at Hughes Aircraft Company to answer questions about Syncom. OAST's 10 revs of top sun weren't a problem for them. That was good news.

But I still didn't have a trajectory. I was assured I'd have a tape by the end of March, unfortunately, not in time for the CIR Dry Run. It seemed as if there were a plot to always have the trajectory delivered a week after I needed it, and that as soon as it was delivered, it was useless because the payloads or launch date would have changed. My decision to take a long maternity leave looked better and better. I might only miss a few useless iterations.

By mid-March, the STS-14 CIR Dry Run had slipped to April 7, during STS-6. I just shook my head, knowing that half the managers would find some excuse to be at the control center instead of at the meeting. But I had to be ready regardless. I was supposed to publish the preliminary Crew Activity Plan by July 15. With my due date of July 8, I'd need to beat that.

The first weekend in April, the L-5 Society held its second annual Space Development Conference at the Astro Village (now the Crowne Plaza) Hotel in Houston. The theme was "Doing Business in Space," and the top speakers were former astronaut Deke Slayton, and former head of NASA Engineering, Max Faget (the first recipient of the National Space Trophy given by the Rotary National Award for Space Achievement—a Foundation I'd work with for many years). The chairman was lawyer Art Dula (1947–) who'd fought (successfully) against the United States signing the Moon Treaty because it ruled out private property in space—considered necessary to future space business development. I remember chatting in the hotel bar with him that weekend—though, being seven months pregnant, I drank only ginger ale. The next Space Development Conference in Houston would be in 1999, and I'd be the chairman.

STS-6: DEPLOY OF TDRS, FIRST SHUTTLE SPACEWALK

STS-6 launched on April 4, 1983. NASA always released a roster of the people working each console, but they were never identified in photos taken in Mission Control. Only the names of Capcoms, flight directors, and visiting VIPs were worthy of being recorded in the official captions. So even though it was Mi-Mi's first time as FAO, no one bothered to take her photo. However, Bob Nute was sitting next to the Capcoms when Vice President Bush dropped by the MOCR to congratulate the crew. Of course Nute's name doesn't appear in the official caption.

Thor was Orbit Team Guidance on STS-6 and oversaw the historic deployment of the first Tracking Data Relay Satellite or TDRS (pronounced T-dress). This deployment was not without a little drama. Through no fault of the flight controllers, TDRS's inertial upper stage placed the satellite into the wrong orbit. It took months to get into its proper orbit. This pushed the next TDRS, scheduled for STS-8, downstream. The "hole" on STS-8 was filled by the payload test article from STS-11. Tucker would redo that timeline now instead of me.

Those of us who'd worked STS-5 were a little jealous when Story Musgrave (1935–) and Don Peterson (1933–) flawlessly performed the first shuttle spacewalk. (Years later, I'd interview Story for a cover article for Child Life magazine.) Thor was on console during this spacewalk. Though, like Nute, he's not identified in the official caption, but he is clearly visible in a photo of the VIPs.

14.3 Thor is standing in the front row of this STS-6 photo taken during the historic first shuttle spacewalk. Astronaut Bill Fisher stands behind the CAPCOM console with Gene Kranz on the row behind (NASA photo)

Paul Weitz (1932–), Karol Bobko and the two spacewalkers returned home on April 9. I was glad to have my husband back. His next flight was STS-7: his first as Entry Guidance. Once he'd mastered entry, he'd move to ascent. He hadn't had time to think about what he'd do after that. If he wanted to become a flight director, he'd need to work at least one other position, such as FDO.

Could I become the first woman flight director? After my maternity leave, I'd have to work at least once as lead FAO (I assumed on STS-14), then transfer to some other position like Payloads. With the flight rate increasing, I might meet the requirements in three years. Carolynn Conley and Anngie Johnson were the only women with more console experience than I had, though Michelle Brekke had been Sim Sup and was now training to become a Payloads Officer on STS-8. On STS-6, only four consoles had women controllers: Payloads (Janis Plesums with Linda Godwin [1952–] as OJT, Anngie Johnson, and Kathy Havens as Upper Stage); FAO (Mi-Mi Lau); Booster (Jenny M. Howard); and Operations Integration Officer (Carolyn Blacknall). More women were coming up through the ranks, like Gayle Weber training to be Guidance on STS-7. Hmm, I'd have to see how hard it was to juggle work and family first.

The STS-14 CIR slipped to June, so the CIR Dry Run slipped to April 27, and a second Dry Run with all of JSC was set for May 15, 1983. The trajectory I was supposed to get at the end of March? The delivery date slipped to April 11, but by then, of course, the launch date had changed and made the data useless. Sigh.

But I did get some good information on the Syncom deploy from Jan McCoy. She explained that instead of the "Jack-in-the-box" ejection like Telesat, Syncom would use a "Frisbee" toss. I.e., the spring was on one side rather than underneath the massive payload.

Back in March, the Speakers Bureau informed me that my travel arrangements for Corpus Christi had been made and paid for by the Texas Women's Forum. I'd almost forgotten about that speech! I updated my old "Typical space shuttle Flight" slide show with new slides showing Rita Rapp with the space food, women astronauts in training, and me on console during STS-4. Finally, I gathered photos of the women astronauts to give to the organizers.

On April 28, I put on my best maternity dress and headed for Hobby airport. My flight got me there by 10:20 a.m. I went to the hotel, ate lunch, gave my speech, and flew back home by 3:20 p.m. The women had a lot of questions, some of which I recorded. "Will we ever switch to nuclear power for shuttle launches?" [No.] How many astronauts are there per flight? [Originally two, but now at least five, but Spacelab will have seven.] What is the difference between a pilot and a mission specialist? [Pilots fly the shuttle during ascent and entry, and mission specialists are in charge of the payloads, and generally have Ph.D. s or M.D.s.] When will "people like us" get to go into space? [Soon, I hope!] Do the Soviets have a reusable shuttle? [Not that we know of.] I got a nice thank you from the women and from PAO.

May 5 was the STS-14 Dry Run. I was the only woman on the agenda, and thus the only one to sit at the table with all the primary "players."

One major issue raised at the meeting had to do with the launch window and deorbit opportunities. After discussion, Leonard Nicholson, who chaired the meeting, agreed we could give up some launch window to preserve an earlier deorbit opportunity on landing day. Even though the launch window would likely change as the launch date changed, it was important to document acceptable tradeoffs like this.

One of the people at this meeting was Mike Hawes who later became an associate administrator at NASA headquarters. He was working on the Telesat satellite in the Payloads Office. Typical of the uncertainty we all had to deal with, he noted that we still didn't know if STS-14's satellite would be an Anik C or Anik D type. The Anik D didn't have any constraint on our use of the Ku-band radio. Anik C required us to turn it off during deployment to avoid interference. I was beginning to wonder if the only way we'd know what payloads were on this flight would be to take a photo when the crew opened the payload doors after launch!

One surprise came from John Sunkel from Engineering who'd done a dynamic analysis on the OAST array. Venting water caused significant stress on the array, though it didn't exceed the load limits. Nicholson said, "We don't want to come anywhere close to that limit."

The astronauts asked if "flushing the commode" would make the array swing back and forth? No one knew. Hartsfield, veteran of STS-4, was the commander and Mike Coats was the pilot. The mission specialists hadn't been assigned yet.

The STS-14 CIR was June 3, 1983. I walked to the end of the long wood table with my stack of vu-graphs. I looked up at a roomful of men staring at me, except for Diane who had a seat in the back. My husband referred to me as "olive on a stick." My tummy was now stretched tighter than a drum and itched like crazy. Liberal application of coconut butter provided little help. Even harder to ignore was the baby kicking me in the ribs!

But I was ready to get this done. My 12-page presentation was one of the first on the agenda. I provided an overview of the seven-day flight from launch to landing.

I'd no sooner stated that we'd built the timeline using a launch from KSC on June 6, 1984, when someone from KSC said that they needed to move that to June 9 because of a conflict. We all expected the launch date to change anyway, so I was told to continue.

I explained that to have two deploy opportunities without keeping the crew up 20 hours, we'd put the crew to bed nine hours after launch. We'd deploy Telesat first thing in the morning of the second "day" in space (which was less than 24 hours after launch). Syncom would then be deployed about 23 hours later in the morning of the third day. We had a back-up opportunity to deploy either one on the fourth morning.

The second half of the flight was for the OAST and Large Format Camera. In the afternoon of the fourth day, the OAST solar array would be deployed, tested, and retracted. The fifth day, we lowered the altitude from 160 to 121.5 nm on orbit 61 for LFC to get a closer view of Earth. The final days alternated between pointing at the sun for OAST and at the Earth for LFC. Landing was on Day 8. It seemed rather simple for all the work that I'd put into it.

But nothing was simple. Syncom objected to being deployed after Telesat. They said that Telesat was going to hog all the power while it was spinning up for deployment. This would limit them to only 500 Watts, and they needed 2000 Watts. Also, since this was the first flight of their kind of satellite, they wanted to go first so they'd have plenty of time to work any problems.

Telesat responded that Syncom being new was a very good reason for THEM to go first. "We don't want to be in the bay when Syncom falls over on us!" Everyone laughed, but we knew that it wasn't an idle concern. The space environment is very unforgiving, and Syncom was enormous. If the "Frisbee" toss flopped, its seven tons of weightless mass could indeed smash Telesat. Or OAST. Or break off a radiator panel and cause a Loss of 2 Freon Loops. . .

Syncom said if they had to wait until Day 3, they'd rather waive one of their communications constraints and be deployed on Orbit 6. While they argued back and forth, I leaned on the table. I took deep slow breaths like they'd taught me in Lamaze classes at the hospital. I ignored the kicks to my ribs and resisted the urge to rub those little feet.

I reported afterwards that "No consensus was reached. Dick Moke said Telesat is going first mostly because they booked first." He expected the electrical power issue to go away. So, my timeline remained intact.

Then the OAST representative threw down his gauntlet. They asked to delete LFC's altitude change on Day 4!

No one at the meeting had the authority to choose between OAST's and LFC's priorities.

The discussion came down to one question: did anyone at the meeting know why OAST couldn't operate at 120 nm? Nope. Larry Williams assigned an action to MPAD to come up with some proposals to be followed quickly by an analysis of the drag by Engineering to determine the effect on OAST operations. The plan was then to come up with a new trajectory that would satisfy both OAST and LFC. I thought we'd already done that, but oh well.

So that issue was tabled, though I had an idea forming to bounce off a few people later. We moved on to more mundane matters such as whether or not the arm would be grappled to OAST for all of their operations—in case something went wrong. Payloads said no, and I said that was my understanding, too.

But Flight Director John Cox said the issue wasn't resolved yet (meaning, I thought, that no one had consulted him) and Rod Rose agreed.

The OAST folks said they wanted to use the arm's elbow camera. If the arm were attached, it'd be like trying to take a photo of a building while leaning against it. The only other way to get images was to mount a camera on their hardware—and that was very expensive. The flight directors were given an action to take a position by July.

Finally, I got to sit down. Charlie Burton of the Payloads Office was up next. He discussed the communications issues with the payloads. More arguing and "clarification" ensued.

In the afternoon, I cornered Larry Ray of Engineering in the hall. He was the only person at JSC who had any real knowledge of OAST's operational constraints. I filled him in on the request to delete the LFC burn. I asked if he could explain the problem with 120 nm. He didn't think that the increased drag at 120 would cause much of an attitude error. The problem was with attitude hold. They wanted to point the arrays very accurately at the sun. A lower orbit zips around the globe faster than one at a higher orbit, so to point at the sun, the ship has to make more little corrections. This means the jets have to fire more often. This in turn shakes the arrays, messing up the accuracy of the pointing. It also burns more fuel.

Ah! Now I understood. I realized only three or four of the OAST tests required the tight attitude hold. If I could schedule those on their first day, before we moved to 120 nm, then that should solve the problem. We could also revisit the option (first devised for STS-11) of delaying the LFC altitude change burn to a later orbit. Both of these ideas would be seriously considered.

The next day was my baby shower which Cindy Simmons organized for me. It was at Mi-Mi's house. Amazingly enough, Sharon Conover joined the party. She hadn't had her triplets yet. We'd had a shower for her back in April assuming she'd deliver early. But she'd been sent home to "take it easy" and ended up going full term. Sharon delivered three healthy boys about a week later.

During my final weeks, I prepared the STS-14 Preliminary CAP. Diane, as lead Timeline, would oversee its publication in my absence. But since she was also lead Timeline for STS-7 that was due to launch in a week, she hadn't actually looked at it yet. So I did all of the work for this book including creating the CAPS timeline and data base files. There were 16 pages of summary timelines, an overview, a section on Constraints and Guidelines, a list of the test objectives, tables showing major events, and the usual list of acronyms.

My idea to do the OAST dynamic tests while still at a higher altitude was well received. But they pushed to have all their tests at the higher altitude. We could do that by delaying the LFC altitude change out to orbit 82. LFC would then only get 24 hours at the lower altitude versus the 48 hours they'd requested. LFC was okay with that, so we changed it.

As a result of the discussion about "who goes first" at the CIR, Telesat lifted their requirement to have a certain ground tracking station (called Allen Park) available within 1.5 hours of their deploy. This moved deploy from Day 2 to Orbit 6, about eight hours after launch.

So MPAD was tasked to come up with yet another trajectory. Of course this trajectory would arrive at least a week too late for me—and probably (it was) just in time to produce another useless iteration for Diane.

The STS-14 Preliminary CAP was published on September 23, 1983. The launch date had moved a few days earlier. Delaying the altitude lowering from orbit 67 to 82 meant the end of mission deorbit opportunity at KSC was no longer available. The timeline showed a landing at Edwards. I'd been told that a landing at Edwards would ruin the LFC's film because it couldn't be removed until the cargo doors were opened at KSC. I assumed that someone had addressed it—or had decided the payload musical chairs would fix it for them, eventually. (It did.)

The real problem I saw with the new timeline was with the crew sleep periods. Putting the Telesat deploy on orbit 6 meant keeping the crew up 3.5 hours longer my original plan, a 19-hour day. Also, the sleep period shifted five hours early during the flight. Apparently, NASA management was so anxious to please their paying customers that risking them being half asleep on entry was acceptable. I thought we'd learned that lesson on STS-2.

Knowing the months of effort I'd put into analyzing all the options and creating the variations of the STS-14 timeline, Diane sent a copy of the published book home to me. She apologized for not being able to give me any credit in the book. My branch chief wouldn't let her list me as a contributor, even in the Acknowledgements where even all the copyeditors were listed by name. I mentioned this to Carolynn, and she said she wasn't surprised. Our branch chief couldn't overtly get back at us for our protest the year before, but he found small ways to exact revenge. I didn't want to believe this but feared she might be right.

RIDE, SALLY, RIDE (STS-7)

In mid-June, excerpts from an STS-7 press conference aired on the evening news. Reporters implied that Sally Ride was flying only because of being a woman. I shook my head. Didn't they know she had a Ph.D. in physics from Stanford? Did they really think NASA hired women only because they were forced into it by the politicians seeking the women's vote?

Maybe politics had played a role in getting us hired. But hadn't we proved we could do the job? Certainly Sally was as well qualified, and more so, than many of the men in her class, few of whom had Ph.D.s. She was one of only six women selected out of 1251 women who'd applied in 1978. She'd do a great job, and then there'd be no doubt that women belonged in space. If I were one of those reporters, what I'd ask is what took NASA so long?!

As this line of reasoning played out in my head, Crippen, the STS-1 pilot and the commander of STS-7, replied to the reporter, "She's flying with us because she is the very best person for the job. There is no man I would rather have in her place." *Go Crip!*

The news anchor ticked off the names of the rest of the crew. The pilot was Rick Hauck, whom I thought of as "the honorary Kentron Lady" who'd worked closely with us to get all our documents consistent. He and Ride and John Fabian (1939–) and medical doctor Norm Thagard (1943–) were members of the Class of 1978, dubbed the Thirty-Five New Guys.

Elvin, Bill, and Chuck were the FAOs. I hadn't been pregnant when my lead assignment for STS-7 had been handed to Holmberg. It still irked me that management had given a lead FAO job to a contractor over a civil servant and yet hadn't promoted Diane to FAO. And he'd been given a lead job ahead of Carolynn, too—who was now lead on STS-8.

I got up early on Monday, June 18, to watch the launch. My friend Leslie Schworm had come from Atlanta to visit. She and Jasper Kitty were there to watch it with me. Thor was on Coen's Entry Team, due on console in the wee hours tomorrow morning. We weren't going to see much of each other this week, my last week at work.

At 7:33 a.m., I watched the launch with crowds waving signs urging, "Ride, Sally Ride!" Walter Cronkite noted that Reagan Cabinet members, Secretary of Health and Human Services Margaret Heckler (1931–), Secretary of Transportation Elizabeth Dole (1936–), plus women's activist Gloria Steinem (1934–) were there to cheer America's first woman into space.

When the engines cut off, Ride said, "If you've ever been to Disneyland, that was definitely an E ticket!" I wondered if I'd ever experience that now that I was committed to being a mother? But I still expected that spaceflight would become routine by the time my child was grown. I still hoped we'd take a family vacation to that Lunar Disneyland. I went to work.

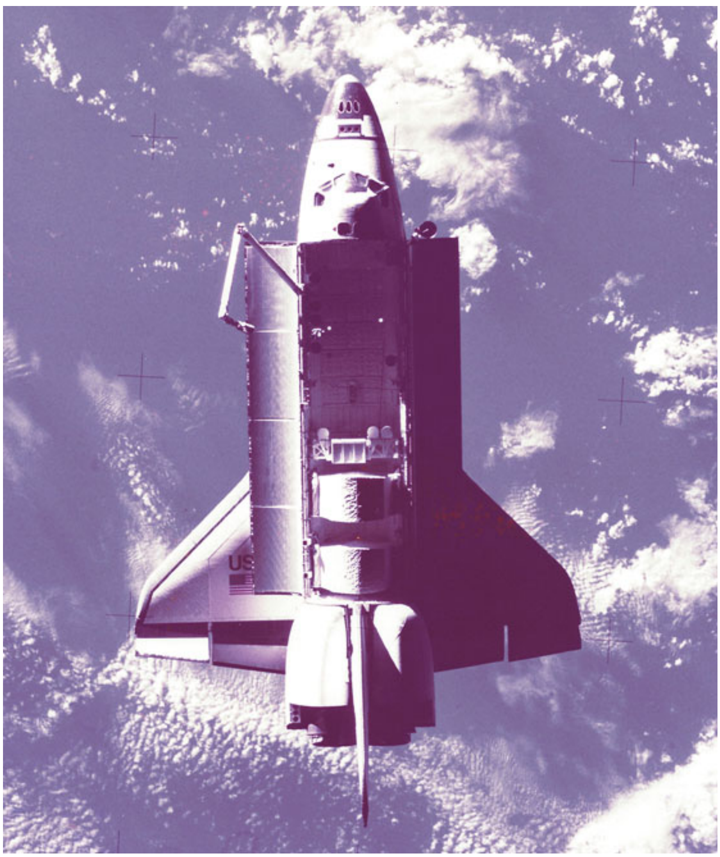
Thor was asleep when I got home. I fed Jasper, made dinner, and read the Houston Post, full of stories about the now-famous Sally Ride. I wondered if any of the male astronauts resented her getting all the attention. Did they worry that having women in the ranks somehow diluted the prestige of "the right stuff"? I couldn't believe any of them would be that insecure. Then again, rivalries and competition were endemic to the military culture. Ever since the Mercury 7 astronauts, people assumed that the best flew first. Would astronauts who hadn't had their turn yet resent Sally going ahead of them? Probably. Would they tell themselves she was chosen ahead of them because NASA needed a woman to help sell the program? I'd bet on it.

The real test of acceptance was whether or not the men would listen to her or always be trying, consciously or unconsciously, to prove they were superior by belittling or ignoring her suggestions on ways to improve the mission. Was that what I was running into with all the iterations on the timelines? I thought that my ideas about STS-14 were being considered the same as if a man had proposed them... but were they? When I objected to keeping the crew awake 19 hours on launch day, was I seen as "mothering" the crew? Would the male astronauts feel as if they had to assure everyone that it wasn't an issue, more so than if a male FAO had made the same objection?

Regardless, Sally would carry this "First Woman" label stenciled on her forehead for the rest of her life. Sure, she'd have her name in all the history books, but living in the media "fishbowl" wasn't going to be easy. Then again, I thought, as I nudged that little foot away from my sore rib, nothing worth doing ever is.

One STS-7 payload was the Shuttle Pallet Satellite (SPAS) that was a frame holding 11 experiments. Fabian lifted it out of the bay with the arm and then let it go. Two hours later, he used the arm to grab it again—the first capture in space. I doubt anyone remembers that particular "first" though that hadn't stopped NASA from trying. Management touted this capability as useful for repairing satellites—such as Solar Max, scheduled for repair on STS-13.

Ride repeated the release and capture of SPAS. On one of the iterations, a camera on SPAS looked back at the shuttle and snapped a photo of the shuttle with the arm bent into a number 7 like in the mission patch. Crippen proudly declared, "We pick up and deliver."



14.4 The first photos of the shuttle in space were taken by the SPAS while it was deployed during STS-7. The crew bent the arm into a number 7 (NASA photo)

Entry was Friday. Thor'd established a go/no go for me to inform him if I went into labor. Prior to this time, he'd hand over his duties to J. T. Chapman. But after that time, no one was to contact him. The shuttle's safety depended on him making sure the state vector was accurate.

Though this was my last day at work, I wasn't due for two more weeks, so I wasn't overly concerned. The landing, planned to be the first at KSC, was shifted to Edwards because of clouds. I watched it at 9 a.m. at work with Tucker and Mi-Mi and Carolynn.

At the post-flight crew interviews, Ride said, "The thing I'll remember most about the flight is that it was fun. It was the most fun I'll ever have in my life" [3]. Maybe her joy would compensate a little for having to deal with the paparazzi.

I cleared out my desk about the time Thor returned from the control center. He carried my stuff to the car. He was tired from all the weird shifts, but happy. The entry had gone smoothly despite the change to Edwards. And he hadn't missed the birth of our baby. I laughed, thinking we had plenty of time. I didn't know that Baby had moved up the launch date.

Saturday night, June 25, was the annual Valhalla Manager's Reunion. We celebrated America's first woman in space, Thor's successful first time as entry guidance officer, and the start of my maternity leave. We had a wonderful evening with all our friends from Rice.

Labor started at 6:15 a.m. on Sunday. Our beautiful baby boy landed safely in Daddy's arms that night.

14.5 Our first family portrait. Daddy is wearing an STS-6 T-shirt under his hospital gown (Photo by the author)

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15

Being Home with Baby

Like a good NASA FAO I recorded all of Thomas's "firsts" on a calendar: first bath on Day 5, first stroller ride on Day 7. Our first outing was to Sharon Conover's to see the triplets.

During Thomas's fifth week, Thor's parents and their exchange student from the Netherlands, Warner Kroll, came to visit. Employees could escort anyone around JSC. We climbed in and out of the shuttle mockups in Building 9, explaining about camera angles and middeck stowage. We were proud to show off our space program, and Warner was suitably impressed.

The rest of the summer went by quickly with lots of "firsts" for Thomas. But one "first" we might have done without was Thomas's first hurricane!

No one had been particularly worried about this storm as it approached. The mayor of Galveston hadn't even ordered an evacuation. We boarded up the windows and decided to ride it out. However, Hurricane Alicia strengthened to a Category 3 storm overnight.

The eye passed over Alvin, 18 miles south of our house, at 6:30 a.m. on August 18th. The 80–100 mph wind blew gravel from the tops of buildings and shot it like bullets at windows everywhere. We lost power and our fences were knocked down.

