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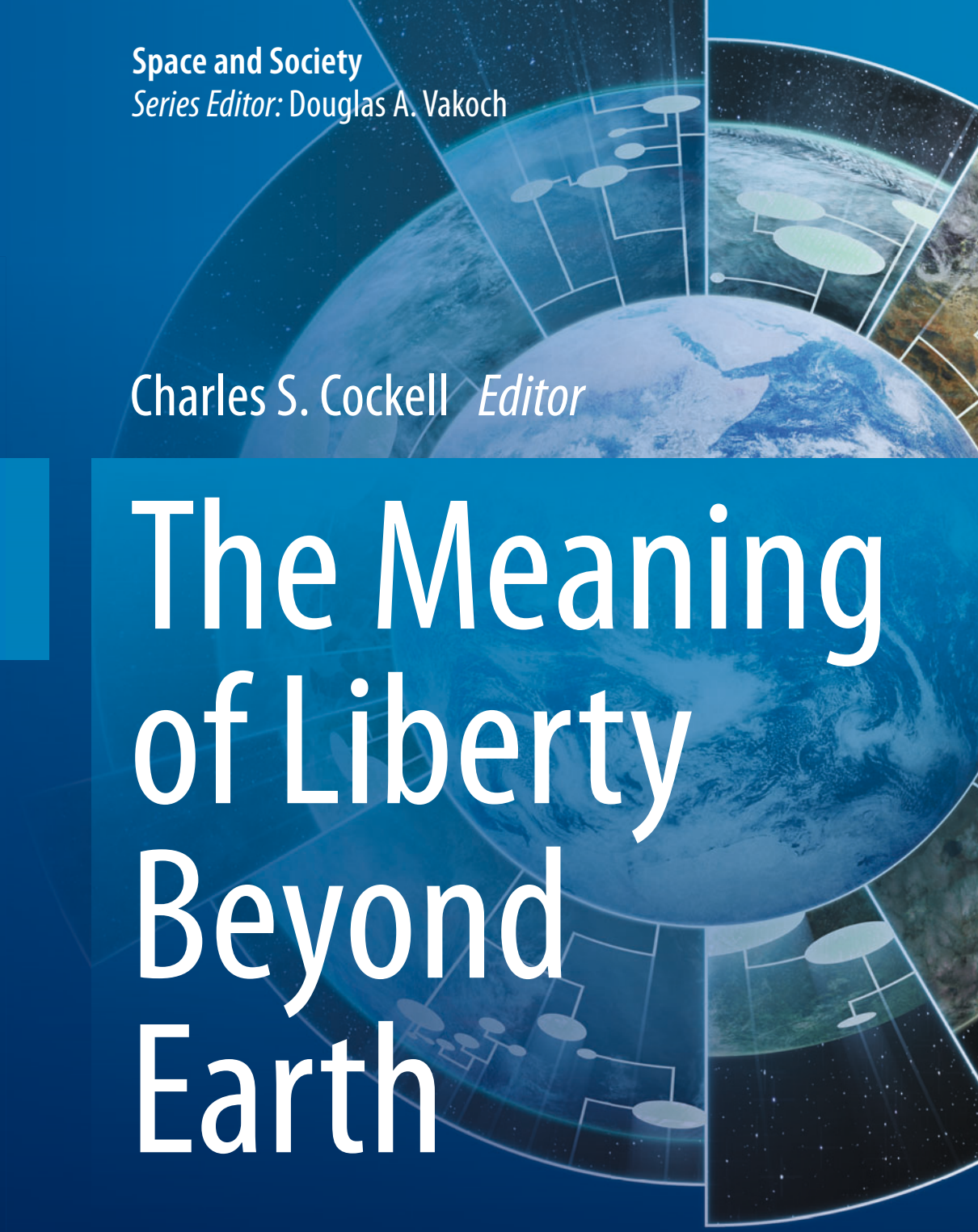
Charles S. Cockell *Editor*

The Meaning of Liberty Beyond Earth



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The Meaning of Liberty Beyond Earth

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Preface

In an age where geographical boundaries are weakening through electronic communications, but strengthening in places where groups of people feel a new found confidence to express their national and ethnic identity; in an age where surveillance has become technologically easier and its means more pervasive; and in an age where environmental concerns have forced us to begin to cooperate on an international level not seen before, the meaning of the word 'liberty' and the place of individual freedom, has become a topic once more of concern to all human beings.

However, alongside these Earth-bound concerns, there is emerging an entirely new playing field on which intellects and governments will decide the fate of human freedom—outer space.

As more national governments develop expansive space programmes and more private companies design and build spaceships with the capacity to launch satellites, robots and humans into space, the number of organisations in space is growing. With this expansion comes the inevitable consequence of an expanding number of interests to protect and so with that, the chance for a clash of ownership, rules and regulations which together define the environment for individual freedom.

There are not, at the time of writing, a large number of humans in space to argue about their liberty, but this will surely change. And this small band of extraterrestrial settlers, whenever they take root on the space frontier, will exert an influence on terrestrial liberty. Having oversight and control over the geopolitically important places above the Earth's gravity well, their view of freedom will be as significant for the people that sit at the bottom of the gravity well into which they peer as it will be for them. It will not take many people in space to make a discussion of extraterrestrial liberty relevant.

This book is a collection of essays on extraterrestrial liberty. The bulk of them is the intellectual progeny of a meeting we held in London in June 2013 co-organised by the UK Centre for Astrobiology and British Interplanetary Society to consider what freedom is beyond the Earth.

We would like to thank the British Interplanetary Society for supporting this discussion, which has led to this collection. We would also like to thank Springer, in particular Ramon Khanna, Charlotte Fladt and Doug Vakoch at the SETI Institute for bringing this book into fruition.

Edinburgh, 2014 Charles S. Cockell

Contents

Chapter 1
Introduction: The Meaning of Liberty Beyond the Earth

Charles S. Cockell

Abstract The environments of space are lethal, mandating a variety of control and safety structures, some of which will be much more pervasive, and potentially intrusive, than on the Earth. Protecting, and even defining freedom, in these environments constitutes an important development in political philosophy. In this volume of essays, we discuss a set of ideas that range from the philosophical foundations to the policy implications of extraterrestrial liberty. The breadth of discussion is by no means exhaustive, but it does reveal the potential for a long and controversial discussion on freedom that is likely to follow humans into space and remain with them for as long as they attempt to settle the space frontier.

Keywords Liberty · Freedom · Extraterrestrial · Tyranny · Political philosophy

Since humans first assembled themselves into complex societies, and with great vigour during the Enlightenment, people have wondered: 'What is freedom?'

To date there has been no successful resolution, probably because the word itself, freedom, defies accurate description. 'Liberty', usually used interchangeably with freedom, is similarly nebulous. No matter how much the question remains unsolvable on account of its inextricable link with human definitions, it nevertheless strikes at the heart of very fundamental and real concerns. The question can perhaps, ironically, be made clearer with a set of more wordy questions such as: 'To what extent can I be independent from other people?', 'How much does my ability to express my own ideas and potential depend on being a member of society?' and 'To what extent does my freedom encompass freedom from the state?'

During the last 400 years, the breadth and depth of this study has been impressive: Hobbes, Locke, Mandeville, Mills, Filmer, Kant, Berlin, Popper, Marx, Paine, Rawls, Skinner—and the list goes on. It is not the purpose of this Introduction to review the arguments and counter-arguments of which this plethora of literature is comprised. However, there is something remarkable about all of these

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tomes—that none of them addresses how the precepts of freedom and individual liberty might develop or change beyond the Earth. Philosophers such as Hannah Arendt have taken intellectual excursions to consider the effects of the space frontier on the human outlook, but extraterrestrial freedom per se remains an unexplored issue.

Any author before the beginnings of 1950s science fiction and the birth of the space age in the first flicker of Sputnik's 1957 communication might be forgiven for ignoring this topic. However, it is surprising that the future of liberty beyond the Earth has failed to capture the interest of political philosophers since then. It certainly has not been ignored by science fiction writers, as Stephen Baxter, in this volume, explains. Independence movements have been a popular trope, for example explored by Robert Heinlein in his novel, 'The Moon is a Harsh Mistress'. Underpinning these stories there still lurks the question of what freedom is beyond the Earth. Science fiction provides a backdrop with which to explore questions about social development in space, but it is difficult in the context of fictional narratives to drill into a subject with academic purpose. Extraterrestrial liberty has so far eluded the formal, and very extensive, line of thinking on liberty. Nevertheless, science fiction provides a rich source of concepts that might be mined.

The question demands our attention because it is not clear that it is a problem restricted to the future inhabitants of the space frontier. If our hopes for settlement come to fruition, then resources, energy supplies and less enticing, the threat of kinetic weapons, will redound to the people of Earth. It is in the interests of both the terrestrial population and space explorers to understand the origins of tyranny and therefore the nature of freedom beyond Earth.

For a long time to come, the population of Earth will exceed that of space, but nevertheless, Earth is spatially small compared to the infinite recesses of the Universe. From a geographical point of view, any species that has ambitions ultimately to leave its home world and expand into space, must, by default, have an interest in expanding the various social questions that have occupied it on its planet of origin.

So far the space environment is one of the most extreme environments explored by humanity. The lack of atmospheres with a composition similar to that on Earth and the very different fate of volatiles, such as water, lead universally to environments that lack readily available indigenous supplies of three commodities crucial to human existence: breathable air, liquid water and food. The paucity of these basic requisites cannot be described as a denial of any form of liberty. Like the inability for a human individual to fly without technology on Earth, they are a fact of Nature, an unassailable result of the extraterrestrial physical environment. However, their want puts into motion human social arrangements that will influence the character of liberty in very profound ways. In this book, John Cain explores how the constraints of living and working in space, and the health issues that result from being an astronaut, directly affect the type of freedom that can be experienced in space.

In this view we find strains of Montesquieu, who, in the 'Spirit of the Laws' (de Montesquieu 1748), so thoroughly linked human societies to their climatic conditions. Although few today would agree with his emphasis on environmental conditions as determinants of human character, and we would probably accept that core

human behaviours are not so readily fashioned by climate as he supposed, the sheer extremity of space makes the impact of the environment on human social institutions, and thereby indirectly on human behaviour, surely unavoidable.

Tony Milligan brings a much needed view of reality into the debate, reminding us that all the romantic views of space exploration, from which a utopian view of extraterrestrial liberty might emerge, must be balanced by an understanding of our human vulnerabilities. He draws on Ballard's and Arendt's space scepticism to fashion a view of how, whatever does become of liberty beyond Earth, it must be constrained by the true nature of the human character. Charles Peterson explores how the human experience will shape our view of liberty and points out that when, and if, we find another planet to colonise that is similar to the Earth the types of liberty experienced there will be familiar to us. However, in the expanses of interstellar space, an environment very different to the Earth in which we have not yet permanently lived, we cannot readily imagine how people will conceive of liberty.

Space environments will require collective efforts of enormous magnitude to extract atmospheric gases from indigenous planetary atmospheres or rocks to make breathable air, to melt ice or extract hydrogen and oxygen from rocks to make liquid water, to build plant growth units, provide them with energy and tend to them to yield food. These thoroughgoing collective efforts will create environments where individualism may appear to be a luxury. Conformity will be rife. The instantaneously lethal external conditions will similarly demand safety protocols and supervision that may sharpen the instruments of tyranny.

Individualism as we understand it today might give way to the more ancient Greek concept of freedom as the capacity to realise one's potential within the City State, the *polis* (Constant 1998). The resources and safety mechanisms generated by the extraterrestrial collective will be the very environment in which one is capable, as an individual, of living and realising one's potential. This view is one easily manipulated into an excuse for collective control—the more people are coerced, the stronger the collective, the stronger one's assurance of survival in a lethal environment and therefore the stronger one's freedom to be more expressive and ambitious in one's personal objectives.

It probably would not be too far wrong, then, to say that the environment and its influence on social policies will be one important factor influencing how liberty evolves in the extraterrestrial environment. The environment will be a crucial influence on how the ancient conflict between individualism and collectivism as the means to attaining the freedom of the individual is to be kept in check.

Flowing from this is the question of how fairness is to be achieved in the way laws and regulations are written and how they are implemented. James Schwartz provides an analysis of how the Rawlsian concept of justice could be applied in the space frontier—to planetary protection, space settlement and the more mundane near-term concern of orbital debris. His chapter underlines at least two important ideas. First, as on Earth, the character of liberty will be decided by how individuals, organisations and the regulations they draw up come together and, crucially, under what principles they come together. Second, extraterrestrial liberty is not some far-spun speculation. The liberty that states and other actors have in how they behave in

locations such as geosynchronous orbits, particularly with respect to space debris, is already a going concern. Extraterrestrial liberty has become a necessary branch of political philosophy.

This point is elaborated by Javier Martin-Torres, who discusses the implication of the detection of life, either microbial or intelligent, on planetary protection and operating guidelines for planetary missions. His chapter underscores the observation that already we are not entirely free in how we conduct ourselves in space. The discovery of life would have implications for the liberty of those operating the mission, as well as ethical consequences for our behaviour with respect to any life discovered. Even in the absence of life, we require protocols to prepare us for the possibility of its discovery alongside planetary protection protocols. The mere possibility of the discovery of extraterrestrial organisms already places constraints on extraterrestrial liberty.

One way to see the problem of extraterrestrial liberty is to reduce it to the simple conceptual question of whether the limits of individual or collective action can be tolerated within the social structure forced upon a society by the extremities of the external environment (Fig. 1.1). When an environment, such as many locations on

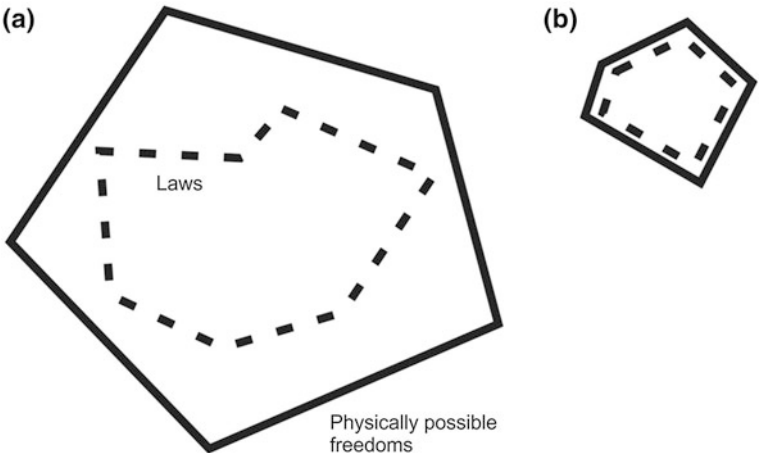

Fig. 1.1 **a** When the environment is clement, for example in many places on Earth, the range of theoretically plausible human actions (*solid line*) is often much larger than those ultimately circumscribed by state laws, edicts and social mores (*dotted line*). Indeed, most civil liberty campaigns are about pushing the dotted line outwards to the maximum extent possible. **b** However, when the environment is extreme, the state and society may be forced to adopt policies (*dotted line*) that are penned in by human capacities and the realities of existence in a lethal environment (*solid line*). Determining when edicts, laws and customs are a necessary result of the restriction unavoidably imposed by the environment, or when they are unnecessary coercion and interference, is a serious challenge in the pursuit of liberty, magnified under extraterrestrial environmental conditions. If some individuals are unaware that certain laws are absolutely required for survival, then when they compare the restrictions imposed by the state in their extraterrestrial environment (*dotted line* **b**) to those of Earth (*dotted line* **a**), they may become convinced that they are living in despotism

Earth, offers a physical space generally clement to human existence, then the boundaries of human action can be wide as few of these actions represent a direct threat to the existence of other humans, let alone the continuity of a very large number of them. A concept of liberty strongly rooted in freedom as the lack of interference and an absence of state intrusion becomes attainable.

In the extraterrestrial environment, where regulations and social coordination are needed to ensure the delivery of air, water and food, the social environment cannot so readily absorb the idiosyncrasies of wild, ambitious and expansive people; the minimum boundaries of authority may restrict many of the behaviours and ambitions regarded as quite normal expressions of individual freedom in some locations on Earth. Minimal state interference may be negligible, but apparently tyrannical nonetheless.

On Earth, this dilemma is not unknown. In polar environments, inclement conditions and sometimes lethal external conditions result in strict and often hierarchical power structures in polar stations. Few of the people that operate in these environments live there: they accept restrictions as the necessary price of doing science in extreme conditions. In environments where people do live permanently in extreme conditions, such as the Inuit of the High Arctic, their methods of collective control are well known. Fossett observed of them:

> Means of enforcing peace and harmony within communities included shaming, shunning, banishment, abandonment leading to death, and execution. Public ridicule and ostracism were the most frequently used methods of social control, and generally had the desired effect of keeping people cooperative. (Fossett 2001)

These communities are not without expressions of individualism. Inuit art is well known (von Finckenstein 2007) and these communities may provide something of a template for understanding how the collective effort required for a community to survive in lethal environments can be reconciled with the projection of individualism. Annalea Beattie looks at art and creative practices in environments on Earth, including Mars analogue environments, and asks what they might be able to tell us about art as a means to pursuing individual freedom in outer space.

In some of the analyses presented here, we see inherent contradictions and paradoxes in space that arise from the need for collectivism to survive and yet this is coupled with the need to find room for the individual in space. Charles Cockell explores the nature of some of these paradoxes and finds them to cut across the political, economic and cultural spectrum of extraterrestrial society. Finding ways to manage them and canalise them in positive ways will be essential if they are not to tear the extraterrestrial society apart.

It is quite possible that extraterrestrial societies may retreat into a more Stoic version of individualism—something found within and expressed through art, philosophy and other activities that do not require free physical movement, with a more subdued form of externally expressed individualism. In such an environment, it becomes irrelevant whether one takes the view that liberty is about freedom from interference or the capacity to realise one's potential. Greater interference becomes necessary and the extreme environment creates social obligations and requirements

that restrict the opportunities for individuals to pursue their own, very unique social projects.

Emphasis can be placed on how individualism might become fashioned by the environment of space, but another factor of enormous significance is the source of tyranny that will erode liberties. On Earth it might be convenient to recognise two types of tyranny, let us call them external and internal tyranny. External tyranny is tyranny imposed on a group of people from outside and is usually in the form of invading armies, international restrictions and the like. Internal tyranny is the tyranny that emerges from within a group of people, from the social conditions that develop from the way in which the community organises itself. It could come from one of their number taking control of the group, such as a dictator. It could come from the subtle appearance of a social culture and creed that emerges from the way in which a group of people adapts to the environment in which it lives.

A tantalising characteristic of outer space is the opportunity to escape external tyranny. Freed into the vast expanses of interplanetary and interstellar space, human societies are granted reprieve from the densely populated cities of Earth, afforded an extraterrestrial anonymity where they can escape persecution, pursuit and coercion. Space has always been seen as a liberating frontier from this perspective. Its boundaries are limitless and its sheer spatial scales will overwhelm even the best organised apparatus of military or law enforcement.

The possibility that space might afford individuals an escape from state regulations experienced on Earth, a type of reversion to a more natural state of nature, closer to a Lockean vision of freedom than has been possible in most modern societies, is explored by Paul Rosenberg. He compares the American wilderness frontier and cyberspace to the possible opportunities for liberty that the infinite volumes of the space frontier might allow.

The immense spatial scales of outer space offer a possibility for those who escape early enough to outrun their pursuers. As Stuart Armstrong and colleagues explain, by setting off into space at a fraction of the speed of light early, pursuers are eventually left with the impossibility of catching up. Indeed, the recognition that the laws of physics aid those seeking freedom might itself induce tyrants, and civilisations as a whole, to pre-empt these possibilities by beginning a mass colonisation effort.

Space is not without inherent limitations on tyrants. Given the immensely destructive capabilities of kinetic weapons, war may be a prohibited option for a civilisation, as Stephen Baxter and Ian Crawford discuss. A mirror image of terrestrial war and violence in space is not a forgone conclusion. It may be limited by the hard realities of physics as much as by human policy.

To escape external tyranny is not to escape internal tyranny. The extremities of space heighten the chances that despotism will emerge within a social group whether by opportunistic activities of dictators who seize upon an isolated and vulnerable group, or from the social coercion that results from even the most liberal and well-meaning attempts to organise society against the lethal external conditions. Escape from external tyranny is no prize when internal tyranny subjugates to a greater extent (Fig. 1.2).

Fig. 1.2 A trivial cartoon that surfaced widely on the internet in 2013 depicting a person released from prison into terrestrial society. However, it very succinctly raises the central question which this book explores—will the apparent freedom of escaping the Earth merely leave humans at the mercy of other forms of entrapment or tyranny in the very societies they construct, regardless of the spatial scale of the interplanetary and interstellar environment?

It is evident that finding solutions to tyrannical extraterrestrial leadership depends much on the character of constituted authority and the form of government. Ian Crawford explores the nature of federalism beyond Earth and its suitability as a means to realising collectivist needs, while maintaining the maximum amount of freedom. He shows that by drawing on the lessons learned on Earth, there is much that can be done in advance to shape a future in space where liberty is maximised.

The choices faced by extraterrestrial societies is examined by David Baker, who explores the issues they will have to contend with while deciding what sort of government they want beyond Earth—decisions that will turn on the very definitions of democracy and liberty that they choose to adopt.

The successful establishment of extraterrestrial settlements will not only depend on the manner in which rules are developed on Earth prior to settlement, but how these emerge in the extraterrestrial frontier and how they will ultimately determine the freedom of future colonists. This facet of liberty is explored by Rick Wylie.

As extraterrestrial governance evolves, what might define basic rights in space? Is it likely that in attempting to protect their right to oxygen, space settlers will end up compromising rights that on Earth would be considered fundamental? William Paley intriguingly wrote in 1785:

> Natural rights are, a man's right to his life, limbs, and liberty; his right to the produce of his personal labour; to the use, in common with others, of air, light, water. (Paley 1785)

It is not clear what Paley really meant by 'air'. Perhaps he was referring to air unadulterated with the fumes of industrialisation, but inadvertently he had written the sort of sentence that one might envisage coming from the eager minds of extraterrestrial denizens attempting to circumscribe the boundaries of their

freedoms and to protect a basic right to breathe oxygen free of coercion and tyranny. Oxygen, or air, has rarely been the subject matter of political discourse on Earth, and when, such as in Paley's case, it has found its way into the literature of liberty, it is not a reference to the possibility of being denied *any* air to breathe. The extraterrestrial environment demands of liberty seekers a newfound interest in what constitutes freedom—and a new focus on the rights and laws that are to be used to protect it.

There can be little hesitation in saying that the nature of liberty beyond the Earth, and its future, will depend on the education of the people subjected to it. Just as our own concepts and expectations about what freedoms we have is fashioned by our societies and our education, so the way in which education develops in space will surely frame the view that extraterrestrial settlers have of the space frontier and its limitations and possibilities for the expression of individual freedom? In a chapter exploring this problem, Janet de Vigne investigates how education will be pivotal in the trajectory that extraterrestrial freedom ultimately takes. We can presume as well, that even if it is a while before people are born in space, it will always be the case that terrestrial education will have a strong influence on how people travelling into space expect others to behave towards them in recognising their liberties and rights. Maybe extraterrestrial liberty should be a point of discussion in terrestrial curricula as well as for those children eventually born beyond the Earth? If space settlements ultimately influence the Solar System economy and the political and economic conditions on Earth, it might be wise for the Earthbound to take more than a passing interest in understanding the history of liberty and its application to the far-flung and seemingly remote societies in space.

The question 'Freedom, more or less than on Earth?' is one way to study liberty in space. It sets the problem up as a comparison. With a wide array of literature on liberty spanning millennia, perhaps it seems sensible that an approach to understanding liberty in space is to compare it with what we know on Earth. Most of the essays in this volume deliberately, or without obvious intention, ultimately make reference to our experiences on Earth.

To some extent the differences between liberty on Earth and in space are a matter of degree. Water and food in most countries on Earth are subject to strict state guidelines on safety. Most of us no longer acquire these commodities from the natural environment. In that sense, many of us are part of an enormous urban life-support system. Perhaps in a very large extraterrestrial settlement many facets of authority and regulation will be no more overt or visible to the population than they are for many people on Earth. However, aspects of liberty in space would seem to be categorically different from those on Earth. The permanent lack of freely breathable atmosphere must surely influence the sense of freedom experienced? The isolation of communities, the delays in communications with other planetary bodies caused by the finite speed of light, that in some ways throws extraterrestrial colonies back to a type of delayed pre-telegraph state of communication, must together act to create a society with a unique feel, a unique sense of what freedom is, what collective ambitions are and what the place of the individual is.

We probably cannot successfully predict the culture of an extraterrestrial society, but it may not be impossible to predict those characteristics of the extraterrestrial environment and of human character that will exert the greatest influence on liberty.

On June 13 and 14, 2013, we organised the first academic workshop to consider the question of liberty in space. 'Extraterrestrial Liberty: What is Freedom Beyond the Earth?' brought together speakers from around the world to the British Interplanetary Society, London, England to present, debate and discuss ideas. From this workshop emerged the idea for a book to explore some of these ideas and provide a lasting record of some of these deliberations.

We made no prescription of what we actually meant by liberty and left it instead to the speakers to explore their own interpretation. Liberty has been interpreted in a plenitude of ways: freedom as the satisfaction of basic everyday needs; freedom as lack of interference; freedom as self-realisation; freedom as the ability to choose one's government; freedom as the protection of basic rights. Aspects of all these versions of freedom are to be found in the chapters that follow.

This book is intended not just as a contribution to present-day discussions on extraterrestrial liberty, but in some sense as a historical record of what people in the 21st century thought about the future of liberty beyond Earth. It might provide a means for future space settlers to reflect on their situation against the backdrop of ancient thoughts. It might merely provide a volume of amusing ideas rooted in prejudices and perspectives long since dissipated. Whatever it is, we offer this book as one contribution to an undeniably and enormously important question for the branch of human society that inhabits outer space: The Meaning of Liberty Beyond the Earth.

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Part I
The Philosophical Basis of Extraterrestrial Liberty

Chapter 2
The Cold Equations: Extraterrestrial Liberty in Science Fiction

Stephen Baxter

Abstract This chapter is about explorations of extraterrestrial liberty in science fiction. Depictions of colonies beyond the Earth, either in space or on other worlds, date back at least as far as Hale's 'The Brick Moon' (1869). Many such works have explored the social and anthropological implications of off-Earth colonies, and as such have anticipated in fictional form much of the discussion elsewhere in this volume. These works of fiction, the result of more than a century's constructive speculation, serve as thought experiments on the subject. And by focussing on human characters, fiction may breathe fire into abstract theories of politics and society.

Keywords Science fiction · Extraterrestrial liberty · Space colonisation · Terraforming · Extraterrestrial life

2.1 Introduction

> It would not be inaccurate to say simply that children born in space will be the first humans to be reared in cages Cockell (2008).

This chapter is about explorations of extraterrestrial liberty in science fiction (SF).

Quasi-realistic depictions of colonies beyond the Earth, either in space or on other worlds, date back at least as far as Hale's 'The Brick Moon' (1869), which described life on an Earth-orbiting space station. Stories of space colonies were written during the development of the modern genre in the 20th century by Asimov (1952), Clarke (1951), Heinlein (1966) and many others, and this continues today in works by the likes of McAuley (2008), Reynolds (2012), Robinson (2012), and the author (Baxter 2013). Many such works have explored the social and anthropological implications

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of off-Earth colonies, and as such have anticipated in fictional form much of the discussion in Cockell (2013) and elsewhere in this volume.

These works of fiction, the result of more than a century's constructive speculation, serve as thought experiments on the subject. They may serve as a source of ideas, and an examination of issues raised; SF has always been an arena for debate. And by focussing on human characters, fiction may breathe fire into abstract theories of politics and society.

It would be inaccurate to call this essay a survey of the field. Any work which seeks to depict realistically a human community away from the here and now must necessarily deal with social and other issues, however superficially. It is clear that the most relevant works for our purposes will have been written with the *intent* to deal with such issues, but the boundary is not easy to draw. General surveys of the SF field include the classic work by Aldiss (1986) and a more recent history by Roberts (2006). The online SF Encyclopaedia (Clute 2013), is a fine, free and up to date resource.

This essay will consider first issues of liberty arising from the confinement and centralisation of extraterrestrial communities, as summarised by the Cockell quote given above, led by a discussion of the classic story from which the essay's title is derived. The essay moves on to a survey of revolutions and society-building in off-Earth contexts, before closing with a brief survey of issues relevant to the further future.

2.2 The Cold Equations: Liberty on the Space Frontier

> 'The door opened and the stowaway stepped through it, smiling. "All right – I give up. Now what?" It was a girl…' Godwin, 'The Cold Equations' (Godwin 1954).

Godwin's well-known short story 'The Cold Equations' (1954) is a stark illustration of the curtailment of human freedom of choice in the constrained environment of the 'space frontier', and since its first publication it has served as a focus for debate in the SF field about the implication of such constraints.

The story first appeared in the August 1954 issue of *Astounding Science Fiction*, edited by John W. Campbell. In terms of historical context (Aldiss 1986), SF, having been pioneered in the nineteenth century with works of great quality by Verne, Wells and others, had by the 1920s become a popular literature of more questionable quality published in the so-called 'pulp' magazines, especially in the US. Campbell (1910–1971), largely through his editorship of *Astounding*, did much to improve standards of literary quality and intellectual rigour in the field, and during SF's so-called 'Golden Age' (roughly the 1940s) nurtured such talents as Asimov, Clarke, Heinlein, Sturgeon and Van Vogt. Yet Campbell himself was a conservative American, arguably a libertarian, and this could be reflected in his editorial policies. Godwin (1915–1980), meanwhile, had worked as a prospector in the harsh environment of the Mojave Desert: a frontier of its age. Many of his

works explored the theme of nature's indifference to humanity—such as 'The Cold Equations'.

As is indicated in Campbell's original preface to the story, 'The Cold Equations' is a tale of the space frontier: 'The Frontier is a strange place—and a frontier is not always easy to recognize. It may lie on the other side of a simple door marked "No admittance"—but it is always deadly dangerous.'

The story is set on an Emergency Despatch Ship (EDS). In Godwin's future, passenger-carrying starships use such vessels as a rapid response to emergencies—in this case, to deliver medical supplies to a plague-stricken planetary colony. The ships have very tight fuel and mass budgets, to the extent that the extra mass of a stowaway will imperil the mission. Yet a passenger on the starship, a girl intent on visiting a brother on the target planet, has stowed away anyhow. And from early in the story the situation is presented starkly: the girl has to be ejected, voluntarily or otherwise.

'It was the law, stated very bluntly and definitely in grim Paragraph L, Section 8, of Interstellar Regulations: "Any stowaway discovered in an EDS shall be jettisoned immediately following discovery…"' There are no options, we are told; even the self-sacrifice of the pilot would result in the loss of the ship altogether. 'To [the pilot] and her brother and parents she was a sweet-faced girl in her teens; to the laws of nature she was x, the unwanted factor in a cold equation.' The girl had had no idea of the penalty: '"You still haven't told me," she said. "I'm guilty, so what happens to me now? Do I pay a fine, or what?"… In a way, she could not be blamed for her ignorance of the law; she was of Earth and had not realized that the laws of the space frontier must, of necessity, be as hard and relentless as the environment that gave them birth.'

Much of the story is presented with the stowaway trying to come to terms with this death sentence. Godwin piles on the sentiment: '"Yet I remember [my brother] more for what he did the night my kitten got run over in the street. I was only 6 years old and he held me in his arms and wiped away my tears and told me not to cry…"' The girl expects the pilot or his commanders to come up with some solution—and so do we readers, raised on a diet of softer-edged wish-fulfilment stories. Yet release never comes; the story stays true to its logic, and is pitiless.

In the end the girl walks voluntarily into the airlock, still baffled: '"I didn't do anything to die for… I didn't do anything…"'

Across six decades this brief story has remained famous, regularly anthologised and adapted for TV and radio. And yet it has also been the focus of intense debate within the SF community, especially over the last decade or so, according to critic Kincaid (2012). On the one hand some advocate the story as symbolising the core values of SF, or at least a certain kind of SF. According to scholar Gunn (2002), 'If the reader doesn't understand [the story] or appreciate its environment, then that reader isn't likely to appreciate science fiction'. Conversely Kincaid has attacked it bitterly: 'To protest that the story is sexist…is to miss the real fundamental problem… The death of the girl is directly traceable back to human agency, not to the law of the universe' (2012).

The debate is between those who argue for the virtues of frontier life—the idea that scarcity and a harsh environment is good for the individual, for society as a whole and perhaps even for the evolution of the human species—and those who argue for, if not utopian forms of stable societies, at least the protection of the vulnerable, the innocent, the weak, from nature's harshness. It can be seen that in Godwin's story this debate is framed in terms of an American sensibility; such was America's commercial dominance of SF during the 'Golden Age' at least that American themes, such as the folk memory of the 'frontier' days of the western expansion of the US, were regularly translated into SF forms. But other dichotomies can be mapped onto this tension: political right versus left, for example.

Kincaid alludes to specific criticisms of Godwin's story such as that it can be seen, retrospectively at least, as sexist, with competent men being contrasted to a foolish girl. But he identifies a deeper problem. In any situation it is not the physical environment that constrains human liberty—that provides an inviolable framework which none can escape—but human choices, laws, agency within that environment. To blur this distinction is to open oneself to an accusation of authoritarianism: *Because there is vacuum beyond that bulkhead, you must do as I say.* And 'The Cold Equations,' sadly, does blur that distinction. The 'competent men' who run the EDS system are really not terribly competent at all; any modern engineer would be appalled by the fact that the *only* deterrent to stowaways is a 'Do Not Enter' sign. It is not nature's indifference that causes the girl to die, but the inadequate design and control of human systems. Because of this flaw, the story cannot bear the weight of debate that has been loaded into it.

With a sympathetic reading the story does, however, work in its own terms. If one takes the story's inner logic at face value, one receives a chilling sense of the frontier's pitiless rigour: in defiance of the conventions of storytelling, there will be situations beyond human control, there will be situations where not everybody can be saved. And it is this natural rigour of the extraterrestrial environment that creates boundaries to human liberty.

2.3 The Quintessential Cages: Long-Duration Space Missions

> The narrow crack traced a high, four sided figure in the face of the rock. It was a door!
> Harrison, *Captive Universe* (1969) (p. 51).

Stories of lives spent in extraterrestrial environments for extended periods have been written by generations of SF authors. Cockell (2013) identifies the challenges to liberty in such environments as arising from perpetual confinement and a reliance on central communal technological systems, factors which encourage tyrannous regimes, and make rebellion difficult or impossible.

Perhaps the purest form of extraterrestrial 'cage' is the long-duration space mission, from which there is no possibility of escape. Even compared to an enclosure on Mars, say, the confinement imposed in such missions is brutally strict.

The author's own *Ark* (Baxter 2009) is about a group of around 80 young people fleeing a dying Earth of the near future, and travelling to the habitable world of a distant star, a journey that will last 37 years. There would presumably be little argument about the ethical choices made by parents giving up their children to a lifeboat of this sort, and indeed the crew candidates compete intensely for places. But little thought is given to the evolution of the crew's society once the mission is underway, and the young people have to find their own solution. One inspiration for what follows was Golding's *The Lord of the Flies* (1954).

At first, especially while contact is maintained with Earth, a military command structure persists: 'Holle, they offered me the role of commander of the trans-Jupiter phase! That's a mission in itself. Then I'll be in prime position to become captain of the interstellar phase' (p. 166).

Later, the crew's limited training encourages them to try a kind of participative democracy: 'But I don't need, and shouldn't have, the absolute authority of a captain of a ship at sea… I want to govern by consensus… If there's a dispute, we'll just talk it out as long as it takes' (pp. 260–261). However this early solution breaks down over arguments about a drastic punishment (a maiming) imposed on a crewman guilty of a crime of passion; his crewmates are not yet ready to accept such authority.

An election results in the emergence of a new leader. Wilson is as competent as the rest in terms of running the ship's systems, but he and his gang retain rule for decades through sheer physical strength, and the manipulation of the ship's internal politics. Here is the most primitive form of human society, the shadow of the chimp, re-emerging light years from Earth. But Wilson becomes bored and corrupt, and begins to prey on the crew: 'Look at me. I'm the most powerful man on the ship. Have been for 10 years… So what's in it for me? I'll tell you. Only the sweetest commodity on the ship. I'm talking about young flesh…' (p. 365).

The new generations, however, have their own issues. No preparation has been made for their raising or education, or to integrate them into the ship's overall purpose. In the resulting social vacuum they have evolved their own subculture: 'Steel looked up along the length of the hull… What she looked for was other shippers like her, shipborn, where they clustered in their little territories, marked by scratchy graffiti signatures on the walls… Nobody much older than Steel even saw any of this going on' (p. 387). Ultimately, enraged by abuse by Wilson's cadre—and fuelled by a comforting myth that perhaps the ship's confinement is not real, that the mission is a cruel Earthbound delusion—the young organise, rebel, and attempt to break out of the hull, with disastrous consequences.

In the aftermath one of the original crew, Holle, with control of the life support systems, assumes total control over the survivors, and particularly over the young. Now the ethic of the lifeboat is imposed, with room for little or no liberty. And Steel, the young leader, is sentenced to death: 'I don't want leadership… Not among the shipborn. I don't want vision, or idealism, or curiosity, or initiative. I don't want courage. All I want is obedience. It's all I can afford, until we're down on Earth III and the day comes when we can crack open the domes and let the kids just walk away. Yes, she's the best of her generation, and that's why she's such a

terrible danger. That's why Steel has to die' (p. 417). The book's essential argument is that the social design of such a mission, and particularly the challenge of managing the education and aspirations of the younger generations, is as important as the ship's technical design, if breakdowns are to be avoided.

Other explorations of the 'generation starship' trope include Heinlein's 'Universe' (1941), Aldiss's *Non-Stop* (1958), and the author's own 'Mayflower II' (2004). Many such stories span a much larger timescale than *Ark*. As the generations pass, typically the mission goals are lost or forgotten, the ship's internal society breaks down, the crew's descendants may forget they are on a ship, and ultimately even the evolution of the shipboard inhabitants may be compromised. In Aldiss's novel, on the ecological island that is the starship, the crew's descendants are dwarfed—as if the ship is ultimately crewed by the 'hobbits' of Indonesia.

Possibly one solution to the challenge of crewing a generation starship might be to reach back to the social forms of the 'traditional societies' of humanity's past on Earth (Diamond 2012): the pre-farming age when humans lived in small, relatively isolated bands, with the integration of children from birth into a limited number of social roles. Such societies may seem alien and constricting to modern-day city-dwellers, but they were clearly enduring forms, dominating for some 90 % of human history, and indeed continuing in a minority of cases today. And in their isolation and self-reliance traditional societies may be closer in their social frame to the starship future than are modern urban social groupings.

One work of SF which explicitly explores this kind of solution is Harrison's *Captive Universe* (1969)—but a significant ethical challenge is presented, for a pre-existing traditional culture is scooped up without its consent or knowledge and used to crew a starship.

For a 500-year mission to Proxima Centauri, the asteroid Eros is spun up and carved into a hollow world with an artificial sky (p. 108). People Harrison calls 'Aztecs', from isolated subsistence-farming communities in Mesoamerica, are taken on board and allowed to believe they are in a closed valley on Earth: 'The Aztecs, chosen after due consideration of all the primitive tribes of Earth. Simple people, self-sufficient people, rich in gods, poor in wealth…[living] as they did when the Spaniards first arrived hundreds and hundreds of years earlier… Taken, unchanged, and set down in this valley in a mountain in space. Unchanged in all details, for who can guarantee what gives a culture adhesion—and what, if taken away, will bring it down?' (p. 109).

And to further ensure stability, the Aztecs have been genetically engineered for low intelligence during the voyage: 'They did take genius. And they tied it down to stupidity. Dimness, Subnormality, Passivity, Prison it in slightly different ways in two different groups of people and keep them apart… Then, some day, the right day, let the two groups meet and mingle and marry… The children [will be]… genius children' (p. 110).

The story concerns a break-out by a young Aztec man, Chimal. The accidental product of a premature rule-breaking coupling between the separated communities, he is over-intelligent and restless. At last, in a scene of classic 'conceptual breakthrough' (a moment in a story when everything a character thinks he or she knows

about the universe is inverted), Chimal finds a way out into the machinery, through a door in a rock face (p. 51).

This book examines the ethics of removing the liberty of generations of unborn for the purpose of such a mission. Chimal himself is enraged by the truth: 'This is no wonder—but a crime. Children…were taught superstitious nonsense and bundled off into this prison of rock to die without hope. And, even worse, to raise their children in their own imbecilic image for generation after generation of blunted, wasted lives.' (p. 148).

The only justification is that the unpleasant choices made in this case have worked, in delivering the long cultural stability required of a generation starship.

2.4 Extraterrestrial Revolutions

> The progressives…believe that in the long run Man has got to explore and master the material universe, or else he'll stagnate… But this sort of argument is no use with the taxpayers. Clarke *The Sands of Mars* (1951) (p. 184).

What if extraterrestrial colonies prosper and, following historical precedent, seek independence? This section looks further into the future and considers SF accounts of a quest for liberty by extraterrestrial colonists revolting against the centre. In an American-dominated genre, many have been inspired by the example of the American Revolution.

One classic example is Heinlein's novel *The Moon is a Harsh Mistress* (1966), a compelling, densely written saga of a revolution by a near-future lunar colony. It was written when Heinlein was 59 years old, at a time in his career when he allowed his personal political views to be expressed in his fiction.

In 2076 Luna City is a colony of convicts from Earth, along with some citizens freed having ended their sentences, and freeborn descendants of convicts. The book is told from the point of view of 'Mannie', one of the colonists, in an argot that is a compound of American English, Russian, Australian. In an economic scenario that looks unlikely to modern eyes, the colonists make a living by mining lunar water and growing wheat, which is exported—using a 'catapult', a mass driver—to an overpopulated Earth run by the 'Federated Nations', a stronger version of the UN. A Lunar Authority, under a Warden, controls the colonists' lives, including the central engineering that provides air, food and water. The Warden even controls the terms of sale of the wheat.

The colonists are confined by the Authority but are not policed internally, and Heinlein depicts a kind of natural morality arising from the very lethality of the lunar frontier: 'Zero pressure was place for good manners. Bad-tempered straw boss didn't manage many shifts' (p. 21); 'Could say our customs are natural laws because are way people have to behave to stay alive' (p. 123). The operation of this 'natural law' includes ad hoc citizens' tribunals with the power to impose the death penalty (Chap. 11).

A revolution foments under the tutelage of Professor Bernado de La Paz, a well informed scholar of history—and a mouthpiece for Heinlein. The proximate cause

of the revolt is the inevitable depletion of lunar resources in a few years: 'Luna must be self-sufficient' (p. 26). With 1776 as a conscious precedent, La Paz prepares for the rebellion carefully: 'Revolution…depends on correct organisation and, above all, communication. Then, at the proper moment in history, they strike' (p. 57). The 'Loonies' are more patriotic to their homelands on Earth than to the moon, so incendiary incidents with Authority guards are stage-managed: 'Easier to get people to hate than to get them to love' (p. 87).

The rebellion itself is difficult to achieve. It is suicidal to strike against the infrastructure itself: 'The woman had been in The Rock almost all her life…yet could think of something as new-choomish as wrecking engineering controls' (p. 44). Meanwhile the Warden controls essential systems from his isolated and heavily guarded complex. In the end Heinlein resolves these problems rather easily by giving the colonists a crucial ally in 'Mike', the colony's central computer, which happens to become sentient, and decides to become an ally of the rebels. This does illustrate however the necessity, and the difficulty, of seizing control of central life-supporting functions. For instance the Warden's Complex is ultimately disabled by Mike cutting its oxygen supply.

War follows as Earth tries to regain control, illustrating a further hazard to extraterrestrial rebellion: the sheer lethality of interplanetary war (see the essay by Baxter and Crawford elsewhere in this volume). On the one hand the colonists, lacking dedicated weapons, improvise by 'throw[ing] rocks at them' (p. 80): the catapult is used to hurl massive loads of moon rocks at Earth. Uninhabited areas are targeted but collateral casualties are inevitable. It is a war of terror, with 3 million 'loonies', able to strike at will against 11 billion Earth inhabitants (p. 126). On the other hand it is easy for Earth troops to crack open even underground pressurised lunar shelters with hydrogen bombs (p. 205). In the end, as with the American War of Independence, the conflict is ended through exhaustion on both sides—and before mutual destruction is achieved—and the moon is free.

In American-dominated mid-twentieth-century SF, 1776-style rebellions of near-future space colonies against the centre were represented as something of a default, a theme picked up by authors from a surprising array of backgrounds. Typically an inner human instinct for expansion was shown to be in conflict with the centre's desire for control—or just for a return on its investment.

Even Dick wrote of war with rebellious planetary colonies. In the novel *Time Out of Joint* (1959), the protagonist Ragle Gumm is the centre of a false reality set in the year 1959, his only occupation being to solve daily newspaper puzzles. In fact the year is 1998 and the US is at war with a lunar colony. The few thousand 'lunatics', safe in their underground bunkers on the moon, terrorise Earth with random attacks: 'It worries them because they can never tell if it's a full-size transport with a full-size H-warhead, or only a little fellow. It disrupts their lives' (p. 173). Gumm has a pattern-recognition skill that enables him to predict the lunar attacks, disguised as his puzzle-solving; he is kept in '1959' because he would have chosen to go over to the moon's side as isolationist tendencies deepened. In this book at least Dick expresses a Heinleinian dream of inevitable migration: '[There was] a deep restless yearning under the surface, always there in him, throughout his

life, but not articulated. The need to travel on. To migrate… An instinct, the most primitive drive, as well as the most noble and complex… We're only pretending to mine ore on Luna. It's not a political question, or an ethical one…' (pp. 179–180).

One way for a rebellious colony to win liberty is to change the rules: to find a high-tech solution to break out of the problem of resource constraints and a dependence on Earth. One such method is explored in Asimov's 'The Martian Way' (1952). After three generations a Martian colony supports 50,000 people, but on a united Earth there is resentment at the investment required to colonise Mars, and with no significant economic return likely in the future. With the colony threatened with closure by withholding the water it needs for physical needs as well as for rocket propellant, the colonists achieve a breakout solution by importing water from Saturn's ring fragments. Asimov allows his colonists to express typical dreams of the frontier: '[On Earth my father] didn't see anything happen. Every day was like every other day, and living was just a way of passing time until he died. On Mars, it's different… If you haven't lived when things are growing all about you, you'll never understand how wonderful it feels' (pp. 34–35). And to probe the frontier is the beginning of man's cosmic destiny: 'Mars is—a ship. It's just a big ship…occupied by fifty thousand people.' (p. 28) 'Mankind will spread through the Galaxy. But…it will be Martians, not planet-bound Earthmen, who will colonize the universe' (p. 41).

Clarke's *Sands of Mars* (1951), his second novel, depicted another Martian rebellion, and another high-tech rule-changing stratagem. In the 1990s anti-Mars sentiment is growing on Earth (p. 32): 'We've sunk in millions and haven't got a penny back…' Chief Executive Warren Hadfield is conducting a 'paper war' (p. 88) with Earth, but independence will be difficult to achieve. 'I suppose you realise what I'm fighting for…[is] self-sufficiency… But there are more skilled trades back on Earth than there are people on this planet' (p. 88). A sturdy pioneer/frontier spirit is evident: 'They had a sense of fulfilment which very few could know on Earth, where all the frontiers had long ago been reached' (p. 118). The high-tech solution is Project Dawn: to ignite Phobos with a 'meson resonance reaction' (p. 187), and create an artificial sun to make Mars habitable quickly. Earth's response is rather gentlemanly: 'You shouldn't have done it, but we're rather glad you did' (p. 201).

Published more than 20 years later, Clarke's elegant *Imperial Earth* (1975), set in 2276 (and published in time for 1976, an earlier centennial of the American revolution) takes another look at the tensions of a colonised solar system, in this case focussing on colonies on Titan. The tough environment of Saturn's moon has enforced a unified society dependent on a few interlinked families: 'Everyone who had come to Titan had been selected for intelligence and ability, and knew that survival depended on cooperation' (p. 59). However Earth and its colonies are divided by simple physical constraints. After a few centuries of adaptation it is difficult for inhabitants of low-gravity worlds like Titan even to visit Earth. Lightspeed communication delays are trivial on Earth, leaving that world relatively unified; but the long delays in speaking to the colonised worlds reduce effective interpersonal contact and so reduce human unity (p. 101). There are cultural divergences too; an Earth recovering from resource depletion and eco-collapse is

reverting to a managed wilderness (Chap. 16), and people conserve the past; Washington DC is like a museum (Chap. 17). All this seems quite alien to colonial visitors.

Colonists on Titan have grown rich thanks to a 'hydrogen economy'; Titan's gravity well, shallow compared to other sources of hydrogen such as Earth and Jupiter, allows the atmospheric mining of the element which is required in large volumes to run fusion-propulsion interplanetary ships (Chaps. 2 and 3). The trade with Earth seems to be a classic example of trade between a centre and its colonies; Titan's raw material, hydrogen, is exchanged for 'expensive items' from Earth (p. 61). But this arrangement is fragile, and is threatened by a single technological revolution, based on a mini-black-hole 'Asymptotic Drive' (Chap. 15) which is much more efficient in its use of hydrogen. Ultimately Titan seeks a new destiny as a science hub, with the building of a new kind of long-wavelength radio telescope among the moons of Saturn (Chap. 35).

The most extensive and detailed modern depiction of a Martian revolution was Robinson's *Mars* trilogy (1993, 1994, 1996). These books, a saga of scientific and political advancement set against the background of the terraforming of Mars, portray an intentional reshaping of human history in the new world.

In the year 2026, the 'first hundred' colonists, all selected by UN and national agencies, land on Mars. Early investment in the colony comes from government and 'transnats', super-rich corporations. But once the colonising spreads, the lack of a proper legal framework for the exploitation of Martian resources and protection of the environment is soon evident; the only governance comes from a 'Mars treaty' based on precedents concerning outer space and Antarctica. Soon the discovery of precious metals on Mars begins a 'gold rush' (p. 324) by Earth nations and corporations, with pressure to build a space elevator to begin the large-scale extraction of Martian resources to Earth. But on Mars there is a growing reaction against Terran exploitation: 'the transnational world order is just feudalism all over again' (p. 445). Habitats, air and water mining gear, communications and other equipment are quietly set aside to support the 'revolution' to come (p. 408).

Thirty years after the first landing, Mars's first 'constitutional convention' is an attempt to renew the existing Mars treaty (p. 469). But the result is a sham, the transnats now wield effective power on Mars, and a still more massive flood of immigrants is brought to Mars.

Martian cities begin to declare independence—and in 2062, revolution is declared. Earth is unyielding; with the rebellion portrayed as the actions of a few scattered terrorists, it is declared that 'Mars is not a nation but a world resource' (p. 602) which cannot be given to a handful of Martians. The Martian rebels attempt one strike against Earth, by diverting an asteroid called Nemesis towards Earth, but this is destroyed. But it is much easier to inflict damage on the Martians: 'It was not hard to destroy Martian towns. No harder than breaking a window, or popping a balloon' (p. 558).

This battle is lost, but Robinson's revolutionary war continues. In *Green Mars* (1994), which begins in 2081 some 60 years after the first landings, resistance movements form on Mars, while Earth is weakened by a dramatic sea level rise.

At last, in *Blue Mars* (1996), whose events begin in 2127, the Martians gain their independence, and the transnats are expelled from Mars. After a constitutional convention the Martians establish a new society, which will lead the terraforming of the rest of the solar system—and the nature of that society is examined in the next section.

2.5 Extraterrestrial Utopias

> 'For what kind of delta-v would it take to escape history, to escape an inertia that powerful, and carve a new course?' Robinson, *Red Mars* (1993) (p. 68).

With the revolution won, what kind of society have the rebels of SF gone on to build?

Heinlein's *The Moon is a Harsh Mistress* (1966), as discussed in Sect. 2.4, was a conscious rerun of the American Revolution set in an extraterrestrial context. The American Founding Fathers of course went on to establish the US Constitution and a federal system of government designed for expansion across the North American continent and beyond (see the essay by Crawford in this volume). What of Heinlein's colonists?

Even as the war with Earth progresses, a constitutional convention is set up, but this is rigged by revolutionary leader La Paz's central cell (p. 222) and is viewed sourly by the main characters. La Paz himself contributes only gnomic suggestions (p. 228): 'Government is a dangerous servant and a terrible master… You might even consider installing the candidates who receive the least number of votes; unpopular men may be just the sort to save you from a new tyranny. I suggest one house of legislators, another [house] whose single duty is to repeal laws… Let your document be studded with things the government is forever forbidden to do. No conscript armies…no involuntary taxation…' La Paz, speaking for Heinlein, describes himself as 'a rational anarchist… In terms of morals there is no such thing as a "state". Just men, individuals. Each responsible for his own acts' (p. 62). La Paz despises government in principle, but accepts the need for some form of it in practice. 'I think that government is an inescapable disease of human beings. But it may be possible to keep it small and starved and inoffensive' (p. 231). In the end these suggestions are not taken up.

Even so it comes as a shock to the reader when, on the book's final page (p. 288), Mannie the narrator, having won his rebellion, chooses to flee from one tamed frontier to the next: 'Quite a few young cobbers have gone out to asteroids. Hear some nice places out there, not too crowded…'

Yet this seems to have been characteristic of Heinlein, who was no utopian. Many of Heinlein's works contain an argument that the only true liberty is to be found on an expanding frontier; in the settled interior of any society such evils as excessive legislation, taxation and corruption are bound to follow. *Time Enough for Love* (1973) is set 2000 years in the future, at the other end of the expansion experiment begun with lunar colonisation in *Moon is a Harsh Mistress.* Heinlein's

mouthpiece here is his undying pioneer Lazarus Long: 'As a thumb rule, one can say that any time a planet starts developing cities of more than one million people, it is approaching critical mass. In a century or two it won't be fit to live on… Migration always involves selection and improvement. Elementary' (p. 31).

Thus, Heinlein argues, there is no worthwhile static society; the only life worth living is as part of a rapacious colonising wavefront, endlessly leaving behind worlds choked by excessive authority. Indeed in such quotes ('selection and improvement') Heinlein seems to venture beyond libertarian thinking into social Darwinism: he speaks of the rigour of the frontier as a positive benefit; the cleansing of the race of the weak and foolish, such as the stowaway child of 'The Cold Equations,' is an evolutionary price worth paying.

Heinlein was and is highly influential in SF, but his is not the only voice. Utopian visions in SF build on much older traditions of literature, dating back to Thomas More's *Utopia* of 1516. Francis Bacon's *New Atlantis* (1627) showed the advancement of science bringing about a utopian state. Similarly HG Wells's *A Modern Utopia* (1905) coupled political progress with scientific advancement. A modern work set in an extraterrestrial context is Le Guin's *The Dispossessed* (1974), which depicts a competition of anarchist and capitalist 'utopias' on a planet and its moon.

The most complete utopian exercise in modern SF must be Robinson's 'Mars' trilogy (1993, 1994, 1996), referenced in the previous section. That Robinson regards his trilogy as a utopian exercise cannot be in doubt. A citizen of a planned community in California, he seems to have arrived at his own philosophy from a consideration of a number of influences. He said in 2002: 'I consider my books to be a political work… There's got to be a utopia strand, there's gotta be positive stories. You can criticize over and over again, but it also helps to have some vision of what should happen' (Smith 2002).

Robinson's Martian revolution is a more complex affair than 1776, for his Martians rebel, not just against a government, but against the system of capitalist democracy itself. Once freedom is won, the subsequent constitutional debates, heavily featured in *Blue Mars* (1996), are a mixture of a reaction against Earth history—the rejection of capitalist democracy—as well as a reaction to the conditions of constraint and scarcity on Mars. The basis of the discussion is a 'master list of fundamental individual rights' (p. 129) such as *habeas corpus* and freedom of speech. In classic American fashion government is to be kept in check with 'an emphasis on local semi-autonomy…many checks against majoritarian rule' (p. 154). On the other hand an environmental court is given very strong powers.

Perhaps the most striking feature of the new constitution is an economic system intended to 'provide for everyone in an equitable way' (p. 64). 'The system called capitalist democracy was not really democratic at all… So, we must change. It is time. If self-rule is a fundamental value, if simple justice is a value, then they are valuable everywhere, including in the workplace where we spend so much of our lives' (p. 143). The fundamental solution is a rejection of corporate capitalism: 'All economic enterprises are to be small cooperatives, owned by the workers and no one else' (p. 144).

And the constitution contains a remarkable pledge to guarantee equal access to 'housing, health care, food, education' (p. 145). This pledge of universal welfare seems uncharacteristic for an American writer, but it is evidently a reaction to the conditions of a young extraterrestrial colony, with its centralised life support systems and their tyrannous implications. It is certainly a blow in favour of extraterrestrial liberty; if this guarantee can be kept (a significant caveat) then tyranny from such causes is evidently averted.

Furthermore Robinson's vision seems a specific rejection of the frontier-scarcity ethos propounded by Heinlein and others. In Heinlein's *The Moon is a Harsh Mistress* the idea of providing security of food, water, air and other essentials to the rebellious lunar colonists is actually raised but mockingly dismissed (1966, p. 159). Robinson however argues that humans can advance, indeed will advance better, without the forcing of struggle and scarcity.

Robinson shows us little of his Martian utopia in action. Its development will be an ongoing process: 'The negotiations would go on for years. Like a choir in counterpoint, singing a great fugue' (p. 746). But the great experiment evidently works, as Robinson assures us in the very last page of the trilogy (of 1,700): 'Nowhere on this world were people killing each other, nowhere were they desperate for shelter or food, nowhere were they scared for their kids' (p. 761).

Robinson's Martians' new society seems to be taking the first steps to the condition of a 'post-scarcity economy' (Chernomas 1984), a society in which the basics of life are guaranteed—the diametric opposite of the forcing ground of the cold-equations frontier. Such an economy is depicted in an extraterrestrial context quite explicitly in the 'Culture' novels of Iain Banks (1954–2013). Banks said of his universe, 'Nothing and nobody in the Culture is exploited. It is essentially an automated civilisation in its manufacturing processes, with human labour restricted to something indistinguishable from play, or a hobby' (1994) (Future Histories 2013).

But modern SF contains a more populist and perhaps more surprising utopian vision of the future:

> Space: the final frontier. These are the voyages of the starship *Enterprise*. Its five-year mission: to explore strange new worlds, to seek out new life and new civilizations, to boldly go where no man has gone before.

These words or close variations have introduced *Star Trek* episodes and movies from 1966 to 2013 (Whitfield and Roddenberry 1968). They have become overfamiliar perhaps, and the very use of the word 'frontier' gives the franchise a perhaps Heinlein-like feel. Indeed, most of the screened stories are set at the frontier of the United Federation of Planets. But what is contained within the frontier is a utopian vision, as can perhaps be judged from an imagined mirror-image of these famous sentences, indicating what the *Star Trek* future is *not*:

> Space: the final unconquered terrain. These are the voyages of the warship *Fist of God*. Its five-year mission: to exploit strange new worlds, to enslave new life and convert new civilizations to the one true faith, to boldly conquer where no soldier of God has conquered before.

The creator of *Star Trek* was Gene Roddenberry (1921–1991). Toughened by experiences as a World War II combat pilot and as a police officer in Los Angeles, Roddenberry was a humanist who wished to show that humanity could better itself by its own efforts. The composition of his ships' crews consciously showed examples of racial equality, religious tolerance rather than conformity, and an acceptance of the other. Of religion Roddenberry said (Notable Names database 2013), 'People were saying that I would have a chaplain on board the *Enterprise*. I replied, "No, we don't."'

Rodenberry's United Federation of Planets, first mentioned in the 1967 original series episode 'A Taste of Armageddon', is an expansionist federal government on the US model. As discussed by Crawford elsewhere in this volume, this model seems the best available for interplanetary governance—albeit a model that applies in the case of *Star Trek* to multiple species. The Federation's values include universal liberty, equality, justice, peace, and cooperation, as listed in the *Next Generation* episode 'The Best of Both Worlds' (1990).

Strikingly, the Federation seems to be a post-scarcity society. We are told that money is obsolete (for example in 'Star Trek IV: The Voyage Home', 1986). The economy seems to be based on 'replicator' technology, a super-advanced version of matter printing, coupled with abundant energy. In the original series episode 'Catspaw' (1967), an alien tries unsuccessfully to bribe Captain Kirk with trays of jewels. Kirk responds: 'We could manufacture a ton of these on our ship. They mean nothing to us.' As for the idea that without scarcity, without the need to work, humanity will become decadent, as a time-travelling Captain Picard explains to a 21st century woman ('Star Trek: First Contact' 1996): 'The acquisition of wealth is no longer the driving force of our lives. We work to better ourselves and the rest of humanity.' In spirit, this is much more Robinson than Heinlein.

Thus, for nearly 50 years, prime-time TV and our cinema screens have been dominated by a very utopian vision of extraterrestrial liberty, almost smuggled across by the gentle persistence of Gene Roddenberry.

2.6 Extraterrestrial Liberty in the Presence of the Other

> I found about me the landscape, weird and lurid, of another planet… I felt…a sense of dethronement, a persuasion that I was no longer a master, but an animal among the animals, under the Martian heel. Wells, *The War of the Worlds* (1898, p. 154)

Looking still further ahead, it seems quite possible that in the course of humanity's extraterrestrial career we will encounter other life forms, perhaps even other intelligences. Such encounters will inevitably shape our moral choices, and limit our own liberty.

In a sense extraterrestrial life is already curtailing our freedom, even though at time of writing it is still only a theoretical concept. Planetary Protection Protocols, rules which govern the cleansing of spacecraft sent to other worlds and delimit human behaviour on those worlds, constrain our actions even today (COSPAR 2008).