Hurricane Alicia was blamed for 21 deaths and billions of dollars in damages, including 50 structures at JSC. When we got the newspaper, we realized how stupid, and how lucky, we'd been. Alicia spawned 14 tornados between Galveston and Hobby airport, in other words, within miles of our house. Though we stayed dry, the tidal surge had been 8–12 feet—roads all around us had flooded. Hurricane Alicia reminded us of the importance of contingency planning.

CHANGE IN SCHEDULE

In the early evening of August 29, lightning arced all around the space shuttle *Challenger* on the pad at Kennedy. No Dyson in Mission Control assessed its effects on systems or timelines. Because STS-8 had originally been scheduled in July, Thor had requested that flight off. Then TDRS was pushed off of STS-8 and the launch slipped into August.

M.J. Dyson, *A Passion for Space*, Springer Praxis Books,
DOI 10.1007/978-3-319-20258-7_15

When lightning delayed launch, we both slept through it. We watched it on TV in the morning, like the rest of the taxpayers. We had this "position" painted on our STS-8 mug.

STS-8 was famous for including the first black astronaut, Guy Bluford, Jr. (1942–). It was also the first night launch. Truly was in command, and Dan Brandenstein was pilot. (Years later, I'd serve on the National Space Society's Board of Directors with Dan.) The other two mission specialists were Dale Gardner (1948–2014) and Bill Thornton (1939–).

15.1 NASA was really into "firsts" as satirized in this comic from the newspaper in 1984 (Photo by the author)

Over the six-day mission, they deployed INSAT-1B for India and did more thermal tests. The altitude was lowered from 191 to 130 nm to study atomic oxygen glowing around the orbiter at night. It landed 43 minutes after midnight on September 5. Carolynn had finally gotten her turn at being lead FAO. She transferred out of Flight Activities soon after.

15.2 FAO Mi-Mi Lau, shown here with Gary Coen and Kranz in the background, was selected to hang the STS-8 Mission Plaque, though right-side up! (NASA photo)

My time at home had gone by much faster than I'd expected. I'd kept in touch with Diane about STS-14. Even though the Preliminary CAP still showed a June 1984 launch, with STS-8 launching a month late, and STS-9 delayed to November, everyone expected it to slip. Did I really need to rush back to work? I wrote, "I decided about two weeks ago that I did not want to go back to work October 11 as I'd originally planned. The new date will be November 14."

I delivered the news to my branch chief in person on September 12. He said he was disappointed by my decision, but he approved the extension of my leave.

On September 16, Thor and I took three-month-old Thomas and flew to Ohio to show him off to my dad, brother, sister, and his great grandparents plus a bunch of cousins and friends.

A week after we got back, we drove up to Fort Hood to visit Thor's high school best friend, John Barson, and his wife Gay who was five months pregnant. Everyone urged me to stay home as long as I could. In the car ride back to Houston, Thor and I discussed me taking leave without pay after I'd used up my paid leave. Could we afford it? How would it impact my career? I still had my passion for space, but my priority right now was being a mom. After all, the job would still be there after Thomas was no longer a baby.

I wrote, "I'm in such a turmoil inside. Today (my boss) asked for a definite when will I be full time. From Thomas's point of view, when is best? Never is not the answer. I will be going back." What I really wanted was a part-time option. "I called an agency. There aren't any jobs that can be done at home in technical writing or programming. All I can do at home is babysit and go to school.

"I had Mi-Mi and Marion over for lunch. They agreed that what our branch chief wants is a commitment to do the job no matter what hours it requires. . .Mi-Mi and I think he is still worried about us as women getting upset because our assignments were taken away." My primary considerations were how long to keep nursing and how long we could afford not to have my income. The work I'd already done on STS-14 was also a consideration. "I like the LFC and OAST people. I want to work STS-14. [But] if my STS-14 assignment is removed, the only motivation for going back to work is money." We could afford to live without my income until May, but my first choice was to return January 1 which was the soonest I wanted to quit nursing.

When I told my branch chief I'd like to return January 1, he said if I wanted to keep my STS-14 assignment, I needed to be back December 1. Determined to find a compromise, I offered to work part-time in December. He wouldn't consider it. He pointed out that I'd already delayed my return twice. (Actually once, from October to November.) He'd held the STS-14 lead job for me while under considerable pressure to give it to someone else, especially when STS-12 (another TDRS flight) had been cancelled.

I told him I appreciated that he'd held that position for me. I was about to give in, to agree to go back full-time December 1, when I thought to ask about Christmas. I'd used all my vacation time. The only day I'd get off was the Monday after Christmas. The family holiday reunion was in Wisconsin. It'd be Thomas's first Christmas. I said I'd come back December 1 if he'd let me have the week after Christmas off. I pointed out that no one would be in the office anyway, and no STS-14 products were due.

In retrospect this was the totally wrong approach for me to have taken. I should've emphasized how I'd jump right in with both feet and make sure I was on top of all STS-14 issues. I'd kept in touch with Diane and had followed all the iterations of the trajectory and schedule delays. Instead of talking about the job though, I brought up the holidays. I should've waited to ask about that AFTER I was already on the job. And if he'd said no, then that was just the way it had to be. He was offering me one last chance to show I was committed, and I blew it by babbling on about the family Christmas.

He shook his head and said he was sorry, but he'd not approve leave without pay for me. He had work that needed to be done, and plenty of qualified people to do it if I had better things to do. Legally, he had to hold a job for me for up to one year. So I could extend my leave up to a year. But once I came back, the only leave I'd have would be what he approved.

The choice was clear: my job or my child. I choose my child. I'd be on leave until May 1, 1984. My branch chief signed the form, and I walked out, in shock at what I'd done.

Thus, October 14, 1983 was the beginning of the end of my career with NASA, though I didn't fully realize it at the time.

Somewhat ironically, I'd been asked to speak at a conference called "Professional Women Speak" at Texas Southmost College in Brownsville, Texas on November 17. The request came in August, before I'd delayed my return. Ethel Cantu, the conference chairman wrote, "Our program first features a woman faculty member who makes a presentation on the historical and statistical representation of women in this particular career field. Our guest speaker then gives a more personal presentation on her career: how she chose it, how she advanced in it, what obstacles she had to overcome, what her typical day is like, and what advice she would give to students preparing for this career. Audience ranges from 50 to 100, predominately Hispanic. The seminars are well covered in the local media. We also videotape the seminars for use in the public schools. We would like a speaker who can relate well to such a diverse group and one who can inspire and motivate students to achieve in mathematics and science."

The NASA Speakers Bureau said there simply weren't any other women available to take this engagement. It was mine to do or cancel. Brownsville was a five to six hour drive, and my talk was scheduled for 7–9 p.m. I'd have to spend the night, and I'd have to take Thomas with me—and that meant Thor had to go, too, to watch him while I gave my speech. He suggested that we rent a plane, and he fly us to Brownsville.

Ms. Cantu agreed to offer me the price of a round-trip ticket to put toward the cost of renting a plane. So I gathered and mailed the data to her about women at NASA:

"There are over 700 women at Johnson Space Center. Women comprise about 21 percent of the work force and over a third [about 7 percent total] of them are professionals. In addition to permanent employees, there are co-op students, 70 to 90 at a time, and 21 percent of these are also women, mostly engineers. The percentage of women at JSC has been fairly constant for the last four years. It has gradually increased from about 17 percent in 1974." (In 2009, *NASA's Support of Women and Girls* reported women were 35 percent of the total workforce with 22 percent professional, and 40 percent of co-op students.)

"Out of 78 astronauts, eight are women. Six of them have Ph.D.s, two have M.D.s. The youngest (Kathy Sullivan) is 32, the oldest 40 (Shannon Lucid). Four of them are married, three are mothers. Six were hired in 1978, two in 1980. The shortest is 5′2″ and the tallest 5′11″. Their weight varies from 98 to 150 lbs. Five of them are private pilots." (In 2014, 11 of 43 active astronauts were women, eight had Ph.D.s, one is black. Data on their heights and weights was not available! Of the four new hires, only one has a Ph.D., and three are single [1].)

So, when November rolled around, off we went to Brownsville.

Prior to my speech, we enjoyed dinner on campus. Our waitress was fascinated with Thomas. She waved several other waitresses over to our table to see him. They chattered away excitedly in Spanish and then one asked, in broken English and with gestures, if she could hold him. I smiled and nodded. She lifted him out of his high chair and, to our surprise, trotted off with him through some double doors! Thinking I'd not understood her request, and not willing to let my precious baby out of my sight, I rushed through the doors after her. I found Thomas in the kitchen with a crowd of women around him, squealing in delight as one after another petted his fine blonde hair and pressed his chubby little hands against their cheeks. "So healthy!" one woman proclaimed, poking his round belly. "Very blue eyes!" said another. "Lucky, mama!" the waitress said as she reluctantly handed him back to me. Yes, I certainly was.

As advertised, my talk was reported in the newspaper and shown to the local high schools. But I think baby Thomas, and the fact that his daddy took care of him while I gave my speech, made the most lasting impression.

With the flight rate up, NASA decided to hire yet another group of astronauts, the Class of 1984. I decided not to apply. It looked like there'd be lots of chances to fly in the future, and not just as career astronauts. Some scientists had already been assigned as payload specialists, in charge of specific experiments. The first of these, Ulf Merbold (1941–) and Byron Lichtenberg (1948–), would launch on STS-9. Also, the NASA Advisory Task Force had issued a report in May approving the flight of private citizens, opening the door for the Teacher-in-Space program.

Thor decided to apply. I wrote on November 26, "Thor is at work though it's Saturday. He's filling out his astronaut application. He still has mixed emotions about it, but I think he wants it." I thought he had just the right stuff to be an astronaut: he was a pilot, a scuba diver, an Eagle Scout, super healthy, scientifically competent, able to fix almost anything, calm and logical, and a fast learner. He'd completed all the coursework for his Ph.D., though he only had an M.S. We thought his experience at JSC might make up for that. Part of me wanted the world to recognize just how special my husband really is, and part of me dreaded having to share even more of his time with that world.

SPACELAB, STS-9

The first flight of Spacelab launched on November 28, 1983. Thomas and I watched it live on TV. Thor was once again working as Entry Guidance Officer.

Spacelab was a module that fit into the shuttle's payload bay and connected to the middeck via a tunnel fastened to the airlock hatch. The module was filled with experiment racks, a design used for space station modules later. The crew of six commanded by STS-1 veteran John Young was the largest yet. The crew was divided into two 12-hour shifts, the first taste of 24-hour operations the Mission Control teams had experienced since Skylab in the 1970s. Keeping track of what the astronauts were doing while planning the next shift for a 9-day flight really put the FAO teams to the test. Nute was lead FAO, and the other two were Holmberg and first timer Gerry Shinkle who was our resident expert on Spacelab systems and procedures.

A new position was added to Mission Control called Command and Data Management Systems Officers (CDMS) responsible for the Spacelab computers. (Lizbeth/Betsy Cheshire was one of the CDMS officers.) Five flight directors were assigned to the flight, one each for Ascent and Entry, and one for each of the three Orbit shifts.

However, there weren't enough flight controllers to fill five separate shifts. So Orbit 2 was basically the Ascent Team with a different flight director, and Thor's Orbit 3 shift was the Entry Team with Larry Bourgeois as Flight instead of Coen.

At a long sim prior to the launch, Thor watched in alarm as the orbiter's state vector "went all squirrely." He recognized the problem as a time tag issue. The state vector has seven parts, three coordinates for position, velocity in three directions, and time. The data was delivered in the downlink in two parts, called frames. Somehow, the two frames were being sent out of order, so that instead of two frames that go with the same time, he'd get one frame from a second ago, and the other from the current time. There were no jet firings in progress to change the velocity that quickly, and the radar data showed the orbiter moving steadily through space. So Thor immediately concluded the problem was with the ground telemetry processing computer (TPC). He reported the issue to Flight and recommended the standard fix for all computer issues: reboot the TPC. This action indeed fixed the problem. The sim continued. However, after the sim, he was charged with finding out *why* the TPC had generated bad data.

"I worked with a woman named Liz Brownig, a contractor with IBM, who figured out the problem," Thor said. Despite all the sims and flights that had already occurred, the TPC had never been left running for 24 hours straight. It'd always been cycled during loss of signal—but with TDRS, those times were not as long as they'd been for previous flights. Similar to the "millennium" problem when computers couldn't cope with going from 1999 to 2000, the TPC couldn't keep track of time tags after 24 hours.

The problem impacted all the telemetry data, but temperatures and voltages don't change much in a second. "With the shuttle moving at 25,000 feet/sec, the position changes rapidly," Thor said. So he'd noticed the problem before the other operators. Once Ms. Brownig discovered the cause, console procedures were changed to always reset the TPC prior to entry.

The flight proceeded smoothly until the last day. The crew and EECOMs had managed the consumables so well that the managers happily agreed to give the crew an extra day in space. Spacelab was shut down, its hatch secured, and preparations made for return on December 8.

The planned landing was at Edwards at 9:58 a.m. CST. The Entry Team, including Thor, arrived in Mission Control around 1 a.m. Around 8:00, Thor recalled, "They were maneuvering to the deorbit burn attitude when one of the computers failed." They still had three other GPCs and the backup, so Flight Director Coen gave them a "go" to continue. The burn that would start their descent was less than an hour away.

Then another computer failed. Post-flight, Young said that after the first computer failed, "my knees started shaking. When the next computer failed, I turned to jelly" [2].

Young and Pilot Brewster Shaw tried for about 40 minutes to revive the computers. Thor and his friend Phil Burly (Entry FDO) prepared a new set of targets in case Flight decided to enter on the next orbit. GPC 2 came back, but GPC 1 remained offline.

Then one of the three IMUs failed. These gyroscopes tell the orbiter which way it is oriented in space. Years before, Holloway had asked me to write a contingency procedure for what to do if their fans failed. I'd concluded that something that would take out the fans would fail the IMUs themselves first—something like a massive computer failure! With two computers down, and one IMU failed independently, Young wasn't the only one turning to jelly.

Flight decided to replace the failed GPC 1 with the onboard spare, and then bring the crew home on one of the afternoon opportunities. The replacement went well while the team discussed and reviewed plans for what to do if another IMU or computer failed during entry. Thor did another weight and balance to account for the difference in consumable usage, then prepared to calculate the targets for entry. He said he felt "wired" anticipating more failures.

As the afternoon entry time approached, the Entry Team had been on console for close to 16 hours. Thor and Phil's Section Chief, Mike Collins, dropped in to see how his guys were holding up. "I told him I wasn't tired at all—I was young and running on adrenaline like the rest of the team," Thor said. He interpreted the fact that Mike didn't replace him with a "fresh" operator as "showing that he had confidence in me as an Entry Guidance Officer even though this was only my second flight in that position."

The entry burn went as planned. They had three of four working GPCs and two of three working IMUs. They'd reconfigured equipment so that the recovered GPC 2 wasn't responsible for anything critical. That turned out to be a very good precaution.

"The thing I remember most is that we made it through entry interface," Thor said, "and at nose gear touchdown, DPS Officer Ernie Smith told Flight that GPC 2 had died again." And that wasn't all.

Director of Flight Crew Operations George Abbey added in an interview post flight that, "John [Young] was on fire when he landed: of course he didn't know it at the time. He didn't find out about it until about a day later." Hydrazine fuel had leaked, and two of the three APUs had caught fire about two minutes before touchdown. Without APUs, the flight controls wouldn't have worked, and they would've crashed.

Thor doesn't recall any special celebration after landing—everyone was too exhausted. The failures were blamed on a loose piece of solder floating around inside the computers and shorting them out. The APU problem caused the program to remove and replace the APUs in *Challenger*, too, delaying its launch from January to February.

Despite the equipment failures, the 10-day flight was heralded as a great success, having completed 72 experiments and proved that non-NASA scientists could do meaningful work in space. The TDRS did its job of transferring all that data to the Payload Operations Control Center in Alabama, too. And the TPC cycling before entry avoided the time tag error.

BABY'S FIRST CHRISTMAS

On Christmas Eve, Thor and Thomas and I flew to Chicago. Mike Savage was there to pick us up for a drive to Wisconsin. The temperature was −11 °F. The plane was coated with ice, and the workers couldn't get the luggage doors open. Thor and I took turns holding Thomas in the lobby. Outside, the weather worsened. Was it even safe to drive? Mike, a veteran Antarctic explorer, wasn't overly concerned. But O'Hare airport was not where we planned to spend baby's first Christmas! About three hours after landing, we got our luggage. I bundled Thomas in his snowsuit, and off we went to Wisconsin. Mike noted that the temperature had plunged to −25 °F. I thought to myself, I gave up being lead on STS-14 for this?!

As we drove, I considered how different this birthday was from any I'd ever had before. I wrote, "... Cindy said that her 29th birthday was really hard on her. She attributes that mostly to a feeling of lack of accomplishment. I feel I've accomplished what I set out to do by age 29, and am satisfied. Thomas has brought me a real sense of fulfillment. ... What more could a person ever want than what I have? All I want is for nothing to change!"

After cross-country skiing in the Dells, we drove with the Dyson grandparents to their home in Mason, Michigan. My mother-in-law Ruth Dyson was an elementary school principal. She asked me to speak to some of the classes. I had a blast! I decided I'd definitely do this again. In fact, I'd eventually turn writing and speaking to kids about space into a second career.

My dad, stepmother Donna, and my sister Carolyn came to Mason to meet the Dysons and visit with us. Seeing the faces of my family interacting with Thomas was the best gift of all.

1984: NEEDED AT HOME/WANTING TO WORK

At Thomas's six-month checkup, the doctor declared him extremely healthy. He was also extremely active, pulling himself up to stand in his crib and swinging his feet madly while riding in the grocery cart. But I was "homesick" for work. I wrote, "I miss my job now, really miss it and want to be with everyone again. I feel left out, out of touch, like I'm losing my training. I want to return part-time *now*. But then I ask myself how I can even consider leaving my baby when he's so dependent on me. ... I thought to myself what a sense of satisfaction it was to be home with him and tend to him. If I were at work, he would be in a crib every morning with no mommy there to hold him. I reminded myself that I'd still have him to hold in the evenings, and could still get him up in the morning. Will that be good enough?"

In early January, Boyd Mounce of Public Affairs asked if I'd give a speech to the Noon Business and Professional Club of La Marque. I sent a note to my managers saying, "I would enjoy the opportunity to speak. Since it is a local area speech, no travel money or paperwork will be needed. However, I do wish to be paid for four hours of work (includes preparation time) even though I am on leave-without-pay status. If this is not possible, please let me know."

My branch chief said absolutely not. If I were able to give speeches, then I should be able to come to work! But my division chief, perhaps more attuned to the needs of boosting NASA's image with the public (and politicians—Reagan had mentioned space station in his State of the Union speech), overruled him and agreed to let me give the speech.

BECOMING A WRITER

But I needed more than an occasional speech to fill the void left by work. I volunteered for Spaceweek, a new organization founded by Dennis Stone to celebrate space. I signed up for Spanish classes at church. But I wanted more. I wanted to try writing, but that required a computer. Could we afford it? Hardly anyone we knew had computers because they required programming skills and cost $400 or more. Both of us had done programming, and hopefully, I'd earn enough writing to pay for the whole thing! We splurged.

Our Eagle PC arrived on January 20th. This fancy little machine had an 8-inch monitor that displayed green text typed in from a keyboard. There was no hard drive. No mouse. But it came with a dual floppy-disk drive, and free word-processing software. I put the program in one slot, and a blank 5.25-inch floppy in the other to hold the files I created. We bought a dot-matrix printer that was as fast as any of the ones at work. I was in business!

I wrote and printed my first set of articles. One was for the Hypatia Cluster newsletter—a group that offered a prize to the first woman to reach the Moon. With Sally Ride's flight the year before, we all assumed this Cluster would be awarded soon (it never was). My other article was a report from a meeting of the American Institute of Aeronautics and Astronautics (AIAA) Houston chapter. This kind of writing came easily to me. I wrote, "I guess I could make a career of writing and speaking, but I'd miss NASA. I like NASA! I like the atmosphere of intelligent people working on the future. I want to continue to be a part of it."

My first articles had been published. I was ready to write for paying markets. But I had to get permission for outside employment. "The intent of my speeches and articles will be to promote space exploration and development to the public. The organizations to which this work will be directed will therefore include all age levels and educational backgrounds. The following topics are indicative of the general areas which I intend to address: women in space, working for NASA, typical or specific shuttle flights, and science in space. Information for these topics will be from publicly-available sources or personal experience. Some of this work will be gratuitous, and same may be for profit."

Permission was granted. Now all I had to do was get some magazine to pay me!

STS-WHAT?

As a perfect example of how some really smart people can have some really dumb ideas, NASA quit numbering shuttle flights in order of launch. Rather than renumber STS-11 to STS-10 when STS-10 was canceled, they renamed it 41B. The first number was for the fiscal year that ran from October to October, in this case 4 for 1984. The second number, 1, was for KSC. (Launches from Vandenberg in California would have a 2.) The letter, B, was for the second flight of the fiscal year from that launch site. STS-9, which had already flown, would've been 41A, as the first flight of fiscal year 1984, even though it launched in November of 1983.

This new system was universally despised by flight controllers. Even the announcement about it in the *Roundup* scrambled the codes for upcoming flights. Flight 41E was almost immediately cancelled, leaving a gap in the lettering. When Spacelab 3, 51B, was delayed, it came after 51C and 51D. And some of the 51s got postponed into fiscal year 1986.

Anyway, 41B, the actual tenth shuttle flight, was STS-11 when I'd handed it over to Tucker last spring. Amazingly enough, it had only slipped a month since then. Even more amazing, the prime payloads had not changed.

Thor was on the Entry Team, so wasn't involved in the satellite deployments, which turned out to be a flop—but not because of NASA. The payload assist modules failed, so the satellites didn't reach their planned orbits. However, these dual failures offered an opportunity for NASA to demonstrate a new capability. After 51A in November deployed its scheduled cargo, they'd rendezvous with the stranded satellites and bring them back to Earth for repair.

The highlight of 41B was the first untethered EVA using the manned maneuvering unit. Bruce McCandless (1937–) got 320 feet away from *Challenger*, becoming the first human satellite while his partner, Robert Steward, checked out the new foot restraint on the arm.

Thor's dad commented on the speed that new capabilities were coming online in a letter during this flight. "Next we'll have the real Buck Rogers flying into view. How long has it been since Kitty Hawk? I can remember running out of the house to see the biplanes go over Philadelphia . . .I must say the thrill is magnified by knowing you guys are part of this terrific program." It certainly seemed possible I'd get to be a starship astrogator one day.

This flight also flew the first refurbished satellite, the German SPAS that had flown on STS-7. An electrical problem with the arm prevented deployment, much to the disappointment of arm operator Ron McNair, the second black astronaut and our neighbor in Meadowgreen.

But Commander Brand and Pilot Gibson (Rhea Seddon's husband) got the honor of landing the first shuttle at KSC. The landing on February 11, 1984 saved more than a week in precious turnaround time. With this capability, NASA hoped to increase the flight rate to one a month. Ten flights were on the schedule for this year already.

On February 9, NASA announced screening applicants for the next class of astronauts. "A total of 4934 men and women applied for approximately 12 positions," the press release said. They'd interview 120 of these in six groups of 20. Thor was disappointed not to be among the 120, though not surprised since he didn't have military experience or a Ph.D.

Our coworkers among the finalists included Chirold Epp, Ph.D. who had come out of MPAD and joined Thor's section; Prop Bill Gerstenmaier ("Gerst") (1954–) that I'd sat in the dark with during the STS-5 fire; and two of the Pointers: Rick Hieb and Mark Brown (1951–). Brown was selected in 1984, and Hieb joined the 1985 class. Epp and Gerst never became astronauts but rose up the ranks of management. (Gerst became NASA Associate Administrator for Space Operations. I wrote his profile when he won the National Space Trophy in 2010.)

Of the 120 finalists, 23 were women. Three were selected: Marsha Ivins (1951–), Ellen Shulman (later, Baker, 1951–), M.D., and Kathy Thornton, Ph.D. (1952–). Ivins was the first woman selected without an advanced degree. She'd worked as an engineer for NASA since 1973 and was a pilot out at Ellington. I took this as a sign there might be hope for me in the future [3].

STS-13, A.K.A. 41C

For several years, 41C had been called STS-13, even though now it was actually the 11th flight. We all joked that surely NASA hadn't changed the numbering system just to avoid 13! But we tended to say this with our fingers crossed behind our backs because no one had forgotten the near disaster that *Apollo 13* had been.

Thor didn't work a shift on 41C but sat beside Will Presley during sims and flight to get trained as an ascent guidance officer for the next flight. 41C was the first flight to have a woman Guidance Officer, Gayle Weber, who had joined us on that flight to the airshow in Kerrville. She was the Guidance expert on rendezvous with the Solar Max satellite.

This was the first time for a shuttle to do a direct insertion. On all the previous flights, they'd shut off the main engines, coasted, dropped the external tank, and then used the onboard OMS engines to reach their final orbit. On this flight, they used the more efficient main engines (which got their fuel from the ET) to take them all the way to the altitude they wanted. This reserved fuel for the important first rendezvous.

The direct ascent went well, but the flight control team didn't get to see it because the MOC failed. Then, the backup failed, too. This was the first time since the fire during STS-5 that Mission Control was offline during a flight. For a very tense hour, the controllers had no data from the space shuttle. Fortunately, the crew knew what to do and kept flying.

The second day went smoothly with the release of the Long Duration Exposure Facility (LDEF) that was filmed for the IMAX movie, "The Dream Is Alive."

On the third day, George "Pinky" Nelson flew the MMU out to Solar Max. The plan was to stick a sort of "plunger" to the side and grab the "handle" with the shuttle's arm. But the plunger didn't stick. When Pinky tried to grab the satellite another way, it tumbled. They added an extra day for NASA Goddard to stabilize the spinning satellite, which almost ran out of fuel. Chasing it required some fancy flying by Crip and Pilot Frances "Dick" Scobee (1939–1986).

Crip then pulled up alongside it, Terry Hart nabbed it with the arm, Nelson and James van Hoften (1944–) repaired it during an EVA, and the fixed Solar Max went on its way. NASA proudly added "satellite retrieval and repair" to its list of customer services.

The flight landed on Friday, April 13, 1984 with one piece of bad luck: they had to go to Edwards instead of Kennedy.

WORKING MOTHERS

"April 29, 1984. . .in another week I go back to work. I took a walk with Cindy and we talked about being working mothers. One of the main points that I need to record is that I need to feel my job is really important in order to justify leaving Thomas. . . .But being home these 10 months has convinced me I'm not essential even if I think I can do a better job than most. . . .

"Cindy and I decided we also need the prestige [of work] and thrive on it. Housewives just don't get the same kind of respect as professional business people do. I'm not sure where the need for recognition comes from, but it's pretty basic, and some of us need a lot to keep us going.

"We are lucky our husbands support us in our decisions and give us so much freedom to choose between options. Cindy thinks her real talent is in religion. She said, 'I'm a genius in religion.' But she wants to teach, and thinks accounting will provide the outlet for that. [She got her Ph.D. in accounting and became a professor.] And me? I don't know what I'm even good at, let alone a genius at! I suppose psychology and astronomy have always been my favorite subjects, or rather people and the stars. Maybe I should be an astrologer?! . . .

"We have to come to terms with the fact that there are always options. None of us is forced to work at one thing our whole lives. Some people have fewer options due to lack of education or drive, but Cindy and I have lots of options and can't fool ourselves by saying 'I work because I have to' like so many women rationalize to themselves. It's not socially acceptable to work because you need recognition for heaven's sake! Or work because you need stimulation. No, we work because we have to pay bills of course, and we're truly sorry our children are being raised by someone else. Not me! I'm going to face it and try to sort it out the way it really is. Maybe I'll write a book."

Our babysitter's first day on the job went great. Her name was Lorelei, and she bonded with Thomas right away. After she left, Thor got on his hands and knees to retrieve a toy from under a chair in the living room while I got dinner. Thomas climbed over the chair, onto Thor's back, and then fell headfirst into the edge of the coffee table.

We took him to the emergency room at Clear Lake hospital. The doctor on duty that night was Astronaut Bill Fisher. The cut required three stitches, and we joked how a facial scar was sort of a badge of honor for a boy. I hoped that one would be enough because as I wrote in a letter to the family about it, "Mom has eight lives left."

I hoped Thomas would go easier on Lorelei because it was time for me to go to work!

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16

Working Mother

I went back to work on my first Mother's Day. I wrote, "I'm officially a working mother now. So how do I feel? Sad, tired, willing to give it a try. One woman at work said I'd be surprised at how quickly Thomas won't miss me. I want him to miss me! I miss him! I don't buy all that crap on 'quality' time—how can I mold and shape my son if I'm not even there 44 percent of the time he's awake?"

I'd written to my mother that "I think I'll like my job more as I get into it again. It is nice to be recognized and respected by adults. I do need that."

Little did I know just how little respect I was going to get, though. In fact, I was literally shoved aside. My desk on the second floor of Building 4 had been moved from the coveted window position to the "nursery," a large windowless interior office used to corral the new hires, mostly contractors. The only other experienced person in the room was Diane (dubbed "Mom" by the new hires) who, despite her years of experience, had still not been promoted to FAO.

At the same time, my former window seat had been given to Holmberg. This move hadn't happened back in October when I'd extended my leave. That would have made it easier to accept. No, the move had come in April, just weeks before I'd returned. I didn't understand why Bill was being given so many plum assignments and perks at the expense of NASA employees. But this wasn't about Bill. It seemed to me that my branch chief had found another small way to punish me for the discrimination complaint.

I was determined to do a good job and *earn* my way back to a window seat. The week before I was to report back to work, the babysitter I'd hired quit. Having to depend on a weekly paper to advertise, I did what I thought was the responsible thing: I'd gone to the office and let them know there was a potential problem. Although I'd be back as planned, I told them I might need an additional week to hire a replacement caregiver. I told management I'd work 40 hours by coming in every afternoon and evening and Saturday and not being paid if necessary.

Instead of the anticipated, "don't worry, we'll work it out," I got a memo from my branch chief dated May 4 and cc'd to my whole chain of managers all the way up to Kranz. It said: "On numerous occasions, we have received tentative dates for you to return from extended leave. We have changed (delayed) your assignments many times. For the last few months, we have been assured you would return mid-May 1984. Recently, assuming

M.J. Dyson, *A Passion for Space*, Springer Praxis Books,
DOI 10.1007/978-3-319-20258-7_16

this would be true, we assigned you as lead FAO to STS 51-H. The CIR is August 28, 1984, and the CIR Dry Run is May 31. We would like you here to prepare for and make that presentation. . . . I will not approve additional extended annual leave, leave without pay, or unusual working hours immediately upon your arrival."

Even though the memo was distributed with a green cover sheet saying "The attached material is subject to the privacy act of 1974" and that it should be kept under locked conditions, the whole world was gossiping about it by the next day.

What did he expect me to do, leave my baby home alone? We didn't have any family to call upon. Day care didn't yet exist, only a few mothers' day out programs at churches. Until I hired a nanny, my only option was Thor. Family leave didn't exist yet, either, so he had to use vacation days to stay home. He'd depleted them during our Christmas and Easter holidays. As it turned out, we hired Lorelei within a week. So the whole thing had been a tempest in a teapot. I wished I'd not tried to be responsible and give them a heads up! But the damage was done.

As I often did, I vented my frustration through writing a response that I'd never send. In this note to myself, I reviewed my decisions to delay my return, noting that I'd given NASA more than a month's notice when I changed dates in the fall, and that only two assignments were impacted, STS-11 and STS-14: both of which had been easily and happily filled by others.

I recounted how my branch chief had written a memo in the fall saying that a lead FAO must be on duty six months prior to launch. "This memo, supposed to be a general statement, only applied to one individual—me. From my point of view, my branch chief was saying, 'Stay home. I don't want you back.'"

When I returned on May 11, my former section chief, who was now deputy branch chief, welcomed me back. I especially appreciated him doing that. I asked him for advice on whether or not to respond to the memo. He urged me to just "let it go."

But I was still embarrassed by all the negative attention, especially by the new women in the branch who didn't know about the discrimination complaint. One of these young women verbally lashed out at me, saying I had nothing to complain about.

Compared to women in other industries, I was indeed lucky. At least the law required that I have a job at the same salary to return to. In contrast, when my mother had complained about having to work long hours on her feet (in retail) without any breaks (she'd had back surgery), she'd been threatened to be reduced to part-time status which would've cancelled her health insurance. She'd also been punished by having to work every weekend and a random schedule so she couldn't even plan a week in advance. And for all that, she only made $5 an hour.

So what if my boss had refused to let me work what would later be called flex-time to deal with a temporary issue? So what if my desk had been shoved into a corner in a back room? So what if my boss had made my personal business public knowledge? These were small things. I'd turn the other cheek. I did indeed still count myself lucky that I worked for NASA. My biggest worry was that, given my "trailblazer" status, I might have jeopardized the efforts of other women to show we could handle the demands of flight operations.

Was that why the new women in the branch had so little sympathy for me? Mi-Mi and Sharon and Kathy had all returned to work without any fuss. Why did I have to be the exception that gave the managers a reason to doubt every woman's commitment to the job?

But was commitment really the issue? Did we have to give up our traditional roles as mothers to work for NASA? Why couldn't NASA accommodate those of us who wanted to nurse our babies longer than six to twelve weeks? Why couldn't they offer part-time options, even temporarily, or flexible hours to aid in the transition back to work? Was I really asking too much?

Apparently, I was just ahead of the times. NASA had a very military mindset, especially in operations. Being sensitive and accommodating just wasn't part of the culture. We worked "missions," not tasks. We were flight activities "officers" even though we were civilians. Women were welcome as long as we behaved like men. We weren't to question "orders." We didn't ask directions. We had to compete, not cooperate.

Unfortunately, as I'd discovered, when women behaved like men, they were still treated like women by men. If we stood up to management, we were "bitching," not showing leadership or "guts." If we saw a problem and took care of it, we were undermining authority, not taking the initiative. If we took time to investigate options, we were indecisive, not thorough. And finally, if we ever raised our voices in a meeting, we were too emotional, not speaking with conviction.

So though the law protected women from being fired when they took maternity leave, no law protected women from being treated differently by management. No law kept management from yanking our assignments and giving them to men. No law kept managers from denying us credit for documents, or inventing new rules to keep us from leadership positions, or publishing memos painting us as indecisive and irresponsible. For these things to change, the male managers needed to become aware of their internal biases and judge women's performance the same way they would men's. After that, women might be bold enough to actually have their concerns seriously addressed. Laws would be passed to allow women to nurse babies at work, to provide family leave for men, to permit job sharing and flex time. JSC would establish a day care center on site. Mission Control work shifts would be standardized to save money on overtime and reduce stress for controllers. These changes to the work environment would benefit everyone.

But this was 1984. For now, it was easier for women to just put up and shut up than fight the military authoritarian culture. Hadn't I proved the point? I wrote in my journal, "The upset I had with my branch chief still hangs over me like a muggy day. I can't get comfortable with it. I guess all I can do is perform well and prove myself again."

Ironically, at the very time I was trying to figure out how to deal with NASA's male-dominated culture, in what could either be seen as another example of "tokenism" or a natural progression of women moving up the ranks, Dr. Carolyn Huntoon was promoted to Special Assistant to the JSC Director (Gerald Griffin). She'd been the first female flight controller, the first female division chief, and now was the highest ranking female manager at NASA. (She would later become the first female center director.)

The May 11 issue of the *Roundup* featured an interview of her. "I've never worried too much about being the first woman doing anything," she said. "I've worried about being good at what I'm doing. It is 1984, and people capable of doing jobs are being selected for them, and maybe that's a statement of the times. You have to be a little bit aware too this Center has really taken a lead within the government of giving women the opportunity to show what they can do in jobs not traditionally given to women. You've seen that of course in the astronaut area, but also in Mission Control" [1].

I read this and smiled.

Huntoon went on to say that she'd been an advisor to Sally Ride and had told her "that her flight would probably not be the hardest part to get through, but that it was going to be all the emphasis on being a woman astronaut." She said she thought "Sally handled it extremely well," and that she was surprised, not at the questions Sally was asked, but "that people had the nerve to ask some of them" [2].

In response, the reporter admitted to feeling guilty asking her questions about gender, and Huntoon quoted a satirical interview by Erma Bombeck where the famous writer asks a man how his wife felt about his job and quips, "That's a nice-looking suit, where did you get it?"

Huntoon said she expected the emphasis on gender to continue. "They will always draw some attention, and rightfully so," Huntoon said. "Although statistically there are more women in the country than men, we are still in the minority in technical fields" [3].

And I thought, unless NASA's culture made it easier for women to get assignments that would lead to management positions, to allow them to work part-time and/or flexible hours to accommodate motherhood, they were going to remain in the minority for a long time to come.

THE MYTH OF THE SUPERWOMAN

I attended two seminars, "The Myth of the Superwoman," and, "Woman to Woman" as part of the Federal Women's Program annual conference in May. I reported that "both were informative and encouraging." These seminars planted the seed in my mind for a way to stay part of the space program but not work full-time: create my own job. I really wanted to stay with NASA, but my branch chief had flatly ruled out any part-time option for me in his memo.

So, to my own surprise, I began seriously entertaining the idea of leaving NASA. The industry was booming: 15 flights were planned in the coming year, and everyone was gearing up for the newly-approved space station. President Reagan's commencement speech at the USAF Academy was all about space: "The bold, not the naysayers, will point the way, because history has shown that progress often takes its greatest strides where brave people transform an idea, which is scoffed at by skeptics, into a tangible and important part of everyday life. . . . And nowhere is this more true than America's next frontier—the vast frontier of space" [4].

In this environment, surely I could find a part-time position that would use my hard-won aerospace skills? I wrote, "If I don't look now, I may get to the point where I'm suppressing my 'separation anxiety' and begin to feel it's not important to be with Thomas. Can I really stick it out full time until we're ready for another child? Do I want to? (No.)"

Considering I was 29, and how hard it had been for me to get pregnant, I didn't want to wait too long to try for a second child. Also, some tragic family news reminded me how fragile life is: Cousin Martha's unborn baby died a month before she was due. The umbilical cord had wrapped around the neck. The family gathered in Wisconsin for a memorial service the first week of June. Unfortunately, I had no time off to attend. As I rocked Thomas the night of the memorial, I decided even being the first woman astrogator came second to being his mother.

And I didn't want him to grow up an only child. Thor and I looked forward to the prospect of another baby. But should we wait until we could afford a bigger house? Interest rates were 10 to 12 percent, so buying was not really an option. Could we add on? I sketched out a plan to add a second story and estimated the cost at around \$15,000. I determined that at our current salaries, I needed to work until February, 1985 to save up \$15,000. So, the "Family Activity Officer" had a preliminary timeline for leaving NASA.

That settled, I dove into the work I'd been assigned. I prepared for the CIR of the Earth observation mission (EOM) that my branch chief had cited as the reason for my timely return. The meeting slipped a month almost before I had time to read the requirements document. By June 4, EOM had slipped from June to November of 1985 to make room for another TDRS flight.

With that assignment on hold, I focused on STS-27/51-I which was a Syncom and dual satellite deploy mission scheduled for August of 1985. But no sooner had I drafted a timeline than the payloads shifted. The game of musical chairs continued.

My "first up" assignment as FAO was on Spacelab 3 scheduled for January. But my only responsibility for the flight was to get myself recertified. So I tackled reading these incredibly dull workbooks full of technical explanations (written by engineers of course!) of how various Spacelab switches and systems operated. Thinking of my mother on her feet all day, I reminded myself that at least I got paid a lot more than \$5 an hour to be bored.

On June 11, I finally caught a break. Anne Ellis, Gerry Shinkle, Pam McGraw, and I were given a red carpet tour of the new Spacelab facilities in Building 36 by Hank Huber. This high fidelity mockup would be used primarily for fit checks and life science simulations. A payload operations control center (POCC) was under construction with a user room complete with consoles that interfaced directly to Mission Control in Building 30. After this tour, I returned to the Spacelab workbooks with enthusiasm. Spacelab was cool! It was a spacecraft inside a spacecraft, a mini-space station with experiments that would really test our mettle.

Besides Gerry (Lead FAO) and Anne (Timeline) who were also assigned to Spacelab 3, I worked with Pat Bahr of Life Sciences on medical tests for the EOM mission, while Frank Knight of GE tutored me on Spacelab 4, a dedicated life sciences flight which was a year and a half away. I longed for something more near-term to distract me from the very real ache in my breasts from weaning Thomas.

But I enjoyed working with Diane again. When we discovered one of the new guys had never heard of science fiction author Robert Heinlein (who wrote *Starman Jones* with the astrogator character), we joked loudly in his hearing how the space program was in such desperate need of contractors now that they were hiring illiterates!

I also enjoyed using the CAPS that I'd helped bring to its operational status. The Harris H500 CPU in Building 4 now supported 10 workstations, including workstations in the FAO support room plus a whole separate system for DOD flights. The CAPS was now putting out two crew activity plans a week. I helped set up a special terminal (called a

ModComp) in the FAO support room to interface Spacelab payload and system data with the POCC. We planned to have this system up and running to support sims for Spacelab 3. I worked with Glen LeBlanc to identify measurements we wanted to have available to us in real-time. I reported with some excitement that, "We also have the capability to run FORTRAN programs on this system." Oh yeah, this space cadet was back in business, now!

HAPPY BIRTHDAY, 41-D

Thomas's first birthday fell on a Tuesday in June. I'd accumulated a day of vacation, so I took the day off. Thor was on console. The day before, STS-41-D, a.k.a. STS-14 had been scheduled for launch. Thor was ascent guidance officer for the first time, a big milestone in his career. But the backup computer wouldn't go to OPS 101. So, with *Discovery* on the launch pad, they sent everyone home, changed out the onboard computer, and reset to try again.

"I moved Thomas's high chair to the living room and alternated channels between Sesame Street and Shuttle Launch Control. We [then] sat on the floor to watch the launch."

It was especially appropriate that I was home watching this flight with Thomas. After all, he was the reason I wasn't over at the control center with Thor, anxiously awaiting the launch and my first time as lead FAO. Mi-Mi had taken my place. The other FAOs were Holmberg and Mark Rolwes.

They reached the T-9 minute hold, and I heard the flight controllers, including Thor, tell Flight they were "Go" for launch. The countdown continued.

"T-15 seconds and counting," PAO said. Once the engines reached proper temperatures and thrust levels, the solid rockets would ignite. "10, we have a go for main engine start. . .7. . .6. . .5," PAO continued. "We have main engine start."

"Look Thomas, there's the new space shuttle *Discovery!*" I said, pointing at the TV. The gleaming white orbiter swayed back and forth on the launch pad as blue fire shot out of its tail.

"We have a cut off!" PAO exclaimed.

Onboard the shuttle, a master alarm blared. As Mike Mullane (1945–) recalled in his book, *Riding Rockets*, "We were strapped to 4 million pounds of explosives and didn't have a clue what was happening a hundred feet below us. . . .Launch Control reported a fire on the launch pad and activated the fire suppression system. Water began to spray across the cockpit windows" [5].

Thor said, "I was in a critical position, and we were counting down. We were ready to go, and the engines started, and then. . .. it stopped. Kennedy Launch Control Center (LCC) was in charge until the shuttle cleared the launch tower. All I could do was sit quietly with all that energy pent up inside and listen to the heated discussion about a fire on the launch pad."

If the crew did an emergency egress, they'd have to open the hatch, run across the access arm, and jump into escape baskets. The baskets would speed them to a bunker a quarter mile away where they could wait—assuming they got there before the rocket exploded.

Hartsfield decided to sit tight. Mullane explained, “It was a decision that might have saved our lives. The post-abort analysis determined the fire had been caused by some residual hydrogen escaping from the engines and igniting combustible material. . . The gas flame may have been as high as the cockpit but since hydrogen burns clear we would not have seen it. We could have thrown open the hatch and run into fire” [6].

They waited for the closeout crew to open the hatch. “We exited the vehicle into the residual rain of the fire suppression system,” Mullane said. “We were quickly drenched. Judy [Resnick]’s hair took a big hit. She looked like a sodden cat” [7].

Mullane continued, “At the press conference we all lied about the tension in the cockpit following the abort and fire. Hank took most of the questions and did the Right Stuff routine of, ‘Aaawh shucks, ma’am. T’weren’t nothing.’ He explained how we train for these things, how confident we had been in the LCC’s reactions to the abort, how we had never doubted our safety. Meanwhile, I was wondering if I had crap in my flight suit” [8].

Thor came home a few hours later. After the way the STS-5 fire had been “handled,” I wasn’t surprised that NASA downplayed the danger. But they went even farther, claiming the 41-D failure was proof that the shuttle program was on track to increasing flight rates. Huh? Associate Administrator for Space Flight, Jesse Moore, painted a rosy picture indeed. He said, “The abort we experienced demonstrated clearly that we are able to control the launch process down to the last split second, to launch when everything is right and to stop without danger to the crew, ship or cargo when something is wrong. . . . We are determined to honor launch commitments to our commercial customers” [9].

The launch was delayed a month to replace the faulty engine. To pick up the schedule, NASA combined 41-D and 41-F, keeping the crew for 41-D, including the first commercial astronaut, Charlie D. Walker (1948–) of McDonnell Douglas who would operate the continuous flow electrophoresis experiment. The Large Format Camera and another small payload called Spartan were bumped to later flights. The combined payloads included three deployable satellites and the OAST-1 solar array.

With the flight postponed, we scheduled Thomas’s birthday party for Saturday, July 7. “The birthday party for Thomas was very satisfying. I really hated for it to end. I want to find a job with fewer hours soon. I feel I’m missing so much. Time goes by so fast, and nothing is more important to me than sharing my life with Thomas as he grows. I keep flashing into seeing the world from his perspective, and I see Lorelei instead of Mommy.”

Back at work, I focused attention on my lead assignment, Spacelab 4. The life science experiments for all Spacelab flights were being integrated and coordinated by a subsidiary of GE, the Management and Technical Services Company (MATSCO). Their local planning person was Kim Ibrahim. He was happy that NASA had finally assigned an experienced flight planner to this mission, and requested my help in reviewing the timeline his group had prepared.

I reviewed their mission science requirements document and found it included levels of redundancy and durations of activities that were not realistic. They’d estimated only five minutes to unstow equipment, take a blood sample from a crewmember, and pack everything back up. I told Kim it would take the crewmember five minutes just to find the right page of the checklist and secure it and himself to the locker containing the equipment. I summarized, “In general, we are concerned that the whole timeline is overly optimistic.”

I reviewed payload integration plans and prepared a memo on STS scheduling guidelines. Publishing a memo was akin to publishing a book: it required dozens of iterations and levels of approval. While I waited for feedback from the Astronaut Office on the issue of maximum crew awake time on launch day, I read more technical workbooks required for my FAO certification and prepared overhead charts for the upcoming CIR for STS-27/51-I (to launch August 8, 1985).