Examining the impact on indigenous life of terraforming another world has been one way in which SF has explored our relationship with technologically inferior life forms. Depictions of terraforming in SF date back to the 1930s and Stapledon's *Last and First Men* (1930), in which Venus is terraformed by electrolysing the oceans to produce oxygen. The term 'terraforming' itself was coined by Jack Williamson in 1942–1943 in the stories collected in *Seetee Ship* (1951).

Clarke's *Sands of Mars* (1951) seems to have been the first attempt to depict the terraforming of Mars. This Mars has an interesting biota, including the 'oxyfera' or 'airweed' oxygen-producing plants, sturdy 50,000-year-old trees (p. 107), and Martians, kangaroo-like animals who live in a kind of symbiosis with the airweed. The terraforming shown is not very realistic, based on the fusion ignition of Phobos into a 'second sun', coupled with the promotion of the native airweed, to produce oxygen from the rocks. However, set in the then-near future (the 1990s) with the terraforming in the hands of a society not much advanced over our own, Clarke highlighted ethical dilemmas that have been extensively explored since.

In his standard text *Terraforming* (1995) (pp. 490ff) Fogg discusses the ethics of terraforming based on classifications including homocentrism—humans should be valued over the rest of nature—and biocentrism—all life has intrinsic worth and should be valued accordingly. These conflicting attitudes are illustrated in *Sands of Mars*. Homocentric progressives back the Mars colony, believing that 'in the long run Man has got to explore and master the material universe, or else he'll simply stagnate on his home world' (p. 184). To the homocentrics even the native Martians symbolise a trap: 'What have *they* done except survive? It's always fatal to adapt oneself to one's surroundings. The thing to do is to alter your surroundings to suit you' (p. 158).

But what about any rights of the Martians themselves? Here, in a nod to biocentrism, coupled with a progressive view of evolution, it is argued that we are not tampering with a living Mars but saving a decayed Mars, and fallen Martians: 'We've had to…bring this world to life again… There was something inspiring in the thought of regenerating not only a world, but also a race which might be older than man… If it became too warm for [the Martians], they could easily migrate north or south… Were they the degenerate survivors of a race which had achieved civilisation long ago?… In any case, it would be an extremely interesting experiment to see how far up the evolutionary ladder the Martians could climb, now that their world was blossoming again…' (p. 188). Of course a modern biologist might say that the native Martians cannot be said to have 'fallen' at all but are well-adapted to their austere environment. Clarke, however, even in this early novel, had a long perspective, and was well aware of ethical challenges: 'For it was their [the Martians'] world, not Man's… Man himself…might well be judged by his behaviour here on Mars' (pp. 199–200).

The consequences of terraforming have been further explored in Robinson's 'Mars' trilogy (1993, 1994, 1996). After the landings of the 'first hundred' colonists, the human transformation of Mars, intentional and otherwise, begins almost immediately, with large-scale excavations to construct shelters, and at first tentative but deliberate steps to terraform, such as the scattering of heat-producing windmills

and genetically engineered algae (1993, p. 219). Robinson's character Ann Clayborn voices disquiet on behalf of a 'red' conservationist movement, as a landscape billions of years old is changed even as humans first inspect it: 'Base camp is like an open pit mine, in the middle of a desert never touched since time began' (p. 190). There is a scientific loss too; when life in isolated pockets is eventually found (p. 388) it is impossible to be sure that it is not the result of terrestrial contamination. But a transformation of Mars is necessary if the colony is to achieve independence: 'we need to terraform in order to make the planet ours' (p. 205). The pace quickens when the UN governing agency approves follow-up colonisation and more terraforming efforts, which are soon large-scale, with solar-heat-collecting mirrors in orbit (p. 310), moholes to release geothermal energy (p. 318), and a massive spread of life forms. A climax to this comes with the injection of the ice of an asteroid into Mars's air through aerobraking (p. 441). Then, 30 years after the first landing, a space elevator is attached and a still more massive flood of immigrants is brought to Mars.

When revolution comes, huge damage is done to Mars itself. Each side attacks the infrastructure, and increasingly destructive blows are struck. Aquifers are cracked, releasing floods not seen since the Noachian era (p. 565). Phobos is used as a surveillance and attack station (p. 585); the rebels find a way to bring the moon crashing down to Mars (p. 610). In the end the space elevator is cut from its orbital anchor; the cable wraps around the planet in a spectacular disaster (p. 589). By the end of *Red Mars* the terraforming programme has been greatly, if roughly, accelerated. But 'every single feature of the primal Mars would melt away. Red Mars was gone' (p. 643).

Robinson himself seems to be a proponent of terraforming regardless of the cost to any undiscovered native life; later in the series he sketches the rapid terraforming of more worlds, as far out as Titan. As for Mars, he echoes Clarke's justification (Clarke 1951) that perhaps the colonists are not destroying a planet but 'saving' a fallen world. There is a search for evidence of primordial oceans on Mars, 'a model that tended to lend moral support to the terraforming project, implying as it did that they were only restoring an earlier state of things' (1993, p. 292). Terraforming, then, is a means to achieve extraterrestrial liberty but presents moral dilemmas in itself.

If, on the other hand, it emerges that the aliens we encounter are significantly *more* powerful than ourselves, the situation may become very uncomfortable for us, even if the only consequence is that moral choices are taken out of our hands. In the *Star Trek* episode 'Errand of Mercy' (1967) superior aliens called the Organians put a stop to a proposed war between Federation and Klingons. Captain Kirk protests at this curtailment to his freedom of action: "We have the right—" "To wage war, Captain? To kill millions of innocent people? To destroy life on a planetary scale? Is that what you're defending?"… "Well, Commander," Kirk says later to the Klingon leader, "I guess that takes care of the war. Obviously the Organians aren't going to let us fight." "A shame, Captain. It would have been glorious…"

An encounter with more aggressive superior aliens could be much more damaging. In Bear's novels *The Forge of God* (1987) and *Anvil of Stars* (1992),

'The Earth is dead, murdered by self-replicating spacefaring machines. A few thousand humans have been saved by other robots, machines sent by the Benefactors to defend primitive worlds and civilisations from the depredations of planet-killing probes… The Law [is] a galactic code that governs the behaviour of civilisations. The Law demands that civilisations which make self-replicating killer machines be punished—with extinction. Humans must carry out this punishment, with the help of the Benefactors… This is how the balance is kept' (prologue to *Anvil of Stars*). The picture is one of a galaxy of predatory and prey worlds alike cowering in silence and high-tech camouflage, awaiting pre-emptive attack or revenge strikes. And the last surviving humans, saved from Earth when still very young, have no freedom at all; their only choice is to serve as soldiers in an unending campaign of extermination. This is one of the darkest visions in SF.

2.7 Conclusions

'Luna was ours'. Heinlein, *The Moon is a Harsh Mistress* (1966, p. 138).

For several decades at least, science fiction writers have explored, and readers and critics have debated, the possibilities of extraterrestrial colonisation, including implications for liberty and social development. Some tentative conclusions can be drawn.

The literature suggests that one key challenge for the long term may be the design, conscious or otherwise, of stable societies with satisfactory lives for the young in confined environments. The most extreme kinds of enclosure, and therefore probably the most tyrannous, are isolated space habitats, including spacecraft on long-duration missions: cages from which there maybe no escape possible, for generations.

With the discussion often dominated by American voices, as the SF field has been commercially, a tension is perceived between those who advocate the social and even evolutionary value of the frontier, and others who dream of utopias, perfectible societies where need and want are no longer drivers of human actions. In practical terms (and anticipating such analyses as Cockell's 2013) the SF community has discussed the difficulties of mounting revolts in closed, heavily technologically dependent colonies—an obstacle to social change and a striving for liberty of the kind exemplified by the American Revolution and the subsequent war.

In the further future, our liberties are likely to be compromised by encounters with other life forms, perhaps even other minds than our own.

That the issues which concern this book continue to be explored in mass popular form in the SF world is exemplified by a Japanese franchise called 'Gundam' (Official Gundam website 2013). The Gundam are 'mecha', mobile fighting suits controlled by human pilots; the name is a neologism from English: 'gun' + '(free) dom' = Gundam. This began as an animated TV series in 1979, and has since (as of 2008) become a 50 m yen franchise spanning TV, movies, manga, novels, and games. With time the saga has developed a complex future history describing the relation of Earth to breakaway solar system colonies, including an age of repressive

control by Earth, a period of devastating space war, an era in which the space colonies dominate, and a far-future era which sees an end of wars in solar system. The stories—while featuring a lot of armoured warriors in combat—explore war, pacifism, the meaning of freedom, and the evolution of humanity. This reached a certain peak in 2008 when an International Gundam Society held an academic conference on such issues as space emigration due to overpopulation, human conflict on Earth and in space, the perpetuity of fascism, and the politics of the technocrat.

As the debate initiated by this book and the seminar that inspired it goes forward, we can be confident that SF and its readership will continue to explore the relevant issues in a dynamic, creative and popular form.

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Chapter 3
Fear of Freedom: The Legacy of Arendt and Ballard's Space Skepticism

Tony Milligan

Abstract Hannah Arendt's critique of the early space program 'The Conquest of Space and the Stature of Man' (1963), provides us with a classic statement of what I will call space skepticism: the plausible view that rather than offering a new arena and new kinds of freedom, what manned space exploration will in fact provide is more of the same or, given a greater-than-terrestrial dependence upon human technology, even less of the same. Yet Arendt also alluded to a further possibility, one which now looks increasingly realistic: the possibility of a dangerous and threatening liberation from an Earthly standpoint, and even perhaps from a sense of our humanity. (I will suggest that this is a possibility which we should take seriously. How, after all, could we sustain a sense of genuine community across distances of space so immense that direct communication would be ruled out?) Arendt's thematic combination, expectation of the same and fear of something different, is familiar also from J.G. Ballard's prescient skepticism about the potential of the space program of the 1960s. On the one hand, Ballard thought it would turn out to be business as usual because it was too soon for a genuine space age. On the other hand, he held that even a tentative movement into space would change our perspective in uncontrollable and threatening ways. Both Arendt and Ballard identified a genuinely escapist, or at least utopian, strand within enthusiasm for manned space exploration. (Reflection upon the works of Dandridge Cole, Gerard O'Neil and, more recently, Robert Zubrin may incline us to accept that they had a point.) Yet when it comes to space, there may be no standpoint which is immune to criticism, none which escapes the bounds of our ordinary human frailties. The plausibility of the Arendt/Ballard diagnosis, and the persistence of a utopian strand even in present-day space ambitions, need not blind us to the fear of freedom, and in particular the fear of new and difficult-to-comprehend forms of freedom, which has been, from the outset, present within familiar forms of space

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skepticism. And to say this is to accept something that we should perhaps always have known: in the context of space, freedom, danger and the acceptance of our human frailty must go hand in hand.

Keywords Space skepticism · Earthlings · Fuge · Vulnerability · Humanity

3.1 Introduction

What follows will be concerned with freedom and with the aspiration to more or less permanently leave the surface of the Earth as a way of enhancing freedom. It will also be philosophical and will draw upon ideas from more than one school of contemporary philosophical thought. It has also been written by a philosopher (or, to be precise, an ethicist) with an abiding interest in matters relating to space. However, it will not be philosophy of the most argumentative kind. It will not contain those familiar layers of move and counter-move, objection and rejoinder, which typify the analytic genre and thereby close it off to a larger audience. Rather its focus will be upon matters of 'depth' and upon the articulation of thoughts which are somewhat elusive, thoughts about what it is to be human and about what extraterrestrial liberty can involve if it is to be liberty for beings like ourselves. (As opposed to liberty of a kind that might figure in transhuman literature which aspires to a beyond-human future.)

More specifically, I will be concerned with an adequacy condition, with a requirement that any plausible account of human liberty in space should meet: whatever other features such an account of liberty has, in order to be plausible it should picture the overcoming of some of our familiar human vulnerabilities but not others. Stated in these terms, the requirement may seem to be something of a platitude, not a pointless claim but a claim which is obviously true but is also somewhat too general or indeterminate to stand in for an actual theory. I shall, however, try to work it into something a little more precise by clarifying the role that the appreciation of a shared vulnerability plays in our lives. This is a role which, I will suggest, any account of liberty in space should *not* seek to overcome.

Although I regard space exploration as important and perhaps even ethically required, my pathway to this clarification will take us through an engagement with texts which question the value of such exploration. They may be regarded as instances of skepticism about space exploration, or more simply as instances of 'space skepticism.' Anyone with a sustained interest in space exploration will be familiar with at least some instances of the relevant kind of skepticism: claims that human expansion off-world simply isn't going to happen (the response which disheartened Goddard); or that it may happen but will be far too expensive to justify (the Van Allen response, also exemplified in recent times by De Groot 2006) or that it will simply reproduce all of the old human problems (a view eloquently portrayed in Walter Miller's classic work of 1950s science fiction, *A Canticle for Leibowitz*).

Some of these doubts can, at least in principle, be settled by appeal to empirical claims about time and advantage. Given enough *time*, it seems difficult to imagine that we will remain strictly terrestrial. Significant numbers of humans will sooner or later spend part of their lives away from the Earth. Indeed, it seems to be a species characteristic that we are territorially expansive. A claim which is not to be confused with the problematic view, widely held within the space community, that individual humans have a wanderlust built into their genes (Philips 2012, p. 12). In terms of *advantage*, expanding our presence off-world *could* bring significant benefits to the planet, to humans, to other creatures and in a figurative sense to the universe itself by extending the precarious reach of life. (The sense here is *only* figurative, the suggestion is that the universe is, in some way, a better place with life in it.) More straightforwardly, moving off-world *could* remove various kinds of vulnerability which result from our restricted presence on the Earth and from our restricted terrestrial access to finite (indeed as ecology reminds us, very limited) resources. Depending upon where we go, how many of us go there and what we do at our destination, moving off-world might allow us (in a phrase beloved of Peter Diamandis) to 'backup the biosphere' i.e. to remove our shared human vulnerability to system failure on the Earth (Dubbs and Paat-Dahlstrom 2011, p. 265). Elaboration of further and rather more terrestrial advantages of a shift off-world, can be found in Charles Cockell's *Space on Earth* (2007) or in James Lovelock and Michael Allaby's *The Greening of Mars* (1984), where the ecological benefits of space settlement are strongly emphasized. I refer the reader especially to Cockell because his vision of the future is set against a realistic background acceptance of the vulnerability of space colonists to authoritarian control (Cockell 2013).

Even so, I am inclined to suspect that statements about the wastefulness of space exploration and about the intractable impracticality of space projects are at least sometimes little more than failed attempts to articulate a somewhat deeper and more interesting skepticism, one which calls for a very different kind of response. Whereas familiar instances of space skepticism may be defused by appeal to the *removal* of human vulnerabilities, deeper instances of such skepticism can only be defused by placing emphasis upon the *continuity* of such vulnerability even in the throes of a human enjoyment of any new freedoms which life off-world might offer. Stated otherwise, some of the more interesting kinds of space skepticism involve a fear of freedom which can only be addressed by constraining our conception of the freedom on offer. This will involve acknowledging the likely continuity of various kinds of fragility and susceptibility to harm which are integral to the living of a life like ours.

To explore this idea a little further I shall examine two of the better-known attempts to articulate a deeper skepticism about space exploration, both of them originating in response to the Apollo-era space programs. The first is Hannah Arendt's classic essay 'The Conquest of Space and the Stature of Man' (1963). The second is the Cape stories of J.G. Ballard (which extend from the time of the Gemini program in the early 1960s through into the early years of Ronald Regan's presidency, in the 1980s). The later involve an attempt to rein-in the more excessive

claims that were made as a result of the Moon landings while the former is the only treatment of these issues by a philosopher of major stature.

At the outset, it may be useful to point out that both represent a qualified skepticism, a skepticism which may be all the more threatening to the space enthusiast precisely because it is qualified and therefore beyond any simple dismissal. Neither express an *in principle* hostility towards space exploration or to the possible emergence of a true 'space age' with overall beneficial consequences. They do not, for example, simply point out the unsustainable financial excess of the early space program. Indeed, Arendt dismisses expenditure-based criticism for its failure to come to grips with the enormity of what is at stake (Arendt 1963, p. 269). Moreover, neither reiterate the thoroughgoing skepticism which is hinted at, but not systematically explored, in certain passages from C.S. Lewis and which associates the prospect of space colonization with a reversion to the arrogance of colonialism (Lewis 2005, pp. 27–28). Rather, both Arendt and Ballard question our capacity to bring about a space age *in the right way* and *at a particular point in time*. Both trade upon an obvious truth (again a platitude of sorts) which is at the heart of pessimism of any sort: the mere fact that making the right moves at the right time is easily conceivable does not at all imply that getting things right in practice will be the likeliest outcome.

3.2 Arendt and the Human

Of these two instances of space skepticism, Arendt's essay is the more elusive. It follows upon the heels of brief comments regarding the epochal importance of space exploration which she also makes at the opening of her classic Gifford Lectures, *The Human Condition* (1958) and it is not intended to trade in certainties. Rather, as she points out, this is an area of discourse where precision breaks down. Directly addressing the question of whether or not our human stature, our conviction of our own importance, will be enhanced or damaged by the 'conquest' of space, Arendt states candidly that 'all answers given in this debate, whether they come from laymen or philosophers or scientists, are non-scientific (although not anti-scientific); they can never be demonstrably true or false' (Arendt 1963, p. 262). The point here is not to be confused with the claim that there are simply no truths about morality (that it's all one whether we champion freedom or endorse slavery). Rather, the point is epistemic, it concerns the limitations not of truth but of what it is within our power to *know* and to *demonstrate* in line with the norms of science.

While allowing that the outcome of space exploration *could* be business as usual, with humans carrying on much as they have done before, Arendt considers two other possibilities. One is an entirely unobjectionable and beneficent expansion of humanity to the immediate environs of the solar system with a resultant expanded sense of human belonging. 'It could add to the stature of man inasmuch as man, in distinction from other living things, desires to be at home in a "territory" as large as possible.' In which case, 'he would only take possession of what is his own,

although it took him a long time to discover it' (1963, p. 273). Even so, the territory in question would still be finite, 'These new possessions, like all property, would have to be limited, and once the limit is reached and the limitations established, the new world view that may conceivably grow out of it is likely to be once more geocentric and anthropomorphic, although not in the old sense of the earth being the center of the universe and of man being the highest being there is' (1963, p. 273). This option overlaps with, and is perhaps a proto-version of, the 'space humanism' espoused in our own times by Jacques Arnould (among others) although the latter is sometimes associated with the idea of occupying what would be, in effect, a 'Greater Earth' (Arnould 2011, pp. 121–131). This beneficent possibility is one which would, in Arendt's view, understandably enhance our stature and sense of achievement, our sense of the worth of being human and the worth of a human presence. Yet in many respects it would be suspiciously close to a modified or slightly extended version of business as usual. The area of occupancy would still be limited, giving rise thereby to a worldview which would be once more geocentric although not in the old sense, with the earth at the center of the universe. Rather, 'it would be geocentric in the sense that earth, and not the universe, is the center and the home of mortal man' (1963, p. 273). Such a scenario appears remarkably close to the idea of a Greater Earth in all but name.

Yet the preferred terminology itself can matter and is, at this point, is worth noting. Arendt appeals not to humans as rational agents or as autonomous centers of free choice (familiar terms when referring to our value and worth). Instead, she uses older terms which are familiar from literature and especially from tragedy, a terminology of 'mortal man,' a terminology which is not equivalent to talk about 'rational agents.' The dissimilarity, and its importance, may seem subtle but we can draw it out a little further by applying a substitution test. We may recall that when Shakespeare's Prince Hal reproaches Falstaff for recruiting scarecrows and pitiful rascals, men who can barely stand upright, Falstaff replies 'Tush man, mortall men, mortall men.' In doing so, he reminds the prince to think better of the poor and the damned, indeed he ought to think of them as in some respects equals: they will fill a pit as well as any hero or nobleman. The same point would not have been conveyed had Falstaff spoken of these unfortunates as 'rational agents' or as 'fellow homo sapiens.' My example here draws upon Gaita (2004) a fascinating discussion of the limitations of the latter sort of appeal.

Arendt and Falstaff share a terminology which involves an appeal to those whose lives are like ours because they may suffer in ways that we suffer. Of course, various aspects of this shared capacity for suffering are cognitively demanding. That is to say, they do *require* rational agency. But such agency on its own is not enough to allow us to make sense of another who lives as I may do. This focus of attention, upon mortal beings, generates a point of significant divergence from space humanism as it is envisaged by Arnould and others, where the machinery of Kantian ethics is brought directly into play and our humanity is identified closely with a capacity for free choice which is exercised by rational agents (Arnould 2011, pp. 184–186). Another way to put the same point would be to say that Arendt separates out the concept of humanity from that of personhood in the familiar

rational-agent sense. There is, in Arendt, a conception of the human condition which we can more readily inhabit.

Alongside the beneficent possibility of localized expansion, Arendt also warned of another possibility, one which she considered to be, on the whole, more likely. Not an advantageous outcome but rather a de-centering of humanity, a loss of our sense of belonging, our sense of finitude and connection to a shared past. To explain what is at stake it may be useful to reflect upon the sense of being anchored firmly here on the Earth which was captured so well by Arendt's fellow phenomenologist, Edmund Husserl, although never fully explained by the latter: to live our kind of life and experience the world *as we do*, is to approach matters as, in a sense, an earthling. It is to see matters from a stable and limited point of origin. Figuratively, in Husserl's terms, 'The original ark (Earth) does not move' (Husserl 1934). And while this renders us vulnerable to certain distortions of perspective, vulnerable even to an overestimation of our own significance it also preserves our sense of having a home, a point of origin, a shared condition and predicament. The point which Husserl and Arendt seem to have appreciated is that our humanity may well be bound up with our finite standpoint or, more simply, with our earthliness.

This again is not a point about humanity in the biological sense of 'bearers of our DNA' or '*homo sapiens*.' Rather it is a point about our humanity in that other, non-biological sense, the sense which we often fail to recognize but nonetheless use. As an illustration, let us suppose that I pass a rather unfair comment upon the novels of Jeffrey Archer and say that he does not show quite the same depth of understanding of humanity as the plays of Shakespeare. (The comment is somewhat unfair because of the nature of the comparison.) By saying this I would not be suggesting that the former might confuse pets and their owners or staff and inmates at the local zoo. My point would not be about the capacity to recognize the distinctive biological traits of the human (something which Mr Archer might do just as well as the bard). My point would, rather, concern what it is like to live *a life like ours*. And this is where Mr Archer might not fare quite so well. Indeed, living and appreciating a life like ours is something which we might conceive of in association with someone who happened to have a different structure of DNA and a different set of ancestors. Indeed science fiction does this all the time and does so without generating any real paradox: Kirk once suggested that Spock was the most human of all those on the *Enterprise*, and he may well have been right. Spock certainly struggles and finds himself perplexed just as we do. His perplexity is essentially a modification of human perplexity rather than an alternative to it.

More generally, *being human* in this other sense, the sense which is not about a category of biology, is about belonging to and acting as part of a community of values, a community which is a product of shared past rather than simply a given of species membership (Cockburn 1990). Admittedly, the emergence of such a community, and a sense of its importance, is a historic accomplishment which has an extremely dark side. Specifically, it has involved the exclusion and the regular mistreatment of the non-human (as if *outside humanity* were equivalent to *less than human*). Such anthropocentrism might lead us to hesitate to embrace anything that called itself 'humanism.' But it is also against the backdrop of an idea of a shared

humanity that great wrongs and injustices (New World slavery, the Holocaust, and modern instances of genocide) may be understood as failures of a special sort, failures to recognize the bonds that join us to others. Indeed such failures may be regarded as a *betrayal* of our humanity, and the normative force of such a charge, its moral gravity, will be readily understood. To lose our purchase upon this sense of a shared human condition without having some appropriate replacement which performs many of the same tasks, would be a great moral loss.

But has there ever been any such threat to our sense of humanity? Or is there ever likely to be any such threat? Given that the appreciation of our common humanity (in the relevant enriched sense) is not biologically fixed, Arendt may be entitled to reply 'yes' to both of these questions. Our present century, which is not so very old, has already provided indications of just how vulnerable our sense of a shared humanity can be, how easily it can collapse into an exclusively-localized and militarized allegiance. Can we then regard our common humanity as invulnerable to the strains and pressures of the colonization of space? How, after all, could we sustain a sense of a genuine community across distances so immense that communication could never take the form of a face to face encounter involving actual conversation?

On a more individual scale, we may think of the experience of disconnection from others which is already a familiar feature of space psychology, and one which kicks in only barely beyond the Earth's atmosphere. Mike Mullane, writing about his time on the Space Shuttle, has noted 'a powerful sense of detachment from the rest of humanity' (Mullane 2007, p. 175). Similarly, we may think of the descriptions of loneliness offered by the astronauts who were left in their Apollo command module while their companions descended to a greater fame on the lunar surface below, a loneliness of a unique sort and one which startlingly contrasts with intimations of a sense of unity and belonging which were given by Ed White during his (and NASA's) first spacewalk, secure in his sense of connection to a ship containing others and secure in his connection to a world above (or perhaps below). A similar sense of awe and belonging can also be detected in the reports of astronauts upon first seeing the Earth from space (Kelley 1988).

Arendt seems to worry about, even in a sense to fear, both the direct phenomenology of standing above the Earth, and *the very idea of* an exterior out-of-Earth point of view and how it might come to affect us even if we ourselves are not able to physically occupy such a position. 'Without as yet actually occupying the point where Archimedes had wished to stand, we have found a way to act on the earth as though we disposed of terrestrial nature from outside, from the point of Einstein's "observer poised freely in space"' (Arendt 1963, p. 273). This concern, one of disconnection from earthly beings whose lives matter, is regularly echoed in our contemporary ecological literature. Rolston's recent work *A New Environmental Ethics* (2012) plays forcefully upon the theme: 'Earth is not simply the stage, but the story. In that sense we do not just want sustainable development, maximum exploitation of the Earth's resources, but a sustainable biosphere, because we are incarnate in that biosphere. We are Earthlings. Our integrity is inseparable from Earth integrity' (Rolston 2012, p. 220).

However, in Arendt it is not so much the connection to the Earth as such which is ultimately at stake, but rather a connection to other humans which is *mediated* by our sense of a shared earthliness. Take that earthliness away and there is a question mark over what we will have left. A view, perhaps, of human activity from the outside, from a standpoint where it is nothing but colorless bodily movement or 'overt behavior,' not in any significant respect different from that of lab animals placed under observation in a maze. It is this fear which prompts Arendt's concluding comment, a comment which allows skepticism to slip directly into pessimism. 'The conquest of space and the science that made it possible have come perilously close to this point. If they ever should reach it in earnest, the stature of man would not simply be lowered by all standards we know of, but have been destroyed,' (Arendt 1963, p. 274).

3.3 Ballard's Skepticism

While Arendt attempts to articulate something deep about our sense of being human, Ballard's skepticism, set in the fictional context of a series of short stories written over the course of more than two decades, is skepticism of a more easily inhabited sort. The stories, published in parallel with the major nodal points of the US space program (from the Gemini missions through to the Moon landings and then under the impact of the Regan years) are set around an abandoned Cape Canaveral in the aftermath of the conspicuous hubris of human over-reaching. 'The space programme had expressed all its failure in that terminal moraine of deserted hotels and apartment houses, a cryptic architecture like the forgotten codes of a discarded geometric language' (Ballard 2006, p. 549).

The Cape is undergoing a, typically Ballardian, New Triassic age, abandoned and overcome by lush vegetation, an indication of the Earth's fecundity, while the fragmentary remaining human artifacts are typified by aridity. Dried up and cracked swimming pools are filled with debris and broken sunglasses, with the latter functioning as a symbolic barrier to the human interior. Ballard's tales provide a fascinating counter-point to the official and flattering narrative of human progress and accomplishment. Long regarded as unfair and excessively critical, the tales have, in more recent times, come to be regarded more sympathetically. The earliest of them can be seen in retrospect as a thoughtful and unusually prescient response to the sudden opening up of space, a response which was in touch with the crushingly restrictive political and economic realities which eventually asserted themselves. Contrary to hopes, but in conformity with Ballard's suspicions, we would not reach Mars well before the end of the century and the stars (by means of some unknown technology) shortly afterwards.

'The Dead Astronaut' (1968), written in the months before the first Moon landing, provides an anticipation of disappointment (Ballard 2006, pp. 260–272). In Ballard's myth, the space race has long since ended and periodically the lost capsules re-enter the Earth's atmosphere with their long-overdue inhabitants or, a

least, what remains of the latter. A couple whose life together has been sterile and blighted go to await the re-entry of a former colleague, perhaps loved by the woman, certainly envied by the man. What they discover is radiation sickness. They find that the glorious mission was nothing more than an attempt to put nuclear weaponry in space. Not a promise of new life, but death coming back to the Earth. This may seem close to a critique of an obvious, and familiar, sort: space programs are bad because of their military connection. However, Ballard is not focusing upon the military connection. Instead he focuses upon the disillusionment, the mistaken investment of hope in all the wrong places. The couple might have lived a better life together without this haunting presence.

Ballard's tales from the 1980s, such as 'News from the Sun' (1981), born out of the Regan years, are dominated by a more complex layering of images. Now that exploration has been abandoned, humanity is in the grip of *fuge*, flight of a different sort, a special kind of 'time sickness,' a flight from present reality and from the reality of change (Ballard 2006, p. 540). Those who succumb to *fuge* find themselves either dislocated from everyday worldly events and (as in Arendt) disconnected from others; or else they suffer from the peculiar fantasy, explored in 'The Man Who Walked on the Moon' (1985), that they actually are astronauts or former astronauts. (In spite of all available evidence to the contrary.)

From the outside, *fuge* is a malady and a chastisement. 'By leaving his planet and setting off into outer space man had committed an evolutionary crime, a breach of the rules of his tenancy of the universe, and of the laws of time and space' (Ballard 2006, p. 544). We were not ready to make the off-world shift, and perhaps man never would be. 'Perhaps the right to travel through space belonged to another order of beings, but his crime was being punished just as surely as would any attempt to ignore the laws of gravity' (Ballard 2006, p. 544). From the inside, the victims of *fuge* do not regard their dislocation as a malady but rather as the advent of a special kind of freedom. To depict the experience, Ballard repeatedly deploys imagery of birth and rebirth, with *fuge*-stricken humans feeling themselves poised on the brink of a great change, a change that will take them into a truer and less limited and time-constrained mode of being, 'At any moment we may be born for the first time,' born into timelessness and, presumably, truth (Ballard 2006, p. 553).

At least three ethically significant background assumptions are built into these fictional scenarios. Firstly, in the earlier texts, there is an entirely correct appraisal of the likelihood that the first-wave space program was going to peter out, the likelihood of a return to business as usual (Ballard 2012, p. 132). A sustainable space age for humanity would not begin until large numbers of people could actually be put directly into space (and not put there only *by proxy*). That was still a long time away. Secondly, Ballard strengthens Arendt's point that even a limited space program *could* be perception-altering for humanity at large. He strengthens it into the more definite claim that this was indeed going to be the case. However, the perception-altering impact should not be understood in an elevated or elevating sense. In Ballard's eyes, its impact upon our ways of seeing made it comparable to the sudden advent of mass pornography with both connected to some intimation of an extinction threat (among other things).