I kept myself occupied, but frankly, I was bored. Thor was challenged working almost every flight and practicing launch aborts in between. But those of us dealing with "the customers," were drowning in reviews of this and that flight rule or payload requirement, documenting every decision in triplicate. Nothing ever stayed approved.

Our only progress in reducing document iterations was to simply no longer prepare detailed documents in advance. For the CIR, a one-page overview was sufficient. Since trajectory tapes took so much computing time, the attitude timeline wasn't done until three months before flight. The timelines themselves also were simplified. Instead of scheduling particular astronauts for activities, we provided a list and a window when things should be done.

This reduced the number of useless iterations, but it didn't address the constant shift of manifest and launch dates. Every week some payload was bumped from one flight to another. Missions were combined, cancelled, renamed, crews assigned, reassigned. No one took team photos—no one knew what team they were on long enough. I no longer felt I was part of a family, or like I was doing something special and important to anyone. I didn't even know all the astronauts by first name any more.

I went to a Flight Techniques meeting for lack of anything better to do. They argued over how many hours of PTC were needed prior to tail-to-sun attitude to protect against a cooling failure. Hadn't we flown STS-3 and STS-4 to answer those questions? Well, yes, but those tests had been done on *Columbia*, and *Discovery* was different: or maybe not? Maybe we'd been overly conservative in our Flight Rules? They decided PTC was only required for flights with high beta (sun) angles. For low beta angles, payload bay to Earth (-ZLV) was good enough.

While daydreaming about beta angles and attitude profiles, I had an insight for Spacelab 4. This flight was dedicated to life sciences. We'd been wrestling with how to minimize the impact of shifting the crew's sleep periods earlier every night because it complicated analysis of human medical data. Instead of moving crew wakeup earlier each day, could the orbital dynamics be adjusted to allow landing to occur later?

I reviewed trajectories we'd flown on previous flights. Flights with inclinations of 57° had "later" landing opportunities than those of 28.5°. For the higher inclination orbits, the track over the landing site was more straight (north-south) than for 28.5° flights, so the "width" of the landing corridor was more likely to provide additional later opportunities. Ah ha!

The usual reason for flying higher inclinations was for Earth observation. A high inclination orbital track flew over a band of latitude (north and south of the equator) matching the orbital inclination. STS-9 had flown to 57° to observe Canada and northern Europe.

Spacelab 4 didn't include Earth observations, and so the inclination had been set to the default of 28.5° (KSC's latitude) which uses less fuel. As far as I know, I was the first to realize that a higher inclination could minimize the circadian shift of the crew and obtain better quality life sciences data. I passed this observation along to Ibrahim at MATSCO.

I also urged the scientists to use one-shift operations instead of the dual shift/24-hour operations of STS-9 and that were planned for Spacelab 3. Life sciences experiments didn't require around-the-clock monitoring. Having all the crewmembers on the same sleep/meal/work schedule would simplify data analysis. This recommendation was enthusiastically embraced. The science community had been working under the assumption that all Spacelab flights had to use two shifts because of orbiter constraints. (Spacelab 4 was renamed Spacelab Life Sciences 1 [SLS-1] and flew as STS-40 in June of 1991, with an inclination of 39° and one-shift ops.)

With 41-D delayed, Thor had time for a vacation. Things between me and my branch chief had been going smoothly. So I asked for a week off, and amazingly enough, he said yes!

I hadn't seen my mother, and she hadn't seen Thomas, since the week he was born more than a year ago. So we rented a plane and flew to North Carolina with Thomas.

We had a lovely trip, visiting parks and museums, feeding ducks and relaxing. Mom had found a creative way to supplement her low-paying retail job doing something she enjoyed: sewing. She'd joined a co-op called Woman Craft that had a store front in the mall carrying handmade items made locally. She'd made $30 profit in her first month through sales of baby bibs and blankets. I hoped writing might one day be my version of Woman Craft.

For Thor, the fun of our vacations was mostly in the flying to and from. But the weather on our way home offered quite a challenge. The rented Piper bucked up and down as we dodged enormous thunderstorms that stabbed the dark sky with blinding flashes of lightning. Though Thomas slept through it just like he had the hurricane, I had enough adrenaline in my system to lift the space shuttle off the pad with my bare hands. Thanks to Thor's piloting skills, we made it home safely. I thought we ought to hold a press conference afterwards and have Thor say, "Aw shucks, ma'am. T'was nothing, really."

SPACE PROGRAM GROWING

The space program was growing and changing almost as fast as Thomas. The first industry briefing about the new space station was held at JSC in mid July, 1984. The *Roundup* reported that three configurations had emerged from the Skunk Works led by Space Station Program Manager Neil Hutchinson, my former flight director. The "Power Tower" with five modules connected together in a "P" shape had been selected as the reference configuration. "All designs could reach initial operating capability after six to eight Shuttle launches and could be manned after the first two or three launches," the article optimistically reported [10].

Much of the work on space station would be done at JSC. Former Flight, now Center Director Gerry Griffin (1934–) said "Like aviation, we are seeing much more private investments in space. We will ultimately be successful at our jobs if that happens" [11]. Everyone was staffing up.

The newly hired astronaut candidates, affectionately called Ascans, were in the midst of training, and industry was busy selecting more payload specialists. Hughes Aircraft announced selection of Gregory Jarvis and Dr. John Harrison in July. Jarvis would fly on the ill-fated 51-L.

In August, President Reagan announced that the first passenger in the newly designated “Space Flight Participant Program” would be an educator to be selected in early 1985. NASA Administrator Beggs said an educator would “inspire young people to excellence” [12].

All these developments translated to me as opportunities for work in private industry, advising, training, preparing more payloads and people to fly in space. I updated my resumé and mailed it to some local companies inquiring about the availability of part-time positions.

Ironically, while HQ pressured the NASA workforce with an increasing flight rate, my workload was actually reduced. Reminiscent of the assignment debacle of two years previous, my branch chief issued a memo in July, removing me from both the Spacelab 2/51-F and the EOM/51-I flights, and not adding anything new to my plate. He didn’t discuss the changes with me ahead of time, either. My assignments went to Phil Engelauf who had transferred from NASA Ames.

I discussed the memo with Carolynn who had transferred to the Training Division. Considering I’d already sent my resumé out, she advised me not to complain. To increase my chances for landing a job in private industry, I needed a good performance review from the NASA managers my future company may have to work with.

So, I followed AA Jesse Moore’s example and spun the removal of these assignments into a positive. I did ask my branch chief why he’d removed my assignments. He assured me that he was just “balancing the workload” of everyone in the branch. With Spacelab 3 sims starting in September, he thought it a good time for me to handover these other tasks. I thanked him for the opportunity to work on Spacelab, sincerely saying how glad I was to be part of that program. I also suggested he keep me in mind if he had any short-term projects he needed done.

I did the most thorough handover I could to Phil and introduced him to all my contacts. He was a fast learner, competent, and pleasant to work with. (He later became a flight director.)

A few weeks later, my branch chief asked if I’d prepare a presentation about flight planning for the Ascans. I cheerfully accepted and really put some thought into capturing the essence of how we prepare timelines and identify constraints both preflight and during flights. I solicited his advice and did my best to do exactly what he wanted. I didn’t complain when he took 100 percent of the credit (my name does not appear on it). I considered this presentation a great product that I could use to sell myself to private industry: just look at all the work that goes into planning a flight: and I have experience with every part of it!

My new strategy of doing my best at what little work I was assigned worked. On August 21, my branch chief allowed me to move my desk to a new office, one with a window! I didn’t have the seat in front of the window, but this was definitely a move in the right direction. I’d paid my penance during the past four months, and I was on my way to a good performance review.

I supported the Dry Run CIR for STS-51-I in August. I didn't feel any of the nervous tension I'd felt when I'd given a similar presentation while eight months pregnant. Most of the issues involved a materials science experiment that wanted to avoid jet firings and crew exercise during operations. Like the old Electrophoresis on STS-3, the Payload Integration Plan contained a g-level constraint that we couldn't meet even with the Vernier jets. I reported, "Jim Tuck at Lockheed is checking some numbers for us, but it doesn't look promising. Supposedly, if we violate their constraint, we 'splatter the specimen on the wall.'"

Another discussion was reminiscent of the STS-14 debate on who goes first between Syncom and Telstar only it was between ASC-1 and Aussat. ASC-1 insisted they had booked first and thus deserved "a front row seat." The satellite closest to the front of the orbiter was deployed first. (The orbiter was unloaded from front to the back to keep the center of gravity such that the orbiter wasn't nose heavy on entry.) The closest to the front was also the last one loaded into the payload bay—allowing more time to prepare for flight and less chance of damage when something was loaded "above" them when the orbiter "stood" upright on the pad.

ICEBUSTING ON STS-41D

The rescheduled STS-14 launched on August 30, 1984. The main engines didn't shut down this time, and Syncom's first "Frisbee" deployment went off without a hitch. Jim Oberg, a flight controller with MacDac who'd later be a reporter for NBC, noted that 41-D was the 100th manned launch if we counted the two suborbital Mercury flights and one Soyuz T-10 flight that hadn't made it to orbit. He also noted that the U.S. had flown more individuals (36) on the shuttle than in the first ten years of human spaceflight. Despite these statistics and Public Affairs declaring this flight would "probably be known as the mission which, after deploying three satellites in three days, put the program back on track and led to the shuttle flights about every 30 days," flight controllers remembered this as the "Icebusters" flight [13].

During 41-D, an ice crystal built up at the water dump nozzle on the port side of *Discovery*. The flight directors were concerned that this block of ice might break loose and hit the orbiter's wing during entry, possibly punching a hole in it. (A hole led to the destruction of *Columbia* in 2003.) So the team produced a procedure to use the robot arm to knock it free. Everyone cheered when the crew reported they'd photographed it floating away. Our resident cartoonist, Marvin LeBlanc, promptly created a logo for the "Icebusters," based on the popular recent movie, *Ghostbusters*, whose catch phrase was "who ya gonna call?"

It was also "Judy's flight" because she was only the second American woman to fly. During the OAST-1 solar array deployment, as the array unfolded and extended upward from its box, stretching 100 feet out of the payload bay, she exclaimed several times somewhat breathlessly, "It's so big. It's so <u>big</u>!" More than one flight controller suppressed a snicker at the sexual innuendo. Upon her return, she was teased rather mercilessly. Photos of the OAST extending from the bay were captioned "It's so big!"

Though my management had completely forgotten my contributions to STS-14 via the CIR and the preliminary Crew Activity Plan, amazingly enough, the scientists had not. I was really touched when I received a certificate signed by the crew (including "It's so big" Judy) with an OAST-1 solar array patch that had flown on 41-D! Thor, who'd worked the flight on console, didn't get one of these: they were only sent to the Payloads and FAO teams.

16.1 The certificate and patch I received after STS-14 (41G) was proudly displayed on my wall for years (Photo by the author)

Besides this memento, the flight offered another bittersweet moment. I wrote to family, “Bush was there during Thor’s shift. . . .I was glad to see my friend Mi-Mi shake hands with Bush. She took my place when I decided not to return to work last fall, i.e. or it would have been me. He gave her his pen after signing a picture. Would you believe it has teeth marks on it?!”

16.2 Mi-Mi (on the far *left*) took my place as lead FAO on STS-14 and was on console when Vice President Bush and Barbara visited (NASA photo)

So, my decision not to go back to work in December had cost me the thrill of a launch pad abort, “Judy’s” flight, being part of the Icebuster team, and five minutes of fame on the world stage with the Vice President. It was a small price to pay for being there when Thomas first spoke “Ki!” for Jasper Kitty and took his first steps.

But working part-time remained an elusive goal. All the companies I applied to had responded that only full-time jobs were available.

With my last FAO training classes done, I had nothing to do but miss Thomas. Fortunately, my new Section Chief Bob Nute found me another short-term assignment: prepare a report on what aspects of pointing FAOs needed.

Elvin’s original plan required all FAOs to serve as both Timeliners and Pointers. That plan had gone by the wayside as a shortage of FAOs quickly developed when the flight rate increased. Marion Griffin and I worked together on the revised requirements. Our report was called, “Level of Knowledge Required of FAO.” We emphasized the need to understand launch geometry, beta angle, ground tracks, celestial tracks, and orbit planes.

My knowledge of pointing which had led to my insight on the SLS-1 trajectory was soon to bear fruit. The Mission Integration and Control Board agreed to review my suggestion about shifting the inclination to adjust the crew schedules and flight duration. My background in astronomy, experience working all those iterations of various trajectories, and problem solving had all come together nicely on this issue. I wasn't going to win any awards or be recognized for this "achievement." But it meant a lot to me that my unique "astrogator" insight would actually make a difference to the quality of the science on that mission.

In mid-September, I was approved for travel to Marshall Spaceflight Center to support a Spacelab 3 sim. Not counting my speech trips, I hadn't been on a NASA trip since I'd gone to Florida back in 1979. This was my first time away from Thomas overnight.

I flew to Huntsville with Gerry Shinkle, Anne Ellis, and Diane Freeman, who had finally been promoted to FAO. We were there for a two-day, long-duration sim for Spacelab 3 to train with the payload team that would staff the Payload Operations and Control Center.

The payload team was divided into two shifts, gold and silver, like the crew, whereas we mission controllers had three teams. The two leads for the payloads were Monroe Hardage and Bob Jackson. Their manager was Carolyn S. Griner (1945–), one of the first three technical women at MSFC. She was a branch chief when I met her, and eventually became deputy director of MSFC. We taught them about teleprinter messages and requesting changes to the timeline, and they coached us on the priorities of their experiments. I loved being back in the flight environment. This was the work that I really wanted to be doing, not "riding" a desk month after month.

The same week I returned from Alabama I was called by Mike Hernandez for an interview about a part-time job. He and Scott Millican had recently founded Hernandez Engineering, Inc. (HEI), a minority-owned business (Mike, a.k.a. Miguel, was a Cuban American). Mike had worked for NASA in the crew training area, then he'd gone to work briefly for another company until he'd decided to strike out on his own.

Mike instantly made me feel welcome. Scott joined us, and we discussed the work I was doing for NASA. They were especially interested in my Spacelab connections because they had a contract to help the Germans with their Spacelab flight scheduled for the fall of 1985. The fact I wanted to work part-time was not a problem—it meant they didn't have to cover health insurance and retirement for me. I left thinking that this might be the opportunity I'd prayed for.

While I waited for HEI's offer, I had hardly any work to do. My only new responsibility was to be designated Fire Warden for our branch. I checked that everyone's hot pots and coffee makers were unplugged overnight and not near anything flammable. The day after I completed my training and received my badge, the fire alarm blared. This was not a drill!

Everyone headed for the stairs and waited outside. I dutifully ducked into each office and the restrooms to check for stragglers and reported to the Fire Chief that everyone was out. Unlike the fire in Mission Control, there wasn't much smoke with this one. The fire had been caused by some "relighting" birthday candles.

PATRONIZING COVERAGE OF STS-41-G

NASA was indeed serious about launching shuttles at least once a month. STS-41-G, another *Challenger* flight, launched on October 5, 1984. This was the actual 13th flight, and the unflappable Crippen, who'd been the commander of STS-13 last spring was once again in charge. Sally Ride had flown her first flight with him, and was with him again on this flight—the first woman to fly twice. Kathy Sullivan was ready to do the first spacewalk by an American woman. This was also the first time that two women were in space. OAST was doing more tests, and the LFC was finally getting into space after being bumped from several earlier flights.

When an antenna got stuck on the second day, the Mission Control team whipped up a procedure to use the arm to tap it into position. Dave Leestma (1949–) and Kathy manually positioned another antenna during a spacewalk.

In the post flight *Roundup*, editor Brian Welch called the news coverage of Kathy's spacewalk "patronizing" towards women. "It should come as no surprise that women are capable, that they are competent and involved. Yet this is still newsworthy, still the subject of some commentary. Maybe one day it won't be. . . . point does need to be made that after many years of breaking down barriers, women are not only involved in what used to be called 'a man's world,' they are also good at it to the same extent that men are good at it. . . .Consider the past few weeks at JSC. Two of the experts on the STS 41-G crew happened to be women. . . .The two flight controllers who were honored with hanging the mission plaque after the 41-G landing were women, Payloads Officer Michele Brekke and Linda Godwin. The Orbit 2 Team DPS Officer, Lizabeth Cheshire, and the Planning Team Flight Activities Officer, Karen Ehlers, along with Planning Team EECOM Barbara Pearson and Public Affairs Commentator Billie Deason, also added to the number of women in the Flight Control Room. . . .

"Having said all this, it is difficult for your editor to draw a conclusion without sounding patronizing, and it is patronizing to comment on a woman's performance in view of the fact that men around JSC have not been honored for jobs well done simply because they are men. At this time and place, however, it is appropriate to contemplate and even applaud the substantive contribution of women in our highly demanding technical atmosphere. The next great step will have to come when editorials such as this are no longer written" [14].

Yet thirty years later, the June 2013 headline about NASA's new astronaut class read, "NASA Picks 8 new astronauts, 4 of them women" [15].

But all anyone can do is live in the present. And I had a choice to make about whether this particular woman was going to remain in the "highly-demanding technical atmosphere" or opt for something less-demanding, at least time-wise. Because on the day 41-G launched, HEI made me an offer. I couldn't sleep all night, not only because I was worrying about how to respond, but because Thor was up at 2 a.m. getting ready for his next shift on console—reminding me that we still had no idea how we'd handle both of us working console with a baby.

Thomas's health was a prime consideration. He'd had one ear infection after another since I'd returned to work. His eardrums had burst several times already, and the scar tissue was impairing his hearing.

It was a long weekend, so I had time to contemplate my decision. A new piece of data factored into the equation: my NASA retirement fund had $9000 in it. I could take this money in a lump sum payment if/when I left the agency. So saving up for the addition to the house was no longer a reason for me to stay until February.

I applied my technical problem-solving skills and created a "matrix of considerations" and a flow chart showing the consequences of each path. My conclusion was that unless NASA offered a compelling reason to stay, I should accept Hernandez's offer.

GOODBYE GOVERNMENT, HELLO PRIVATE INDUSTRY

With some anxiety, I met with my branch chief. I felt I had to give him a chance to try to persuade me to stay. I went over my current assignments, which was a rather short list, and expressed my sentiment that I could do all of them in 24 hours a week without any trouble. He replied that part-time work was just not appropriate for my grade level (GS-12). Besides, he wouldn't approve it. I then said that I'd be willing to stick around until after Spacelab 3 if he felt it was too close to the flight (scheduled for January) to train a replacement. He said if I planned to leave after that flight, he'd rather I just went ahead and left now.

The decision was made. "October 12, 1984. This morning I resigned my job with NASA. My last day will be November 2. Even though I've made my decision, and told everyone at work, I still don't believe it. I feel sad about it. I'm going to miss that job! I'll miss the thrill of being FAO, sitting at the console.

"Thor is working the planning shift for the entry tomorrow of flight STS 41-G. . . . Shuttle flights have surely gotten more routine now. But there is still a lot of prestige associated with Mission Control. I will miss it. I keep telling myself it's better for me to sacrifice a few (5?) years of my career to be with Thomas and any future child. I hope this will prove to be the right decision."

My branch chief didn't waste any time choosing my replacements. Neil Woodbury took my FAO spot on Spacelab 3 as well as my SLS-1 work. Gail Schneider took over my STS 51-I tasks.

Harder to handover was my "corporate knowledge" on procedures. I briefed Nancy Jackson who was the book manager for Post Insertion, and Liz Evans who was in charge of Contingency Deorbit Prep. I reported, "A lot of info has been lost in all the transitions between book managers."

Not only was I taking my "corporate knowledge" with me, I was also taking my observations and assessments. During my last week, I toured the new Spacelab simulator in Building 5 with Diane and Gail. Claudia Crides from the Training Branch was our tour guide. I was one of the few people assigned to work Spacelab that was cleared to enter this building. Soon, I'd no longer have access, and no longer have my red secret clearance badge to enter Mission Control, either. For years, that badge had allowed me to come and go into any building on campus. So I tried to soak up as much detail as I could to help my new company.

On my last trip to Building 30 and Mission Control, I took a good look around. I sat at the FAO console one last time, wishing I could work Spacelab 3. But rumors were already circulating that it would be delayed. Thomas was growing up fast, and I didn't want to miss it.

Turning in my Mission Control headset, I got a big lump in my throat realizing that I'd never sit in the MOCR again.

Whenever anyone left, they were given a large photo which everyone signed. I chose the photo of "Pinky" Nelson free flying on STS-13 to retrieve the Solar Max. Though his retrieval failed, the team figured out another way to do it (using the arm), and the mission had been a success. I thought this photo was appropriate for me. I was "freefalling," too, leaving the safety of the "shuttle," and flying into an unknown situation in my new job. Like Pinky, I had good training and skills, and with the help of the "team" including my NASA friends and new coworkers at HEI, and especially Thor, we'd find a way to solve any problems we encountered.

I had an "exit" interview with my management. Not surprisingly, they said that I had a tendency to dictate to management and that I "forgot my place" and put people on the defensive. They suggested I'd be more successful if I were more "directable" and more patient waiting for responses. I couldn't help but wonder if they'd dare say any of these things to a man.

So when asked what I thought they could do to improve, I suggested that they trust employees more. Instead of just assigning them jobs, they should ask each one what they want to do and then try their best to let them do it. Instead of giving orders, they should ask for opinions and suggestions via regular section meetings. They smiled politely and ignored my suggestions as I ignored theirs. But there were no hard feelings.

My next to last day, we had the traditional going away luncheon at the Crazy Cajun on NASA 1 in Seabrook. I was surprised when more than 50 people showed up including Carolynn, then working for Barrios Technology, and Mi-Mi and Diane and Marion, my best friends and closest associates. I'd miss working with all these people, but I'd see many of them again through my work with HEI and at various NASA anniversaries over the years.

I was expected to give a short speech and present some gag gifts at the luncheon. I started with, "First of all, let you put your minds at ease regarding the most pressing question you must have about my leaving—Mi-Mi has already claimed my file cabinet!"

I gave Mi-Mi a little cardboard orbiter I'd marked with coordinates, and a lock to keep it from leaving the console. I gave Nute a Murphy's Law calendar. I gave my former section chief a button saying, "The Boss is Always Right." My branch chief got a paddle which I called "a symbol of authority" engraved with three rules on it: Rule #1: The boss is always right; Rule #2: When the Boss is wrong, see Rule #1; Rule #3: Those who break the rules must pay the consequences." Is that what I was doing now?

We all had a good laugh, and the secretaries, Cindy Kochan and CeCe McGraw presented me with my signed going-away photo.

I emptied out my government gray desk, and took the long walk from Building 4 across the Duck Pond to the Security Office in Building 45. I handed over my NASA badge: my ticket into Mission Control, my “status” symbol as one of the elite workers in the space business, my “identity” and forever now my “former” status. But I’d gotten about as close as possible to being an “astrogator,” and I’d still be part of the space program.

I walked to my car alone that cool and sunny November day, looking up at a sky as blue as my baby’s eyes. “Thomas, sweetheart, Mommy’s coming home!”

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17

Becoming an Aerospace Consultant

I settled into work on Mondays, Wednesdays, and Fridays in my new private office. No more battleship gray metal desk for me. At Hernandez, I had an actual wooden desk and carpet under my feet. My giant window looked out into a three-story atrium. And I didn't even have to answer the phone! Mike hired a top-notch secretary to screen all our calls: Sue H. Garman. Her husband Jack, a former Apollo flight controller, worked for NASA. Years later, he'd be Thor's boss. And both of them would answer to Sue because in 1987, after she earned her CPA, she went to work for NASA as the Associate Director of JSC.

On my first day at HEI, Mike took me along to a luncheon with the JSC Director. I noted that "Griffin talked candidly about the future contracts to the contractors. There was nothing new (to me) in what he said. That made me wonder if I'll be out of touch from now on?"