Finally, the Cape stories present a diagnosis of the false dawn of the Apollo program, and nostalgic talk about its renewal during the Regan years, as *complicit* in a flight from reality, as complicit in *escapism* of a reprehensible sort. Hence, rather obviously, the persistent imagery of *fuge*, of flight. On the face of it, this latter charge is harsh but difficult to entirely reject. Reflection upon the works of Konstantin Tsoilkovsky, Dandridge Cole and Gerard O'Neil (perhaps, in a very qualified sense, even the works of Robert Zubrin) may incline us to accept that Ballard had a point (Cole and Cox 1963; O'Neil 2001; Zubrin 1996). After all, for Tsoilkovsky, gravity was not just a physical phenomenon but a symbol of our human bondage, a symbol of our separation from liberty. This is more typical of the space exploration genre than we might imagine. O'Neil's attempt to recreate a version of 19th century pastoral life out among the stars, complete with yards, meadows and white picket fences may also shade into more plausible scenarios of space colonization where the element of *fuge* is altogether more subtle but never entirely absent.

Reflection upon the emergence and history of science-fiction as a genre may similarly lead us to accept that there has been, from the outset, an escapist element in the longing to break free of the Earth and from its complex, seemingly-intractable problems. Such escapism may be far from harmless when it functions, not as a relief from the stresses and strains of being human, but as an alternative to the effective addressing of problems. It can be harmless or ethically suspect. It certainly generates is own counter-culture, an inverse (dystopian) model where 'the company' reproduces earthly authoritarianism and must be resisted by the outsider and the free minded. It also shapes reactive texts of science fiction which succeed in the difficult task of preserving a sense of moral ambiguity by rejects flight in favor of doing justice to the experience of being human. (I will suggest Stanislaw Lem's classic *Solaris* and more recently Stephen Baxter's fascinating *Ark*, as examples.)

However, to reiterate a point made at the outset, none of Ballard's claims individually or collectively imply that there could be no real Space Age *at some point in time* or that it would always be wrong to pursue such an option even at the expense of some unavoidable concessions to our escapist inclinations. Indeed, Ballard's own fiction, with its recurring imagery of the New Triassic, where a dying humanity is always drawn South to the swamps, might itself be regarded as a conspicuously escapist if rather dystopian response to modernity. But here I am suggesting little more than the obvious point that writers do not criticize what is truly alien, but rather specialize in the criticism of their own faults. (Personally, I have a fondness for criticizing puritanism and escapism.)

What is perhaps more interesting about Ballard, what brings him closer again to Arendt and to her elusive concerns and fears for our sense of the human, is the specific form of the escape which Ballard's imaginary *fuge* involves: a flight into timelessness, movement into space as an image of movement out of our ordinary human temporality. What fuge aspires to is a kind of immortality, an invulnerability to change, alteration, decay, and the many traps of the Earth that go with being human. Invulnerability of this sort comes at a price. Without time there can be no building of a shared past and hence no sense of a historically-formed connection to one another. Through flight into the infinite, we gain the expanse of time but lose

everything that gives a shared human existence its meaning. Symptomatically, Ballard's *fuge*-liberated victims may attempt to move together into the infinite but ultimately they are alone.

3.4 Humanity and Frailty

I am not going to suggest that Arendt and Ballard get matters right 'all along the line.' (I am not sure what writing of that sort would look like.) Indeed, they embed their shared space skepticism in very different sorts of responses to the modern world: Ballard is atavistic and longs for a return to something more primitive; Arendt acknowledges a rupture from the past which cannot be healed. However, there seems to be something particularly insightful about what they share. More specifically, their skepticism seems to place a legitimate question mark over conceptions of freedom which are escapist in the sense that they tend to undermine our appreciation of a shared sense of vulnerability and thereby our shared humanity. What Arendt and Ballard point to is an appreciation that our human vulnerabilities, symbolized by our belonging to a particular place and having our being in time, are among those things which help to bind us together with others and more specifically with others who share a life like our own. As an upshot, skepticism of their sort can, I suspect, be answered, but not by appeal to the removal of such vulnerabilities. (By pointing out that space exploration offers advantages x, y and z.) After all, it is precisely the removal, or partial removal, of a sense of vulnerability that they find threatening. On their shared view, any promise of freedoms which promises too much will then also risk removing the basis for a specifically human sense of belonging with all of the susceptibilities to harm that this entails. If they are right then any conception of future liberty which looks strongly utopian will involve a conception of the future about which we should be cautiously concerned.

But it is not 'only' our sense of a shared humanity that is at stake. Other concepts which are closely associated with the latter can also be brought into play. For example, at some point in time the thorny question of rights in space will have to be addressed. Or at least this question will have to be addressed if we are not simply to embrace the kind of *laissez faire* ethic which has seemed so problematic when implemented terrestrially. Rights enter the picture because it is our human vulnerability which makes a good deal of rights talk (and talk about the defense of such rights) seem necessary. Sue Donaldson and Will Kymlicka have recently re-emphasized the point: 'Simple or brilliant, selfish or saint, torpid or vivacious—we are all entitled to basic human rights because we are all vulnerable selves' (Donaldson and Kymlicka 2011, p. 30). The most systematic exploration of some aspects of this vulnerability/rights connection is perhaps Robert Goodin's *Protecting the Vulnerable: A Reanalysis of our Social Responsibilities* (1985) where Goodin advances a 'Vulnerability Principle' which holds that we have responsibilities towards others precisely *to the extent that* they are susceptible to harm as a result of our choices and actions. And here again we may complete the connection by tying-

in such a conception of rights to what it is to be human such that humans are the kind of beings that we cannot legitimately subject to intentional harm in various ways. Obviously, to see someone as fully human is, among other things, to see them as a being who ought not to be degraded and gassed. If we do not recognize this about them then we do not see them as fully human. In other words, entitlements of various sorts have come to be a built-in part of our (enriched) concept of the human. Perhaps other kinds of beings ought not to be harmed in a similar fashion. They too should perhaps be entitled to rights, but at the very least humans are so entitled.

Even so, perhaps we may reflect that something better than humanity, human rights and a shared human bond may be possible. A working familiarity with the harms caused by anthropocentrism, the darker side of our human mutual-identification, may half persuade us that this is the case. (On Tuesdays and Fridays I am almost convinced.) And indeed, one day we may no longer need any sense of a shared humanity, a shared vulnerability to harm and a restriction of agency cast in the language of 'human rights.' Some other, perhaps better, bond may become just as vital. But, at the risk of stating the obvious, we do not, as yet, have any viable substitute. And whatever does ultimately come to replace our grasp of a shared humanity may need to share some of its better features. This much of the legacy of Arendt and Ballard may be worth preserving.

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Chapter 4
Freedom in a Box: Paradoxes in the Structure of Extraterrestrial Liberty

Charles S. Cockell

Abstract Extraterrestrial environments have within them paradoxes of liberty, most of which derive from the need that people will have to work under a strong collective ethic to survive in a deadly environment, whilst at the same time pursuing the need for individualism to counter these conformity-generating extremes. These paradoxes are manifest at political, cultural and economic levels. Defusing them successfully, without allowing an extraterrestrial society to completely unravel, will one of the primary challenges facing emerging extraterrestrial societies.

Keywords Paradox · Liberty · Extremes · Economic challenges · Isolation

4.1 Introduction

As early extraterrestrial societies emerge they will contain within them an inherent tension—the friction between the collective effort needed to survive in an extreme environment and prevent instantaneous death and the deeper human urge to individual liberty and an independent state of mind. The extraterrestrial environment has a tendency to centrifugally drive these two states apart to their utter extremes.

The lethal nature of the extraterrestrial environment mandates a requirement for centralised control in all manner of safety checks and social mechanisms that must be used to ensure the safety of the community. The tendency for people to seize upon this necessity to consolidate power has the potential to generate ever more demanding states of autocracy.

But the extreme extraterrestrial environment is also the mainspring of individualism. The collective effort required from humans to survive in space and the likely conformity this will cause will impel individuals to seek their own identity. In ful-

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filling the need to be recognised as a contributor, a benefactor to the success of the precarious extraterrestrial condition, some people will be driven to seek ways to demonstrate their individual capabilities. Still others, fearing their inability to contribute something noteworthy to society through individual skills, will seek identity through their personal lives and their own activities performed in the privacy of their own time.

More so than on Earth, this contradiction is poised to collapse either into a collective despotic hell or an anarchic individualism that rips society apart.

For a successful extraterrestrial society to be constructed, social paradoxes must be understood because they are the girders that run through the edifice of society; the successful control of the tensions within them is the basis of the maintenance and order of society. If we are to understand extraterrestrial liberty, we must understand its intrinsic contradictions and paradoxes.

4.2 Political and Social Paradox

Extraterrestrial society, with its paucity or lack of indigenous food, water and air, may not be categorically different from terrestrial societies in many social respects, but rather a more extreme version. Examples of these terrestrial societies include the High Arctic and extremely hot deserts, where water and food are equally scarce and can only be procured with great effort. A lack of these most fundamental requirements in both the extraterrestrial and terrestrial cases promises rapid death (in at least a matter of days). However, the extraterrestrial environment suffers from the imposed veneer of a lack of readily available breathable atmosphere, a situation which will cause death within seconds[1] (Cockell 2008).

The instantaneously lethal conditions in outer space bring an urgency and focus to survival that is greater than even the most extreme environments on Earth. It places demands on society and particularly those who run it[2] (de Tocqueville 2008). Their responsibility is to align the settlement of people in such a way that everyone is guaranteed their basic survival needs. Faced with the prospect of presiding over

[1] This complication is summarised by Cockell (2009): "The problem of oxygen is the problem of extraterrestrial economics and, more generally, extraterrestrial liberty".

[2] "I have often asked myself what was the source of that passion for political liberty which has inspired the greatest deeds of which mankind can boast. In what feelings does it take root? From whence does it derive nourishment?… It is the intrinsic attractions of freedom, its own peculiar charm—quite independently of its incidental benefits—which have seized so strong a hold on the great champions of liberty throughout history; they loved it because they loved the pleasure of being able to speak, to act, *to breathe unrestrained*, under the sole government of God and the laws [my italics]" (de Tocqueville 2008, p. 168). In this quote de Tocqueville quite overtly (although of course serendipitously) discovers the major source of potential tyranny in space. It certainly never occurred to him that the love of being able to breathe unrestrained without your oxygen being tyrannically controlled by someone else could become a significant problem for a branch of humanity beyond the Earth.

fatalities that might be caused by the most trivial engineering oversight or structural inadequacy, they will almost certainly err on the side of caution; in other words, they will take conservative decisions designed to protect safety even if those steps have unforeseen and unfortunate consequences for individual liberty. Paradoxically, if individuals acquiesce and accept the necessity of control over air supplies and other essential needs as a means to escape the perpetual feeling of being under duress, this in itself will be an acceptance of the necessity of the dominating force of extraterrestrial authority.

The situation is not unlike that experienced by western states at the time of writing. Faced with the threat of terrorism, a conflict between personal liberty and national security has arisen, which is nothing new, but has achieved a new intensity and more sharply defined discord[3] (Wilson 2009; Grayling 2009). The clarity of this conflict will be perpetual in the extraterrestrial environment. Although not brought about by human action, the lethal environment forces safety and engineering checks upon society that will blur the division between "necessary" oversight and draconian oversight. Few people will be willing to challenge these demarcations if there is the likelihood that they will be held accountable for the tragic consequences of a more liberal approach.

Almost all activities ultimately fall prey to the demands of collectivism in space on account of the inability to achieve completely free physical movement. Whether that be mining, tourism, farming or construction, each one of these will require people in spacesuits and habitats with all the collective effort needed to keep these systems operating and functional.

Whatever the tendency towards individualism in space, the environment will mandate a more collective socially cohesive culture, pulling society towards this extreme more completely than it does on Earth[4] (Cockell 2008).

The lethality of extraterrestrial environments goes hand-in-hand with another one of its overarching problems—the assault on the human senses and sense of individualism[5] (MacKlem 2006). Being continuously incarcerated within a habitat or spacesuit makes the diversity of smells limited compared to those experienced in any environment on Earth, where a single walk can expose a person to the smell of trees, flowers, lakes, buildings and innumerable other permutations of material, biological and abiotic aromas. Most extraterrestrial environments have little variety

[3] The similarity between the terrestrial case and problems related to oxygen in the extraterrestrial case is intriguingly (but unintentionally) made by Wilson (2009) in the following observation: "According to the Metropolitan Police Act of 1839 a policeman could arrest anyone for words or behaviour which could lead to a breach of the peace. This act was immensely popular with the police, who called it 'the Breathing Act' because a constable could interpret its general wording in order to make an arrest for any kind of public nuisance, including breathing."

[4] These problems with the collective culture and their effects on political institutions are explored in Cockell (2013).

[5] MacKlem (2006) states: "Privacy is not the preserve of hermits. For most people, privacy is a matter of restricting the potential range of one's human contacts, so as to form deeper connections with a more limited number of people." This requirement may be equally crucial to human mental health as actions defining individuality.

in their colours, largely a consequence of their lack of biospheres. Mars is dominated by reds and oranges, a landscape of volcanic rocks and their weathering products; the Moon, and almost every other planetary body where humans might land, is dominated by greys and black.

The lack of complex hydrological and atmospheric cycles in extraterrestrial locations where humans might live makes many extraterrestrial environments tedious and predictable. Thus, because their continuous lethality, these environments are predictably dangerous. Through all of this conformity the natural human desire to be an individual will continue, a yearning likely made more extreme by these alien conditions. Expressed through science, art, philosophy or just the human personality itself, individualism will be one antidote to monotony.

Diverging on paths far more extreme on Earth, two paths caused by the dangers of extraterrestrial environments will lead to two conflicting requirements—the need for a sense of collective responsibility and the need to be an individual. The successful balance of this paradox is crucial to the longevity of extraterrestrial societies. A collectivism that stifles individualism will breed resentment and potentially political instability; an individualism that erodes a coherent collective culture will likely lead to disaster[6] (McKercher 1989).

An extreme version of this paradox is likely to manifest itself in the leaders, or leader, of an extraterrestrial society. Faced with enormous external challenges and the possibility of instant death, there is a likelihood that settlers will look to charismatic and forceful leaders to hold society together and achieve its safety. This yearning for strong leadership does not need particularly unusual alien conditions: human history, including modern history, is replete with examples of populations accepting dictatorship on account of the stability and certainty that tyrants offer.

The type of person who emerges to lead an extraterrestrial society, as with tyrants on Earth, is an extreme form of "superman" or "superwoman", seen by the population as possessed of unusual human skills, powers of personality and intellect to run the society and enforce the collectivist creed necessary for society to function, for individuals to be kept in check and for dangerous people, particularly criminals, to be held within the system of social organisation[7] (de Tocqueville 2008). This type of human is an extreme individualist personality type, regarded by the population as almost unique yet made possible by the extraordinary conformity and collectivism that many people might regard as essential to the continuity of the settlement. Thus,

[6] McKercher (1989) observes: "Ideally all individuals would be free to express their individuality 'in things which do not primarily concern others'". But as few activities rarely do not concern others, particularly in the extraterrestrial case where a greater number of life's vital supplies are part of an interconnected network, there must always be an exacerbated tension between collectivism and individualism in space.

[7] Still one of the best quotes exemplifying this state of dependency remains de Tocqueville's (2008) observations on the culture before the French Revolution: 'They felt for him [the King] both the tenderness one feels for a father and the respect one owes only to God. By submitting to his most arbitrary commands, they were yielding less to constraint than to love; thus they often kept complete freedom of soul even in the most extreme state of dependence' (p. 123).

the charismatic leader is the ultimate manifestation of the paradox between individualism and collectivism, embedded within society generally but personified in the leader. And yet again, managing this paradox lies at the heart of the extraterrestrial society. Elect or declare a leader to run a society who does not have the skills to exert forceful leadership and inspire people with an unusual personality, and society will begin to dissolve, and probably, given that fear of disintegration will grip the populace, give rise to a new and more forceful leader. Elect a leader whose force of personality comes with a thirst for power, which is a common combination, then society will easily decline into nothing more than a tyranny.

The paradox between collectivism and individualism is particularly problematic for a small settlement, which will be the case for early societies. Small societies harbour a strong sense of camaraderie whose benefits include the ease with which agreements can be made about the way to do things among a small group of people, and the generally strong social bonds that emerge among small groups of people that share common challenges, experiences, triumphs and failures[8] (Price 1991). Strong collective cultures emerge in small societies, reinforced by a physically close-knit community.

Nevertheless, despite the camaraderie, the small society nurtures more constraints on individualism[9] (Russell 2004). A lack of anonymity in a small group makes it difficult for idiosyncrasies to be absorbed; they stand out as anomalies with greater distinction than a much larger society. With few social options, there is enormous peer pressure for individuals to conform, underpinned by a fear of ostracisation[10] (Fossett 2001). This very sense of being hemmed in by social mores can intensify an individual's need to find ways to express their individualism, creating tension and discord between the paradoxical needs for the small group to remain whole and the needs of the individual to escape a crushing conformity.

The paradox between collectivism and individualism is a type of problem that emerges from the political requirements of the settlement and the social requirements of the individual. There are other ways in which differing political and social needs can manifest themselves in inherent contradictions and paradoxes in the extraterrestrial society that again may be readily identifiable in terrestrial societies, but made more extreme by the environmental context of a space settlement. One of the most prominent of these is the paradox between a culture of utilitarianism and idealism.

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[8] Price (1991) states: "From hence it is obvious that civil liberty, in its most perfect degree, can be enjoyed only in small states where every independent agent is capable of giving his suffrage in person…" (p. 24).

[9] Russell states (2004): "The Greek City State…has revived because its methods of propaganda have again become available" (p. 158). In the extraterrestrial case, access to communications technology in confined environments with small numbers of people makes coercion and propaganda effective.

[10] This is a well-known pressure in small communities on the Earth. For example, as Fossett observes (2001) among the Inuit: "Means of enforcing peace and harmony within communities included shaming, shunning, banishment, abandonment leading to death, and execution. Public ridicule and ostracism were the most frequently used methods of social control, and generally had the desired effect of keeping people cooperative" (p. 207).

To begin with it is worth some definitional clarity. Here I simply use utilitarianism to refer to a culture of a society driven by practical needs and outcomes; I do not necessarily refer to a society that explicitly pursues a strict Benthamist interpretation of that word in attempting to achieve the greatest happiness for the greatest number. By idealism, I mean a society underpinned by overarching ideals and social visions; I am not using this word in the rigorous philosophical sense of reality being a mentally constructed phenomenon, the usual meaning of "idealism". In this sense, I am using these terms colloquially.

To survive in outer space requires a pragmatic perspective and approach[11] (Manin 1997). Basic problems will present themselves that appear banal, but may lead to dire situations. Blocked waste drains could threaten the functioning of a life-support system and the supply of materials to plants and animals or physical infrastructure dependent on an unhindered flow. A broken power circuit might lead to lethal temperatures for a section of habitat. It hardly needs explaining what weaknesses or structural flaws in habitat outer casings and spacesuit skins will cause. The list of small problems whose immediate resolution is essential goes on. There is little room within all of this for high-minded ideals. The environment will require people to have a utilitarian view of society that seeks to maximise the comfort and safety of everyone by whatever means can be mustered in the extreme conditions.

In the early stages of a settlement, redundancy in people will be largely unavailable. The challenging number of tasks to be undertaken and equipment to be maintained will ensure that almost every individual has a predefined purpose in society and set of skills necessary to be contributed and applied to the interconnected requirements of society. The impractical, theoretically minded thinker will find themselves unwanted, but more to the point, probably selected out from the settlement at an early stage. As the society develops in space, so the pressure for people to retain a grounded view of society and its operation will continue; even those individuals who started off assigned to very prosaic tasks and who have a propensity towards idealistic thinking will find that their opportunities to indulge these sentiments will be few and far between—almost certainly confined to the dinner table and moments of light relief rather than everyday planning.

Yet within the extremity of space and its unforgiving danger, humans will require a vision of their social purpose beyond their mere existence as automatons performing tasks made necessary by the exigencies of existence[12] (Alford 2005).

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[11] If a credo becomes completely established in the extraterrestrial society, for example a culture of safety against the extreme environment, and it begins to permeate politics, economics and culture, then it can become tyrannical—"totalized" as Manin (1997) puts it (p. 215).

[12] Although in the very extreme case allowing the collective to overwhelm one's need to be distinctive can be a form of liberation. Alford (2005) observes: "A young man said that upon joining the Nazi Party he felt free for the first time… How could this be?… Fusion with power… an experience readily confused with freedom, as both experiences bring with them similar emotions of relief, abandonment of the burden of oneself, and power…"

Consider this quote: "Justice has released us from our grave in deep space". In the 2013 production of Beethoven's *Fidelio* by the Opéra de Lyon, set on a spaceship, Aniara, heading into deep space, the chorus pronounces these words. Faced with the pointlessness of the darkness of

For if there is no purpose to their lives other than fixing life-support systems, tending to habitats and surviving in a deadly environment, then what meaning is there in life? Now the cynically minded might well point out that on Earth today many people do in fact live very circumscribed lives, focused on jobs in which they are a defined cog in vast corporate machines carrying out specified tasks. Although this might well be the case, many of them can at least enjoy the freedom of a planet where the air is available and outside movement is possible. This, at a minimum, provides a context within which to experience individual freedom that is lacking in an isolated outpost, millions of miles from other inhabited regions and enclosed within lethality.

The monotonous, dangerous and tedious space environment will encourage, and can be dealt with by, some high-minded ideals about human society and its purpose. What those ideals are we cannot say exactly, but given some of the purposes that we know about for space exploration and settlement, we could attempt to guess what they might be. An outpost on asteroids might see its long-term purpose to be to contribute to preventing an asteroid collision with Earth. A base on the Moon or Mars might see its purpose as contributing to the economic expansion of humanity and its access to resources, even if initially the commercial incentive is strongly driven by tourism. These lofty long-term objectives would redound to society by influencing the everyday purposes and objectives of individuals who see themselves as part of this larger scheme that brings a greater meaning and depth to their existence.

More practically, high-minded ideals might themselves be needed to reinforce the very utilitarian view of life required for society. A sense of selflessness, a sense of duty to the settlement and its survival and a sense of collective effort for the benefit of all were notoriously demanded, with limited success, from citizens of 20th Century socialist nations. In the absence of economic incentive, these demands are difficult to inculcate into the population. Yet the very survival of a group of people with unforgiving extremes requires that they are successfully instantiated in the view of society and one's purpose for carrying out tasks for its benefit. There is no reason why economic benefit should not play a part in enticing people to carry out their tasks successfully; nevertheless, it cannot be relied upon and given the essential nature of many tasks it is likely that a strong social sense of responsibility and purpose will start to take root in the ethos of society.

From these basic requirements a paradox emerges in the political philosophy and social pressures that are inwrought in the extraterrestrial society. A very strong utilitarian, practical view of everyday life, the responsibility to carry out vital survival tasks and the need to behave with a no-nonsense approach to living will run juxtaposed to high-minded ideals desired by people as a means to counter the banal extremity of the outside environment.

(Footnote 12 continued)
endless deep space, the protagonists, in this unusual rendition of a classic, find meaning through their pursuit and realisation of a higher purpose.

As with the paradox between individualism and collectivism, this paradox is not novel. Human society has constantly been faced with a struggle, both at the individual and societal level, for a balance between the needs of society, particularly if it exists in extreme environments, and the need that people and society have to believe in a higher purpose and sense of being than merely the carrying out of functional requirements mandated by society. Nevertheless, it is the extremity of the extraterrestrial environment that cultivates a particularly functional view of life, and the extremity and uniformity of the outside environment that encourages its displacement with high ideals, causing these two requirements to diverge and create a rift between them.

Like the Earth, the paradox has to be successfully balanced. An extraterrestrial society focused solely on practical objectives with no recourse to a higher purpose will surely drive its inhabitants to despair and hopelessness as ultimately they begin to question their purpose, their humanity and any meaning in their lives. A society full of high-minded people who have forgotten to forge a culture of a strong utilitarian ethic and spend much of their time discussing and debating the existence and reason for humanity in the Universe, pursuing ideals of social harmony and cohesion, while forgetting the second-to-second details of survival, will ultimately run into disaster. Utilitarianism and idealism are not necessarily opposed. There is no reason why a sense of duty, higher purpose and vision should not co-exist in a person's mind with a personality trained to deal with the everyday demands of living and survival. However, it is paradoxical that the extremities of environments beyond the Earth will be responsible for amplifying both of these urges, thereby intensifying the schism between them and adding greater demands on the self-discipline of individuals and society to successfully keep them in balance.

The paradox revealed by the extraterrestrial environment runs not merely into the edicts, laws and rules that intertwine the various functions of society and affect the collective culture and the capacity for individualism, but it also runs right to the heart of the political culture and system itself.

Consider briefly a structural failure observed in its nascent state within a girder essential to the integrity of a large habitat. The size of the habitat is relevant because the structural failure could affect large numbers of people and large segments of industrial and life-support capacity. To shut the habitat down for repairs would require moving a large number of people and cause considerable disruption to various lines of life support and infrastructure. Now the apparent failure comes at a time when some other nefarious wheeler-dealings have been uncovered related to financial transactions of the authorities. It is the view of the inhabitants that the structural flaw within the habitat has been over-exaggerated to distract attention. They want time to convene a committee to discuss the problem, get objective expert advice and decide a course of action[13] (Brenkert 1991). But within the inhabitants there are those who regard this as a risk too far: take too long deliberating and the

[13] In discussing the sterility of freedom as merely a lack of constraint and the requirement for the right institutional context to make freedom meaningful in the things people are capable of doing, Brenkert (1991) states: "Accordingly, freedom is closely connected with democratic views of society".

structure might fail, killing people and causing long-term and severe catastrophic disruption to the settlement.

Eventually, the overwhelming view is that safety trumps concern for the democratic process. The people should be moved, the life-support systems temporarily diverted and inconvenience caused while the girder is replaced. Afterwards, a review and enquiry into the whole debacle can begin and the necessity of the procedure examined. No one would forgive themselves or indeed be left unaccountable if the slow process of discussion, counter-discussion and democratic involvement of the polity resulted in catastrophe.

The imaginary situation is a small-scale example of the problem that inheres throughout the extraterrestrial society. The lethality of the external environment will generate a variety of situations, both short and long term, that require people to act with decisiveness and with minimum consultation and deliberation with the wider polity. Diffidence and procrastination in extraterrestrial decision-making may cost lives. The authorities are therefore under pressure to take decisions rapidly in all things that concern the intersection of society, its physical infrastructure and standard supply of basic commodities with the outside environment. Inevitably, this leads to a more authoritarian culture based on central command rather than a democratic process. Even in a participatory democracy, where the individuals within an extraterrestrial settlement have the opportunity to physically gather in one place to deliberate, the time taken to assemble people, consider evidence and possibly re-convene to discuss new evidence may be too long for many decisions. People themselves will tend towards greater conservatism, particularly individuals without full knowledge of any particular issue at stake. They will often assume, for the sake of their own credibility, that a more vociferous advocate of a particular course of action has more knowledge and wisdom than themselves in matters that concern life and death[14] (Hayek 1960). The tendency will be to trust those with longer tenures and experience dealing with particular problems and to give them the benefit of the doubt. Gradually, a conservative, rather dictatorial arrangement of society will emerge from this state of affairs.

However, paradoxically, democratic process and open deliberation will in some arenas be the safest way to minimise the chances of errant decisions being taken by capricious or rash officials wielding the power to take instantaneous decisions that affect the lives of many. Decisions on the architecture or engineering required for infrastructure that will pervade an entire settlement must be done with caution and with due consideration, since once these structures are physically implemented across a large scale, failures within them will be difficult to rectify.

Democracy will be the safeguard against many of the other negative consequences of the extraterrestrial environment—an overwhelming collectivist culture,

[14] Hayek states (1960): "There are at least two respects in which it is almost always possible to extend democracy; the range of persons entitled to vote and the range of issues that are decided by democratic procedure. In neither respect can it be seriously contended that every possible extension is a gain or that the principle of democracy demands that it be indefinitely extended" (p. 91). The public may themselves even support a restriction in the extraterrestrial democratic franchise or the range of issues to be debated if it seems prudent for safety.

economic isolation and a decline in the open and free exchange of information between people.

At once, therefore, a paradox emerges in the extraterrestrial society in the political system. The extreme extraterrestrial environment mandates that decisions are taken quickly and centrally in any field of decision-making in which lives are at risk. Yet the same extremities are the very reason why people must work with vigour to defend democratic process and deliberation in society to prevent this very culture from subsuming the extraterrestrial society into an isolated despotism. As with many other paradoxes in the extraterrestrial society, the physical environment drives a wedge between the two facets of the paradox, forcing them apart, enhancing both the tendency towards central collectivism and intensifying the need to curtail collectivism at the same time.

It must surely be the most serious and important challenge of an extraterrestrial polity to prevent the tensions in society that result from its paradoxes from causing society to spin apart and disintegrate.

4.3 Economic Paradox

No less in the economic sphere than in the political and social sphere, the extraterrestrial society and the environment in which it is situated will face contradictions and paradoxes in the way in which emerges.

Extraterrestrial society needs a great deal of free enterprise. There are ways to attempt to motivate organisations to explore space, some of them laudable in their intentions—to make humanity a multi-planet species as an insurance policy against extinction on Earth, to learn more about Near-Earth Objects to protect the Earth-bound population from asteroid and comet collisions and to explore the unknown. However, few of these objectives will truly motivate organisations, both governmental and private, to settle in space indefinitely and to establish a permanent human presence. To encourage private organisations to expend vast efforts to leave Earth and build settlements and outposts with all the dangers and problems that entails necessitates that they are given free rein to make profits. This not merely provides the economic incentive to explore and settle in space, but also ensures that they maximise the profits that will be necessary for them to reinvest and continue their activities to the following stages.

The laissez-faire economy requires that private individuals and corporations are in a position to claim extraterrestrial land, build on it and extract resources without hindrance (Cockell 2009). The motive might look selfish, but the effort will benefit humanity by maximising the number of individuals and organisations that settle in space and by ensuring that once established there, they have the motivation to continue their efforts.

The long-term success of humans in space requires the successful establishment of trade routes and commerce, which will have the effect of multiplying competition, enhancing the plurality and diversity of goods on offer across a space-bound

society and reducing the chances that societies become isolated autarkies. The vast spatial scales of the Universe and the time required to travel between many locations and planetary bodies greatly increases the chances that isolated settlements will degrade into autocratic economically isolated and venal colonies run by despots. The only way to mitigate this outcome is to ensure the free and extensive flow of goods, people and money between settlements. That is likely to be achieved only through the encouragement of an interplanetary laissez-faire economy with minimum interference by states and bureaucrats and an open field to entrepreneurs.

The laissez-fair economy has a very practical use in outer space—encouraging redundancy. Without breathable air, liquid water or food available in the external environment, it is crucial that there is redundancy in the means of supply. An isolated settlement short on a vital part for oxygen-production machines, for example, could face disaster. A localised deficit of such a product in a small space—a single spacecraft—can be ameliorated with some improvisation from other parts. Apollo 13 is the canonical example of this approach. However, a settlement with many identical machines all lacking a single spare part on which many people rely will face a catastrophe. The safety of society is best served by having access to many different machines doing the same thing and using many different spare parts to achieve redundancy and flexibility in output when something goes missing.

Paradoxically, success in space requires the marshalling of huge resources. The construction of even the smallest self-sustaining outpost on another planetary body requires the following: the means to extract oxygen and other atmospheric gases either from the indigenous atmosphere (as is the case for Mars) or from rocks; the ability to extract water from the atmosphere or ice (as on Mars and some comets and asteroids) or produce it from independent supplies of H and O atoms from rocks; and the means to build greenhouses or growth units to provide food. These challenges cannot be met incrementally. A settlement requires food, water and air the moment it is established. Supplies of these shipped from other places will be expensive and even when they are provided, they will run out, creating a need for industrial processes to achieve self-sufficiency. All of the example industrial processes outlined above are non-trivial and must be implemented at the same time as building habitats, power supplies, waste disposal and all of the other amenities and basic needs of human existence.

Therefore, particularly in the early stages of the establishment of settlements, there is a need for concentrated wealth, for single organisations that have the wherewithal to collect and focus huge technical, human and political resources on space settlement[15] (Russell 2004). These organisations could be government or they could be large private corporations. The reader might reasonably point out that it need not be a single organisation. It could be a consortium of state or private

[15] The same tendency to concentration occurs in any enterprise involving large-scale logistics as Russell (2004) recognises: "When two organisations with different, but incompatible objects coalesce, the result is something more powerful than either previous one… there is an advantage if the whole steel industry, from the extraction of the ore to ship-building, is controlled by one corporation. Hence there is a natural tendency to combination" (p. 141).

organisations, brought together in cooperation to achieve settlement, in the case of private industry cooperating because of the promise of profitable rewards, even if those profits must be split between the component organisations.

Whether the organisations that implement settlement construction are single entities or conglomerates of organisations, each with an expertise in some specific facet or element of a settlement, leadership will still be required, oversight that will come from a single dominating interventionist organisation, or a board assembled from the constituent organisations, but which itself will become a body, directing and facilitating the implementation of the settlement construction and running plans[16] (von Mises 2007).

Concentrated wealth in the extraterrestrial environment is dangerous[17] (Hayek 1944). There are many examples of the ways in which concentrations of money and power will be deleterious to extraterrestrial settlers, but as has been pointed out before, oxygen provides the particularly lucid example (Cockell 2009). Required on a second-to-second timescale by all people, organisations that control the supply of oxygen have power over human life with a thoroughness that few other commodities can command. They need not control the entire supply network: any vital part of the oxygen supply network controlled by an organisation will give them vast economic and political leverage, whether that be the machines that mine the ore or atmosphere from which the oxygen is to be extracted, the machines that produce the oxygen itself or the machines or pipes that distribute the oxygen to the population in the settlement. Every one of these steps is crucial to the reliable supply of oxygen. Every one of these steps provides a bottleneck where bureaucratic inefficiency, coercive practices, venal attitudes and just plain corruption find an opportunity to leverage control over the very existence of people in exchange for profits and power[18] (Hayek 1960).

The coalescence of wealth and resources in the early stages of an extraterrestrial settlement will inevitably influence the later course of developments. As a settlement expands, the original organisations that founded it, having put in vast effort

[16] von Mises (2007) examines eloquently, and with conciseness, the consequences of large-scale bureaucracy, including the culture that results from it.

[17] In the first line of his chapter on economic control Hayek (1944) states: “Most planners who have seriously considered the practical aspects of their task have little doubt that a directed economy must be run on more or less dictatorial lines”. There is of course a vast literature from Hayek, von Mises and others on the link between economic and political freedom, but the essential point must be that the concentration of wealth needed to construct an extraterrestrial settlement has a high chance of collapsing into something akin to a centrally planned economy with all of its tyrannical appurtenances, even if it is done by private corporations.

[18] Note that with some commodities, however, it may be impossible, even in the most enthusiastically endorsed free market economy, to avoid monopoly, particularly in the early stages of space settlement when some resources are scarce. As Hayek (1960) states: “It is one of the unpleasant factors of life that certain capacities (and also particularly advantages and traditions of particular organisations) cannot be duplicated, as it is a fact that certain goods are scarce. It does not make sense to disregard this fact and to attempt to create conditions ‘as if’ competition were effective” (p. 231).

and human energy to achieve the establishment of the outpost, are unlikely to yield control, even if they do overtly support a laissez-faire economy and the expansion of economic diversity (Russell 2004). Although they may welcome new economic entities into their sphere of influence to encourage greater economic success, they are likely to maintain a high degree of control over the political structure of the settlement. Thus, the paradox has long-term economic implications, because the early need for concentrated effort may well stifle the drive for economic diversity at later stages simply by placing political and economic control and influence at an early stage in the hands of entities that will seek, through profit motive or just a lust for power, to consolidate and enhance their advantage.

This is not an entirely new phenomenon, either in small or large societies on Earth. Supermarkets' control of food supply networks on Earth provides the supermarkets with enormous political influence. Any commodity that people require for their basic physiological needs will always provide a lever for economic power. It is in the degree of this possible coercion that we should be particularly concerned about in the extraterrestrial settlement, the control over something which cannot even be gathered in the extraterrestrial environment by individuals on the run and with which they cannot go without for longer than seconds. It might be legitimate to argue this is a matter of degree. However, I think it goes further than this into a categorically different level of potential tyranny compared to the situation on Earth.

So here we have a paradox. An environment that encourages us to maximise the plurality of organisations, products and suppliers for all manner of goods to enhance redundancy, mitigate autarky, minimise coercion and tyranny, and maximise the free flow of money and goods between settlements; yet at the same time, we need concentrations of wealth to ensure the successful construction of self-sustaining settlements with all the vast technical, political and economic complexity that will be required to get these outposts off the ground and to be self-organising and sustainable.

As the extraterrestrial economic enterprise expands, the economic paradox will intensify and with it the need to find ways to encourage cooperation and concentration. At the same time legal agreements, oversight bodies and individuals with a wider sense of responsibility to the economic and political health of a settlement are needed to work tirelessly towards preventing huge material and construction efforts from collapsing into tyranny in which the populations of settlements are merely slaves doing the bidding of economic enterprises controlling oxygen and other vital resources.

The requirement for generating systems of supplies and making them reliable at once reveals another paradox in the system of economics, that of the need for simplicity and complexity.

The plurality of the means of supply from oxygen-producing equipment to habitats, spacesuits and spare parts for all manner of machines suggests that economic complexity is good. I take complexity here to mean a large number of economic entities and multiplicity in the production of commodities including those with the same function. By generating diversity in economic entities and output,

several key advantages can be gained. First, it enhances the redundancy in society, as described earlier. Second, it strengthens choice and offers the possibility for both societies and individuals to reject corporations that they perceive to be operating tyrannically or unnecessarily coercively in favour of other providers. Third, it provides large-scale economic redundancy in ensuring that supply networks and human settlement activities throughout the Solar System can absorb the consequences of the collapse of any single entity. Finally, complexity begets further economic activity by enhancing the number of different products bought and sold, the number of companies attempting to generate new products to sell and by increasing the total creative effort and wealth in circulation, which makes it more possible for new entities to find new ideas and products that have a market.

Nevertheless, complexity can lead to a high probability that a settlement runs short of a vital product when its industrial and mechanical capacities are small. A newly formed settlement will not necessarily immediately have access to the vast diversity of products on offer through a space-faring civilisation. It might have a subset of products from highly intricate and complex supply chains. Herein lies the possibility that if this new and small settlement runs short of a vital spare part, it will be endangered. Thus, for many settlements there is a pressure to produce and own machines and their attendant economic systems that are simple and widely available.

An analogy for this problem on Earth might be cars. In developed countries the complexity and diversity of cars that any consumer can buy is huge. Some of these cars can be repaired relatively easily while some require more specialist help, but within any city or town of a good size one can usually find a garage that will service most makes of car. As a car becomes more complex and expensive, so the servicing costs may rise and the choice of garages capable of providing service diminish. In a developing nation, such as many locations in sub-Saharan Africa, owning an expensive and electronically complex car would be impractical and unwise. Simple cars that have limited servicing requirements and can be repaired, if necessary using improvised spare parts, are a much more sensible option.

So it is in space. Isolated and new settlements will have a tendency to avoid engineering systems that are complex and they will have an interest in avoiding too many varieties of machines doing the same task, for although that variety might create redundancy, it also increases the complexity of the administrative and logistical task of finding all the various spare parts required to deal with the diversity of different machines. Simple machines in large numbers will be a default economic desire in small space settlements.

Again, a paradox emerges. Complexity is one of the surest ways of mitigating tyranny and monopolies in the means of supply in outer space, of generating the diversity of equipment that minimises economic autarkies, increases choice and ultimately contributes to economic pluralism. In contrast, simplicity, particularly for small isolated outposts, is a vital requirement for reducing the multiplicity of supply chains necessary to resupply settlements with the spare parts they need and the machines that must be kept running.

The balance within this paradox is probably not difficult to accomplish. Complexity in its broadest sense should be the objective of the settlement of the space frontier. The benefits that are to be accrued by economic plurality in the long run far outweigh the short-term needs of simplicity for some settlements. The requirement for simplicity can be met at the local level of settlements themselves; there is no reason why different settlements should not use different machines to accomplish different industrial and societal needs, but each outpost would have a tendency to use one specific set of machines. Every group of people can achieve some degree of simplicity and uniformity in its practical safety and commodity supply by choosing to restrict the number of diverse appliances they buy. As the number of settlements increases, so the tendency of particular settlements to focus on particular makes or brands of appliances could be offset by the different choices made by different settlements. Economic complexity can be made consistent with local mechanical simplicity.

Complexity and simplicity in economic systems and supplies has a direct mirror image paradox in the extraterrestrial workforce. Small space outposts with small populations require generalists. There are three reasons. First, generalists provide redundancy in the population, such that if a vital skill, for example the repair of oxygen-producing machines, is lost either by a person moving away from the settlement or even death, then other people may take that person's place. Second, generalists are able to turn their hands to a wide variety of activities such that if a skill becomes obsolete, perhaps because a machine or specific industrial process has been replaced, then those individuals can turn their attention to a new skill. Third, generalised skills reduce the risk of unemployment or more to the point, unemployability. The extraterrestrial society may well be able to afford a few individuals that have limited use or purpose in society, but such persons are a wasted resource, and if they turn to criminality, then they could represent a serious threat to the settlement. Quite apart from these social inducements, there is a personal human urge to be widely skilled. No individual wants to suffer the opprobrium of being a useless individual, particularly in a small isolated community of people where being seen to contribute to society is vital to one's own sense of worth, but also to the sense that others have of one's contribution to society. Individuals will have a strong incentive to learn new skills and knowledge to make themselves useful and to ensure a versatility in their ability to contribute as conditions and economic realities alter.

The long-term health of society, however, depends on specialisation. The realisation that the division of labour is the key to economic performance and efficiency was recognised before Adam Smith's time, but most convincingly explained by him using an analogy with a pin factory (Smith, 1776)—more pins can be produced by individuals specialising in different facets of pin production than a single individual working sequentially on each part of the pin production for each individual pin.

In the absence of large-scale industrial productivity, particularly in the early stages of an extraterrestrial settlement, it seems unlikely that specialisation will be demanded for economic performance in quite the same way as the pressures felt in

Victorian England[19] (Cockell 2010). Nevertheless, specialisation will create efficiencies by allowing people to become particularly good at doing specific processes and making things (even in isolation from other processes) and as industrial capacity is improved in settlements, specialisation will allow small communities to become better at producing specialised products and services that they might even be able to sell to other settlements. As with having sufficient generalised skills to be able to be useful in a settlement, having specialist skills allows an individual to develop a sense of uniqueness in an otherwise austere and uniform extraterrestrial environment. Avoiding the fate of becoming yet another worker in an isolated outpost on another planetary body can be achieved by developing a special skill or knowledge that is admired by or useful to others.

The paradox arising from the need to be a generalist and a specialist does not necessarily lead to conflict. It is very possible and common to have generalist skills and specialist knowledge. In the alien environment, people will quickly learn to develop generalist skills of use for a settlement, and at the same time to learn specialist knowledge that fulfils their need to be individuals and have a benefit within the group. Despite this, it is the case that this paradox of needs is an overt and well-defined economic paradox magnified in small groups in isolated locations. It will continue to be a defining characteristic of the extraterrestrial economic environment until settlements become sufficiently large that individuals can become highly specialised without compromising the redundancy available within the settlement and their own employment prospects.

4.4 Cultural Paradox

Separating political, economic and cultural paradoxes and their intersections with liberty is difficult since political thought is influenced by culture and vice versa, and so too with economic thought. However, there is a general paradox deeply ingrained in the culture of extraterrestrial society that emerges as a result of the need for conformity and expressions of individualism. This paradox may not seem very different from the first paradox I discussed in this essay, but the cultural version of this paradox relates more directly to expressions of art and culture.

Living under extreme conditions, predictability will be one of the desired characteristics in the population. This is true for adults, but particularly the case for young people if they are to be born in extraterrestrial settlements. Wild, vivacious and unpredictable people are not so much a direct threat to society, unless they are mentally unstable, but they can inculcate fear in a population unsure of their motives or future actions. In environments where disruption to infrastructure could lead to instantaneous depressurisation, there are substantial burdens to ensure that

[19] In this essay (Cockell 2010) I explore some of the economic origins of tyranny.

the population is transparently well-meaning, stable and that individuals fall into line with social mores.

Yet the restriction in personal movement and thought caused by the environment and the social culture that it spawns may equally lead to an intellectual liberation in areas of human thought and action that do not require the physical movement of people themselves. Scientific investigations in laboratories are one way in which the scientifically inclined could express their individualism and unique ideas without being a threat to the settlement or perceived by others to be a danger. Philosophy can become a thorn in the side of authorities when it brings into being ideas and points of view in conflict with the social order, but generally speaking, much of philosophical thought is benign, particularly that focused on the limits of the human mind, the human purpose and the nature of existence. Philosophy will be another way in which the intellectually inclined can become individuals, recognised in society for unusual contributions without undermining the social order. Art is yet another expression of human creativity that will be of direct benefit to a settlement. Paintings, pictures, sculpture, video and any manner of visual artistic expression will provide settlements with variety, a visual reprieve from the monotonous colours of the outside environment, a creative outlet for people in the settlement.

A paradox arises not because the need for social stability and conformity is in contradiction to individual creativity; this tension exists in terrestrial societies. A paradox arises from the fact that both conformity and creativity are the children of the extraterrestrial environment. The extremity of space creates the social and physical restrictions that impose the need for regularity upon society, but this same extremity is the mainspring of the counter-culture that drives people to express their individuality through artistic, philosophical and scientific creativity[20] (Powers 2011).

Nowhere is this paradox more obvious than in education and the time and economic effort expended in advancing it. To achieve a population of pragmatic thinkers who have the necessary skills to hold society together will require that they are versed in some of the major scientific and technical principles that underpin the function of society. Individuals will need to know about how life-support systems work, the scientific principles behind them, how oxygen-extraction systems work and the basic atmospheric or geological principles that allow gases required for the atmosphere to be synthesised or extracted from local resources or materials.

Engineering will be a vital education, not just for engineers, but the entire population. The populace of an extraterrestrial settlement will live in entirely artificial surroundings. On Earth, the imminent collapse of a building or the appearance of a crack in its structure might not need to concern passers-by

[20] Of course, the history of European censorship should not lead one to the naïve belief that creativity itself is not susceptible to tyranny. Although electronic means of communication make this more difficult, an isolated outpost with no instantaneous communication to outside societies might fall prey to zealots. In discussing the various policies of the Habsburg censor, Karl Hägelin, Powers (2011) reminds us of some possible extremities: "Hägelin… forbade using the terms liberty, freedom, and Enlightenment on stage. Nor could performers mention tyranny and despotism…" (p. 95).

(although of course if they are the first to notice it, they might well have sufficient responsibility to report it). In space, such failures could result in depressurisation and instantaneous death, so having a population educated in engineering matters, aware of their surroundings and able to pick up on possible sources of danger will be vital. Great energy and effort must be expended in continuing education for everyone in a settlement as engineering and industrial processes develop and evolve.

This education in matters related to survival is not merely a greater guarantee of safety, it is the very bedrock of extraterrestrial liberty[21] (Ferris 2010). If the only people who understand the engineering and scientific concepts behind the construction of an extraterrestrial settlement are functionaries employed by the authorities, then they have the ability to wield enormous despotic power. Authorities will require experts and as experts will have objective knowledge of life-support systems, they will control objective, unchallengeable power. They will become the worst manifestation of Foucault's fears (Foucault 1980). They can use the possible imminent failure of an engineering structure (real or imagined) to move people around, strike fear into people, remind people of their daily reliance on the authorities for their existence, and generally stir up a coercive and authoritarian regime and culture. If the general people themselves have a full understanding of the operation of the settlement's physical infrastructure, then they have a better chance of challenging dictates and playing an active role in the assessment of social and political policies implemented in the settlement.

For liberty and pragmatism, continuing scientific and engineering education is crucial. However, an education solely focused on the technicalities of existence is quite inimical to a flourishing society and will quickly cause the extraterrestrial society to deteriorate into a group of scientifically capable individuals devoid of any culture and even creativity. Further exacerbated by the extreme monotony of extraterrestrial physical and environmental conditions, and lacking any prior social history to infuse society with the cultural influences of former years, the outpost in space will very quickly become intellectually sterile.

It seems essential that if the environment is not to utterly overwhelm an extraterrestrial settlement, then vigorous efforts must be made to provide education and inducements to learn about art, music and other forms of culture, including terrestrial history, particularly among young people. These forms of culture, although of no obvious direct benefit to the day-to-day running of the outpost, will provide long-term benefits in the health of the colony, not merely by making people less effete in thought, but also by providing a creative impetus to generate forms of art and culture that will be an antidote to the lethality of the outside environment.

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[21] Ferris (2010) explores the link between science and liberty on the Earth and concludes that they are inextricably linked. In the extraterrestrial case, scientific progress might well be linked to improved living conditions and physical freedom (for example better and less bulky spacesuits that enhance the freedom of movement of people). Importantly, widespread scientific knowledge will be an essential precondition for liberty. The link between knowledge and the power that people wield is also explored by Foucault (1980).

Again, from the extraterrestrial environment emerges a paradox. The extreme conditions of space generate a technocratic society that threatens autocracy unless the people learn the basic scientific and engineering skills to remain masters of their fate, yet the extremity of this environment will drive society into sterility and cultural death if the people do not also take up education and efforts in artistic and cultural education and creativity. Both needs must be met. A potential conflict arises from this paradox in how economic resources and efforts in time and people are to be apportioned between these two objectives.

The conflict is to be observed on Earth. Should money be spent on science or art? The question need not be a brutal decision between one and the other, but in any society where resources are limited, choices must be made. Beyond Earth, both science and art are essential for the success of society; finding a way to manage the competing needs of both will be a great economic and social challenge.

It would be an incomplete exploration of cultural paradoxes not to mention religious influences. Partly connected with the paradox raised earlier about the need for a utilitarian culture, but bearing in mind the concomitant need for ideals, many denizens of the space frontier will turn to some type of religious worship, whether that be a conventional God in the Judeo-Christian sense or some sort of pagan worship of the extraterrestrial environment. So utterly lethal is the extraterrestrial environment, so unforgiving is it to human life and so ready is it to consume and destroy the flecks of carbon that makes humans that space will find no better place for religion to flourish[22] (Weber 2007). Within religion, people will find an escape from the desperate extremity and destructiveness of alien environments. But paradoxically, the complete meaninglessness of space, the extent to which it brings into sharp focus the godless violence that is the Universe, particularly when people are parted from the pale blue oasis of Earth, will equally drive some to an acceptance of this view of the Universe. We have within the extremity of space a dividing force, one that compels extremities in thought. Fervent religion and the certitude of atheism will grow side-by-side in the extraterrestrial settlement.

4.5 Conclusion

Running through the structure of extraterrestrial freedom are inherent contradictions and paradoxes. These opposing tensions either have the potential to tear society apart, or in less extreme forms, to destabilise the polity. Many of these paradoxes stem from the concomitant need to encourage collectivist and conformist approaches to surviving in the lethal extraterrestrial environment and the need that any individual will have to protect their identity and sense of self. These two requirements are fundamentally in opposition and yet both are required for the cohesion of

[22] Regardless of one's view of religion, one should not necessarily assume that its success in space will lead to negative outcomes, as Weber (2007) explored for the terrestrial case.

society. Other contradictions stem from the effects of the extraterrestrial environment on society. Although paradoxes within the structure of freedom have the potential to destabilise society, they will nevertheless be an inescapable part of the character of its institutions and people. From a more positive perspective, understanding them provides the foundation for comprehending the nature of extraterrestrial liberty, knowledge which will itself enable extraterrestrial settlers and their governing powers to more successfully balance the competing needs of society to maximise the conditions for liberty.

Many of these paradoxes are not a new human experience[23] (Muller 1966). In particular, the paradox that the cohesion of society requires individuals to conform to social norms and yet a healthy society needs innovation and enterprise to be able to adapt, in other words individualism, is a paradox that has been at the heart of human social arrangements since societies were first born.

In outer space, extreme environmental conditions magnify many of these paradoxes and may in some instances turn them into social conflicts. The extent to which the fear of death can drive society to extreme forms of dictates and coercion in order to ensure safety and the extent to which the utter desolation and barrenness of many extraterrestrial environments might drive people to acts of individualism and creativity to achieve some semblance of personal meaning may generate not merely a paradox, but direct confrontation.

Paradoxes such as these underpin the very notion of liberty. For some people, liberty may be the freedom from the fear of death, made possible by the conformity and predictability of the population and only protected when society can be sure that all individuals subscribe to a common set of rules. For others, too, the collective may be the source of liberty. The resources that must be mustered by an individual to achieve anything in the extraterrestrial environment can only be acquired through collective effort[24] (Priestley 1993). Liberty is therefore achieved by the individual's subordination to the collective. In this interpretation of liberty there is much in common with the ancient Greek version of liberty as the capacity to achieve one's potential, through the city state, to be a responsible and politically active member of the polis[25] (Roberts 1994).

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[23] Muller (1966) explores a number of contradictions and problems with freedom in this and his other works.

[24] Priestley's (1993) point is no different from other political philosophers' ideas about why humanity emerged into societies, but his manner of expression is particularly pertinent to the effort required to get resources in the extraterrestrial case: "As far as mere strength can go, it is evident, that numbers may assist an individual, and this seems to have been the first, if not the only reason for having recourse to society" (p. 30).

[25] A particularly good tome investigating the somewhat ambivalent view on the merits and demerits of Athenian democracy is Roberts (1994). Nevertheless, giving allowances for the fact that it was an early and pioneering experiment in democracy that fell foul to demagogues and majority passions at times, a point expounded on by Rousseau [*Discourses on the Origin and Foundations of Inequality among Men* (1754)] and others, it provides an insight into how a culture that situates liberty within part of belonging to a group can develop in small groups and would likely develop in space.

Yet the modern concept of liberty—as a space free from interference and wherein the individual can act in an uncoerced manner by the others and the state—is a vital source of a sense of individual worth, even if a wider social culture embraces the collective as a means to personal fulfilment[26] (Berlin 1969). A society that places complete emphasis on the collective at the expense of individualism must surely degenerate into despotism. Under these conditions, the individual becomes secondary, even worthless, in comparison to the priorities of the state and society.

How the paradox of collectivism and individualism emerges in social laws and conventions will influence the extent to which different people perceive their liberty as being protected or betrayed. It therefore becomes an essential effort in understanding extraterrestrial liberty to understand from where these paradoxes emerge and how they are manifested in the political, economic and cultural arena.

The paradoxes cannot be removed from society, but with a fuller understanding of how these paradoxes come about, potential conflicts can be minimised and the conditions for liberty that meet both the needs of extraterrestrial society and the needs of individuals can be more fully realised.

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[26] Berlin (1998) was certainly not the first to explore the differences between individual and collective concepts of liberty, but his distinction between liberty as a lack of interference (negative liberty) and liberty as perceived as the capacity to do things (positive liberty) is one of the better-known elaborations. Benjamin Constant also contrasted the modern notion of individualism with that of more ancient views of liberty as being part of a collective: Constant, Benjamin 1988. The Liberty of the Ancients Compared to that of the Moderns, ed. Benjamin Constant, *Political Writings*, 307–328. Cambridge: Cambridge University Press. The changing conceptions of liberty are also explored in Skinner, Quentin and Stäth, Bo. 2003. States and Citizens. Cambridge University Press.

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Chapter 5
Fairness as a Moral Grounding for Space Policy

James S.J. Schwartz

Abstract This chapter takes seriously the prospects for applying Rawlsian ideas of fairness to various aspects of space policy. I argue that Rawlsian ideas of fairness are naturally suited to underwrite orbital access regulations, debris mitigation recommendations, and planetary protection policies. I also explore some of the obstacles to applying fairness to more speculative aspects of space policy, including asteroid mining and space colonization.

Keywords Fairness · Space policy · Rawls · Planetary protection · Access to geostationary orbit

5.1 Introduction

Many sectors of space activities currently fall under the remit of regulations which are intended to promote the fair and sustainable use of space. For instance, the International Telecommunication Union (ITU), which regulates access to Earth orbits—including geostationary orbit (GEO)—pursues a policy of allotting GEO slots for all member-nations, even those that are not currently capable of operating a satellite in GEO. Regardless of whether ITU regulations in practice prove to promote the fair use of GEO, it cannot be ignored that these and many other policies having to do with conduct in space are advertised as upholding some or other ideal of fairness. It might of course be the case that this emphasis on the fair and sustainable use of space is nothing more than a token concession to political correctness. After all, who could claim to be in opposition to policies that promote fairness and sustainability? However, it has been well-detailed that in application to international policy—space policy being no exception—the concepts of fairness

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and sustainability are unhelpfully vague. What precisely are we advocating when we pursue policies designed to ensure that space is used in ways that are fair and sustainable? To whom (or what) are we attempting to be fair? And what is it that we are trying to sustain?

In this chapter I would like to take seriously the prospects for using basic Rawlsian ideas about fairness to provide a moral grounding for policies having to do with the fair and sustainable use of space. I believe that this conception of fairness has the ability to provide a philosophical context for ITU Earth orbit access regulations, orbital debris mitigation recommendations, as well as planetary protection policies. The aptness of the Rawlsian understanding of fairness derives from the fact that the types of missions regulated by the above policies—operations within the cislunar sphere and scientific exploration missions—are principally conducted as *services* to denizens of Earth. We have a rather good sense of the kinds of services that such missions provide, and we also have a rather good sense of what individuals, corporations, and states are benefiting from these services. This allows us to make sense of questions concerning whether the actual provision of these types of space services is fair or unfair. It also allows us to make some headway on the question of what kinds of *burdens* or *responsibilities* are borne by those who engage in space activities.

The apparent success of Rawlsian ideas about fairness for the above policies raises the question as to whether this ideal of fairness should also provide the basis for regulations governing conduct for other kinds of space operations. Should fairness be a focal issue in designing regulations for asteroid mining or for space colonization? There is of course a sense in which these more speculative varieties of space operations would qualify as services, which opens the door to questions about what it would mean for these services to be provided in a way that is consistent with the Rawlsian ideal of fairness. Nevertheless I am skeptical that we have, at present, enough information to make sense of how Rawlsian ideas about fairness should apply to such missions. In contrast with operations within the cislunar sphere and with scientific exploration missions, we can say very little with confidence about who will be the providers and beneficiaries of colonization and space resource exploitation missions. It would therefore be premature to either morally condone or condemn space resource exploitation and space colonization on the grounds that they promote or obstruct fairness.

The structure of this chapter is as follows: In Sect. 5.2 I give a brief characterization of the Rawlsian notion of fairness, and show how it can be modified to apply to conduct in space. In Sect. 5.3 I show how this space-relativized notion of fairness can be fruitfully applied to ITU orbital access regulations, orbital debris mitigation recommendations, and planetary protection policies. Some have argued that an environmental ethics basis is appropriate in the latter two cases—I argue that the application of environmental ethics creates certain difficulties that the notion of fairness is able to sidestep. In Sect. 5.4 I discuss my reasons for doubting that the notion of fairness can be clearly applied to speculative missions like asteroid mining and space colonization. I end the chapter in Sect. 5.5 with a brief discussion about how the moral perspective advanced here can help vindicate the oft-voiced demand for a pragmatic approach to space policy.

5.2 The Space Capability Veil of Ignorance

According to Rawls (1971), the idea of fairness plays a vital role in determining what counts as a just distribution of a society's basic goods (e.g., survival needs, personal liberty, opportunity, the bases of self-respect). He proposes a version of social contract theory[1] designed to remove the biases individuals might have as a result of their station in life—in particular, those biases that come as a result of the talents (or shortcomings) individuals possess through no effort (or fault) of their own (e.g., by birth). To do this he proposes that a fair or just distribution of goods reflects the decisions rational agents would agree to from the "original position" or behind a "veil of ignorance"—i.e., without knowledge of their stations in society. Rawls contends that minimally risk averse individuals would agree on two principles governing the distribution of society's basic goods: The first principle, known as the Basic Liberties Principle, holds that "[e]ach person is to have an equal right to the most extensive total system of equal basic liberties compatible with a similar system of liberty for all" (Rawls 2001, p. 188). The second principle, known as the Difference Principle, requires that inequalities (both in the distribution of goods and of opportunities) are only permissible when they are to the benefit of the least advantaged.

My focus here is on the application of the Difference Principle both to conduct in space and to the use of space resources. I propose the following modification of Rawls's basic idea: Instead of describing the original position as a situation in which individual persons are ignorant as to their station in life, in application to space policy it is preferable to describe the situation in terms of states and their space capabilities. Below I will often speak of the "space capability veil of ignorance." This is a hypothetical situation in which states are ignorant about their space capabilities (including here not only a state's technical skill but also their access to the requisite material resources for, e.g., rocket construction) so that their policy decisions are made without the prejudices that would likely arise were each state aware of its capacity to engage in space operations. From this hypothetical situation it can be seen to be rational for states to prefer policies that only permit unequal access to space or to space resources when such inequality leads to the least space capable state receiving greater benefits than it would receive under a policy of equal access to space and space resources. It is important to note that what is under consideration here is not so much the distribution of *space capability* itself (the know-how and material resources needed to access space) but rather the distribution of the *benefits* that come from space operations. Whether fairness demands the redistribution of states' *terrestrial* natural and human resources in the sense of redistributing the *potential* for developing space capability is not a question I consider here.