But I need not have worried. On Wednesday, one of my contacts at GE-MATSCO called. His boss wanted to hire me on a contract to help with the SLS-1 timeline. I wrote, "It made me feel good to bring business to my new company."

Mike asked me to familiarize myself with the German Spacelab mission, D1. This mission was considered a springboard to space station. Mike said he was grooming me to be their "Future Projects" specialist for space station operations. I liked the sound of that.

The next shuttle flight, STS 51-A, launched on Thursday, my day off with Thomas. We watched it on TV. Thor was an "on-call" guidance officer. Mi-Mi was lead FAO again.

STS-51-A's challenge was to retrieve and return to Earth with the two satellites deployed via STS 41-B in the spring. Their success put another commercial "feather" in NASA's hat. Griffin said, "What we are now capable of doing in low Earth orbit will be carried to higher orbits. Using the space station as a staging point, we will eventually send people to geosynchronous Earth orbit." Concurrent with launch day, NASA released the Announcement of Opportunity for soliciting a teacher to fly on the shuttle as the first private citizen [1].

But once again, human interest was the big news: NASA had flown the first mother!

Anna Fisher was the fourth woman to fly in space. Her astronaut husband Bill was the doc who'd stitched Thomas's eyebrow back in May. Their daughter, Kristin, was just a month younger than Thomas. Baby Kristin was a big hit with the media as the little girl

M.J. Dyson, *A Passion for Space*, Springer Praxis Books,
DOI 10.1007/978-3-319-20258-7_17

whose parents were both astronauts. Perhaps this was the start of her media career because Kristin grew up to become a reporter with a CBS affiliate in Washington.

On Friday, November 9, 1984, I wrote, “Just finished my first week in private enterprise. I think I’m going to like it!” I also noted that Spacelab 3 was postponed to April.

The future looked bright for the private sector. The November 16 *Roundup* announced that the Commercial Space Launch Act had passed. “The act is an outgrowth of President Reagan’s policy on the commercial uses of space and his order last February establishing an Office of Commercial Space Transportation within the Department of Transportation. The one commercial launch in the U.S. so far, by Space Services of Houston, required clearance by 18 federal agencies and had to pass 22 separate statutes. This act is designed to streamline that process and bypass the many regulations” [2]. Yep, we’d be taking vacations in space soon.

But first we had a trip to Ohio for my brother Jeff’s wedding to Jane Sells. Thor got home from working the last planning shift of STS 51-A at 11 p.m. on November 15. Neither of us got much sleep, and we were up at 5 a.m. to watch the shuttle pass over Houston. I wrote, “Really neat! There was a jet trail, but the sky was still dark.” We were lucky to see it because the clouds moved in soon after that. We drove to the airport in a downpour.

At the rehearsal party that night, Thor and I dominated the conversations—me in the living room and Thor in the dining room “both of us talking about NASA. I felt proud to be able to discuss what I did and make a good impression.”

Jeff was disappointed that I’d left NASA. “Now I can’t brag about you anymore,” he said. Would I ever do anything worth bragging about again? Being a flight controller was hard to beat.

Though I couldn’t brag about my job, I could brag about Thor’s. In our Christmas letter, I noted that he was one of only two people in the world qualified to be an ascent guidance officer. He was also busy designing the new computer system for the upgraded Mission Control. This work won him a promotion to GS-13 and made him eligible for management. He’d also gotten a raise that offset my reduced income. The downside was that he had even less time at home.

The week we got home from Ohio, Thomas had another run in with the coffee table. He opened the same eyebrow, but the cut went much deeper. He got 13 stitches.

Back at work, Mike had me prepare a training document for the German space agency, called DFVLR. On December 5, we hosted a party at HEI for the visiting European payload specialists; Wubbo Ockels (1946–2014), Ernst Messerschmid (1945–), and Reinhard Furrer (1940–1995). The American mission specialists came as well, including Bonnie Dunbar, Guin Bluford, and James Buchli. The commander was Hank Hartsfield who remembered me from STS-4. The pilot was Steve Nagel. As a flight controller, I’d never partied with astronauts. It seemed somehow backwards that now that I was no longer with NASA, I was free to socialize with them.

We headed to Florida to share Christmas with the Dysons and Kanes. We took Thomas to Epcot and imagined the world he’d grow up in. When I’d been his age, no spacecraft had flown yet. Now I was turning 30, having seen men on the Moon, participated in the launching of shuttle flights, and betting my future on commercial space. I saw colonies in

O'Neill cylinders, solar powered satellites, and mining operations on the Moon by the time Thomas was 30. I never imagined that in 2013, the United States wouldn't even have a ship capable of reaching low Earth orbit.

1985: THE SPACE SHUTTLE'S BUSIEST YEAR

This year would end up being the busiest ever for the shuttle. First up was 51-C, scheduled for January 23. Cold weather delayed the launch one day. Thor worked as Guidance on this first completely secret flight. All that was published were the names of the crew: Mattingly, Shriver, Onizuka, Buchli, and payload specialist Gary Payton (1948–), its inclination (28.5°), and that it was on *Discovery*. PAO didn't report loading cryogenics during prelaunch or speculate about this payload like they'd done for STS-4. I assumed it was a deployable because of the inclination and three-day duration. But Craig Covault didn't ask me.

Thomas continued to have one ear infection after another. His left eardrum burst the night before 51-C. Thor had to be on console. If I'd still been a flight controller, I don't know what we'd have done. Who could you hire to be with a sick child at 2 a.m.?

A few days after *Discovery* landed, Thomas had tubes inserted surgically in his ears. I wrote, "The operation was more traumatic for me than him."

Now that I was working part-time, we shifted from a nanny at home to taking Thomas to a babysitter. He never even cried when I dropped him off. I joined him for lunch, and afterwards, he followed me to the door and shut it behind me.

That day was also my first day at Lockheed as a consultant (for HEI). Carolynn was there, too, with both of us working for Jim Bilodeau who had recently retired from NASA. Our task was to help write the Mission Operations portion of Lockheed's bid for the Space Transportation System Operations Contract (STSOC).

On March 4, 1985, I started work at GE MATSCO, reporting to Kim Ibrahim, to help plan the SLS flight. The SLS team planned to monitor Spacelab 3, now delayed to April 29, as a sort of dry run for their flight in 1986. Mike also wanted me to observe Spacelab 3 to burnish my credentials to help the Germans on their Spacelab flight scheduled for October.

While I split my time between Lockheed and MATSCO, things were changing back in Flight Activities. Nute was promoted to deputy branch chief, and the assistant branch chief became branch chief. Thor's friend, FDO Brad Sweet, left NASA in March. We joined him at his going-away dinner. He and Brian Perry, Thor's airplane buddy, decided to go into business together. Because Brian wasn't going to have any spare time, he asked Thor and Ed Gonzales to buy out his share of the Long-EZ. It'd be several years before Thor and Ed finally admitted they wouldn't finish it. (We bought a Cessna 172 in July, 1987 and mothballed the Long-EZ.)

Changes were in work on the home front, too. We used the money from my NASA retirement fund to add an upstairs to our house. The whole job only took six weeks. We now had space for another baby.

Though Thomas kept me busy (got his fourth set of stitches on April 11), I found time to write. My first children's story was rejected, but I kept writing.

STS 51-C, THE FLIGHT OF THE FLYSWATTER

STS 51-C launched on April 12. Its seven crewmembers included Senator Jake Garn, Charlie Walker, and Rhea Seddon on her first flight, the fifth American woman to fly.

Thor was both the Ascent and the Entry Guidance Officer. But the big news of the flight was that Syncom, tossed out in the now familiar "Frisbee" fashion, had not activated.

Mission Control geared up to save it. Seddon built a "flyswatter" out of flight data file covers to hit the "on" switch on the Syncom. David Griggs and Jeff Hoffman did an EVA to mount the makeshift tool to the arm. Then Karol Bobko and Don Williams flew *Discovery* to Syncom. Seddon was given a six-minute window to "swat" the switch on the satellite. Timing was critical. Once the satellite activated, the engine would fire 45 minutes later.

The first try failed. On the second attempt, the flyswatter made contact and ripped off, as expected. Thirty seconds later, Seddon hit the lever with the backup tool: the "Lacrosse" stick. At 4 minutes into the window, Seddon hit the lever with the base of the flyswatter. They'd done all they could. The shuttle maneuvered away in case the satellite engine fired. But it didn't.

The salvage attempt was a "successful failure" that Bobko said showed "JSC at its finest" though the news media declared it a failure. However, plans to retrieve and repair Syncom were soon added to STS 51-I, just a few months away.

SPACELAB 3, 51-B

Spacelab 3, a.k.a. 51-B, launched on April 29, 1985, just 17 days after landing of the previous flight on the same orbiter. We really were going to fly these birds twice a month! I was impressed. But the TV commentator didn't praise NASA. Instead he said NASA was trying to restore its credibility "after a series of delays and cancellations." Then he pounced on the fact it launched all of 2 minutes late and focused on problems deploying a Get Away Special.

I watched the launch at home. Thomas got quiet long enough for me to hear Thor say, "Guidance converged," on Channel 33. "Thomas, did you hear Daddy on TV?"

"Da da," he replied. He was more interested in driving his truck.

Everything was going well, and I was feeling lucky. Thomas and I'd gone for a bike ride that morning, and I'd found a 1979 penny on the tennis court—the year Thor and I got married. I took it as a sign that we'd been successful conceiving a second baby the night before.

The seven-man Spacelab 3 crew split into gold and silver shifts working 12-hour days. I was thankful not to be working those crazy shifts in Mission Control, but I also missed the MCC environment. When I heard the crew report, "a massive vent" like a water dump on the left side, I couldn't help wondering what it meant to the timeline.

The news media reported every problem and hyped each one: plumbing issues, communication problems, computer failures, and a latch failure. The most embarrassing was rat and monkey waste blown into the cabin. One of the worst PR blunders was showing the rats poking their little faces out of holes, looking rather cute while the NASA commentator blithely stated that the rats would be killed later that day and their organs harvested. Public reaction predictably caused NASA to never release any photos of test animals in space again.

17.1 The monkey waste getting into the cabin became fodder from some cartoons like this one by Sheldon generated in Mission Control (Photo by the author)

I escorted one of the German Spacelab team members, Paul Stumpfl, to the FAO support room one afternoon and showed him the CAPS. He was suitably impressed and very enthusiastically looking forward to Spacelab D1 in the fall.

With 14 of 15 experiments successful, 51-B landed on May 6 at Edwards. The landing was majestic, a white bird gracefully dropping from a blue sky to the lonely desert. But the news media focused on reporting that their sonic boom had set off house alarms in Los Angeles.

More ominously, and unknown to most everyone at the time, a post flight inspection showed an SRB O-ring failure on *Discovery*'s recovered boosters similar to what would cause the loss of *Challenger*. Unfortunately, this alarm would go unreported to and by the media.

MOTHER'S DAYS

Just after Mother's Day in May, Dr. Stephen Falk confirmed that the lucky penny really had been lucky: my second child was due January 15, 1986.

Last time we'd celebrated my pregnancy by getting a water bed. Because Dr. Falk also restricted me from lifting more than 25 pounds, this time we got a garage door opener.

What I really needed was Bendectin for my morning sickness. But because of lawsuits, it was no longer available. In June, I wrote, "I'm supposed to be getting ready for work. Instead, I'm lying here on the bed, too sick to get up. It's been like this every morning for two weeks, the ever constant nausea, the days when not even crackers will stay down. . . .I am getting concerned for the health of both me and the baby. . . I want to be normal again."

I informed Mike Hernandez about my pregnancy immediately. I told him I wasn't sure I'd be able to work SLS next spring. Mike said not to worry about SLS—it would probably slip anyway. (It slipped years because of *Challenger*.) Also, I couldn't go to Germany to work D1 because my doctor said I shouldn't travel that close to my due date. Mike noted that I was providing valuable insights to the MATSCO team, and he thought I'd do the same for the Germans during D1. I couldn't have asked for a more accommodating boss.

NASA hired another batch of 13 astronauts in June. FAO Rick Hieb had made the cut, and all the FAOs were very proud of him. Only two women were selected: Linda Godwin and Tamara Jernigan. How would we ever get gender equality in the astronaut corps if we selected so few women? Even accounting for women not being test pilots, I thought NASA could do better than 10 of 90.

SUMMER FLIGHTS

Thor was ascent Guidance for STS-51-G, the 18th shuttle flight which launched on June 17, another flight of *Discovery*. The crew included Shannon Lucid, the sixth American woman to fly. It also included a payload specialist named Sultan Salman Abdul Azziz Al Sa'ud. The media had a great time stumbling over the name of the first Arab, first Muslim, and first member of a Royal family to fly in space. This short flight deployed three satellites including one for Mexico and one for the Arab League. The flights were so routine now that there was no TV coverage. NASA said the flight would be "heralded as a truly international mission" and as the flight of the 100th American, Steve Nagel (who would fly again on D1). It also marked the deployment of the 100th piece of space hardware built by Hughes. None of these "firsts" created much excitement with the public. We left for vacation in the middle of the flight.

We flew (commercially) to San Francisco and then drove to Eagle Falls with my brother Tommy, his wife Martine, and their five children. Thomas turned two years old on this trip.

The day after we returned to Houston, Thor's parents and their German friend named Beate Engel arrived in Houston. On July 5, Ruth went with me to the doctor's and we listened to the baby's heartbeat. Dr. Falk assured us that the baby was fine despite how awful I felt.

My exhaustion and nausea continued the next week, and I had a real scare at work. After 90 minutes of what felt like labor pains, fearing I might lose the baby, I called my doctor. The nurse told me go home, put my feet up, and put a hot water bottle on my tummy.

Thomas was at the sitter's, and Thor was on console, ascent Guidance for STS-51-F, a.k.a. Spacelab 2, one of the flights I'd been assigned to work as FAO. It'd originally been scheduled for April, but tile repairs on *Challenger* had pushed it into July.

So while I prayed that I wouldn't lose the baby, *Challenger* was on the launch pad. At T-3 seconds, the computers registered a malfunction in main engine 2's coolant valve. The engine shut down. Launch was scrubbed, but no fire followed. Thor wrote to my mother that "I was the Guidance for flight 41-D last summer when the same thing happened. It was only slightly less traumatic the second time through."

Thankfully, my cramps also "shut down." Disaster had been avoided for all.

Challenger's main engines were replaced on the pad, and launch reset for July 29, 1985. The team at KSC now had to deal with four orbiters at once. Atlantis, being prepared for its maiden flight, was in the Vehicle Assembly Building (VAB). *Discovery* was in a different part of the VAB, *Columbia* was in the Orbiter Processing Facility, and *Challenger* was on the pad. The KSC team was meeting the schedule and doing an amazing job juggling our spacecraft.

Yet despite the KSC "pad rats" best efforts, the launch of *Challenger* on July 29 was delayed an hour and 37 minutes because of an uplink issue. Then, three minutes after launch, a sensor for main engine 1 failed. Two minutes later, a second sensor failed, triggering engine shut down. This was the first (and only) engine shut down during flight. A sensor also failed on main engine 2. "It all seemed real familiar," Brian Perry told the *Roundup* after the flight [3]. He was the FDO whose job was to determine which abort mode to choose when the engine went down. He was also Thor's airplane buddy and was sitting right next to Thor in the MOCR when this happened. Brian and Thor both thought it seemed like a sim.

Brian had been monitoring the trajectory and Bruce Hilty was watching the Abort Region Determinator. Booster Jenny Howard (later Stein) was tracking the main engine parameters. The sensor that failed was a thin platinum wire. Each of the three engines has two of these, six sensors in all. As the temperature rises, so does the resistance. If the temperature goes high enough, the wire melts. If two of them melt, the engine is assumed to be too hot and is shut down. This is what happened to main engine 1. *Challenger* was 58 nm high and couldn't return to KSC. Brian checked where the external tank would impact if they continued on two engines.

He realized that they had to go faster to reach a safe location to drop the tank. He called Flight and recommended that the crew select abort-to-orbit (ATO). This selection dumps 4400 pounds of fuel from the OMS engines, burning as it goes, speeding them up and making them lighter.

Flight approved, and Capcom told the crew. The time from engine 1's shutdown to Commander Fullerton's selection of ATO was 25 seconds.

17.2 Booster Jenny Howard made the call to inhibit a sensor to keep a second shuttle engine from shutting down during 51F. CCW, Lee Briscoe, John Cox, Mike Coats, Richard Richards, Mark Rolwes (FAO), Gene Kranz, Jenny Howard, unidentified (NASA photo)

However, Jenny noticed that when they reached 8 minutes into flight, if another engine shut down, the tank wouldn't go into water. It could land in a populated area. Both engines must keep going for at least another minute to avoid that. Engine 3 was already down to one sensor. So she decided to inhibit its remaining sensor. If it melted, it wouldn't shut down the engine. The engines cut off at 9 minutes 42 seconds. They made it to orbit. The tank went into the Indian Ocean. Kranz said, "Everyone did what they were supposed to do, correctly, quickly and crisply. I love to hear it crackle like that."

"I was a little overwhelmed by all the attention from the news media," Jenny said afterwards. "I just didn't want another engine to go down, and the call to inhibit the limits was made to protect against that. That's our job."

Head Flight Director Tommy Holloway said, "It is certainly correct to say that the call potentially could have saved the Shuttle.... If we were passing out medals for that day, I think both Howard and Perry would have gotten them" [4]. They hung the mission plaque.

17.3 Flight Director John Cox had Booster Jenny Howard and FDO Brian Perry hang the STS-51F mission patch in Mission Control. Mike Collins is in the background (NASA photo)

THE FINAL STRETCH

While the flight controllers battled balky engines and sensors, I continued to fight nausea into August. Most nights I was so exhausted I fell into bed before Thomas. I couldn't imagine going through a pregnancy like this again. How did other women manage? Was I just a wimp?

At my next exam, the doctor said the heartbeat was very strong. I asked if he thought it was a boy or a girl, and he didn't hesitate. "Boy," he declared. Coincidentally, I'd dreamed that it was a boy the night before.

So, Thor and I discussed boy's names. "How about Ray?" I suggested. "That was my grandmother's maiden name and my father's middle name. It's simple and easy."

Thor said it was too plain. "How about Roger? That sounds good with Dyson." It would also give the boy the same initials as Thor's dad, Ralph.

But then I thought of his time on console with Jim I'anson (who'd died the previous December), who always said, "Roger that Dyson." I quipped, "We'd have to make his middle name That!" We laughed so hard tears ran down our faces. We agreed to keep searching.

Thor was getting burned out working flight after flight. He wrote to my mother in July, "I'm trying to get an assignment to work on the Space Station Project. This has been very frustrating because my section head will not let me go. I can't even transfer to a different branch. Looking at it from his point of view, I can't blame him as I am one of two qualified ascent guidance officers. However, it's still aggravating. I see this great opportunity to get in on the ground floor of a project as well as a lot of promotion potential and can't get in.

"The flight schedule continues at a high and accelerating pace. It's driving everybody nuts as we are still trying to do things as if we flew once per year. The problem is that the future planning is not being done under the pressure of 'that next flight.'"

THAT NEXT FLIGHT (51-I)

On August 27, *Discovery* launched on STS 51-I. Engle commanded this one with Dick Covey, James van Hoften, Bill Fisher (Thomas's stitches doctor), and John "Mike" Lounge (1946–2011) as crew. After deploying the two satellites onboard, they nabbed the broken Syncom deployed in April. The arm's elbow drive shorted out. Lounge had his hands full controlling the arm in its degraded state. "The extra time involved in that type of operation made it necessary to rewrite the flight plan and do two EVAs instead of one," Engle told the *Roundup* post flight [5]. After van Hoften and Fisher did an EVA to repair it, they sent the satellite on its way.

Although NASA announced the salvage as successful, the ground team wasn't able to restore the UHF signal. It was declared lost on Sept. 27. But on October 28, operators made one last try to contact the wayward satellite. Jay Greene, the lead flight director for 51-I said, "It was either going to blow up when they fired the rocket, or it was going to work" [6]. Thankfully, it worked. Syncom reached geosynchronous orbit and began supporting naval operations.

But an even bigger surprise for me was the September announcement that the STSOC contract had been awarded to Rockwell. *Roundup* reported, "Rockwell Space Operations Company, a newly formed subsidiary of Rockwell International, will grow from an employer of 500–3500 by Jan. 1, 1986" [7]. The contract included work in MCC, the Shuttle Avionics and Integration Lab, and flight preparation and analysis. Carolynn and I, who'd worked on the Lockheed proposal, were disappointed. Fortunately, HEI still had work for me.

Throughout the summer, NASA Administrator Beggs thrummed the drum for space station as a springboard for establishing a lunar base with Mars "the next logical niche for human habitation in the universe." He told the *Roundup*, "Why not go to Mars to stimulate progress in our own space capabilities, to develop new cutting edge technologies—propulsion, life support, habitation, non-terrestrial resource use? Why not go to Mars to build on the framework for international cooperation the space station will have begun?" [8].

With the space business booming, Friendswood Development Corp. moved forward with a $1 billion real estate investment in the Clear Lake area. "NASA is the key," L. J. Roy Pezoldt, Vice President of Friendswood Development, told *Roundup*. "The fact that the space shuttle is an operational, proven system and that the space station has been funded are the key factors to the development of this area." Three new residential areas were in work: Bay Knoll, Bay Glen, and Bay Forest. Our neighborhood of Meadowgreen doubled in size, and the two-lane El Camino behind us expanded to four lanes [9].

The technical work of the space program continued out of the media spotlight. The first week of September, we had a long sim for Spacelab D1. Being six months pregnant, I wrote, "I kept thinking the men wouldn't take me seriously. At the same time, I didn't hide the fact I want the day shift, and I didn't refuse help carrying books to the car." I enjoyed the sim as if it were a really cool role-playing game (which it was).

I wrapped up my work at MATSCO, and completed a document called the *Columbus Crew Complement*. Scott Millican awarded me a $250 bonus for finishing on schedule and then surprised me with a $2/hour raise. "This extra will help offset my time off. They [HEI] make it so easy to keep working that I wonder how long I can really stay away?"

Anticipating that I'd have some free time on maternity leave, I signed up for a correspondence course with the Children's Institute of Literature. I wrote a short story, "The Easter Candy Caper," as part of my application that, in retrospect, was absolutely awful.

With no fanfare, and almost no media coverage, NASA launched another secret DOD flight, STS 51-J, on October 3. The only newsworthy item was that it was *Atlantis*' maiden voyage. Judging from the short duration and inclination, I assumed it was another set of satellite deployments. Thor can't confirm or deny if he worked this flight, and I actually can't remember!

DEUTSCHLAND-1 (D1): CUSTOMER SUPPORT

The launch of STS-61-A, a.k.a. D1 was on October 30, 1985. I arrived at the Customer Support Room (CSR) in Building 30 in time for launch at 11 a.m. CST.

17.4 Mike Hernandez and I worked in the 61-A Customer Support Room (NASA photo)

I had a sense of déjà vu riding up the same old elevator to Mission Control. Though I'd been there a few times since leaving NASA, observing SL-3 and for sims, this time I was actually working the flight. The last time I'd worked a flight, I'd been pregnant with Thomas, and it had been November. Here I was, pregnant with a new baby, and back in Building 30.

The CSR wasn't far from the old FAO support room, but much nicer. I had an upholstered desk chair, a wood table, a color TV, and the floor was carpeted. NASA knew how to make its customers comfortable.