Let me take a bit of time to address some of the philosophical questions raised by my application of the veil of ignorance to states and their space capability. First, it is

[1] Thanks to Eun-Jung Katherine Kim and Travis Figg for many useful suggestions about the application of Rawls's ideas of fairness to the issue of space capability.

worth noting that Rawls himself has attempted to sort our how the notion of fairness applies to interactions *between* states or societies, which is carried out in (Rawls 1999). There his concern is primarily with the interpretation of international policies having to do with when one state is justified in intervening in the affairs of another state. The reason I have opted not to mirror *this* use of the veil of ignorance is because I tend to view the question of the fair use of space as a question about the fair distribution of resources, and the original position of (Rawls 1999) is less well-suited to this issue than is the original position of Rawls (1971). There are, however, some potentially serious disanalogies between the distribution of basic goods to individuals, which is one focus of the original position of Rawls (1971), and the distribution of the benefits of space capability to states.

First, the benefits of space capability are often thought of as luxuries rather than as basic goods. This is almost certainly the case as far as certain space services are concerned, e.g., the provision of satellite television signals. But there are clear examples of space benefits that qualify as vital goods, e.g., satellite based weather and environmental monitoring. And further, given the confines of an increasingly populated Earth, space will increasingly provide an outlet for new sources of state and personal liberty and opportunity, e.g., through the establishment of space colonies. A conception of fairness seems essential for ensuring that "luxury" uses of space never override "basic good" uses of space. Though I will engage in very limited speculation on the issue, I am certain that the space policy community could benefit from increased discussion on what kinds of uses of space are mere luxuries and what kinds of uses of space fulfill basic needs. (I should add here that I tend to include scientific exploration activities mostly under the "basic need" category.)

Second, what justifies the redistribution of basic goods according to Rawls (1971) is that the least advantaged individuals are least advantaged through no fault of their own—those least advantaged by choice (a nebulous notion, to be sure) are not owed compensation. This clarification is important in the present circumstances, because it is not necessarily the case that states which lack space capability are this way through no fault of their own. On one hand, states which lack the means to develop space capability are not culpable for their being unable to access the benefits of space activities. On the other hand, states which possess the means to develop space capability but choose not to do so *are* culpable for their being unable to access the benefits of space activities. Fairness demands providing assistance to the former, but not the latter kind of state.[2]

[2] I am bypassing a very large number of complicating circumstances: Is a state that faces a mutually incompatible choice between developing space capability and developing its national infrastructure (or something else of comparable importance) culpable or not for being unable to access the benefits of space, should it choose to develop its national infrastructure rather than choosing to develop space capability? How do past injustices among states affect whether states are culpable for their inability to access the benefits of space? These and many others are important questions, but they fall beyond the purview of this provisional examination of fairness in space policy.

Let me say something in the way of justifying my focus on the actions of states. There is no doubt that much more falls under the purview of fair space conduct than the actions of governments with space programs. There are corporate actors in space, and perhaps at some point in the future individual persons will be capable of autonomous activity in space. I believe that much of what I say below can be modified to suit the cases of corporate and individual conduct in space—however, it greatly simplifies matters to focus on the conduct of states and of those on state-sponsored missions. Another reason for focusing on states is that doing so fits in more naturally with the specific items of space policy discussed below. Moreover, most of the legal precedent for current space policy was set by the United Nations Outer Space Treaty (OST), and Article VI of the OST stipulates that a state is liable for any damages caused by any objects launched from its territory—even non-state sponsored launches (United Nations 1967). However, nothing I say below is intended to show that the idea of fairness is *only* applicable to the actions of states.

5.3 Aspects of Fairness in Current Space Policy

In this section I would like to show how the space capability gloss on Rawlsian ideals of fairness can be seen to support a number of current policies and regulations. The fitness of this approach derives from the fact that most operations in space are conducted as *services* for certain members of Earth's human population. In some sense, space is of a natural resource that can be fairly or unfairly accessed, used, or distributed.

5.3.1 ITU Orbital Access Regulations

Article I of the OST stipulates that activities in space are to be conducted with due regard to the "interests" of all states. Article I also demands that space is to be free for exploration by all states. But the OST does not guarantee that all states should have the freedom to access slots in popular Earth orbits.[3] However, the United Nations does regulate access to GEO by the ITU. Article 44 of the ITU's Constitution states that

> …orbits, including the geostationary-satellite orbit, are limited natural resources and that they must be used rationally, efficiently and economically…so that countries or groups of

[3] C.f. (Marshall 1995, 1999)'s concern about the inequitable distribution of space resources. Linda Billings worries that "those with the means to get to the 'store' of space first get all the goods. Those who get there late may get nothing—a system more in the spirit of imperialism than of the Outer Space Treaty" (2006, p. 252).

> countries may have equitable access to those orbits and frequencies, taking into account the special needs of the developing countries and the geographical situation of particular countries.[4]

As per ITU policy, an agency (governmental or otherwise) may only place a satellite in GEO provided it successfully applies for an orbital assignment. In order to ensure that countries have *equitable* access to GEO, ITU policy also dictates reserving orbital slots (orbital allotments) for the exclusive use of nations, even those that are not currently space capable. However, member-states must apply for allotments if they do not already have them,[5] and ITU members which already have allotments must apply for assignments. Given the amount of bureaucracy involved, one might feel skeptical that the process is, in practice, equitable.[6] Moreover, there is an apparent tension between ensuring "equitable access" to GEO and at the same time ensuring that GEO is used "efficiently and economically." Should GEO slots be reserved for states that have no interest in operating a satellite in GEO? By what metric is it to be decided when the efficient and economic use of GEO overrides the goal to ensure equitable access to GEO? It is noteworthy that the ITU Constitution does not define 'equitable' (Viikari 2008, p. 113).

As the ITU Constitution correctly suggests, GEO is a limited natural resource. (Though I would hasten to add that GEO is an *inexhaustible* resource—the current occupation of a GEO slot does not, in principle, prevent another's use of this slot at a later date.) GEO slots are resources by analogy with radio frequencies and shipping lanes, rather than by analogy with petroleum deposits and coal mines. That is, GEO offers a *milieu* in which to conduct *services*, rather than some kind of material substance that is to be extracted and processed. Such services include weather monitoring, telecommunication, global positioning, environmental monitoring, and astronomical observation, among many others. So when contemplating fair or equitable access to GEO, what is of primary importance is not so much *physical* access to GEO itself but instead fair access to the services that can (or can only) be conducted in GEO (in addition to the freedom to select from among the various possible services that can be conducted in GEO).

The interpretation of fairness under discussion here provides the possibility for gaining traction on what it would mean for the use of GEO to be genuinely equitable: Unequal access to GEO is only permissible when this creates an increased benefit for the least space capable state than under a policy of equal access to GEO. Fairness, then, does not necessarily require equal access to GEO slots, but it would require that states and corporations operating in GEO and in the rest of the cislunar sphere make efforts to fairly distribute the *benefits* of their operations to states that are not space capable through no fault of their own (be this through the distribution of satellite data or some other means). Given that ITU access policies seem to be insensitive to the question of whether states possess or

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[4] Available at http://www.itu.int/net/about/basic-texts/index.aspx. Accessed 22 April, 2013.

[5] ITU Radio Regulations (REV.WRC-07) Appendix 30b, Article 7.

[6] For discussion, see Viikari (2008, pp. 85–93).

lack space capability through their own choice, my proposal is somewhat more restrictive than actual ITU policies. It would *not* be demanded by fairness, I claim, to reserve GEO slots for states that lack space capability through their own choice.[7]

An important temporal element is missing from this analysis. States that are not space capable are no more capable of utilizing space for the benefit of themselves than they are of utilizing space for the benefit of others. If all states were to remain fixed with respect to their space capability, then it would make little sense, as far as benefit distribution is concerned, to reserve GEO slots for states that are not space capable. With fewer slots in use, there would presumably be fewer total goods to distribute. However, many states that are not currently space capable will some day develop space capability. What counts as fair access, then, would seem to vary over time, given that the extension of the concept 'space capable state' varies over time as well. This suggests the need for a trans-generational emendation to the simple Rawlsian analysis I am proposing—the space capability veil of ignorance must also incorporate trans-generational ignorance—i.e., ignorance about when in time a state becomes space capable.

The incorporation of trans-generational ignorance might be thought to create intractable difficulties. States develop space capability at varying rates. Consider the issue from the perspective of a state that will develop space capability in 25 years (a slightly longer period than average satellite operational lifetimes), but no sooner. At the present time, should there be a GEO allotment for the sole use of this state? What if the state will not develop space capability for 50 years? Or for 100 years? Perhaps these are empty questions given that policies will likely undergo dramatic changes during the time periods under consideration. But given that the ITU regulations are designed to ensure that all states have access to Earth orbits for *future* use, it is not unreasonable to ask *just how far into the future* we must look in order to ensure that all states have fair access to space. To say that a state should be guaranteed a GEO slot *no matter how long it will take this state to develop space capability* is hardly justifiable as an *efficient* use of this GEO slot, especially if another state could put this slot to good use in the meantime.

An interesting legal case here was the "sale" of GEO assignments by the small state of the Kingdom of Tonga. Via ITU mechanisms, Tonga successfully acquired six GEO slots (ten other applications were unsuccessful) and promptly began "renting" these slots for millions of dollars apiece. Some have suggested that Tonga's activities constituted either an abuse or an inefficient use of the ITU regulations (Tronchetti 2009, pp. 183–187). But I would like to float the possibly heretical suggestion that Tonga's "abuse" of the ITU regulations is nothing more than a clever strategy by which a state without space capability (through no fault of its own, I suspect) came to *benefit* from resources which ordinarily are only of benefit to wealthier, space capable states. Whether or not a state is capable of developing space capability, Tonga's actions demonstrate that allotting GEO slots for all states (perhaps exempting states without space capability by choice) provides

[7] Thanks to Eun-Jung Katherine Kim for this observation.

every state with an in-principle means for benefiting from the use of space resources and services—either from engaging in their own space operations, by contracting these operations to a third party, or by granting another state temporary or permanent access to their GEO allotments.[8] Indeed, it is clearly in the spirit of the Rawlsian idea of fairness that states without space capability (rather than the ITU alone) retain control over whether their GEO slots are used and by whom. Granting this kind of autonomy (subject of course to the restrictions that states not use their GEO slots for harm or otherwise interfere with the operations of other states) facilitates the goal of ensuring that unequal access to space nevertheless benefits (to some acceptable minimal degree) states without space capability (through no fault of their own). Moreover, such a policy would, in effect, provide a reason for *every* state to seek access to the benefits of space, and would likely encourage increased international participation—especially from smaller states—in space policy discussions.[9]

5.3.2 Debris Mitigation Recommendations

"Space sustainability" is currently something a buzz-word. It is no longer possible to ignore the orbital debris problem and its threat to continued (i.e., sustainable) activity in the cislunar sphere—especially in low-Earth orbit (LEO), medium-Earth orbit (MEO), and geostationary orbit (GEO). A baseline policy for debris mitigation has been presented by the Inter-Agency Space Debris Coordination Committee (IADC 2007) with the support of the United Nations and major space faring nations. Recommendations include passivating fuel tanks of satellites (as they near the end of their operating lives) and of used rocket stages (if they are to remain in orbit after they have delivered their payloads), as well as the reorbiting and deorbiting of satellites as they near the end of their operational lifetimes. These and other recommendations are designed to place checks on the *increase* of orbital debris. Debris *removal* would be ideal, but there are many reasons why removal policies have not been advocated—perhaps the most salient reason being that conventional strategies (e.g., attempting to destroy larger debris objects, using spacecraft to capture and haul-away debris) are more likely to *contribute* to, rather than help solve, the debris problem. Destroying larger objects would just create numerous smaller objects that would be more difficult to track; attempting to capture debris would put the capturing craft at great risk of itself becoming the

[8] In the latter two cases, it would be desirable for there to be provisions in place that ensure that states that are not space capable aren't taken advantage of in their dealings with other states.

[9] It is usually axiomatic in space policy discussions that everyone *wants* access to space and to space resources. Whether it is true that all states desire access to space and to space resources is an empirical matter that I will not attempt to settle. An interesting question is to what degree we should seek space policies that are paternalistic in the sense of encouraging states to desire accessing space benefits.

victim of a catastrophic debris impact. So, at least for the time being, implementing debris mitigation policies presents the best means for sustaining space services.[10]

What is unclear, however, is whether the orbital debris problem is seen as anything other than a mere threat to continued space operations. For instance, planetary scientist Martyn Fogg once observed that the debris problem tends to be viewed "merely as a threat to personnel and hardware safety and does not bring to the fore any more fundamental questions of the rights and wrongs of space utilisation itself" (2000, p. 206).[11] Charles Cockell suggests that the current debris situation is partly the result of a "lack of communication between environmentalists and space explorers" (2007, p. 104). The implication is quite clear—spacecraft engineers and mission planners have failed to translate environmentalism—concern for one's surroundings—from Earth into space.

Though the debris problem is an environmental concern in many senses—orbital debris is a form of pollution that threatens the sustainable use of Earth orbits, much as various forms of pollution on Earth threaten sustained human activity on the planet—there is a potentially important disanalogy. Many individuals are willing to defend the idea that Earth's environments are worth protecting for their own sake, but I am not aware of anyone that has argued that GEO and other Earth orbits are worth protecting for their own sake.[12] The moral grounds of environmental concern in Earth orbit are decidedly anthropocentric, and I believe that the interpretation of fairness under consideration provides an intuitive context for the anthropocentric issues raised therein.

Returning to the space capability veil of ignorance, it should be clear that no state would agree to a system in which orbital debris threatens continued operations in space. It would be to the detriment of *all* states should debris cause GEO (or other popular orbits) to become inaccessible. This implies that no actor in space is permitted to produce debris (beyond the point of necessity). Thus states are not morally permitted to use their GEO slots (either themselves or by leasing them to others) unless they can demonstrate that they have sufficient debris mitigation measures in place and that they do not plan on engaging in any activities (e.g., testing weapons in orbit) that pose a significant risk of increasing the amount of

[10] That debris removal appears to be technically infeasible is somewhat worrying given that there is evidence that the current debris population is unstable (Liou and Johnson 2008). Worth mentioning here is that the militarization and weaponization of space generally has a negative effect on the safety of space operations–a concern that was brought to the fore in 2007 when China destroyed one of its Fengyun weather satellites in LEO as part of an anti-satellite weapons test. In 2013 the debris from the explosion damaged a Russian spacecraft (David 2013). See Alby (2010) for a relatively recent assessment of debris impact risks and Vance and Mense (2013) for a discussion about the economic value of active debris removal.

[11] It is unclear, given the placement of this passage in the article, whether Fogg himself endorses this observation or whether it is merely a claim about the then-dominant views of the space policy community.

[12] This of course does not prove that, e.g., GEO is not valuable in itself, but I admit to a very high degree of skepticism about the intrinsic value of GEO (as I do for claims of intrinsic value generally—see my discussion of planetary protection policies below).

debris in space. The sustainability of space operations is in the interest of all states (space capable or otherwise), and in consequence, considerations of fairness suggest a moral grounds for debris mitigation and other space sustainability policies. This, it should be acknowledged, is an application of the Basic Liberties Principle rather than an application of the Difference Principle, and as such does not concern the distribution of benefits of space activities but instead concerns the burdens borne by those engaging in space operations.

As in the case of fair access to space, the emplacement of debris mitigation policies presents another avenue for increased international discussion about space policy and sustainability issues.[13] But here there is a concern that sustainability-focused policies might work against fair access. Producing as little debris as possible during space missions requires added expense and engineering expertise. If, e.g., IADC debris mitigation recommendations are elevated to the status of binding legal requirements, this might delay or otherwise impede the space operations of states that cannot afford to fully implement debris mitigation strategies. I would like to suggest that this conflict is not as troubling as it might sound to some. The Rawlsian framework under consideration here presents a moral grounds for debris mitigation policies. Under this framework, part of what it is to engage in fair conduct in space is to avoid (as much as is possible) the production of orbital debris, because such debris threatens freedom of action in space. In extreme cases, without fair *conduct*—i.e., without debris mitigation—there is a greatly increased risk of producing a situation in which *no one* benefits from space services (e.g., because of debris impacts creating a chain-reaction event in GEO). A state could *not* reasonably complain that it has been denied fair access to space (or to space services) if it cannot prove its actions to be in compliance with sustainability policies that had previously been shown to be fair under the space capability veil of ignorance (For instance, it would seem to be a violation of fairness, rather than an example of it, for a motorist who could not afford to maintain their brake system to nevertheless be permitted to drive on public roads. Satellite operators that wantonly produce orbital debris should not be treated any differently. If anything, rogue satellite operators should be treated more harshly—a motor vehicle in poor working condition does not have the potential to threaten the safety of other motorists for millennia, but a rogue satellite does have the potential to threaten the safety of other space missions for millennia).

5.3.3 Planetary Protection Policies

Thus far I have discussed issues—fair access to and fair conduct in Earth orbit—that are more or less geocentric in a physical sense. However, it is also worth exploring whether Rawlsian ideas of fairness can be applied to operations beyond

[13] See, e.g., Williamson (2012) and Weeden and Chow (2012).

Earth orbit. To date, the vast majority of such missions have been conducted for the purpose of the scientific exploration of the solar system.[14] Of interest here is Article IX of the OST, which states that parties to the treaty shall "pursue studies of outer space, including the Moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination…" As Williamson (2006) laments, the OST does not specify to whom or what we are to avoid "harming" through the contamination of space. But one plausible way of interpreting 'harmful contamination' is in relation to one of the main items of interest in scientific exploration missions: the potential discovery of extraterrestrial life. In order to minimize the chances of false-positive test results for life, it is necessary to decontaminate spacecraft before they are sent on missions. Policies encouraging this behavior, known as planetary protection policies, have been developed by the Committee on Space Research (COSPAR)[15] and have been widely implemented by space faring states. COSPAR's recommendations in particular are designed to minimize "organic constituent and biological contamination in space exploration." These policies include provisions to reduce forward contamination of sites of potential scientific interest, requiring varying levels of spacecraft/instrument decontamination prior to missions (the greater the chances that the craft will contaminate a site of interest, the more thoroughly the craft must be sterilized).

These policies can find support via the interpretation of fairness under consideration here. The basic idea is that sites of scientific interest can be thought of as limited natural resources. If the exploratory endeavors of one state (or scientific mission) were to jeopardize the scientific viability of this site, then all future exploration missions would be unable (or less able) to gather useful scientific data from the site (e.g., if a Mars rover contaminated a site of interest in the search for extraterrestrial life). From behind the space capability veil of ignorance, it would not be rational to agree to policies which would permit the wanton contamination and destruction of sites of scientific interest. Suppose a mission planner does not know when in time their mission will take place—either before or after similar missions to the same site. Such a planner would of course wish that, if other missions were carried out prior to theirs, that these prior missions would not jeopardize the scientific viability of the data they intend to gather. It would be a violation of fairness to spoil a site of interest for all future missions—especially if the guilty party could not guarantee to others that it collected (and plans to freely disseminate) *all* useful scientific data from the site.

It might be suggested that the notion of fairness under consideration, given its anthropocentric character, is inappropriate as a foundation for planetary protection policies, and that, if a site were truly home to extraterrestrial life, that life would be worth protecting for its own sake. Many find anthropocentric approaches concerning because they offer little motivation for protecting extraterrestrial life after

[14] Of course, for many Cold War Era missions, scientific purposes played second fiddle, with national prestige functioning as the primary motivation.

[15] Available at https://cosparhq.cnes.fr/sites/default/files/pppolicy.pdf.

"the scientific novelty wears off" (Lupisella and Logsdon 1997, p. 4). If any extraterrestrial life is discovered in our solar system, it is extremely likely that it will be microbial life. Does this life have a value apart from its "scientific novelty"? As Cockell observes, extraterrestrial microbes exhibit "the properties of having a 'good of their own' that we respect" (2011, p. 86), which suggests that extraterrestrial microbial life would fall under the remit of life-centered views, of both individualistic (organism-centered) and holistic (community- or species-centered) varieties, which claim, respectively, that organisms and holistic entities are loci of intrinsic (or, more generally, non-instrumental) value. Though a detailed examination of the merits of life-centered views must be reserved for another occasion, I can at least relay some of the reasons why I approach these views with a degree of caution.

It is not clear that an organism's possessing a good of its own—which any organism has simply on account of the fact that its latent tendencies can be realized or frustrated—counts as reliable evidence for the intrinsic (or otherwise non-instrumental) value of this organism. As O'Neill (1992) observes, the claim that '*x* is good for *y*' is not equivalent to the claim that '*y* is good in itself'. Thus to say that an extraterrestrial microbe (or a community of such microbes) has a good of its own is not by itself sufficient evidence for claiming that this microbe (or community) is good in itself.[16]

Nevertheless, that it is unclear that microbial life is intrinsically valuable does not preclude arguing that microbes have value derivatively on account of the functions they perform in extraterrestrial ecosystems—ecosystems that themselves may be loci of intrinsic value. Cockell has argued previously that microorganisms fall under the remit of holistic environmental philosophies, such as Leopold's land ethic, because microorganisms perform vital functions in the ecosystems in which they reside (2005, pp. 386–387).[17] This does not answer but only shifts the question of intrinsic value. Should an extraterrestrial environment or community of life be counted as intrinsically valuable?

It must be admitted that it would be a sort of Earth-chauvinism to suppose that only Earth-based ecosystems (or communities of life) are intrinsically valuable. Might we reason by analogy that, since Earth's ecosystems are intrinsically valuable (a hotly contested claim in its own right), we ought also be open to the possibility that extraterrestrial ecosystems—including those in which the only living things are microorganisms—are also loci of intrinsic value? I see no compelling reasons against the idea that we ought to be open to the *possibility* that extraterrestrial ecosystems are intrinsically valuable. But I am somewhat concerned that the kinds of *reasons* commonly used in support of the claim that Earth's ecosystems are

[16] Of course, consistency demands that if such high standards are required for demonstrating the intrinsic value of extraterrestrial microbes, then we ought to also require high standards for demonstrating the intrinsic value of human beings—a point seldom recognized by anthropocentric critics of biocentric and ecocentric philosophies.

[17] See Callicott (1986) for discussion about the application of Leopold's land ethic to extraterrestrial life.

intrinsically valuable are nevertheless inapplicable in support of the claim that extraterrestrial ecosystems are intrinsically valuable.

Terrestrial ecosystems are claimed to possess any number of allegedly value-generating features: autonomy, beauty, diversity, integrity, stability, etc. Would an extraterrestrial ecosystem or microbial community possess these qualities in such a way that it would make sense to describe this ecosystem or community as intrinsically valuable? Concerning aesthetic properties, Williamson claims that there should be "no difference between an aesthetic appreciation of terrestrial objects, events, and processes and extraterrestrial ones" (2006, p. 185). Are there similarly no differences between an appreciation of the autonomy, diversity, etc., of terrestrial ecosystems and extraterrestrial ones? Or are these high-level properties only value-generating for terrestrial ecosystems, in which case using the criteria of autonomy, beauty, etc., would still be a form of Earth-chauvinism?[18] If we insist that high-level properties like autonomy, beauty, and diversity are *the* value-generating features of ecosystems, then we must acknowledge the possibility that extraterrestrial ecosystems could fail to exemplify these properties to sufficient degrees, and hence could fail to be loci of intrinsic value.[19]

I am not certain whether the right conclusion here is "So much for the intrinsic value of extraterrestrial ecosystems," or "So much for the idea that autonomy, beauty, etc. are *the* value-generative features of ecosystems." But which conclusion we opt for should be decided without dogmatic adherence to the idea that extraterrestrial ecosystems simply *must* (or must *not*) be loci of intrinsic value. If we wish to maintain that extraterrestrial ecosystems are intrinsically valuable but that they nevertheless exemplify a set of radically different or otherwise "alien" higher-level properties, then we are obliged to defend, on independent grounds, that these different, alien properties are value-generating properties. But without knowing in advance what extraterrestrial ecosystems are like, we cannot say what these properties would be, or why they would be value-generating. It therefore stands to reason that we are not in a position to positively assert (or deny) that extraterrestrial ecosystems, if any exist, are loci of intrinsic value.

Let me be clear that nothing I have said should be construed as an argument that extraterrestrial ecosystems and microbes are *not* intrinsically valuable. I have only identified some gaps in the reasoning of those who make the positive assertion that these things *are* intrinsically valuable, and I have suggested that some of the

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[18] For skepticism about the status of beauty as a relevant moral feature, especially in the context of the value of microorganisms, see Cockell (2008b).

[19] Cf. (Manson 2012, p. 287): "[A]lien life does not possess the extrinsic properties of having been experienced by humans or of being genetically related to humans, but if we are truly nonanthropocentric… we should not think these properties are morally relevant… we are guilty of spatiotemporal parochialism if we think spatiotemporal proximity to the planet Earth in the early twenty-first century makes some lives and some ecosystems more important than others." Notice that what I have said here is insensitive to the extrinsic characteristics of extraterrestrial ecosystems (e.g., proximity in space and time to present-day Earth), but concerns instead the various *intrinsic* properties that are purportedly responsible for the intrinsic value of extraterrestrial ecosystems.

underlying assumptions of this reasoning are more controversial than many individuals typically assume. Fairness, by contrast with intrinsic value, provides a less tenuous grounding for planetary protection policies.[20]

5.4 Applying Fairness to Speculative Endeavors

In the preceding section I made the case that basic Rawlsian ideas about fairness are capable of underwriting some of the policies that are in place to ensure fair and responsible conduct in space. It would seem that this understanding of fairness also provides a means for removing some of the ambiguity from regulations and recommendations that paint with a broad brush when using terms like 'fair,' 'equitable,' and 'sustainable.' I believe that the tenability of using Rawlsian ideas about fairness is largely the product of interpreting space operations as *services* which are conducted for the benefit of identifiable groups of humans. Can this focus on fairness be sensibly extended to provide a moral basis for regulations governing more speculative kinds of space operations, e.g., the exploitation of asteroids, or the colonization of a planetary surface?

5.4.1 Exploiting Space Resources

Current regulations neither clearly prohibit nor clearly encourage the exploitation of space resources. The OST remains the only significant source of legally binding policies covering developmental activity beyond Earth orbit. As far as the exploitation of space resources is concerned, the most salient aspect of the OST is Article II, which prohibits *national* (but not, apparently, corporate or individual) appropriation of space resources. Article XI of the Moon Agreement attempted to set a firmer precedent, stating that the Moon and its natural resources are "the common heritage of mankind" with the recommendation to establish an international regime "to govern the exploitation of the natural resources of the Moon as such exploitation is about to become feasible" (United Nations 1979).[21] But as yet, no major space faring nation has ratified the Moon Agreement.

The exploitation of space resources beyond the cislunar sphere raises many questions which make applying Rawlsian ideas about fairness rather difficult. Let us grant the moral force behind the idea that the resources of space ought to be fairly distributed to all states. How should this idea be implemented? Should fairness

[20] One might go so far as to say that planetary protection policies are necessary because the space environment ought to be protected for its own sake, independent of whether certain of its parts (e.g., planetary surfaces) are home to life. See Schwartz (2013) for discussion and criticism.

[21] For a detailed legal analysis of the "common heritage of mankind" concept as it applies to space law, see Tronchetti (2009).

apply primarily as a restriction on the variety and quantity of resources states are permitted to exploit? Or should fairness apply primarily as an influence on the distribution of space resources, regardless of who does the exploiting? So much here seems to depend on the kinds of resources that we might seek to exploit as well as on the actual forms of exploitation that we might employ. I don't know of any reliable answers to these questions, and without such answers, I don't believe that it is possible to state in any great detail what it would mean to describe a form of space resource exploitation as either fair or unfair. That is not to say that there aren't any clear examples of fair and unfair exploitation activities: It would be a violation of fairness if a state or corporation monopolized the resources of the main asteroid belt; it would be consistent with fairness if a state or corporation made efforts to distribute its exploits to all interested parties. However, I do not see that at present we have sufficient information to inform concrete policies governing the exploitation of space resources. To reveal the depth of the difficulties involved, let me focus on the issue of exploiting the resources of the main asteroid belt.

One factor working against the need to produce fair access policies is the sheer volume of asteroid material available for processing—over the next 100–200 years it is severely unlikely that any one state's activities will severely hinder the exploitation opportunities for other states (though perhaps one state might attempt to monopolize a certain type of asteroid, e.g., the metal-rich M-type asteroids). And nor is it likely that such exploitation will be conducted to satisfy a basic need. There is a limited supply of asteroid material, but the supply to demand ratio is much, much higher than in the case of GEO slots. Of course, 50 years ago one might have made the same argument concerning GEO. Who in the 1950s and 1960s could have foreseen the GEO congestion problems we have today? The trouble is that ignorance about future capabilities, needs, and problems cannot form the basis for rational policy decisions —neither for policies favoring firm international control over space resources or for policies permitting all forms and degrees of space resource exploitation.

In the case of GEO we at least have a fairly clear sense of what the roles are and who fills them—how many states have launch capabilities, how many states operate or would like to operate a satellite, what kinds of services can be conducted in GEO, etc. But as far as the full-scale exploitation of asteroid resources is concerned, we are not even clear on what the roles are. Nor is it clear what kinds of resources will ultimately be harvested, and whether they will be harvested primarily for consumption on Earth or for consumption elsewhere in the solar system. Perhaps if the sole purpose of exploiting asteroid material is for Earth-based consumption it would make sense to apply something like the Difference Principle as a distribution policy. But what if asteroid resources are being exploited for consumption on a Mars colony or in an asteroid-based society? Would such societies still be in some kind of meaningful cooperation with Earth? Would exploiters still be duty-bound to ensure that Earth's residents get their fair share of the asteroid material? Should we think that proximity to a space resource is an important factor in determining what counts as a fair and responsible use of that resource?

On the other hand, there are factors working against the idea that asteroid materials, once exploited, ought to be fairly distributed regardless of who is doing

the exploiting. The Rawlsian ideal of fairness permits an unequal distribution of goods only when such a distribution maximizes the receipts of the least-advantaged. Implementing this model of distribution in the case of asteroid resources would seem to severely diminish, if not eliminate entirely, any profits a state (or corporation) might derive from the exploitation of asteroid material. Why should one state (or corporation) invest considerable time and money in the development of critical mission technologies if they cannot expect to profit from the endeavor? Is it consistent with the spirit of fairness to accept that the exploitation of space resources will, at least initially, lead to greater inequalities? Or does the likely outcome of increased inequalities constitute evidence that the exploitation of space resources is morally impermissible? I should think the outcome here depends on whether we take the promotion of fairness to set *restrictions* on space operations or we take the promotion of fairness to be the *motivation* or *reason for* engaging in space operations. If the former, then it would appear consistent with the spirit of fairness to accept an initial increase in inequality as a down-payment for a later, fairer distribution of space resources. If the latter, then the possibility that space resource exploitation leads to greater inequalities is (perhaps defeasible) evidence that such operations do not advance the cause of fairness, and should not be pursued.[22]

It is easy to slip into thinking that these issues suggest nothing other than a *reductio* of the application of Rawlsian ideas about fairness to the exploitation of asteroid material. I find it difficult to deny that too much emphasis on fairness as far as the distribution of exploited resources is concerned would produce powerful disincentives for developing critical mission technologies. That would be unacceptable. But it would also be unacceptable if a more *laissez-faire* approach failed to prohibit a situation in which a state or corporation acquired a monopoly over the resources of the main belt. However, I am not convinced that we have good evidence for thinking that basic Rawlsian ideas about fairness are ultimately defective when it comes to exploitation regulations, if only because it is not clear whether *any other* policy basis would provide a more attractive grounding. There are simply too many questions on the books about who will be doing the exploiting, who will benefit from the exploiting, and what resources in particular will be exploited.

Nevertheless it might be helpful to consider the issue under certain idealized circumstances. Let us suppose that the exploitation of the asteroids is to be carried out now and in the future solely for Earth-based consumption in order to satisfy the basic needs of Earthlings. In this idealized situation I believe it would be sensible to regulate access to asteroid material in a way that is similar to how I suggested that access to GEO ought to be regulated (as a supplement to the explicit wording of the ITU regulations). Here, each state would be guaranteed the asteroid-correlate of

[22] In Schwartz (2011, 2013) I stress the environmental virtues of supporting space exploration, and I would not be comfortable defending the idea that the promotion of fairness is the ultimate reason why we should be conducting operations in space. So if pressed, I would insist that fairness provides a moral grounding in the sense that it recommends certain *restrictions* on conduct in space rather than in the sense of supplying fundamental reasons *for* engaging in space operations.

mineral rights to a certain volume of asteroid material. This right could be waived or transferred if the state in question decided it had no interest in exploiting the resources themselves. Alternatively, the state could contract out the exploitation to a third-party.

Insofar as the exploitation of asteroid resources is conducted for the sole purpose of providing raw and processed materials for consumption on Earth, fairness dictates that it would be impermissible for one state to monopolize more than a small fraction of the available asteroid material. How closely this ideal situation will resemble actual future practices requires more speculation than I am comfortable entertaining here. A myriad of issues are raised having not only to do with fair access and distribution in the present, but also with to what degree long-term sustainability concerns factor into the use of space resources (including the long-term effects on Earth of the consumption of these resources). There is a large, but finite and non-renewable quantity of asteroid material available in the solar system. This serves as some evidence that human limits to growth are not in-principle set by the environmental conditions and material resources available on Earth, but it seems unlikely that the use of space resources will solve the various ecological crises in which we find ourselves. At best, the use of space resources, together with the prospect of establishing permanent off-Earth colonies, shows that reducing our imprint on Earth's environment is consistent with an expanding human population —provided that most of the expansion occurs off planet.

Does the idea of fairness raise a similar set of difficulties when considering permanent off-Earth settlement? It is to this issue that I now turn.

5.4.2 Colonizing Space

There appear to me to be at least two avenues for discussion concerning the application of Rawlsian ideas of fairness to the subject of permanent space settlement. The first concerns whether fairness has implications for the composition of prospective groups of colonists. Beyond any necessary technical qualifications, do we have a duty to ensure that peoples of all walks of life have representatives in a prospective off-Earth colony? Or, for instance, would it be permissible for one ethnic or religious group to develop their own settlement, barring admission to those not belonging to their ethic or religious group? The second avenue for discussion concerns whether fairness has implications for the conduct of colonists on settlements. It stands to reason that for the sake of the continued survival and flourishing of the colony, it will be necessary for colonists to exploit space resources. Are colonists the only group for which fair access and distribution rules apply? Or are the resources of, for instance, the surface of Mars, resources that should be preserved or conserved for the benefit of all humankind, as opposed to the benefit of present (and future) colonists?

There are many reasons why a state or organization might be interested in establishing a permanent off-Earth settlement. One reason might be to set up a permanent base for conducting scientific exploration. Another reason might be to

establish a permanent base for the exploitation of space resources. And yet another reason might be to establish an additional habitat in which the human race can continue to survive—perhaps as an outlet for relieving population pressures on the home planet. To simplify matters, I would like to focus on the idea of establishing a permanent settlement for human survival—a settlement with no explicit mandate to send material resources back to the home planet.

Science fiction literature is full of fanciful futures in which ethnic and religious groups develop isolated space settlements. Does fairness have implications concerning the cultural composition of a space colony, e.g., the initial settlement of Mars? One might argue that colony berths are valuable, limited resources that should be distributed fairly amongst all who have an interest in taking part in the settlement efforts. One might further argue that, if indeed the purpose of permanent space settlement is to ensure the long-term survival of the human race, then we have an even stronger obligation to make sure that colonies preserve Earth's diverse peoples and cultures. So much here depends on the nature of the colony and its capacity to support growth (either via birth or via immigration). I see nothing fundamentally problematic with a small, non-diverse group of humans hollowing out a small- or medium-sized asteroid for living space, provided that this group's actions do not harmfully interfere with the well-being of other groups who wish to live or work in a nearby volume of space. But there is something seriously wrong with the idea of a non-diverse group of humans prohibiting anyone else from attempting to settle a planetary surface, e.g., the surface of Mars. So much here depends also on the urgency of space settlement. Suppose some imminent natural disaster or materials shortage will prohibit the establishment of more than one or two colonies and preclude the possibility of later emigration from Earth. Here I feel there should be a strong compulsion to ensure that the colony is as diverse as possible. But even if colonization is not attempted to mitigate any sort of urgent, species-damning disaster, and even if initial acts of colonization do not preclude later emigration from Earth, there would still be some impetus to insure that a space colony contains a diverse human population. Early colonization efforts are more likely to set social precedents when compared to later efforts, and it would be both unwise and undesirable to instigate space colonization with ethnic and cultural barriers in place (whether formed by design or accident).

Does fairness have implications concerning whether and to what degree colonists are permitted to exploit local space resources? I believe so, but only to the extent that such activities would lead to fair or unfair circumstances for other colonists, and not to what is fair to *every* human, including those that remain on Earth. Once established, a self-sustaining space colony would no longer be a beneficiary of Earth's resources, and so it would make little sense to demand that colonists share in the burden of supplying new resources for humans back on Earth. Assuming that a colony succeeds in remaining isolated from other human populations (or joins a federation of colonies that remains isolated from Earth), it would not be duty-bound to ensure that every human or state has access to its "fair share" of the colony's local resources. For the most part, it would seem, the only morally significant interactions colonists will have with other human beings will be with

fellow and future colonists.[23] This could change if, in the future, there exists an efficient means for exchanging resources between distant locations in the solar system.[24]

This discussion perhaps gives us the ability to make some small bit of progress on coming to terms with how to handle fairness in application to space resource exploitation. The idea suggested here is that it should not be considered a violation of fairness if colonists monopolize a local resource for their exclusive consumption.[25] Perhaps this claim should be made with the qualification that colonists would not be permitted to monopolize a rare or otherwise difficult to access resource that serves a vital need for others (but not for the exploiters). For instance, asteroids are likely to be vital sources of water for colonists regardless of where the colonists reside. Those residing in asteroid based-communities could potentially monopolize this resource, depriving planetary-surface dwellers of a vital resource.

Returning to the more general case, I think that it must be admitted that the application of fairness to space colonization is highly sensitive to the why and the how of space colonization, just like the application of fairness to space resource exploitation is highly sensitive to the why and the how of this exploitation. And there are simply too many questions on the books about which motives for colonization will be adopted and about which forms of colonization will be implemented (if, as I hope, this is the kind of activity that we as a race will one day attempt). But, just as in the case of resource exploitation, it is not obvious that these questions are unique to the issue of whether *fairness* is an appropriate moral grounding for colonization policies, because any other moral basis would have to cope with the same uncertainty about the why and the how of space colonization.

5.5 Conclusion

I am not certain whether the space policy community will greet my application of Rawlsian ideas of fairness with skepticism or with open arms. Perhaps some will find certain of its conclusions unintuitive—especially concerning the fair use of GEO. Nevertheless I believe that this discussion helps to substantiate a claim made often in policy discussions—that it would be foolish to suppose that conduct in space should be regulated by a fixed set of guidelines that are to apply regardless of the form, intent, or degree of the use of space resources. The lesson here is that this pragmatic approach to space policy runs deeper than one might otherwise think—it also affects how we ought to think about the very basics of moral or ethical conduct

[23] For an interesting discussion about the development of interpersonal freedoms in a space colony, see Cockell (2008a, 2009).

[24] Thanks to Eun-Jung Katherine Kim for some useful suggestions on these issues.

[25] To say otherwise would have some rather counterintuitive consequences. For instance, it would imply that Earth's resources ought to be equitably distributed to space colonists as well as to Earth-based humans.

in space: It would not *only* be foolish to design policies that would uncritically permit or prohibit a form of space resource exploitation or a form of space colonization without knowing the likely details of the situation (who is doing the exploiting/colonizing, who is benefiting from the exploiting/colonizing, etc.)—it would *also* be foolish to *morally* commend or condemn such activities without the same basic situational knowledge. This means that critics of space exploration should not jump immediately to the conclusion that an increased human presence in space would only preserve, rather than mitigate, the social and economic disparities and other related problems we face on Earth. But it also means that proponents of space exploration should not jump to the conclusion that the wider solar system is a panacea for solving social and economic problems, or that the solar system is an arena in which one's actions have negligible consequences for other humans. The solar system may be a resource in many senses, but it is not a source of absolute freedom.

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Chapter 6
Space: John Locke's Ultimate Triumph

Paul Rosenberg

Abstract This chapter is a projection of mankind's future in space based upon the "natural state" hypothesis of John Locke, as presented in his *Second Treatise on Government*, published in 1690. This idea has been taken seriously at some times since its publication, and less seriously at others. (I see it as being taken less seriously in our present time, at least inside academia.) I will first be presenting some facts to support my opinion that Locke's formulation was substantially correct, and then I will apply the "Lockean" hypothesis to mankind's future in space, especially as it regards liberty and governance.

Keywords John locke · Second treatise · Natural state · American wilderness · Cyberspace · Extraterrestrial liberty · Rulership · Spacefarers

6.1 Introduction

What is generally passed-over by commenters is the radical nature of Locke's Second Treatise, and especially the first half of that document. Locke's work was profoundly radical, and precisely because of the intellectual expedition he describes so carefully in the Second Treatise. That "thought expedition" was an attempt to uncover the base nature of mankind, before they were influenced by edicts, intimidation and domination.

That there was such a time is essentially a mathematical certainty: At the end of the most recent ice age (9,000 BC or thereabouts), Earth had the same habitable area that we now enjoy, but only about 5 million inhabitants.[1] At that level of dispersal, freedom from domination is easily within the reach of whatever persons

[1] US Census Bureau, *Historical Estimates of World Population.*

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desire it. We have limited information from this time, but the evidence we do have suggests, strongly, that even whole villages thrived without any rulership, such as the ancient village now known as Catalhoyuk, in central Anatolia.[2] So, Locke's hypothesis does have a foundation.

And, if Locke's formulation is substantially correct, it will have profound effects when mankind once again disperses into the infinite expanse of space. In fact, that is precisely what happened as mankind expanded into the previous expanses of new continents and the new realm of cyberspace, as we will examine below.

6.2 Locke's Radicalism

What makes the Second Treatise radical is that in it, Locke overturns the hierarchy of humanity. He dethrones the rulers and informs the peasants that they are not only equal to the prince, but of better morality. This radicalism is clearly seen in several passages of the Second Treatise, but it is also seen in the fact that Locke published the book anonymously and never allowed his name to be attached to it while he lived. While Locke left no explanation for this decision, he allowed his name to be used for many other publications. So it is clear that he thought something in the Second Treatise might be dangerous for him.

I think Locke knew precisely how radical his new idea was. In fact, I think the idea was so radical that Locke himself was uncomfortable with it. He was not a radical man by nature. Rather, he was bookish, serious and conflict-averse. But he was also an honest man, and he followed the truth where it led.

If my interpretations are correct, there are several places in the Second Treatise where Locke grasps for ways to fit his new theory to the ruling hierarchy of his time. Presumably this was done to soften the blow that he knew he was landing.

6.3 Locke's Tool & What It Uncovered

Locke's new tool for finding the right was to turn away from the political wranglings of his day and go back to human origins; to understand man in his original state and to specify what was right for him, before he was overrun with unnatural edicts, impositions and fears. He wanted to understand man in his natural setting and to discover the natural laws that affected him before man-made laws were imposed.

And so, Locke began his thought experiment on the "state of nature." This wasn't purely an imaginary exercise, of course; Locke was an avid student of history, as well as science and contemporary events. He brought a full life of learning and all of his considerable abilities to the task.

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[2] See Michael Balter, *The Goddess and The Bull*, and Ian Hodder, *The Leopard's Tale*.

In his Second Treatise of Government, Locke did precisely this, and decided that:

> (All men) are naturally in a state of perfect freedom to order their actions, and dispose of their possessions and persons as they think fit, within the bounds of the law of Nature, without asking leave or depending upon the will of any other man.

Please take a moment to consider that statement. It means that nature has NOT designed man to answer to any sort of rulership or hierarchy. The "any other man" that we shouldn't have to answer to includes every potentate who has ever lived. You and I may call that radical, but potentates would call it treasonous, as it implies that every ruler's monopoly on violence and justice is unnatural and false. And it gets worse. In another early passage Locke maintains that every man is free to enforce justice:

> Every man may restrain, or where it is necessary, destroy [an offender]… Every man has a right to punish the offender, and to execute the law of nature.

As I say, I don't believe that Locke ever wanted to be radical, but his search for truth led inescapably to a radical conclusion. And because he believed it to be true, he took the great risk of publishing his findings. I know of no greater commendation for the greatness of Locke as a man.

6.4 Locke's First Triumph

In my newsletter (Free-Man's Perspective, Issue #23), I set up a hypothesis for proving Locke's theory. (To be scientifically proper, I should have expressed it as a way to disprove him, but this way was better for communication and the results are the same in either case.) My hypothesis was this:

> If Locke is correct about the natural state, men taken out of the ruled world and placed in an isolated, unruled setting should revert toward his "state of nature."

In particular, people in a state of nature should begin considering themselves free of "the will of any other man," to postulate new ideas that are founded in such a sentiment, and ultimately to demand to be treated as if their will was as good as that of "any other man."

The first support for Locke's idea comes from the example he had in mind while writing about it—the wilderness of America.

The occupants of this American wilderness famously declared independence and broke away from Great Britain, but that is not, in itself, good enough evidence for this experiment. There have been many revolutions throughout human history; the issue here is why did they declare independence? To serve as evidence for this experiment, their reason had to be "because of a reversion to their natural state."

Also, if we are to be fair, we must consider Locke's effects upon these people. If they were merely enamored with Locke's work and following his ideas, our results

are tainted. While it may also be true that people who were already reverting to their natural state would cling to Locke—who expressed what they were already feeling—this experiment requires some significant evidence that cannot be traceable to Locke himself.

So, let us begin with evidence prior to the publication of the Second Treatise in 1690.

American settlers pushing back against authority began with the Jamestown colony (the first of them all), and continued up to, through, and after the American Revolution. The Rhode Island colonies, in particular, provide an excellent record of "natural state reversions" prior to 1690:

- In 1636, a preacher named Roger Williams, who advocated a complete break with the Church of England (religious authority), was banished from Massachusetts Bay and founded the Rhode Island Colony, which became a haven for other religious refugees from the Puritan community.
- In 1637, a more-or-less Baptist leader named Anne Hutchinson purchased land on Aquidneck Island from the local Native Americans, establishing a settlement in what is now Portsmouth, Rhode Island. Others followed and complete religious freedom was declared by the people of Aquidneck Island in 1641.
- In 1641, this same Anne Hutchinson became convinced that government itself was contrary to the scriptures. She persuaded her husband to quit his minor governmental post, "because of the opinion, which she had newly taken up, of the unlawfulness of magistry." Note that Mrs. Hutchinson's objection was not with any particular magistrate, but with magistry itself. Her biographer, Winifred Rugg, explained it this way:

  > She was supremely convinced that the Christian held within his own breast the assurance of salvation… For such persons magistrates were obviously superfluous. As for the other, they were to be converted, not coerced.

- The people of Aquidneck were derided by people still tied to the British government as the Isle of Errors and Rogue's Land, and bitterly persecuted for a long time. Clearly, authority was displeased.
- Beginning in the 1650s, large numbers of Quakers not only held, but doggedly promoted, ideas that we would call politically libertarian and religiously liberal. A Quaker named Mary Dyer was hanged for her opinions in 1660 in Massachusetts. In response, a Quaker historian named George Bishop (living at that time) wrote this to the authorities of Massachusetts Bay:

  > Your bloody laws were snapped asunder by a woman, who, trampling upon you and your laws and your halter and your gallows and your priests, is set down at the right hand of God.

- Quakers were bitterly persecuted during this period for being (in the words of Massachusetts authorities), malignant promoters of doctrines tending to subvert both our church and state. Again, this was decades before Locke wrote his treatise.

Regarding these events, it is important to remember that there were millions of very religious people in Europe at this time, and that such changes are unseen in the European record. The primary difference was that the American continent was a wilderness.

Turning now to the 18th century, after Locke:

- Samuel Adams, almost certainly the most persistent and involved man of the American Revolution, very specifically considered the wilderness of North America an asylum: a place men ran away to—a last refuge. In one place, he writes this:

> Men of Virtue throughout Europe heartily wish well to our cause… Liberty seems to be expelled from every other part of the globe & the prospect of our affording an Asylum for its friends in this new world, gives them universal joy.

- In a letter dated December 28, 1770, Adams writes about:

> This little part of the world—a land, until recently happy in its obscurity—the asylum…

- These ideas were not limited to Sam Adams and his friends. George Washington —not a natural radical and a man with whom Adams did not always agree—has the same opinion and uses the same word. In one place he says:

> I had always hoped that this land might become a safe and agreeable asylum to the virtuous and persecuted part of mankind, to whatever nation they might belong.

And in another:

> … who have assisted in protecting the rights of humane nature and establishing an Asylum for the poor and oppressed of all nations and religions.

- John Adams (a younger cousin of Samuel Adams) contrasted Americans with people held in subjection to governments. This is a passage from a letter he wrote in April of 1776:

> Fear is the foundation of most governments; but it is so sordid and brutal a passion, and renders men in whose breasts it predominates so stupid and miserable, that Americans will not be likely to approve of any political institution which is founded on it.

I conclude with the thoughts of Edmund Burke, a member of the British Parliament, from a speech in the House of Commons on March 22, 1775:

> The colonies in general owe little or nothing to any care of ours, and they are not squeezed into this happy form by the constraints of watchful and suspicious government, but, through a wise and salutary neglect a generous nature has been allowed to take her own way to perfection.

So, Edmund Burke—a serious and informed observer, then present—agrees that neglected men in the North American wilderness changed, and for the better.

I think it fair to say that Locke's hypothesis finds strong support here: Men removed from coercion revert toward what Locke calls their "natural state." Living by their own wills puts men in direct contact with nature and their natural place in it. They begin to face the man next to them directly; class distinctions wane;

processes that were once regulated and restricted are thrown open to anyone who can do them; old ways fade and men confront reality directly, not through filters and edicts. This is precisely what happened in the wilderness of the Americas.

As one further piece of evidence, consider the correlation between the opening of the new world and the production of utopian novels: Wikipedia lists only six such works before Columbus, and includes among them The Republic, Revelation and City of God—not precisely what most of us would consider utopian novels. From Columbus to the end of the 17th century, however—a mere two centuries—Wikipedia lists these:

Utopia, by Thomas More, 1516.
Gargantua, by François Rabelais, 1532.
La Citta Felice, Frane Petric, 1553.
Christianopolis by Johann Valentin, 1619.
The City of the Sun, by Tommaso Campanella, 1623.
New Atlantis, by Francis Bacon, 1627.
The Law of Freedom in a Platform, by Gerrard Winstanley, 1652.

6.5 Locke's Second Triumph

The second pillar of support for Locke's thesis comes from the second frontier to open since 1690: The wilderness of cyberspace.

The combination of Internet and strong encryption, which emerged together in the early 1990s, created a new frontier. In particular, it gave innovative young people a way to wall-off parts of the Internet to themselves, creating new, free territories of a sort.

The first people to understand that there was a new frontier were those who were deeply involved with computers and related technologies. These people quickly began corresponding and cooperating, forming a loose group, generally referred to as Cypherpunks. And on their new frontier, they quickly developed a Lockean philosophy, even though they had all been educated in strongly statist (anti-Lockean) institutions for the majority of their lives.

As an example of their new Lockean ideas, here is a passage from A Declaration of the Independence of Cyberspace, which appeared on the Internet in about 1996:

> Governments of the Industrial World, you weary giants of flesh and steel, I come from Cyberspace, the new home of Mind. On behalf of the future, I ask you of the past to leave us alone. You are not welcome among us. You have no sovereignty where we gather.

A few years prior, a Cypherpunks FAQ had appeared, including this passage:

> Transactions can only be *voluntary*, since the parties are untraceable and unknown and can withdraw at any time. This has profound implications for the conventional approach of using the threat of force, directed against parties by governments or by others. In particular, threats of force will fail.

> What emerges from this is unclear, but I think it will be a form of anarcho-capitalist market system I call "cryptoanarchy."

In an influential paper entitled Toward A Private Digital Economy, this passage appeared:

> Our object is to design a space that mimics the cash economies we are familiar with in the "real world", but with more privacy, more trust, more freedom, and without privileged entities.

I think reversion to Locke's natural state is quiet evident in these passages. It is even more evident in the pro-freedom culture that has grown up with the Internet. Consider the popular graphics shown here.

These new ideas, generally ignored by the organs of the old culture, are now common on the Internet. And even though the freedom of the Internet has been brutalized by government spy agencies, this neo-Lockean culture is growing.

So, I think it is fair to say that a natural state reversion has also been seen in the new wilderness of the Internet.

One final bit of evidence lies in the area of utopian novels. In just two decades of life on the Internet frontier, eleven major utopian (Cypherpunk) novels have appeared:

True Names, Vinge
Cryptonomicon, Stevenson
Snow Crash, Stevenson
Diamond Age, Stevenson
A Lodging of Wayfaring Men, Rosenberg
Fall Revolution, MacLoed,
Halting State, Stross
Rule 34, Stross
Black Glass, Shirley
Pattern Recognition, Gibson
Neuromancer, Gibson.

6.6 Locke's Ultimate Triumph

I say that space will be John Locke's ultimate triumph because of all the evidence above, and because space is without borders—it is an endless frontier. As such, I believe it will produce a natural state mentality without end. Locke's 'natural way' will become humanity's 'normal way' from the moment space exploration becomes normal, and for as long as it remains normal… which stands to be a very, very long time.

Expansion into space has gone more or less dead to humanity since 1972, when the last astronaut left the moon. There is no great goal to strive for, no bold exploration in front of us. Partly as a result, in my view at least, we have been living through an era of peak conformity and an ebb of personal courage.

Humanity, however, does not sleep forever, and the next time they wake up, they will head back to the stars. And once they do, physics dooms rulership, leaving Locke's way as the only viable way.

Once beyond Earth's gravity well, the spacefarers will be gone forever, as far as earthly rulers will be concerned: Taxes and automatic obedience will no longer be forthcoming. The escapees will heap scorn upon the distant barbarians who demand their money and attempt violence to get it.

Space will be the 17th century American wilderness on steroids. Politicians and tax gatherers have no hope of keeping up. While the territory of the Earth is calculated with a square function, the open area of space must be calculated with a cube function:

$$V = \frac{4}{3}\pi r^3$$

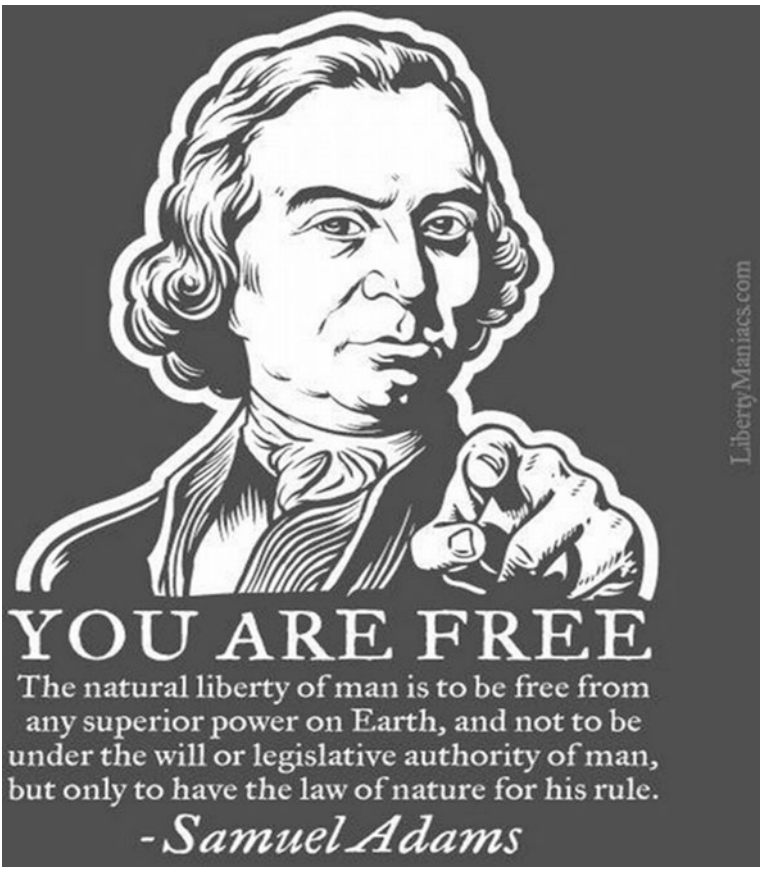

Fig. 6.1 Popular internet poster showing Samuel Adams' paraphrase of John Locke. Courtesy, LibertyManiacs.com

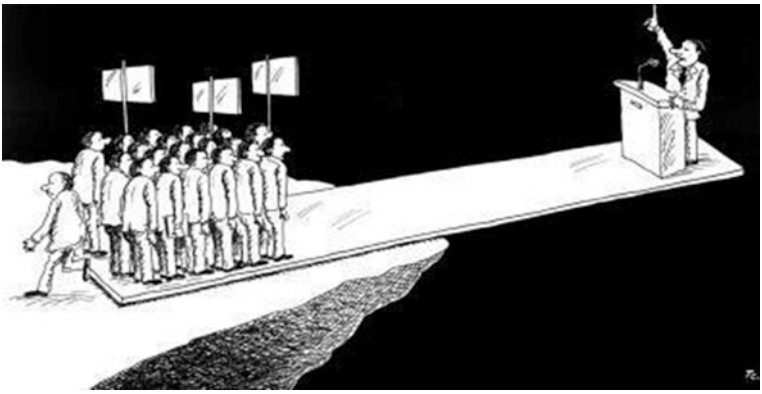

Fig. 6.2 People walking away from politics. Author unknown

Formula for the volume of a sphere.

This formula dooms rulership in space. The rulers may be able to control the first hop or two, such as a moon base, but once past that, they will simply be overwhelmed by the numbers—there will be an infinity of places to go to, and governance cannot instill the necessary fear to control them all. That would require them to hurt every person who attempts to escape, and they simply will not be able to keep up.

Let's be honest about this: How many of us would give half our income to politicians we complain about daily, if we knew we could keep the money and not be hurt? (Figs. 6.1, 6.2, 6.3 and 6.4)

Fig. 6.3 Poster demonstrating the coercive nature of the state. Courtesy Bastiat Institute

Fig. 6.4 Poster promoting voluntaryism, a philosophy based on the concept that voluntary actions are moral and that involuntary (coerced) actions are immoral. Author unknown

6.7 Conclusion: Locke's New Normal

Once away from Earth, the rulership scenario that we grew up seeing as 'normal' will be seen as barbaric. Consider the contemptuous tone of this passage from Carl Sagan's *Pale Blue Dot*. These are the words of an establishment scientist, merely imagining his presence beyond Saturn. (The "pale blue dot" is Earth, seen in a famous photo from the Cassini space probe. Earth appears as a tiny blue dot—a single pixel in the photo.)

> Think of the rivers of blood spilled by all those generals and emperors so that in glory and triumph they could become the momentary masters of a fraction of a dot. Think of the endless cruelties visited by the inhabitants of one corner of this pixel on the scarcely distinguishable inhabitants of some other corner.

Once space opens again, Locke's way will become the expected way, and the old way of domination will be considered a dark chapter in the history of human development. In short, the re-opening of space will change human organization permanently, and Locke's hypothesis will have permanent support from clearly observable human action.

None of this, of course, should imply that Locke's extra-terrestrial natural state will be some type of utopia. Until human nature improves dramatically, that cannot be the case. But it will be a condition where the dominance of one group of men over others is clearly held to be immoral. Whether we consider that a good thing or not is aside from the point here; both the historical evidence and the physics point to this hypothesis being valid.

As for the problems of this era, I will close with a quote from Thomas Jefferson, during the first Lockean experiment:

> I would rather be exposed to the inconveniences attending too much liberty than those attending too small a degree of it.

That is the situations that will face those of us who live to see man return to space: It will be a time for dealing with the inconveniences of full liberty, rather than fighting the domination of rulers.

Paul Rosenberg Free-Man's Perspective www.freemansperspective.com.

Chapter 7
Extraterrestrial Liberty and Creative Practice: A Firsthand Experience of an Imagined Future

Annalea Beattie

Abstract In extra-terrestrial settlements of the future, liberty will be aligned with one's ability to act with spontaneity and forethought from a position of psychological safety, away from censorship and surveillance. Though humans are often perceived to be the vulnerable link in space systems, this chapter discusses an aspect to sustainable new settlement that is rarely mentioned: how art making can address wellbeing and the nature of isolation through an emphasis on inner experiences and self-determinism. Through the lens of a first-hand experience within a space analogue, this text explores networks of relations generated from shared practices within a confined space in an extreme environment. As the links between art and liberty are evaluated, imaginative works are positioned as acts of free will, offering an intimate connection to an alternative reality, one that links freedom to failure. In a constrained, unfamiliar future world, art making can nourish and promote notions of freedom, build autonomy, strengthen communities and help shape new cultural identities. Finally, in such a place, for humans to really inhabit a role in a new world, this chapter suggests that creative practices in future extra-terrestrial settlement need to be clearly prioritised and mandated as transitional space, occupying a significant role as part of and apart from daily life.

Keywords Creative · Autonomy · Collaboration · Liberty · Extra-terrestrial

> It is imagination that has taught man the moral sense of color, of contour, of sound and of scent. It created, in the beginning of the world, analogy and metaphor. It deconstructs creation, and with materials gathered and arranged by rules whose origin is only to be found in the very depths of the soul, it creates a new world, it produces the sensation of the new. As it has created the world (this can be said, I believe, even in the religious sense), it is proper that it should govern it. (Baudelaire 1859)

In a world of few resources, where life depends upon establishing links between technology, the limits of breathable atmosphere and economic and political control, people must adapt to situations where interdependence and isolation are the key

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features of actuality. We can only guess how inhabitants of new worlds far from earth will make decisions about their daily existence. Still, we must begin somewhere and it is reasonable to speculate that if an individual is to live a life full of significance amongst lethal environmental conditions, new perspectives are required that engage and translate something of the contradictory character of extra-terrestrial frontier communities.