The crew had two shifts, red and blue, and, unlike the MOCR, we did also. I was on the blue shift and Ulrich Hutch ("Hoot") took the red. Nagel, Dunbar, and Furrer were the blue shift onboard *Challenger*, and Buchli, Bluford, and Messerchmid made up the red shift. Hartsfield, and Ockels were "floaters" between shifts. This crew of eight was the largest to date.

The Germans were big on protocol and weren't shy about expressing their disapproval of NASA calling their astronauts "payload specialists." Hans-Ulrich Steimle, the Spacelab D1 mission manager (their equal to Kranz), said, "We demand that the science astronaut concept be developed so that these proficient crewmembers can be designated for such a flight [as D1]. Instead, NASA now has become involved in running a travel office for visiting dignitaries, and this is counterproductive when you want to perform a serious science mission" [10].

Ouch. He may've been responding to NASA's announcement that Bill Nelson (D-FL, 1942–), on the House Space Science Subcommittee, would fly on 61-C, the flight after D1.

Mindful that I was just a peon, I settled into my chair and tuned in the familiar air/ground and flight director's loops. My primary task was to "translate" NASA jargon for the Germans and note any impacts of orbiter system issues on their payload.

HEI employee Earl Thompson was in Germany to serve as our lead operations person. Scott Millican was the Biorack experiment representative at KSC. I didn't even rate a call sign. I was simply "Customer Support" at JSC with Mike. But I was totally okay with that!

Many of my former coworkers were working in the MOCR. Chuck Knarr and Gap Pennington were flight directors. Thor was Ascent/Entry Guidance, and his Long-EZ buddy, Ed, was FDO. The photographer for our wedding, Don Halter, was GC. The Castles became the second married couple in Mission Control, with Sharon as lead Payloads, and Bob as INCO. The Orbit 3 Capcom was Sally Ride, and that team's FAO was Anne Ellis. DPS was Lizbeth (Betsy) Cheshire, and EECOM was Barbara Pearson (who'd debuted on 41-G).

The other FAOs were Wayne Louis and Neil Woodbury (who I'd later train with in Kuk Sool martial arts) with Steve Gibson as lead Timeline and Nancy Jackson, who'd taken over Post Insertion, also serving as Timeline. Gibson would be the first black FAO come STS-29.

Launch was picture perfect. Then, just after OMS 2 (I translated: "the orbital maneuvering system engines second burn to circularize the orbit"), around 54 minutes into the flight, the RCS ("reaction control system, the small jets used for attitude maneuvers") fuel tank pressure dropped. Prop ("the controller in charge of the engines") reported that the helium regulators appeared failed. (“The regulators would add helium to the fuel tanks of the RCS to maintain pressure whenever fuel was used.”)

17.5 On D1, Bob and Sharon Castle became the second married couple to both work MOCR positions on the same flight (NASA photo)

I explained that if both regulators failed, we’d come home on Orbit 7. I sure hoped they weren’t going to witness the first use of the Launch Day Deorbit procedures that I wrote!

After four long minutes, data indicated that the pressure, though low, was holding steady. Capcom gave the crew the go to open the doors. Then Mission Control went into trouble-shooting mode, having the crew feed propellant from the right to the left RCS and check the pressures. The tests confirmed one of the regulators was failed, but the other was okay. We’d come awfully close to testing my old procedures. The crew was go for orbit.

The German Space Operations Center (GSOC) was in Oberpfaffenhofen, near Munich, Germany. After I “translated” what was going on in the MOCR, one of the “local” Germans (usually Jürgen Stegemann) would repeat what I’d said in German to the GSOC Team. One of the Germans on blue shift with me, Rudolph Vogel, tried in vain to get me to say Oberpfaffenhofen without spitting and/or laughing. I did learn to pronounce Munich as “munch-in” versus “mew-nick.” I kept imagining Earl Thompson and the other “munchkins” munching away on snacks over there in ober-pfaff-(ah-choo! God bless you!) en-hoff-en (ha ha ha!).

I wrote, “The Germans were all very pleasant companions. Vogel taught me a few German words, and we talked about how we feel about our environment and families. Jürgen used my smokeless ashtray and kept his sense of humor. [Hans-Gerd] Neuhaeuser was busy with TV, and I didn’t get to know him. Ulrich [Huth], my replacement, was a real diplomat. He was always early, always prepared, always ready to help.”

17.6 I had the pleasure of working with Ulrich Huth of the German Space Agency during Spacelab D1 (Photo by the author)

I got off shift just before midnight that Wednesday night. I was tired, but not exhausted. Not being responsible for anyone's lives, besides the one growing inside me, made an enormous difference to my stress level. But I was on the hook to work 12-hour shifts eight days in a row. So I went home, peeked in on sleeping Thomas, and then headed straight for bed.

My next shift was on Halloween, and I was supposed to be on duty from noon to 11 p.m. I explained our holiday tradition of trick-or-treating to the Germans, and how much I wanted to share this experience with Thomas. Jürgen promised to cover for me and urged me to go. I dashed home and took Thomas around the block, wearing his Superman pajamas as a costume. If I'd been FAO, I would've missed that precious hour with my two-year-old.

Prior to the flight, I'd met with the TV Working Group and PAO Jeff Carr to help coordinate TV segments with the German media—which was 7 hours ahead of Houston time. Protocol required all questions to be in both English and German. This advanced planning led to a hugely successful FD6 press conference. Several questions had to do with Spacelab as a precursor for the space station. Furrer said longer durations were necessary "because short time flight will disappoint some investigators." The scientists always wanted more data.

Ockels, the first Dutch person to fly in space, added a light "cultural" touch noting that everyone liked the Gouda cheese he'd brought along from home. I patted my tummy and told the guys I was craving pickles and Gouda cheese now. We all laughed. The shift flew past.

After my shift ended late that night, I waddled out to the car. I didn't like to drive while pregnant, but I didn't have a choice. No bus service or taxis could come on site. When I got to the car, parked out in the "boonies" across from Building 30, the lights wouldn't turn on. Huh? With my seat pushed all the way back, I uncomfortably twisted and pulled knobs to no avail. The battery was fine. I had flashers: just no headlights.

Thor had often teased me about how mechanical things fail in my presence. It was true. In fact, the CAPS development team rather counted on this "talent" to test new software. They knew that if it were going to fail, it would fail for me. And conversely, if it didn't fail for me, it would work for anyone.

With no cell phones yet, I'd have to walk back to Building 30 to call Thor. But if he picked me up, how would I get to work tomorrow? He needed the other car for his shift. I wrote in my diary, "I drove home with the flashers on, running all kinds of hard-luck stories through my head to tell any cops that tried to keep me from home! I laughed so hard I cried when I got home. Thomas thought I was crazy."

Spacelab D1 was all about science, with more than 70 experiments, but Biorack became the media favorite. A few days into flight, one of the fruit flies went missing. Experimenter D. Mesland reported, "Fruit flies like fruit, flying and sex. However, in the Spacelab experiment of Prof. Marco from Madrid the flies in space neither get fruit nor much space for flying. They get a mold extract supplied via a tray inside a small plastic box. So what else can they do than making love? And that is exactly what the professor wants. He has put 10 male and 25 female flies in each of his little boxes. The flies merrily mate and the females lie their eggs into the trays, which are to be collected by the astronauts. Now, during a daily tray exchange, one of the flies, discontent with its confinement, managed to escape. . . .The suspicion exists that Willie, as the fly was called, is female and fed up with the unequal opportunities."

Willie the Fruit Fly quickly gained a fan following. On FD6, Biorack reported, "The search for freedom of our adventurous fly Willie has tragically come to an end. Willie never left the confines of the glove box and ended in the filter system where escape is not possible." In the "Parting Shot" sent by the science team, the crew were told, tongue-in-cheek, "Willie's family has been notified of his heroic achievements and untimely death. They have requested that his remains be returned to West Germany for a proper burial. Maybe all of you can accompany him and attend the ceremony. D. G. of ESA [Director General of the European Space Agency] has already confirmed to be present and make the funeral oration."

Another dose of humor was provided by a navigational experiment called NAVEX studying relativistic effects. Einstein's equations predict that less time will pass for objects (or people) traveling at high speeds than for objects moving more slowly. The NAVEX team's "Parting Shot" report said, "When you are back on Earth, and we meet again, don't be afraid about our looking very old. It's definitely not because we are tired of D1. You lucky people won about 175.4 nanoseconds due to Albert Einstein, and will feel much better than we."

Kidding aside, serious science was accomplished by D1 thanks to support by the teams and execution by those "scientist astronauts" of Dr. Steimle. NASA Administrator Beggs called the "near problem-free flight of Spacelab D1" a "harbinger of things to come" [11].

HEI got good appraisals, too. We participated in the crew debriefings on November 8. Earl Thompson's major feedback was that the contents of the payload flight data file hadn't been defined ahead of time, formatted consistently, or revised/coordinated on schedule during flight. It looked like there'd be plenty of work for me after maternity leave.

WRAPPING UP THE YEAR

The last shuttle flight of 1985, STS 61-B, launched two days before Thanksgiving. Once again, Thor was Ascent/Entry Guidance. It was the first flight for Mary Cleave, the eighth woman to fly in space, and for former flight controller Jerry Ross (who'd become the "most flown" astronaut by flying seven times) and three other mission specialists. Shaw (Capcom from STS-4) was the commander, and the first "commercial" astronaut, Payload Specialist Charlie Walker, was making his third (and final) spaceflight with the Electrophoresis experiment.

The flight deployed three satellites and Ross and Sherwood Spring performed the 50th spacewalk by U.S. astronauts. But most Americans were busy celebrating Thanksgiving, and didn't pay much attention. My dad, Donna, and Carolyn came to visit on the 28th.

While I took them on a tour of the mockups, Thor oversaw the landing of *Atlantis* on December 3. Little did any of us know that this would be his last time on console. Because my due date was January 15, he'd requested both 61-C and 51-L off. Currently 61-C was scheduled for Dec. 18, but it might slip (it did), and the baby might also come early (he did). Then again, I might be late, and 51-L was planned for January 22.

17.7 Jim McDede and Linda Hautzinger (later Ham, the first woman flight director), shown here with Flight Director John Cox, hung the plaque for 61B which was Thor's last flight as a controller. He's in the background with an unidentified AF guy, Brad Sweet, and Chirold Epp (NASA photo)

Thor was looking forward to the break and still hoping to transfer to space station. As I noted in a "Look Back" in 1990, "Folks had started to burn out. Not feel as important. Not part of a team: just doing a routine job with a potential for national disaster. Folks told me I got out at a good time. All the timelines were generic, loose, lots of free time for the crew: not so many constraints. It was no longer a difficult puzzle to solve. No one bothered trying to track every activity like I'd done. If they were late, so what? I decided they were right. I'd left before the job lost its appeal and challenge. Payload planning on the customer side was the place to be."

The STS 61-C launch scheduled for December 18 was delayed. The attempt on December 19 was scrubbed at T-14 seconds because of a solid rocket booster issue. They reset the launch date to January 6. Thor remarked how glad he had that flight off.

My maternity leave started December 23. I was one centimeter dilated. "Doctor doesn't think I'll be more than a week." This was great news. I was tired of being pregnant.

We spoiled Thomas with all sorts of toys and treats for Christmas. But our future engineer's favorite present was a $1 Transformer I'd bought at a garage sale.

The shuttle launch wasn't the only one delayed. On December 29, I wrote, "Well, as usual, the predictions were wrong. It's been a week now since Dr. Falk said I'd be a week."

New Year's Eve came and went. I finished an embroidery with the title, "Babies Don't Keep," thinking that apparently this one did! On January 9, 1986, I was at two centimeters, my mother had arrived, and I was still pregnant. But that night, my water broke.

The next morning, Thor toweled off our new little boy and handed him to me. He cried frantically until I lifted him to my breast—and he latched right on. We laughed—this boy was born hungry! We named him Scott.

Mom brought Thomas to meet his little brother. He reached out his index finger and tapped Scott on the top his head and giggled. I thought this was a good sign—the boys would bring each other lots of laughs. I wrote, "Friday's child, loving and giving. I'm so lucky."

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18

The Challenger Disaster

Roundup declared that 1986 was the "Year of Space Science." Voyager 2's flyby of Uranus was in January, and deployment of two planetary spacecraft by shuttles was on tap for May: Galileo to Jupiter and Ulysses to the sun. Halley's comet would be observed by cameras on STS 61-C and 51-L, and by Astro-1, to be deployed by a shuttle in March. The Hubble Space Telescope and the High Energy Astrophysics Lab would be deployed by the shuttle later in the year. Yes indeed, 1986 was to be a busy year in space.

Teacher-in-Space Christa McAuliffe (1948–1986) would help share the wonder of space with students everywhere as part of STS 51-L. When asked what message she'd emphasize, she said, "That space is for everybody. It's not just for a few people in science or math, or for a select group of astronauts. That's our new frontier out there, and it's everybody's business to know about space.. . . Just having me fly is a very clear message that space is accessible. . . . Not everybody has had an astronaut in their life, but most everyone has had a teacher in their life" [1].

McAuliffe had it right. More important even than having a role model was believing that you had opportunity. *Star Trek* had shown me a future that included women in space—I'd felt it was inevitable. And, like Starman Jones, I'd prepared myself for that "astrogator's" job that hadn't existed when I looked up at the Moon from camp on July 20, 1969.

If people believed that space was indeed for everyone, then it really would be. I'd considered the teacher-in-space program just another gimmick to get political support. But listening to Christa, I realized how vitally important it could be. Flying politicians and princes and even specially-trained German scientists wouldn't make much difference to how people viewed the space program. Hiring a handful of women and blacks as astronauts helped. But many kids lacked the self-confidence or physical abilities needed to be the next Sally Ride or Guy Bluford.

But if a teacher flew in space, then surely it wouldn't be long before whole families could fly in space, even make homes there. That skinny red-haired girl from Ohio might fly as a space reporter even if she struggled with thermodynamics. That bright black boy might build hotels in space if his eyesight ruled out pilot training. The little Asian doctor wouldn't have to worry about being too short. Space could and would be for everyone. What a great lesson!

M.J. Dyson, *A Passion for Space*, Springer Praxis Books,
DOI 10.1007/978-3-319-20258-7_18

The interviewer suggested that as a teacher, McAuliffe would have an easier time than the Journalist-in-Space (soon to be announced) because she'd only be called upon to do what was natural for her, "just to teach." McAuliffe was incredulous. "Just to teach?!"

The interviewer apologized, saying that was a poor choice of words. Then he clarified, "But the journalist will have to be a poet. The journalist will be expected to represent thousands of other writers and communicators. The journalist will be asked to produce what will have to be his or her best copy or videotape ever. That's a lot of pressure."

Undaunted, McAuliffe answered, "So? You think there's a lot of pressure to make sure that your lessons are something that will stand up to attention by the entire country? Teaching is not a natural thing. . . . There is always something to learn, always a way to make a lesson better. . . . So don't tell me teaching is easier than being a journalist. I don't buy it."

Barbara Morgan (1951–), McAuliffe's backup (who would fly on STS-118 in 2007), added, "When people ask if our training is grueling, or if you are working us too hard, I almost get the feeling that people think this is really hard and teaching isn't" [2].

Ha ha! Reading this while caring for a newborn and a two-year-old, I had to laugh. Wasn't it just like a man to automatically assume that "women's work" was easy and "men's work" was hard?! She could certainly "teach" some of the men at NASA a thing or two.

McAuliffe planned two lessons, one called "The Ultimate Field Trip" to compare life on the shuttle with life on Earth; and the other "Where We've Been, Where We're Going," that would help people understand the advantages of manufacturing in space.

Unfortunately, we'd all suffer through a much more tragic lesson about putting schedule ahead of safety. NASA had just published a projection of 24 flights/year by 1990.

The pressure to launch was intense. When the already twice-delayed STS 61-C launch was scrubbed at T-31 seconds on January 6, 1986, NASA took a beating in the press. They reset for the next day, but at T-9 minutes, the weather wasn't good. Two days later, they scrubbed again. During the reset, they discovered a probe had gotten inside the propulsion system. If they'd launched, John Young said the probe might have caused a catastrophic explosion.

The attempt on January 10 got rained out. On the 12th, the flight's seventh try, Astronaut Steve Hawley wore a Groucho Marx disguise in an attempt to "fool" the shuttle into not recognizing him and letting *Columbia* launch. It worked. *Columbia* finally lifted off.

But NASA managers weren't amused. Delays cost money, and NASA's budget was on the chopping block. Particularly embarrassing was that Congressman Nelson was on the 61-C crew. He'd bumped Gregory Jarvis (1944–1986) for the spot, the second time Jarvis had been bumped by a politician (Garn had taken his spot in 1985). The rest of the 61-C crew included Commander Hoot Gibson; pilot and future NASA Administrator, Charles

Bolden, Jr. (1946–); Franklin Chang-Diaz (1950–), the first Puerto-Rican astronaut; Pinky Nelson; and Robert Cenker (1948). Their primary job was to deploy *one* satellite. They also carried some materials experiments and 13 Get Away Specials. For this they needed seven crewmembers? I was reminded of Herr Doctor Steimle's remarks about NASA running a travel office, and just shook my head.

They deployed their satellite and then the Comet Halley monitoring experiment failed.

Pressured by its own promises to be "operational," NASA decided to end the flight a day early. They planned to land at KSC. John Young had objected via a memo dated Jan. 6, citing KSC's weather and the danger of "more than significant" damage if nose wheel steering failed and the hypergolic propellant in the nose hit the ground. Young felt that saving a few days in turnaround wasn't worth the risk. "Our experience is telling us that if we continue to use the Shuttle Landing Facility for end-of-mission landing, sooner or later we will have an accident."

Yet NASA continued with plans to land in Florida until forced to Edwards because of the weather. *Columbia* not only didn't land early, it landed two days and one orbit late. As a result, STS 51-L slipped from January 22 to January 23, then 24th.

"A MAJOR MALFUNCTION"

Launch of 51-L was slipped yet again, to January 25 because of weather at the trans-Atlantic (TAL) abort site of Dakar. Casablanca was then designated as a TAL site. But Casablanca was not equipped for a night landing, so launch moved to Monday, January 27. During closeout, a locking tool got stuck and had to be cut off. During this delay, crosswinds exceeded the return-to-launch-site limits. Launch was scrubbed for 24 hours.

Thor wasn't working this flight (Ken Patterson was now the third ascent-qualified guidance officer). So he went into work at his usual time on Tuesday morning, January 28, 1986. It was my first week on my own, with both boys. My mother had left the Tuesday before.

Brian Perry, who was Ascent FDO, had told Thor he expected them to scrub again for weather. So I didn't even turn the TV on when I got up. There was no Internet, no cell phones, no 24-hour news. I didn't know that launch was still go, but delayed to 10:38 a.m. CDT.

At KSC in Florida, temperatures had dropped into the teens overnight. Water pipes had been opened to prevent bursting, creating icicles up to 18 inches long on the launch pad. After the two-hour delay to let the sun warm things up, the 51-L crew of Scobee, Smith, Resnick, Onizuka, McNair, Jarvis, and McAuliffe were strapped in and given a go for launch.

I was nursing the always-hungry Scott when the phone rang just before 11 a.m. I let the new answering machine Thor'd gotten me for Christmas take a message. Scott finished nursing, and I put him in the bassinet. I hit playback on the machine. "This is Cynthia. I just saw it on TV, and I'm so sorry. I just had to call. It's so awful, and I feel so bad for you and Ted and all your friends there at NASA."

Saw WHAT on TV?

I rushed to the living room and turned the TV on. I saw a white launch plume that separated into a "Y" shape with pieces falling. "No!" I exclaimed, backing away and collapsing onto the sofa. The commentator confirmed that the shuttle had exploded. "Oh my God!"

"What's the matter, Mommy?" Thomas asked, tugging on my arm.

I thought of Judy and El and Ron. . .all of them dead, boom, just like that. The commentator rambled on about a Coast Guard search for survivors. I knew there wouldn't be any. There was no crew escape system, no ejection seats, no way to survive falling miles into the ocean. My eyes welled with tears. I put my arm around Thomas. "Oh sweetheart, the space shuttle just blew up," I said.

He stood there looking very solemn, studying my face. He'd never seen me cry before. He patted my hand with his and said, in his sweet little two-year-old voice, "Don't cry, Mommy. We get you a new one."

"You don't understand, Thomas," I said, wiping my tears. "There were people inside the shuttle when it exploded. They were each one very special. They can't be replaced."

Of course he didn't understand. He had no experience with death. But he knew what to do when someone was hurting—he climbed up on my lap and hugged me. And so as the explosion played over and over on the TV, I hugged Thomas tightly. I thought of Ron who had a son the same age as Thomas, and El's daughters were some of the neighborhood babysitters that had been recommended to me. Those poor kids would never see their fathers again. And Judy! How could she be dead?! She was everything I thought a woman astronaut should be: confident, intelligent, capable—and beautiful on top of that. I wished I'd gotten to know her better.

On the replay, I heard the familiar launch sequence. I studied the images and listened to PAO say, "Liftoff, liftoff of the 25th space shuttle flight, and the shuttle has cleared the tower." Control had passed to Houston. I imagined being in Mark Maschoff's seat at the FAO console. He wouldn't have seen the explosion because we weren't allowed to have TV in the MOCR.

18.1 Because of damage to the O-ring, Challenger was doomed even as it cleared the tower on January 28, 1986 and control passed to Houston (NASA photo)

Telemetry showed the orbiter in good shape. But even at liftoff the right solid rocket had already begun to fail. A rubber-like ring, called on O-ring for its shape, was supposed to keep hot gas headed down and out the bottom of the rocket tube. But this booster had been used before (and refurbished), and it was no longer perfectly round. Some tiny gaps existed between the ring and the metal cylinder. These gaps were sealed with putty. When the boosters ignited, the cylinder shook and pushed the ring to one side, compressing the putty, and opening the gaps more. If the putty hadn't been so cold, like a sponge, it may have rebounded and closed the gaps. But the cold made the putty stiff. It didn't rebound, and the gaps grew. Hot gas shot through.

Cameras recorded a series of eight consecutively blacker puffs of smoke emerging from the aft joint, on the side facing the tank. "The black color and dense composition of the smoke puffs suggest that the grease, joint insulation, and robber O-rings in the joint seal were being burned and eroded by the hot propellant gases," the Presidential Commission reported [3].

The crew initiated the roll program. If Thor had been on console, he'd have confirmed that to the flight director. In this case, Ken made that call to Flight Director Greene. (Greene had been Thor's section then branch chief before becoming a flight director.) On the air-to-ground loop, I heard Capcom Dick Covey say, "Roger roll, *Challenger*."

PAO reported, "Engines beginning throttling down now." They were entering the ascent "bucket," when the engines were restrained from full power to reduce the maximum pressure, max Q. (There's always a max Q, where the friction through the air is greatest, but the value is less if you slow down until the air has thinned.) Everything seemed routine.

While passing through the "bucket," post-flight data showed that Challenger's guidance, navigation, and control systems reacted to intense wind shear conditions, violently shaking the vehicle, more than on any previous shuttle flight. This motion likely exacerbated the leak.

PAO reported the three engines were running normally, they had three good fuel cells, and three good APUs. I imagined myself following along, like I'd done just last fall for D1.

PAO announced that the engines were throttling up to 104 percent at about 51 seconds into launch. Pilot Smith was heard to exclaim, "Feel that mother go!"

Seconds later, a camera captured the first flickering flame on the side of the right booster. No one in Mission Control or at KSC saw it. Capcom said, "*Challenger*, you're go at throttle up."

Scobee responded, "Roger, go at throttle up."

By 59 seconds, the flame had swelled into a well-defined plume. Max Q (720 pounds per square inch) was calculated to have occurred at the same moment. Recorded telemetry showed a chamber pressure difference between the right and left boosters, confirming the leak on the right booster. Even if Booster had realized what was happening, there was no action that anyone could've taken to prevent the pending disaster.

On CNN, one of the few TV stations that hadn't already cut away from launch coverage, Correspondent Tom Mintier said the shuttle was on its way after "more delays than NASA wants to count. This morning it looked as though they were not going to be able to lift off" [4].

The flame was like a blowtorch applied to the tank. It spread to include the strut that attached the booster to the tank. At 64 seconds, the tank was breached. At 72 seconds, the strut gave way, and the booster rotated around the upper strut. By 73 seconds, the entire bottom dome of the tank dropped away releasing a massive amount of hydrogen. The accident report said this release, "created a sudden forward thrust of about 2.8 million pounds, pushing the hydrogen tank upward into the intertank structure." At the same time, the rotating right booster slammed into the oxygen tank (above the hydrogen tank).

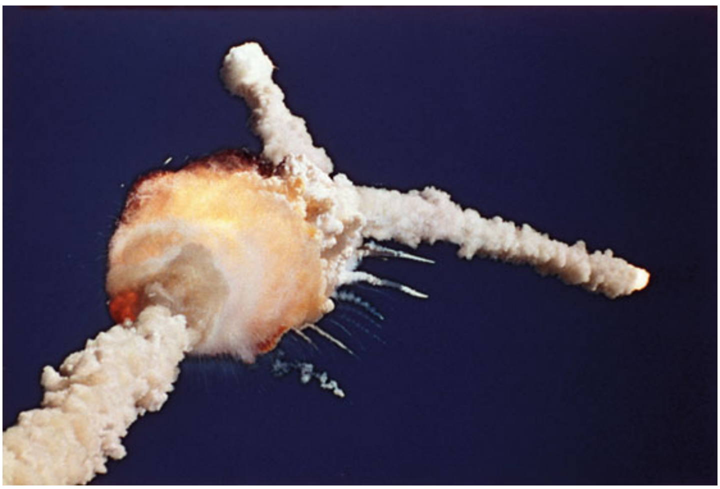
Smith saw the fire out the right window and uttered his final words, "Uh oh." Within milliseconds, at 46,000 feet, the tank exploded. Communications ended by 74 seconds.

PAO, oblivious to the explosion, announced, "One minute 15 seconds, velocity 2900 feet per second, altitude 9 nautical miles, downrange distance 7 nautical miles."

Spectators stared at the sky in confusion. What was that bright flash? The CNN reporter said, "It looks like the solid rocket boosters flew away from the shuttle in an explosion."

PAO said, "Flight controllers looking very carefully at the situation." Then, in one of the worst understatements ever, he said, "Obviously a major malfunction" [5].

The explosion plume broke into a "Y" with the two solid rockets heading in opposite directions. The orbiter wasn't meant to fly sideways, and it immediately shattered: a wing, the nose, and the tail section shot out of the main cloud in different directions.



18.2 After Challenger's hydrogen tank exploded, the solid rocket boosters continued off in separate directions, creating a "*Y*" shape in the sky (NASA photo)

One TV camera remained pointed at Christa McAuliffe's parents and husband watching from the viewing stands. Her father said quietly in disbelief, "It broke apart" [6].

In Mission Control, it took only seconds for Brian to confer with controllers at KSC. As the pieces fell toward the water, PAO said, "We have a report from the Flight Dynamics Officer that the vehicle has exploded. Flight director confirms that. We are looking/checking with the recovery forces to see what can be done at this point."

Recovery efforts had to wait until the Range Safety Officer (RSO) declared the area safe from falling debris, some of it still on fire.

Meanwhile, the orbiter's nose section fell toward the water with the crew inside, trailing a mass of umbilical lines yanked from the payload bay. The forces of the breakup were determined to be survivable. Were they alive when it struck the water?

When the cabin separated from the rest of the vehicle, the crew only had a few seconds of oxygen in the lines. Each crewmember's helmet attached to a personal egress air pack, and four of these were recovered—three had been activated. The non-activated one was Scobee's, and at least one of the activated ones belonged to Smith. The other two likely belonged to Resnick and Onizuka, since one of them had to activate Smith's pack. Momentum carried the nose up to a peak altitude of about 65,000 feet. Without supplemental air at that altitude, if the cabin had depressed, the crew would've been knocked out in just a few seconds. (It's not possible to "hold your breath" in low-pressure. The air is literally sucked out of your lungs.)

The cabin struck the ocean going 200 mph about 2 minutes and 45 seconds after the tank exploded. I learned later that a middeck locker, two helmets and partial remains, probably from McNair, McAuliffe, or Jarvis, floated to the surface and were recovered that awful day. The flight deck was found on March 7 in 100 feet of water 17 miles northeast of the Cape [7].

After the initial shock wore off, I wondered what Thor was doing. Was he coming home? Why hadn't he called me? I really needed to hear his voice. I dialed his office. I got a recording saying all the lines were busy, please try again later. Everyone was calling everyone.

Thor hadn't been watching the launch, either. He'd been writing a report in Building 17 where his office had recently moved. "A guy I worked with, Charlie Parker, poked his head into the room and said, 'We just lost it,'" Thor recalled.

"Lost what?" he'd asked in confusion.

"We just blew up a shuttle," Parker said.

Thor and I weren't the only ones caught by surprise. President Reagan hadn't seen the launch in real-time, either. At 1 p.m. EST, an hour and 20 minutes after the accident, the president met with reporters at the White House. The press conference had been previously scheduled as a briefing on his State of the Union address planned for that evening. His assistant for National Security Affairs, John Poindexter, had seen it on a news flash and told him.

In the midst of the biggest space disaster in history, the NASA Administrator, Beggs, was on forced leave because of an indictment that was later dropped. Acting Administrator William R. Graham (1937–) was in a meeting with a congressman instead of at the launch [8].

President Reagan addressed the nation on Tuesday night. He spoke of the crewmembers' bravery and hunger to explore. I pulled Thomas close to me as he addressed the children. Then he said, "We'll continue our quest in space. . . .I wish I could talk to every man and woman who works for NASA . . ..' Your dedication and professionalism have moved and impressed us for decades. And we know of your anguish. We share it" [9]. I remembered his visit to Mission Control during STS-2, and knew he spoke from the heart.

The memorial service was Friday at JSC. I couldn't attend because I was no longer an employee. Thor offered to stay home with me and watch it on TV, but I wanted him to be with the other flight controllers, especially Brian and Ken who'd been on console. I wasn't cleared to drive yet so soon after childbirth, but a friend gave me a ride to church for a service there.

The whole "lawn" between Building 1 and the duck pond was cordoned off. A platform tent was set up with Building 16 as the backdrop. Everyone except the families of the crew had to stand. Loudspeakers were set up, so everyone heard the president's words of reassurance that the loss of our friends, neighbors, and coworkers would not mean the end of the Space Shuttle Program. Reagan noted that "every family member I talked to asked specifically that we continue the program, that that is what their departed loved one would want above all else. We will not disappoint them. Today we promise Dick Scobee and his crew that their dream lives on, that the future they worked so hard to build will become reality. . .Man will continue his conquest of space. To reach out for new goals and ever greater achievements—that is the way we shall commemorate our seven *Challenger* heroes" [10].

At church, I bowed my head and said my own private goodbyes to the crew. As I walked outside, the jets buzzed overhead. They'd flown the "Missing Man" formation.

ROGER'S COMMISSION RECOMMENDATIONS

Reagan selected 12 people to investigate the tragedy, headed by former Secretary of State William Rogers (1913–2001) and co-chaired by Neil Armstrong, the man I'd watched step onto the Moon all those years ago. The token woman was Sally Ride. She told a reporter, "I think we may have been misleading people into thinking that this is a routine operation, that it's just like getting on an airliner and going across the country and that it's safe. And it's not."

The Roger's Commission finished their investigation in June. They offered nine recommendations to fix the immediate problem and to prevent future accidents. Number one was to redesign the boosters. Two was to restructure the management of the Shuttle Program, including promoting more astronauts to management. Anticipating this recommendation, Admiral Dick Truly, the STS-2 pilot and STS-8 commander, was brought back from the Navy to take charge of the program in February.

Recommendations 3, 4, and 5 had to do with reviews, setting up a safety office, and improving communications, especially with Marshall Spaceflight Center which hadn't shared information about the boosters that might have changed the launch decision. The commission listened to John Young and included a recommendation to land at Edwards until all issues with the nose wheel and tires were addressed.

Although escape during the first two minutes of flight wasn't possible, the commission endorsed adding a crew escape system. This was a pole that could be extended from the side hatch to get free of the wings to allow the crew to bail out below 100,000 feet.

Realizing crew escape would make my old Loss of 2 Freon Loops Deorbit case survivable, I wrote a story using it. "Fireworks in Orbit" appeared in *Analog Science Fiction* magazine in 1990 (and is reprinted on Kindle). I sent a copy to Milt Heflin, who'd recently been promoted to flight director. He said he thought my solution was workable, but expressed the hope we'd never have to test it. (Unfortunately, *Columbia* broke apart too high for crew escape.)

One of the final recommendations said, "NASA must establish a flight rate that is consistent with its resources. A firm payload assignment policy should be established. The policy should include rigorous controls on cargo manifest changes to limit the pressures such changes exert on schedules and crew training" [11]. The payload musical chairs and the push to fly 24 flights a year would stop.

Three of the first manifest "casualties" were the "year of space science" flagship missions: Astro-1 would miss Halley's Comet in March and was cancelled altogether; Galileo and Ulysses would miss their windows in May and would be delayed at least 13 months. Commercial satellites would move to expendable rockets. A new TDRS, the primary payload of 51-L, and military satellites would take top priority once flights resumed.

By the beginning of March, Acting Administrator Graham instructed NASA to halt shuttle marketing activities. Intelsat, one of the shuttle's best customers, switched to the European Ariane for its next launch. Contractors laid off 1200 workers.

NASA estimated the cost of recovery at $5–$6 billion, with $2.8 billion for a new orbiter: a third of the agency's total $7.3 billion budget. The Air Force also requested more than $2 billion to buy expendable rockets to replace the lost shuttle flights [12].

The schedule pressure had been addressed, but not the underlying cause of it—money. Delays cost money. Repairs and spare parts and crew escape systems and training to use them cost money. If we'd had more money, maybe we wouldn't have felt the pressure to keep flying with a failed fuel cell, to downplay fires in Mission Control and on the launch pad, to bring a flight home early to KSC despite used tires, to launch when it was too cold for the O-rings. Despite all the safety reviews in the world, managers would continue to make decisions based on cost. Eventually, this pressure would contribute to the *Columbia* disaster in 2003.

MORE TRANSITIONS

The last week of February, Cindy came to see Scott. She noticed that Jasper Kitty didn't look well. With a new baby and a two-year-old, I hadn't paid him much attention. I took him to the vet the next day. But, it was too late. He died of an infection on March 3. The wonderful kitty who moved to Houston with me was gone as suddenly as the shuttle and its crew.

Time marched on. A park in Friendswood was named *Challenger* 7. John Denver performed a benefit concert on March 27 at Jones Hall. And NASA got a new administrator, James Fletcher (1919–1991), who'd had the job back when I'd been a congressional intern.

With the shuttles grounded, plans for commercial space were canceled. But Mike had work for me helping the Italians prepare documentation for their space station module.

So I was back working part-time, and Thor was still with NASA. I wrote to his Uncle Evan, "In response to your questions about the *Challenger* accident, Thor hasn't been affected fortunately, except maybe for morale. The space station job he wanted is on indefinite hold. However, with all the reorganization going on, it's likely a new section will be created that he can apply for. [It was, and he got it.] . . . My income is from foreign sources, so I'm lucky in that respect. Europe wants to be autonomous in space, especially after the accident."

In the fall of 1986, I wrote, "I'm working with HEI's 'new' employee [he'd been an Apollo flight controller], Jim Hannigan whom I worked with on the STSOC proposal for Lockheed. . . . He fondly remembers the Mercury program like I'm sure I'll remember STS-1 someday. It started me thinking about where I'm going career-wise and if I want to find myself writing proposals when I'm 56 . . .. I guess I could do worse! I told Jim I haven't lost all of my idealism yet, that I believe that space is the future for the human race. He said he'd lost his, then stopped, and said he hadn't really.

"I think we all need to remind ourselves why we are doing what we are doing. Thor and I really do feel our efforts are part of the movement to get our race into space—to keep humans growing and thinking about new things. Writing a proposal to win a contract to support life sciences is just a necessary business part of getting the job done. My role is not going to be front page news, but I hope I will contribute more than a few paragraphs."

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19

Space for Everyone

I focused my love and attention for the rest of the 1980s and 1990s on raising my two amazing children, working part-time and polishing my skills as a writer. I thought that I might do more good for space as a writer than as an aerospace worker—especially because I didn't see much potential for me becoming a leader in the space program outside of NASA (where women were even more rarely promoted to management positions). But I also realized that aerospace work, even low-paid technical writing positions, paid a lot better than what I'd earn as a writer. So Thor and I made a deal—that when the boys reached high school, if I weren't making the cost of college tuition via writing, then I'd go back to work in aerospace.

So while our sons grew into gifted young men (Thomas has a Ph.D. in engineering and works for GE, and Scott has a masters in educational psychology and is fluent in Chinese), I supported my husband in his work at NASA, and slowly built a career for myself as a space science writer and children's author.

Thor was selected as a section chief in 1988. When the new Information Systems Directorate formed, his section became part of it. In 1991–1992, he served on a source board for the Information Systems Contract and then became a deputy branch chief. He moved to the office of the Chief Information Officer in 1994 and worked there ten years, until the office was subsumed into the Information Resources Directorate. He was JSC's chief network guru for years, his careful oversight saving NASA millions of dollars in equipment and software costs. As JSC's Chief Information Security

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Officer, he thwarted hackers and kept the networks running. He accepted an early retirement offer in 2011, and now spends his time as a volunteer pilot for the Coast Guard. Our Cessna 172 was destroyed by Hurricane Ike in 2008, so we upgraded to a Cessna 182 which we take on many adventures that often find their way into my stories. In 2013, we donated the parts of the Long-EZ to an enthusiastic pilot who hopes to finish it.

My first paid publication was in a space magazine in 1988, and my first two science fiction stories (both having to do with shuttle flights) were published in 1990. Writing about the space program, such as the first woman flight director, Linda Hautzinger/Ham, was definitely more fun than preparing technical documents such as “Ground Data Systems Definition Study for Space Station Freedom” even if I didn’t get paid much. But I wanted to do more to help the space program. Since I was no longer a government employee, I decided to help in the political arena.

As a former congressional intern, I knew the importance of getting constituents involved. So I joined local political groups, got elected as a precinct chairman (I got more votes than Bob Dole in my precinct!), worked on campaigns, and got elected as a delegate to state conventions—always championing space issues and NASA’s budget. I wrote about these experiences in Ad Astra, the magazine of the National Space Society (NSS), to encourage other space enthusiasts to get involved. I also became editor of a space lobby group’s newsletter, Spacecause News.

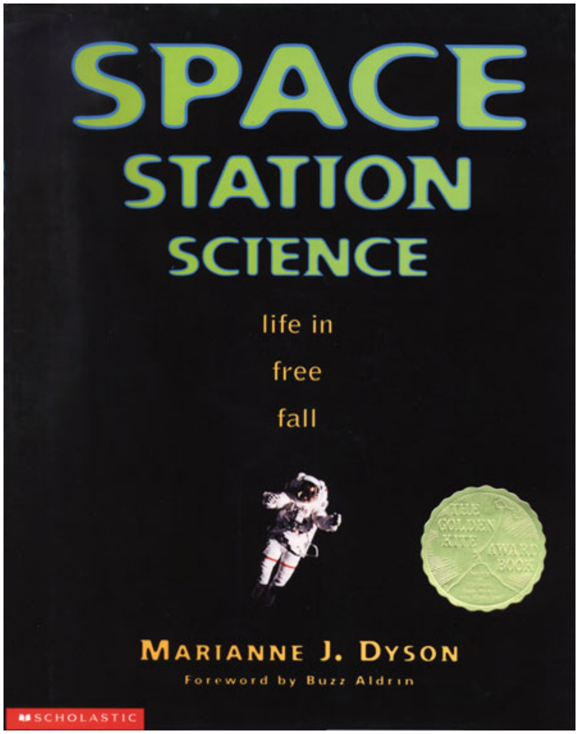
As a mom, I discovered just how important parks and libraries are to developing the minds and bodies of healthy kids. So I got myself elected as a trustee of my community association. I used my chairmanship of the Parks Committee to oversee the design and building of a handicapped-accessible space-themed playground next to Freeman Library.

My other volunteer work involved serving on the Board of Directors of the National Space Society. I worked on educational programs with *Apollo 11* Astronaut Buzz Aldrin, then chairman of the board, first commercial astronaut Charlie Walker, then president, and Majel Roddenberry of *Star Trek* fame. (Later, Buzz wrote the Foreword of my first book and recently, I coauthored a book with him.) I was elected to officer positions within NSS and worked with Robert Zubrin as he promoted his concept of “Mars Direct.” I also organized and co-chaired, with Murray Clark, the International Space Development Conference in Houston in 1999. I retired from the NSS Board in 2006 and established the NSS book review section of the website and, with David Brandt-Erichsen, continue to connect space writers with space readers. I also frequently contribute to *Ad Astra* magazine and served as editor in 2008.

19.1 I was honored with the Space Pioneer Award in 1996, presented to me by NSS President Charlie Walker at the ISDC in New York (Photo by the author)

As the boys reached high school, I was not yet earning enough money from writing to cover their college educations. No part-time consulting jobs were available in aerospace, but my community contacts led to a job as the publications coordinator for The Rotary National Award for Space Achievement (RNASA) Foundation (http://www.rnasa.org), a job I worked part-time (with a few years off for book contracts) until 2013. This wonderful program recognizes the unsung heroes of the space program as well as the celebrities. I created and maintained their website, solicited ads for their souvenir program books, and had great fun interviewing, profiling, and writing about all the winners, including Neil Armstrong, my old boss, Mr. Kranz, and the first woman shuttle commander, Eileen Collins (1956–).

Writing for Odyssey children's magazine honed my skills for my first children's book, *Space Station Science: Life in Freefall*, published by Scholastic in 1999. I was really flabbergasted when it won the Society of Children's Book Writers and Illustrators' Golden Kite Award for best children's nonfiction book of the year. I was grateful for the practice the NASA Speakers' Bureau had provided because promoting this book required lots of appearances at schools and libraries, some broadcast on CNN. Kids are the best audiences because they still believe, like I did on the summer night in July 1969, that anything is possible.

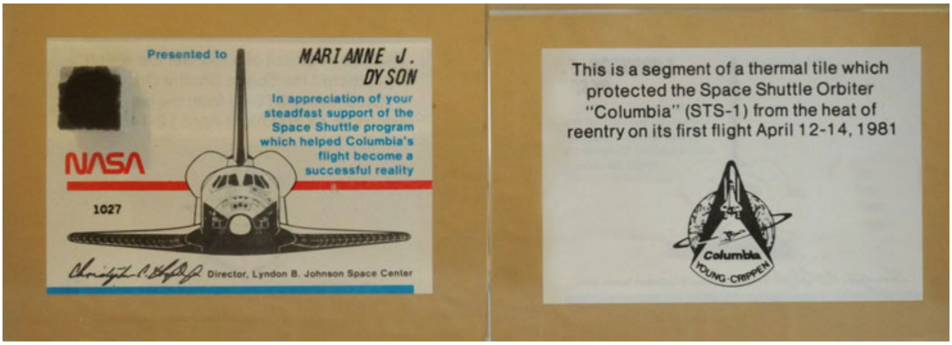


19.2 My first book, *Space Station Science*, was published by Scholastic in 1999 and reprinted by Windward in 2004. It won the SCBWI Golden Kite Award (Photo by the author)

My editor left Scholastic just as *Space Station Science* went to print. I had what's called an option contract, so owed my next book to Scholastic. The editor who inherited me there wasn't interested in my proposals about space. The only topic she and I agreed on was computers (I got my domain and programmed my website in 2000). I wrote *Homework Help on the Internet* in 2000—and then followed my previous editor to National Geographic.

My third book, *Home on the Moon: Living on a Space Frontier*, was published by National Geographic in 2003 and won the American Institute of Physics Science Writing Award. The recognition and encouragement of the physics community to use my knowledge of space to write for kids was especially meaningful after the *Columbia* disaster the spring the book was released.

Though I didn't know the *Columbia* astronauts personally like I had the *Challenger* crew, I'd followed the flight because I'd planned to write about their experiments. During the memorial service, I sat with other space reporters in the JSC newsroom in Building 2. I held my little piece of *Columbia*—a tile set in plexiglass given to all of us after STS-1. President Bush addressed the NASA employees and the families of the seven crewmembers, like President Reagan had done for the *Challenger* back in 1986. Once again Thor was out on the mall, standing with his friends, listening, and watching as astronauts flew the "missing man" formation overhead.



19.3 I held this piece of Columbia close during the memorial (Photo by the author)

I kept asking myself how this could happen again. One answer was in the eerie words of *Challenger* Commission member Richard Feynman (1918–1988) when he talked about how management had accepted escalating risk apparently because they'd gotten away with it the last time. He called it "a kind of Russian roulette . . .. [The shuttle] flies [with O-ring erosion] and nothing happens. Then it is suggested, therefore, that the risk is no longer so high for the next flights. We can lower our standards a little bit because we got away with it last time" [1]. Although NASA restructured itself and added safety panels and reviews after *Challenger*, this tendency to "normalize" standards had taken root again with tragic results. Foam had fallen off the tank during launches before, and the shuttles had returned safely. But this time, it didn't.

AFTER *COLUMBIA*

The reaction to the loss of *Columbia* was at first encouraging (we will continue to explore). The Bush Administration decided to retire the shuttles when the space station assembly was complete. The retirement would then supposedly free up funds to build a new crew capsule and rocket that would be similar to Apollo but include modern technology. This vehicle would taxi crews to and from the station and, using an upgraded booster, take us back to the Moon and on to Mars. NASA engineers got busy designing the parts of what was called the Constellation Program: a booster called Ares, a capsule dubbed Orion, and a Moon lander named Altair.

The shuttle *Discovery* launched on the "Return to Flight" mission in July 2005. Unfortunately, the flight proved that the foam issue was still not solved. The shuttles were grounded for another year. Regular assembly flights to the ISS resumed in July 2006.

While the ISS assembly was on hold, I returned to Scholastic as a writer (for *Stars and Galaxies*) and technical consultant on their popular Space University series in 2004. I then wrote an adult history book, *Space and Astronomy: Decade by Decade*, for Facts On File, published in 2007. Afterwards, I served as a National Geographic Explorer and technical consultant on an elementary physics series called "Push and Pull" that included filming some scenes with me as the "actress" at JSC that were included on DVDs with the books.

I continued part-time with the RNASA Foundation and supplemented my writing income through appearances at schools, libraries, and events, speaking to tens of thousands of students about space. These were the kids who would get to fulfill my dream of living on the Moon. I was excited for them, and teachers told me my enthusiasm was contagious.

19.4 During the first decade of the new millennium, I spoke to tens of thousands of students each year, like these at Briargrove Elementary in Houston, and appeared on CNN, C-Span, and Great Day Houston, to excite young people about space (Photo by the author)

Then, in 2010, the Constellation Program was canceled by President Obama. Many of us had expected part of the program (the Ares booster) to be canceled or restructured. But the outright cancelation of the whole Moon program was an enormous shock. Thousands of aerospace workers lost their jobs.

Morale at Johnson Space Center plummeted, and my own enthusiasm for talking to kids about space did also. I no longer felt sure these kids would even have an opportunity to be astronauts or flight controllers with no U.S. program planned beyond the space station (currently approved to 2020), let alone reach the Moon. My editors weren't interested in any more space books. I returned to science fiction and published "Fly Me to the Moon" in *Analog*.

The MOCR we used for STS-1 was completely gutted and "repurposed" for Constellation. When that program was canceled, it was redone for space station. The third floor MOCR we used for STS-5 and some DoD flights, is now a national historic landmark. It has been reverted to the way it looked for Apollo with the only exception being that the shuttle mission patches remain on the wall. (If you take the tour, say hello to the STS-5 patch for me.) The Shuttle Mission Control used for more than 50 flights was mothballed after STS-135, in July 2011.

Congress saved Orion and part of the booster program, renamed the Space Launch System (SLS). But their future remains cloudy. Orion is the only vehicle that has the ability to return to Earth from deep space (which requires a beefed up heat shield). It has no capability to land on an asteroid or the Moon. It has no airlock or robotic arm, so spacewalks require evacuating the whole capsule—severely restricting the number of spacewalks and crew it can support. It must be attached to another module to have enough fuel to go anywhere. When it returns to Earth, it can't use a runway like the space shuttles did. It has to splash down in the ocean and be picked up by a special aircraft carrier. It's also so heavy that, fully loaded, no current booster can lift it into orbit. The earliest Orion might fly with a crew is 2021.

The SLS is designed to lift massive payloads (like Orion) or future cargo to the Moon or Mars. Yet SLS managers admit SLS production is too expensive to launch it more than once every two years. The low launch frequency of the shuttle, averaging 4/year and maxing out at 9/year, was a major reason cited for its operational expense: and a big driver for its retirement. If the country couldn't afford the shuttle with all its capabilities, it seems doubtful it can afford to operate Orion and SLS, especially with no commercial use of SLS identified. (Current boosters are already underutilized, and increasing the frequency of launches on them would help drive costs down.)

The astronaut corps dwindled to 43 in 2014 (plus 8 candidates in training), never having reached gender equality. NASA's 2013 class of eight (selected from 6100 applicants) included four women. The Russians, who control half of the space station crew slots, have only one woman in their cosmonaut ranks. NASA has no requirement for pilot astronauts since it has no vehicle for them to pilot. With no more than three American astronauts flying to the station per year, astronauts may have to wait 10 or more years for their turn in space.

What happened to the plans for a commercial Space Operations Center, O'Neill cylinders, and the future I saw on *Star Trek* or imagined via *Starman Jones*?

Abandoning commercial enterprise after *Challenger* was certainly a major factor. The shuttle was no longer the facilitator of new business and a future space economy. It was restricted to being a truck whose primary purpose (after it finished its military missions and repaired Hubble) was to prepare for and assemble the space station.

The station took ten years to assemble and cost about $100 billion. Originally envisioned as a business incubator and research center, it has mostly been a testbed for systems and human adaptation to freefall. We now know how to build and maintain life support, computer, and power systems that are dependable for long-term operations. Spacewalks have become routine. We have also mastered the necessary international logistics, no small feat, to keep the station supplied with crew, food, water, and fuel. Mission Control was pared down to a minimum team with regular shifts. (Women have served in all positions, though they remain a minority.) The bone-loss problem has mostly been solved via exercise and nutrition. A series of year-long missions are planned to better understand medical effects on astronauts of long duration exposure to freefall. But another important long-term benefit of the station (one Herr Steimle probably doesn't approve and NASA resisted) is that it has ushered in the first profitable human space industry: tourism.

Dennis Tito was the first space tourist, or as he prefers "spaceflight participant." He flew to the space station in April 2001 against NASA's objections. He was followed by Mark Shuttleworth in 2002 and Gregory Olsen in 2005. Anousheh Ansari was the first self-funded woman to fly. She went up in September 2006. Five more men, and one woman, Yi So-yeon of South Korea, have flown since then. Others are in training.

While people now have an option to fly into space other than as government astronauts or scientists, only a handful of people can afford the tens of millions it takes to fly. When there was a shuttle program, any child could dream of one day becoming an astronaut. If they lacked money, they could join the military and become a pilot or win a scholarship to become a doctor or scientist. But I recommended to my middle-school astronomy students (that I taught via my district's gifted program) that if they want to fly in space, they should probably look to law or business careers that are more likely to earn enough money to afford a ticket.

After the shuttles retired in 2011, the price the Russians charge for humans to fly into space on their Soyuz quickly rose from $55 to $76 million per person in 2014 [2]. Prior to 2012, the U.S. paid millions to have supplies delivered to the station. Now, two American companies, SpaceX and Orbital Sciences, are delivering cargo to the station for us. Crew-capable vehicles are in work by SpaceX and Boeing. If all goes well, NASA will be their customer starting in 2017 and as long as the station requires crew, currently only approved to 2020.

Will they have a market after that?

Many people are willing to pay money to experience freefall. For about $5000, a company called Zero-G provides 20–30 seconds of freefall 15 times on a jet flying parabolas (like a roller coaster in the sky). I experienced 40 of these parabolas on NASA's "Weightless Wonder," a.k.a. the "Vomit Comet," when I flew as a journalist in 1999. I wrote about my experiences in Ad Astra and Analog magazines (and reprinted them on Kindle).

Virgin Galactic is planning suborbital flights that will give passengers about 15 minutes of freefall time plus a view of the Earth from space. At a cost of $200,000–$250,000 each, about 700 people booked flights. An accident in 2014 claimed the life of one of the pilots. However, the first commercial flight is still expected in a year or so.

Suborbital flights can also reduce trip times around the world significantly. Imagine taking a suborbital "hop" from the United States to China or Japan in about an hour? Many business travelers and emergency response teams would benefit from such short trip times.

Bigelow Aerospace has a contract with NASA to test one of their inflatable modules for two years on the space station starting in 2015. If SpaceX and Boeing can bring down the launch cost, perhaps there will be enough market to support a private space station or hotel made of these modules.

In addition to tourism, there are other ways that companies hope to make money in space. Planetary Resources and Deep Space Industries are planning robotic forays to asteroids with the long-term plan of mining them for precious metals and creating space fuel depots. They claim that one asteroid could be worth trillions of dollars in platinum and other elements.

So if the private space industry is going to open the space frontier for everyone, why do we need NASA?

THE GOAL: SPACE SETTLEMENT

There are strategic reasons for the United States to have a vibrant space program—like the general said back in 1982 that "NASA has been a major contributor to our national prestige overseas." But NASA has a long-term goal, one that is perhaps more relevant now than ever.

The purpose of NASA isn't to win a political battle, to push our technology, to provide jobs for engineers, to answer fundamental science questions like where we came from, or to inspire young people to study their math and science. It might achieve those things along the way. But the real purpose of the space program was clearly stated in the Space Settlement Act of 1988, the year the shuttles returned to flight after the *Challenger* disaster.

This act boldly declared that space settlements are the "long-range objective of the American space program." The act said that "exploring, prospecting, and settling are parts of our heritage and will most assuredly be parts of our future; the United States space policy needs long-range goals and direction in order to provide understanding for near-term space projects and programs; the establishment of space settlements will inspire generations of future Americans; and human settlement of space is fully consistent with the policies and objectives of the Nation's space program as articulated in the National Aeronautics and Space Act of 1958" [3].

A number of possible near-term objectives have been identified that build on the legacy of the space station program, could be executed within similar budget constraints and timeframes, and would continue to support the budding commercial space business that is necessary to lower the cost of space access and sustain any long-term occupancy of space.

My personal favorite is the establishment of a human-tended telescope on the far side of the Moon. Why a telescope? We've been lucky so far, but it only takes one comet or asteroid to wipe out civilization. Preventing our extinction is certainly an appropriate project for international partners to undertake together. The far side of the Moon is an ideal place for a radio telescope to search the sky for potential threats, and also to do some cutting-edge astronomy. Sure, we could put a telescope elsewhere in space more cheaply, and I support doing that as soon as possible. But building and operating a telescope on the Moon to be the "Night Watch" for Earth is far superior and something that the public can get behind—especially once they understand this project could also open the space frontier to them.

A staff of four to six people could assemble and oversee the operation of the telescope while studying the Moon's resources and developing skills and tools needed to extract oxygen, water, and minerals from lunar soil—technology that can be applied to manufacturing fuel cells and mining asteroids for precious metals. Private industry could support this new government lab with cargo and crew transportation like they do for station—and then expand their market by opening up the Moon for tourists and business. Couples may honeymoon on the Moon. People may buy jewelry made of 4.5

billion-year-old stones. Athletes may ski down lunar mountains as tall as Mt. Everest. Business may develop advanced robots to manufacture solar arrays and fuels to power humanity's expansion into the solar system.

This international lunar station might be built using Orion and SLS or a combination of commercial and international assets. Spinoffs in new technologies and industries plus astronomical discoveries that could rewrite our understanding of the universe, could payback much of their investments. And saving the planet from an asteroid strike is, of course, priceless.

The availability of lunar and asteroid materials and in-space transportation systems will make building and supplying the first Mars settlements affordable. A whole new branch of human civilization may evolve on Mars, or in O'Neill space-based settlements.

McAuliffe's lesson about space being for everyone can be achieved.

But it won't be easy, especially for young women who want families. At the Lunar and Planetary Science Conference in 2012, the women of planetary science held a banquet to discuss the reason that more women weren't in management positions despite being a majority in graduate school. The answer came clearly when a baby cried out from the back of the banquet hall. Women were dropping out of the workforce to care for their children. Many of them are still making the same choice I did, especially if they want to continue nursing, their child is frequently sick, they don't feel that their employer appreciates them, or they can't earn enough money to justify paying for daycare.

NASA still doesn't offer part-time positions to professionals, even on a short-term basis. Child care remains a difficult challenge for all parents, especially for children with chronic health issues. Schools continue operating on schedules inconsistent with a normal 9–5 workday and all-year employment. And I've unfortunately had multiple reports from women that men at NASA and with NASA contractors continue to take credit for their work and are favored for plum assignments and promotions, reducing the incentive to even try to juggle family and work.

But some improvements have been made. JSC opened an onsite day-care center in 1990. In 1993, federal law required up to 12 weeks of unpaid leave to both men and women for the birth or adoption of a child. In 1997, smoking in federal buildings (including Mission Control) was outlawed. In 2006, JSC offered workers more flexible hours. In 2010, a federal law required employers (of more than 50 people) to give break time to women to express breast milk and a place to do it. Women now serve in many top management positions, including JSC director.

Overall, NASA's done a good job providing opportunities for women who want to be part of the space program. I'm grateful I had the chance to be among the first women flight controllers. I'm also thankful for the opportunity that Hernandez Engineering (subsumed into Bastion Technologies) offered for meaningful work when I was a new mom. I'm indebted to the editors who have helped me become a better writer so I can continue to promote our space program through stories, articles, and books, including *Welcome to Mars: Making a Home on the Red Planet*, coauthored with one of the men who walked on the Moon that Sunday in July of 1969, *Apollo 11* astronaut Buzz Aldrin.

So though no women (or cats) have (yet) been to the Moon, there are no factories in space, and people don't live in O'Neill colonies, I still believe that eventually, these things can and will come about through the combined efforts of government, industry, international partners, and kids who are impatient to visit the real Tomorrowland.

The story of that skinny red-headed girl from Ohio who wants to be an astrogator is still a work-in-progress. If she can't be an astrogator on a starship, maybe she can provide the stories and information others need to become astrogators when the opportunity beckons.

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Appendix A

FIRST WOMEN FLIGHT CONTROLLERS

No women flight controllers have been identified as holding MOCR positions during the Gemini and Apollo programs, though some worked support positions. Data was unavailable for Skylab 2 (May 25–June 22, 1973) and 3 (July 28–Sept. 25, 1973). For Skylab 4 (Nov. 16 1973–Feb. 8, 1974), the only MOCR operator identified was **Dr. Carolyn Huntoon** who served as (Medical) Experiments. No women were listed as MOCR operators for Apollo-Soyuz (July 15–24, 1975). No staffing charts were published for the Space Shuttle Approach and Landing tests (August–Oct., 1977). Skylab re-entry (July 1979) included at least three women, GNCs, **Bonnie J**. **Dunbar** and **Cindy Major**, and **Debbie Pawkett** as Apollo Telescope Mount Digital Camera Software Control Officer. Shuttle flights up through the 25th flight, STS-51-L (Jan. 28, 1986), are included except for STS-51-C (Jan. 24–27, 1985) which was a classified flight.

This list does not include women who worked as flight controllers in support positions or launch controllers at Kennedy Space Center. The International Women's Air and Space museum lists JoAnn Morgan as the first woman launch controller.

Not all positions were listed for every flight (such as PAO/Surgeon). Some positions were later moved to a support room or merged with other positions. Any position listed as being a MOCR position was "counted" (such as Aero and Command) as long as it was on the published roster. For women who worked the same flight, the Ascent Team members are listed ahead of the other teams, and otherwise, in alphabetical order by last name. Most women worked multiple flights, but are only listed for their first appearance in the MOCR.

M.J. Dyson, *A Passion for Space*, Springer Praxis Books,
DOI 10.1007/978-3-319-20258-7

WOMEN SPACE SHUTTLE FLIGHT CONTROLLERS 1981–1986

1. Sharon R. Tilton—Surgeon, STS-1 (Ascent Team)
2. Lizabeth (Betsy) H. Cheshire—Computer Command, STS-1 (Entry Team)
3. Anngienetta (Angie) R. Johnson—Payloads, STS-2 (Ascent Team). First black woman
4. Linda G. Horowitz—Aerodynamics, STS-2 (Orbit Team)
5. Sally K. Ride—Capcom, STS-2 (Orbit Team)
6. Carolynn L. Conley—FAO, STS-3 (Ascent Team)
7. Ellen L. Schulman—Surgeon, STS-3 (Ascent Team)
8. Marianne J. Dyson—FAO, STS-4 (Entry Team)
9. Jenny Howard—Booster, STS-5 (Orbit Team)
10. Carolyn H. Blacknall—OIO, STS-5 (Entry Team)
11. Mary L. Cleave—Capcom, STS-6 (Planning Team)
12. Kathryn A. Havens—Upper Stage, STS-6 (Planning Team)
13. Cheevon (Mi-Mi) B. Lau—FAO, STS-6 (Entry Team)
14. Debbie T. Pawkett—Payloads, STS-7 (Orbit Team)
15. Gayle K. Weber—Guidance, STS-7 (Planning Team)
16. Michele A. Brekke—Payloads, STS-8 (Orbit 1 Team)
    (No new firsts on STS-9, STS-41-B, or STS-41-C)
17. Linda M. Godwin—Payloads, STS-41-D
18. Karen F. Ehlers—FAO, STS-41G (13) (Planning team)
19. Barbara N. Pearson—EECOM, STS-41G (13) (Planning team)
20. Linda P. Patterson—GNC, STS-51A (14)
    (Missing data for DOD flight STS-51-C, no new firsts on STS-51-D)
21. Diane L. Freeman—FAO, STS-51-B (Orbit 2)
22. Linda J. Hautzinger (Ham)—Prop, STS-51-B (Orbit 2)
23. Sharon B. Castle—Payloads, STS-51-B (Orbit 3)
24. Billie Deason—PAO, STS-51-G
25. Janet K. Ross—PAO, STS-51-G
26. Patricia A. Santy—Surgeon, STS-51-F
27. Barbara A. Schwartz—FAO, STS-51-I
28. Karen M. Alig (Engelauf)—FAO, STS-51-J
29. Shannon W. Lucid—Capcom, STS-61-A (D1) (Orbit 1)
30. Kathy V. Cannon—Payloads, STS-61-A (D1) (Orbit 3)
31. Anne F. Ellis—FAO, 61A (D1) (Orbit 3)

Appendix B

FIRST 25 SHUTTLE FLIGHTS

Flight	Dates	Orbiter	Crew (in order: commander, pilot, mission specialists, payload specialists)
STS-1	April 12–14, 1981	*Columbia*	John Young, Robert Crippen
STS-2	Nov. 12–14, 1981	*Columbia*	Joe Engle, Richard Truly
STS-3	March 22–30, 1982	*Columbia*	Jack Lousma, Gordon Fullerton
STS-4	June 27–July 4, 1982	*Columbia*	TK Mattingly, Hank Hartsfield
STS-5	Nov. 11–16, 1982	*Columbia*	Vance Brand, Bob Overmyer, Joe Allen, Bill Lenoir
STS-6	April 4–9, 1983	*Challenger*	Paul Weitz, Karol Bobko, Don Peterson, Story Musgrave
STS-7	June 18–24, 1983	*Challenger*	Bob Crippen, Fred Hauck, Sally Ride, John Fabian, Norm Thagard
STS-8	Aug. 30–Sept. 5, 1983	*Challenger*	Richard Truly, Dan Brandenstein, Guy Bluford, Jr., Dale Gardner, Bill Thornton
STS-9 SL 1	Nov. 28–Dec. 8, 1983	*Columbia*	John Young, Brewster Shaw, Robert Parker, Owen Garriott, Byron Lichtenberg, Ulf Merbold
STS-11 41-B	Feb. 3–11, 1984	*Challenger*	Vance Brand, Robert Gibson, Bruce McCandless, Robert Stewart, Ron McNair
STS-13 41-C	April 6–13, 1984	*Challenger*	Bob Crippen, Dick Scobee, Terry Hart, James van Hoften, George Nelson
STS-14 41-D	Aug. 30–Sept. 5, 1984	*Discovery*	Hank Hartsfield, Mike Coats, Richard Mullane, Steve Hawley, Judy Resnick, Charlie Walker
STS-17 41-G	October 5–13, 1984	*Challenger*	Bob Crippen, Jon McBride, David Leestma, Sally Ride, Kathy Sullivan, Paul Scully-Power, Marc Garneau
STS-51-A	Nov. 8–16, 1984	*Discovery*	Fred Hauck, David Walker, Joe Allen, Anna Fisher, Dale Gardner
STS-51-C	Jan. 24–27, 1985	*Discovery*	TK Mattingly, Loren Shriver, Ellison Onizuka, James Buchli, Gary Payton

(continued)

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Flight	Dates	Orbiter	Crew (in order: commander, pilot, mission specialists, payload specialists)
STS-51-D	April 12–19, 1985	*Discovery*	Karol Bobko, Don Williams, Jeff Hoffman, S. David Griggs, Rhea Seddon, Charlie Walker, Senator Jake Garn
STS-51-B SL 3	April 29–May 6, 1985	*Challenger*	Bob Overmyer, Fred Gregory, Don Lind, Norm Thagard, Bill Thronton, Taylor Wang, Lodewijk van den Berg
STS-51-G	June 17–24, 1985	*Discovery*	Dan Brandenstein, John Creighton, John Fabian, Steve Nagel, Patrick Baudry, Sultan Salman Abdul Azziz Al Sa'ud
STS-51-F	July 29–Aug. 6, 1985	*Challenger*	Gordon Fullerton, Roy Bridges, Sotry Musgrave, Anthony England, Karl Henize, Loren Acton, John-David Bartoe
STS-51-D	Aug. 27–Sept. 3, 1985	*Discovery*	Joe Engle, Richard Covey, James van Hoften, Bill Fisher, John Lounge
STS-51-J	October 3–7, 1985	*Atlantis DOD*	Karol Bobko, Ron Grabe, David Hilmers, Robert Stewart, Maj. William Pailes
STS-61-A SL D1	Oct. 30–Nov. 6, 1985	*Challenger*	Hank Harstfield, Steve nage., James Buchli, Guion Bluford, Bonnie Dunbar, Reinhard Furrer, Wubbo Ockels, Ernst Messerschmid
STS-61B	Nov. 26–Dec. 3, 1985	*Atlantis*	Brewster Shaw, Bryan O'Conner, Sherwood Spring, Mary Cleave, Jerry Ross, Charlie Walker, Rodolfo Nieri Vela
STS-61-C	January 12–18, 1986	*Columbia*	Robert Gibson, Charles Bolden, Jr., George Nelson, Steve Hawley, Franklin Chang-Diaz, Robert Cenker, Rep. Bill Nelson
STS-51-L	January 28, 1986	*Challenger*	Dick Scobee, Mike Smith, Ellison Onizuka, Judy Resnick, Ron McNair, Gregory Jarvis, Christa McAuliffe

Appendix C

ACRONYMS AND ABBREVIATIONS

AOA	Abort once around
AOS	Acquisition of signal
APU	Auxiliary power unit
ATO	Abort to orbit
BFS	Backup flight system
CAP	Crew activity plan
CAPCOM	Capsule communicator, astronaut in Mission Control
CAPS	Crew activity planning system
CFES	Continuous flow electrophoresis (payload)
CIR	Cargo integration review
COAS	Crew optical alignment sight (navigation device)
CPCB	Crew Procedures Change Board
CRT	Cathode ray tubes, computer displays
CSR	Customer support room
DFI	Detailed flight instrumentation
DOD 82-1	Designation of the secret military payload on STS-4
DPS	Data processing system
EECOM	Environmental consumables and mechanical engineer (MCC position)
EEVT	Electrophoresis equipment verification test (STS-3 payload)
EGIL	Electrical generation, instrumentation, and lighting engineer (MCC position)
E&M	Electromagnetism
EMU	Extravehicular mobility unit
ET	External tank
FAO	Flight activities officer (MCC position)
FBO	Fixed base operator (at airports)

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FCS	Flight control system
FD	Flight day
FDO	Flight dynamics officer (MCC position)
FES	Flash evaporator system
FLIGHT	Flight director (MCC position)
FOD	Flight Operations Directorate and MCC position
GAS	Get-away special
GUIDANCE	Guidance officer (MCC position)
GNC	Guidance, navigation, and control (MCC position)
GPS	Global positioning system
IECM	Induced environment contamination monitor (STS 2, 3, 4 experiment)
IMU	Inertial measurement unit
INCO	Instrumentation and communications officer (MCC position)
JSC	Johnson Space Center
KB	Kilobyte, 8192 bits
KSC	Kennedy Space Center
KW	Kilowatt
L−	Launch minus
LOS	Loss of signal
MCC	Mission Control Center
MECO	Main engine cutoff
MER	Mission evaluation room
MET	Mission elapsed time
MLR	Monodisperse latex reactor (STS 3 and 4 payload)
MMU	Man maneuvering unit
MOCR	Mission operations control room
MPAD	Mission Planning and Analysis Division
OAST	Office of Aeronautics and space Technology, a payload for STS-14
OMS	Orbital maneuvering system
OPS	Operations
OU	Ohio University
PAM	Payload assist module
PAO	Public affairs office or officer (MCC position)
PDP	Post insertion deorbit prep (STS-1, 2 document), Plasma Diagnostic Package (STS-3 payload)
PIP	Payload integration plan
PLBD	Payload bay doors
POCC	Payload operations control center (at MSFC)
POP	Perpendicular to the orbital plane
PSI	Pounds per square inch (pressure unit)
PTC	Passive thermal control
RCS	Reaction control system
RMS	Remote manipulator system, also MCC position

RMU	Remote manipulator systems, mechanical systems, and upper stages (MCC position)
RTLS	Return to launch site (abort)
SBS	Satellite Business System, STS-5 payload
SIR-A	Shuttle imaging radar, part of OSTA-1 payload on STS-2
SPAN	Spacecraft analysis
SRB	Solid rocket motors
STS	Space transportation system
TIG	Time of ignition (of the deorbit burn)
UHF	Ultra-high frequency (radio communications)
UNCG	University of North Carolina at Greensboro
VFR	Visual flight rules (for pilots)
VOR	Very high frequency Omni-directional radio (used by airplanes)
ZLV	An attitude with the Z (top to bottom) axis pointed at the center of the Earth and the wings defining local vertical

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