When art making is actively pursued, it offers revolutionary possibilities for human factors in space travel. In space, alienation, combined with sensory deprivation can lead to severe depression and this may affect group dynamics as well as individual morale. In unfamiliar surroundings where interdependence, logistics problems, radiation concerns, communication lag times, workloads and many other additional issues conspire to impair performance and affect the behaviour of long duration settlers, the changing focus of creative practice can be used practically; as part of the diversity of the polity; as a means of building community and cohesive relationships; as a targeted and stimulating way of combating individual loneliness and isolation; and as a method of modifying behaviour, for instance in adapting to such complex space travel issues as visual disorientation and motion sickness. In this context, positive liberty exists when one has opportunity to make one's own work: to choose materials, form and content and develop processes and methods to search for meaning. As art is able to interpret and transform complex encounters of ordinary life, amplifying the imagination and offering extraordinary, visceral excitement, it would be advantageous for long term space settlers to situate art making at the heart of daily routines as part of the activities and experiences that constitute a person's normal existence in an anomalous setting.

Apart from space art, art making in space is rarely considered when human factors in future settlement are discussed, though common sense tells us that creative thinking is a useful and perhaps necessary element for survival in any extreme environment. Though there is scientific concern about the effects of deep space travel on human behaviour, particularly as travel to Mars seems inevitable if not imminent, research around the role art could play in space in the past 30 years has mostly been confined to environmental factors, such as habitat aesthetics, (Adams 1998; Clearwater and Coss 1991; Coss 1965; Connors 1985; Okushi 2005; Pinni 2003; Staderman and Adams 1999). There are limited earlier studies about the nature and place of recreational opportunities in space, some of which unfortunately equate art to leisure and entertainment, (Eberhard 1967; Fraser 1967) although clear design implications emerge for architecture when psychologists and behaviourists discuss the role of privacy and personal space on extended duration missions, (Appleton 1990; Elrod 1995; Raybeck 1991).

Material relevant to promoting ongoing creative work, as a powerful and practical way of interpreting and understanding complex experiences of long duration space travel is meager, though artists have always had an interest in space related themes. Collaborations between space agencies and artists in the last decade have become more common. Like Chris Hadfield, Japanese artists Ono and Negeshi (2013) have an interest in music in microgravity and have designed instruments for astronauts, built for inventive sound in weightlessness. Other artists have collaborated with

scientists to achieve common goals. A work of art by well-known British artist, Damien Hirst, *Spot Painting/Beagle 2,* (2003) consisted of sixteen multi-coloured spots on a 5 × 5 cm aluminium plate, was sent to Mars aboard ESA's Beagle 2 lander to be used to calibrate the full range of the X-ray spectrometer. Lost in space, the painting was last seen heading for the red planet after Beagle 2 separated from mother ship Mars Express on December 19, 2003, where it vanished without trace.

Art designed to disseminate information to a wide audience helps us understand something of the intricacies of space travel. *Symbiotic Sphere* is a high-tech, interactive, free-floating sculpture created by Hill (2013), for the European Module of the International Space Station. "Designed to interact with and absorb experience (in the form of audio, visual and biomedical information) from astronauts and cosmonauts, it is also responsible for collecting and distributing housekeeping data, i.e., orbital height and radiator orientation data from the ISS and biomedical and physical data from the environment inside it." (Hill 2013, p. 2). In an unusual collaboration with Projekt Atol Flight Operations and the Gagarin Cosmonaut Training Center, artist Bradley Pitts was allowed to float and fall freely with his eyes closed, ears blocked, naked in variable-gravity space in the cabin of the largest parabola aircraft in the world, the IL76-MDK. The expressed aim of his project *Singular Oscillations* (2008) was to produce immeasurable, subjective experience. Almost the antithesis of all these works is the domesticated cosmos of Welsh artist Bedwyr Williams, who built his own observatory, *The Starry Messenger* (2013), for the Welsh Pavilion at this year's Venice Biennale. Created from found objects, Williams is fascinated by the properties of the universe and the dedication of star watchers. *The Starry Messenger* was constructed in homage to an amateur astronomer who made a telescope out of baked bean cans (Fig. 7.1).

Fig. 7.1 Blueberries, M.D.R.S. Utah

So apart from being diverse, what is art anyway and who cares? As Dieter Roelstraete (2009) has noted, definitions of art already litter the landscape and it's almost easier to ask what contemporary art isn't. Like definitions of life, how art is seen is contingent and depends on point of view. As microbiologists determine life differently to physicists, interpretations of art also rely on position. Resembling freedom in its most absolute, art is scalar and open and to define what it is, closes it. Even though where art comes from is perplexing, it exists beyond appearances as more than representation, exceeding wish-fulfilment, play and ritual to reach past social life to the deepest origins of behaviour. There is a case to be made for selective components in the evolution of aesthetic experiences as they arise within human behaviour in the ethological sense (Dissanayake 1988, Boyd 2010), but in this situation, when we think about liberty and the future, what is crucial is not what art is, where it comes from or even how it is valued but what art does.

There is global consensus that the activity of art is typically associated with special significance. From my point of view, there's no doubt art is widespread, encourages liberty, growth and expansion and whatever the reason, is habit forming, contrasting with or adding to our everyday realm. At the same time, I puzzle over the role of artists? Doesn't art belong to everyone? Isn't everyone an artist? Does art relate to freedom? Apart from space art, what role can artists have in space environments and what can they contribute to the collective goals of small extra-terrestrial communities? As I caught a plane to the Mars Desert Research Station in Utah in April 2012, I wondered how these thoughts about art and artists could be practically applied to how we understand constraint and liberty in the future frontiers of space.

The Mars Desert Research Station was built by The Mars Society in the middle of Utah, USA, to be used by scientists as an analogue for Mars and sometimes by NASA to train astronauts. In April 2012, our enthusiastic Crew 118 dressed in full space suits, simulated a landing and ate only dehydrated astronaut food for several weeks as we lived and worked together in a small capsule in the barren, isolated, high-altitude desert. The ground was strewn with dinosaur bones and shell fossils. Outside it was stark and silent and when it was windy, nothing in the landscape moved.

In his memoir *Diary of a Cosmonaut* (1967), Valentin Lebedev suggested that space analogues have limited value beyond earth. Our field trip to MDRS allowed me to cast an experimental eye over an unusual situation and the small insights I gained have taught me much about how creative interaction can occur in a contained space within infinite or open space. As a starting point for making art, I intended to trial participatory, multisensory and transitory practices that have characterised much contemporary art over the last 20 years. I figured these ways of working might be appropriate for communities where interdependency will be a key factor. To create work bridging art and science, I originally decided to poach scientific methods and frame my investigations through a series of science questions. My plan was to use observation and hypothesis to symbolically represent some aspect of the physical world that could be internalised: a focus on themes of adaptation and full cycles of development could be useful and perhaps appropriate

for space travellers. From the first day I struggled with these abstracted ideas. Significantly, the immensity of the desert overwhelmed me and I felt uncertain and removed from my plans. Every day my senses were further overloaded by the enormity of the physical environment. Even the fast running shadows of clouds and the patterns of wind on the bright sand preoccupied me. I imagined myself to be in a state of disconnectedness or unreality, where one's mind is set adrift and time disappears, similar to that of the "break-off phenomenon" that astronauts describe when they euphorically identify with space not earth. I was absorbed, definitely immersed, sometimes lost, as I wandered around in my space suit, breathing heavily in the heat.

In April in Utah it was almost summer and the sun rose hot and red on the Morrison formations. At MDRS our crew met early in the day and ate our dried astronaut diet together. Each of us had distinct roles and responsibilities. Mine revolved around human factors. As well as our defined schedules, we were assigned rotational daily tasks; pumping water, monitoring and repairing machinery and equipment, organising and preparing food, cleaning, report writing for mission control, education outreach and embarking upon strategic field trips relating to the necessary science experiments. Our days and often nights in the desert were busy, so time to develop art was short. Creative work needs energy and reflection and there was little occasion for either. During the day, we collected soil samples and learnt why rocks are central to our understanding of the universe. At night, our commander, an astronomer, taught us about the sky and I learnt how to photograph and how to draw stars. We polarised the giant telescope and watched the moon set through its lens. Inside the habitat in my tiny cubicle in the dark, sometimes I would put my ear to the wall and imagine infinity outside. Through thin walls I could hear the howling of the wind and the snap and hard slap of the Mars flag on the roof.

Although I knew I could rely on immersion in an unknown setting to provide me with working methods, at night, wide awake when I should be sleeping, the practices of other artists drifted past my mind's eye in a steady flow. I thought of how socially engaged Harrell Fletcher (2013) validates his art with small communities by developing levels of technical expertise. I remembered the DIY aesthetics and ecological principles in the sculptures of local Melbourne artist Emily Floyd (2013). I wandered about the esoteric forms of knowledge found in the experimental geography of Joachim Koester. I searched the abundant particularity in the material layering of the desert and star drawings of Vija Celmins (2010) and wished I had drawn them. I visualised the playful and provisional models of the universe of Sarah Sze (2013) and empathised with her desire to locate herself in a disorientating world. I recalled the confined spaces, the architectonic and futuristic visions of Walter Pichler (2013) and then, even a memory of silence—the sound of my breath and the thudding heavy pulse of my blood in the solemn, anechoic chambers of Kimsooja (2013). Slightly dampened as I thought gravely about the work of others, I lay in my compact bunk and worried about how resourceful I could be in this otherworld reality, isolated and dominated by routine and mission control. When time is precious and there is science to be done, could I convince anyone about the value of making art?

Trying to set a good example amongst strangers, I set up my studio on a small table next to the bed in my cubicle. Though my interest in space art is minimal, I began painting and drawing what I could see or translating mental images using memory, mostly desert, rocks and people in spacesuits. This was a good move. Immediately, away from surveillance cameras and the activity of our shared main room, I felt my personal space stretch and extend. I pinned up my drawings and small paintings and on the table I had easy access to materials, to my new books from the San Francisco Museum of Modern Art and to pens and paints and collections of stones from the desert. I began to engage, looking at strands of the work and thinking about what I could see. I stuck up a display of spherules, similar to blueberries found on Mars and denoting time, I drew their shadows directly on the wall. The studio became at once a working space and an exhibition space and with this approach, I defined my role as dedicated to art making, for myself and for others. It was a small but meaningful focal point, creating autonomy and difference in a habitat full of equipment and routine.

Almost a hundred years ago, Henri Bergson (1919) suggested that the more rigorous our schedule, the more preoccupied we are in our day and the less time there is for contemplation. As we move through usual routines, by necessity our vision narrows. We see more than we acknowledge, isolate what interests us and prioritise what we need, recognising and classifying but mostly ignoring the rest. Bergson reminds us that the aim of art is, "…to show us in nature and in the mind, outside of us and within us, things which did not explicitly strike us our senses and our consciousness." (Bergson 1919, p. 161). Imaginative projections and the mental, emotional and physical commitment required do evoke an inner, contemplative world, one that is immersive over duration. Through material exploration, art changes our perceptions, distilling experiences and testing the possible, slowing down moments by encouraging reflection. In immutable space, as we search for belonging in worlds that have their own imperatives, art making can create another life, one that evades the heaviness of routine and the intransigent thinking that might grow from the burden of regimented activity.

In the desert, to track my thoughts, I wrote daily in a notebook about the key themes of art making and about my feelings of confinement in an extreme space. While I voiced my impressions through writing, I actively sought for subtext. These explorations proved to be an illuminating way to catch sensory responses and develop my point of view. As I photographed the stars at night, read the memoirs of astronauts and wrote about the challenges of art and space travel, I dreamt myself as being in deep, deep space. All the while I recognised this inventive context as productive territory for astronauts, many who are already familiar with memoir writing as a literary genre.

The astronaut/cosmonaut memoir is often begun in space and finished as a publication back on earth. Far from his native planet, Lebedev, my favourite cosmonaut, wrote regularly to create personal freedom, to interpret complex experiences of space travel, as a lifeline to reach out to his family and friends and to stave off depression and isolation whilst in sustained travel above the earth. It was Lebedev (1968) who pointed out that in space tears run upwards. Unlike Buzz Aldrin

who years later claimed that no one was on board Apollo to translate the experiences of being 384,400 km from home, and that NASA should have sent an artist or poet to the moon (Hanlon 2012), Lebedev wrote to understand where he was. One particular recollection stands out in my memory. As he orbited round and round the world, the Russian cosmonaut began to understand pattern in all the lights of the earth as they came on and went off. He recognised not only the regularly recurring dark and light rhythms of civilisation, with its cities and roads but also how these merged with the glitter and sparkle of nature as the sun hit the surfaces of the great lakes and rivers of continents below. In continuous space travel, Lebedev willingly wrote about his understanding of earth as a distant planet, speaking from his own observations, from perception and from memory. In his writing he expressed new knowledge about the earth to the earth. This exquisite moment, when he observed and translated something of his experiences on Soyez is unrepeatable and unmediated. At the core of my thinking about freedom, these kinds of self-representations focus upon notions of liberty created by inner experiences and imaginative associations.

In the Utah desert, in spite of a bit of confusion, what's the point and a few unanswered questions, from trust and common experiences, possibilities for creativity slowly emerged. Gradually, through conversation and example, in a remote and exhilarating setting, interest was sparked in art making. There was a bit of flurry and exchange. Through ways we could not have predicted, some of MDRS Crew 118 began to make objects and images, using methods and processes already familiar to each of us.

Working resourcefully with whatever is at hand, making do or making something from nothing is always a great place to start art making as these activities can arise democratically, from any level of consciousness. For me, the playful interaction and the developing sense of purpose that occurs at the start of the collaborative process is an initial state of grace where expectations and criticism are suspended. Local knowledge is a constructive starting point for invention. For example, we used the tools of the geologist to make jewellery from strings of ancient, fossilised oyster shells, our engineer sifted and pounded clay to form magnificent gem-studded coil bowls which fell apart as quickly as he could make them and our documentary maker shaped mandalas of coloured sands in the landscape and forests of trees constructed from fragments of petrified wood. Reaffirming his Maori identity, the physicist/school teacher painted the red, white and black koru of his Maori flag. Aesthetic knowledge is accumulative and catchy and the signature flag painting quickly caught on. The Australian engineer painted the Aboriginal flag, repositioning aboriginal culture over the red, white and blue Union Jack in the corner of the Australian flag. Our Kiwi-Romanian commander painted her flag, marking territory with her colours of origin and I painted the Mars flag. Art clearly signalled the elements and our inner world within MDRS. There was emotional resonance and if our contributions were sometimes clumsy and ephemeral, the poetry of the artefacts we made was purposeful and direct in response to this new domain and our position in the landscape (Fig. 7.2).

Fig. 7.2 Bruce Ngataieru's painting of the Maori flag

It was strange but because there were no other humans in our vicinity, our perception of space in Utah was that it was totally blank and free. The word 'space', itself refers to an empty expanse and I often heard the phrase 'free land' as defining the desert. There did seem to be a kind of frontier nostalgia around these words that shifted the desert concept to and fro from wilderness to resource. Yet firsthand contact emphasised that in spite of the isolation, the Utah deserts are full of links to modern ecologies and there are complex chains of relationships that link the landscape to its people and its past. For instance, under my feet, the desert was scattered with the remnants of hunter gathering and flood plain farming; ancient hand tools, arrowheads, and implements of bone and wood. These objects are similar to modern souvenirs that can be purchased at the nearest local Utah petrol station, made on the reservations by local Navaho tribes. The point is that my space analogue/wilderness experience, however profound, was not really of free space or of a wilderness. Was I in a simulated space station in a simulated wilderness? Even so, the imprint for me read like blindsight, translating my thoughts easily to the frontier environments of deep space.

One of the things that did seem to characterise my experiences in the harsh desert environment was the palpable way I responded to extremities of scale. As I walked to generate ideas, even the rhythm of walking disorientated me. My eyes moved from the ground at my feet to the horizon and then up to the sky, up, down, from the small to the immense and back again. I have to agree with artist Robert Smithson who said, "The desert is less nature than concept, a place that swallows up boundaries." (Smithson 1979, 89). While my senses exaggerated and muddied

relationships between the endless terrain and the open whole sky, my point of view was repeatedly fixed and lost against the horizon. Everywhere was vast space and everything exterior was pitched against it. Our crew would stay outside for as long as we could then retreat inside to escape the elements. We all recognised that there seemed to be no middle ground, just interior and exterior extremes. This disorientation has a profound effect on the senses and on our being, one that I believe is consistent with the experiences of space travel.

Apart from changes in visual acuity due to microgravity, there is no depth of field in space, no soft shadows and the lack of reflective matter makes it difficult for astronauts to determine the true shapes of objects. The steady interior of our ship remained a small, solid, controlled, task-driven space under the horizon line, focused on survival and safely under surveillance from media and mission control. In contrast, the outside seemed at once unknown, dangerous and sublime. No abstract imagery can ever express the sensation of moving from the tightness of this interior world to the exterior, from stimulating but claustrophobic living with strangers, to the vivid sense of aloneness I felt as I explored the huge desert remoteness, thoughts and footsteps magnified. Like a trauma or an epiphany or a very strong dream, this heightened experience is still with me and evokes a physical response.

Good intentions around creative thinking abound: aims can be established, models can be made, other art can be examined, deadlines can be set yet the actual process of thinking through materials that leads to art defies theoretical underpinnings as much as it informs them. On the other hand, although objects of great art can inspire wonder and the artist process is elusive, contrary to much popular opinion, art does belong to everyone and there is no real mystery in the activity of art making.

The affective character of art as an emergent process dynamically frames and is framed by reflexive and dialogic practices. Freedom is present on this road as the artist vacillates between the concrete to the abstract to invent methodologies that embrace shifts in form and content. If this is understood, then it's not surprising that the process of art making lends itself so easily to the pursuit of collaborative goals, as much as it does to developing individual self-expression. Art is both isolating and about social cohesion. "Reflection," says Sartre, "yields affective consciousness." (Sartre 1972, p. 215). Through art making, we become aware of what we feel and we feel and think through art.

At MDRS some more than others engaged and felt that liberating inner experience that is part of the imaginative journey of making art. While I was concerned about how to work with people who had their own busy agendas, I realised early in the interchanges between our crew that discussion is crucial for the conceptual development of collaborative artwork, especially between people who have disciplines that follow different languages. As artist, my part was not fixed and I was able to be anything that was required—collaborator, supporter, producer, spectator or facilitator. In every role I tried to maintain some line of continuity yet sometimes framing the situation was almost enough: the responses and the knowledge that

Fig. 7.3 Don Stewart's clay bowl

others brought to the project frequently generated new ideas and encouraged us to go somewhere quite unexpected (Fig. 7.3).

With regard to collaborative practices, artist Francis Alys talks about his experiences when he was making a film called *Cantos*—it was based on a Mexican story of a ferryman who lost his way. Somewhere, while he was working with others to make the piece, Alys lost his own way and lost the meaning of the work. The more he worked on the story of the ferryman, the less he could remember about why he began it. Alys claimed, "If the story is good enough it will get back to you or achieve its shape by itself. If it isn't, then it's better for it to die away." (Ferguson et al. 2007, p. 18). This story resonates with my experiences of collaboration: how it can be about letting the original scenario go, leaving it to be translated by others and allowing it to be bounced back and forth. It's true, art is in the making.

From my experiences of working with scientists on field trips and in our simulated space analogue, the most difficult step seems to be about how to begin: how to build confidence and share common goals with participants from very different disciplines. It seems self-evident but when new art is constructed, individuals often draw upon the familiar and offer local knowledge as a way of beginning. Creative thinking must always be thought about through the materials that contribute to it and individual contributions given without compulsion or coercion recognise positive freedom in collaborative art making. Human social experiences are formed by reciprocity so this initial negotiation is a meaty moment with regard to future matters of extra-terrestrial liberty as it pinpoints how people engage and work together, in this case by generously acknowledging and expanding upon difference.

On Mars, because people will be restrained by the toxic atmosphere and monitored for the greater good, interdisciplinary communities will be forced to co-exist and zones of freedom will, by necessity, involve collaboration. Fortunately artists thrive upon network behaviour and aesthetic knowledge travels well by association, particularly if open environments of exchange are supported at all levels by the state. Notably, artist run studios and collectives have functioned well throughout history, promoting socially rich, cross- fertilizations of methods and ideas. As in many other disciplines, exchange between contributors can sharpen purpose and generate change and divergence. When the work is the cynosure and goals are generously shared, productive thought is stimulated by diversity of practice and individuals are sustained by cooperative effort. In this communal way, and because of its intrinsic affectivity, art making supports connectivity and integration, promoting practices that place importance upon negotiated, democratic social relations as much as on independence and private freedom. How individuals will respond to group values and shared goals in nocuous environments is of utmost importance to those who are planning new extra-terrestrial settlements. Yet the nature of collaborative art making and its links to understanding notions of constraint and liberty seems so little understood by human factors scientists that its enormous value to future extra-terrestrial settlements is deemed unrecognisable and insignificant.

What was apparent to all of us at the Mars Desert Research Station in Utah is that the art studio can be anywhere you are, even in infinite space. Thinking back, the actual objects and images we made at MDRS were a kind of after-effect, true artefacts of our experience, modern archaeology or maybe they were just space junk. On an alien planet in an alien landscape, we would certainly try to recreate our own image, mark territory, reference memory and history as we find materials to represent and decorate ourselves, our dwellings or at the very least make functional form. This behaviour is part of human life, full of relationships.

Bill Fox emphasises the value of these first hand experiences when he says, "We can image and imagine Mars all we want, but if it's important for us to know it, we have to go there in person. And then, in addition to cataloguing and analysing its rocks, we'll have to make paintings, poems, music, dance and novels of it all, because these are the ways in which we translate sensory results from one person to another. If we want Mars to be more than space or alien terrain, if we want it to become a place within grasp of human society, we'll have to learn how to re-create our sensory impressions of it in art." (Fox 2006, p. 90).

After claiming I have no interest in space art, here I am drawing mineral rich asteroids with my silver and cobalt pens. Two months ago in London, at the conference that prompted this book, I invited conference delegates to participate in a doodling experiment while I presented. Inspired by the work of Venice Biennale artist Lin Xue (2013), who doodles cosmological images with a sharpened twig, I asked the audience to use doodling or its close companion scribbling to make me a drawing while I spoke and I would draw something in return. To participate all that needed was an open mind. I had nipped up to the art shop and bought some paper and a few pencils. The idea was to experiment and explore ideas without judging. The wonderful thing about doodling is that many people already feel comfortable

with it. It isn't time consuming, it doesn't have to have a subject and it doesn't have to be on paper. It can be fast, slow, very slow or blind. It can be purposeless or relate to one's own work or to other visceral, spatial, conceptual, material and temporal concerns. Either way, doodling can yield surprising results and is not primarily associated with drawing skill though this does evolve. The habit itself was chosen because there is no pressure for the drawing to look like anything. Even so, many people are suspicious of art and rightly feel it's not their language. Several at the conference doodled away and then didn't hand their drawings over. I saw one person screw up his drawing up into a ball and put it in his pocket, making my point that creative practices are directly associated to identity and to notions of liberty and failure.

To conclude, the unpredictable nature of contemporary art with its emphasis on collaborative practices and liberating inner experiences has much to offer space-farers. With its multiple of authorial positions and trans-disciplinary input, art making relies on variation and selection with ideation at all junctures, setting constraints that are easily broken and testing new ideas without ever needing to commit to them. Art, like evolutionary features of life, free ranges and adapts to survive limitations. Direct appeal for spacefarers might be that the imaginative realm of art lies outside the surveillance of mission control and the zones of media saturation, emphasizing private space and self-determination. However, whether the focus is communal activity that builds social cohesion or personal practice, consistent art making builds autonomy and expands horizons through experiential learning, creating an unrivalled opportunity to live, think and develop in a way that suits one, a condition of freedom lacking in space travel. As on earth, creative work will be always be restricted by such boundaries as funding, health and safety, ethics, materials, site specificity and time constraints. However, to maximise liberty and the potential for art to create independence and transform monotony, future settlers should not be worker bees but highly ingenious motivated individuals who are prepared for restrictions, finding resourceful ways to share goals and build communities. For humans to really inhabit a role in an alternative world, creative practices in future extra-terrestrial settlement need to be clearly prioritised and mandated as transitional space, occupying a significant role as part of daily life. One direct route to understanding freedom in extra-terrestrial societies of the future will be formed by visionary modes of art making, bringing us strangely to a closer relation with the unknown.

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Chapter 8
Elsewhere, Liberty

Charles Peterson

Abstract Any attempt to discuss the concept of *liberty* in the context of some type of extraterrestrial existence requires an attempt to describe what the physical parameters of the possible contexts are. Also important in such a discussion is some effort to describe the concept of liberty itself, including its necessary relationship between the individual and society (whatever society might exist in each individual context), as well as the relationship of the individual to the environment that exists, and the relationship of evolutionary human traits within the individual as they must be adapted to environments that are different to the environment in which those traits evolved. Finally, the choice has been made in this discussion to limit the possibilities to those that current knowledge of physical and biological science might potentially allow, without giving credence to concepts such as faster-than-light travel or the creation of human-robotic hybrids, or other imaginings that are so much an accepted part of modern, popular fiction.

Keywords Philosophy · Space exploration · Colonization · Liberty · Culture

8.1 Possible Contexts of Extraterrestrial Existence

There are many potential scenarios in which human space travelers could find themselves participating. Each scenario would necessarily require different adaptations on the part of each individual, and could easily alter the very definitions of liberty and freedom for those participants, be they explorers, colonizers, or citizens of the places they are part of. A few examples would be:

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8.1.1 Within Solar System

Round-trip, short and long duration, scientific exploration
One-way, trailblazer or establishment exploration
One-way, immigrant colonization
Subsequent colonial generations
Transition to independent state

8.1.2 Outside Solar System

In-transit, trailblazer generations
Subsequent generations of a new world

8.2 Philosophical and Definitional Considerations

Liberty is a cultural and intellectual concept which only has meaning in the context of the relationship between an individual and a larger community or state, or between an homogenous group, such as a religious or political sect and the larger community or state in which they exist. Otherwise, liberty has no functional meaning when thinking about the individual in relationship to their own self. Therefore, liberty, as it is used here, is defined relative to the *other*. The associated concept of *freedom* can and often is used when discussing an individual's relationship to their own self, as in *freedom from addiction*. In the context of what is said here both liberty and freedom are used to describe the relationship between the individual and the larger group.

Humans, our physical nature and our intellectual constructs, are a product of billions of years of an evolutionary process that has occurred in the natural, and constantly changing, environment of this planet, and only this planet. Whatever influence the moon, planets and stars have had upon our psyche, that influence is only the result of our imaginations, imaginations that evolved here. We are embedded in, and are a product of, this place, and the nature of this place. Whether those of us alive today have experienced our major influences in cities or rural areas, deserts, forests or mountains, or highly technological or agrarian societies, we find ourselves contemporaneously connected together in an increasingly global society where, for better or worse, wisely or mistakenly, we share increasingly common concepts and ideas. Liberty is one of those concepts. And while the struggle for liberty and freedom is often remembered historically as a struggle by specific groups against an oppressive majority, in the end liberty is not about that which is experienced by the group, but rather by each of its separate individuals. Perhaps it is emancipation from slavery that is sought, or the right to vote, or the right to equal pay, or the right to speak one's mind without fear, but it is the individual that is the intended recipient of any new liberty, or any liberty that has been enjoyed for so long that it's privilege of use is assumed.

The philosopher Immanuel Kant promoted the idea that freedom means the individual can act with autonomy (self-law), but that each act must be based on reason grounded in knowledge. And empiricists such as John Locke said that our knowledge comes from our sense impressions of the world. If we are to believe that something is true, the world in which we live must confirm it, and we should seek that confirmation. In the end we have natural concepts of history, politics, religion, and philosophy that are derived from thousands of years of accumulated human experience. And this is also the source of any definition of any words, including the concept of freedom or liberty. But there is more. The ability to be creative, to do—not just to think—is vital to not just the idea of liberty, but to the practice of it.

Liberty is a practice, not a thought or idea. And its origins are based in history. So if we are going to try to imagine what the concept of liberty might mean for humans who have departed this planet, and departed from its history and its human culture, we are going to have to stretch our imaginations beyond anyone's experience. Attempting to find analogies in prior human exploration or colonization will fail. It will fail because the environment of the space traveler will always be, literally, astronomically different. And they will be separated from all prior, common human experience in ways that we will fail in attempting to describe. But we can still try.

8.3 Round-Trip Solar System Explorers

We can quickly dispense with exploratory space travel within the solar system if that exploration is based on the idea that the explorer will return home. Even missions to Mars that may last several years will allow the individuals involved to maintain some level of intimate connection with their friends, families, and society at large. The type of issues that arise in 6 month–1 year missions at the International Space Station, which define conflicts between an individual's sense of personal freedom relative to their duty to the system that sent them there, are already well known. And for almost anyone who has made the choice to participate in these missions, as well as anyone who might choose to embark on somewhat longer ones, the sense of privilege that they get to participate in such an exciting and rewarding (for them) adventure is undoubtedly viewed as experiencing a high degree of freedom. Their historical connection to contemporary human values remains intact.

8.4 Martian Colonizers

It is rather more interesting to consider the concept of freedom and liberty when imagining the possibility, however remote, of permanent colonization of Mars, and the even more remote concept of humans traveling to other remote, habitable, stellar

systems. In the first case, permanent colonization of Mars, we must accept the idea of one-way travel by a large number of individuals who would establish a society that could only be considered permanent if it, in fact, it ceased to be a colony and became its own self-sustaining society, and therefore a self-governing society. The concept for this case is to not imagine some terraforming extravaganza out of science fiction. Throughout this essay the idea is to work within the realm of the most likely reality to unfold, and to avoid the kind of glib ideas that would make it all seem easy and wonderful. It will not be easy, and whether it will be wonderful or not remains a question that only those engaged in the effort can decide.

Mars is not much more than half the diameter of Earth, with only 11 % of the mass, yielding a surface gravity 38 % that of Earth. An individual weighing 100 kg (220 lb) on Earth would have an equivalent weight of 38 kg (84 lb) on Mars. The atmospheric pressure is less than 1 % that of Earth, and is comprised almost entirely of carbon dioxide, with less than 5 % of the oxygen humans are accustomed to. The temperature averages approximately −55 °C (−67 °F). The atmosphere and climate will obviously require that humans either remain inside whatever limited working and living areas can be provided, or be constantly encased in protective gear when outside. But the rather straightforward medical problems associated with weighing only 38 % of what evolution designed us for is another matter. Everything from eyesight to circulation to muscle maintenance and the working of organs will be affected in ways that will only be discovered by experience, but which medical science has some clues about as a result of forty years of low Earth orbit missions. But none of that recent experience can accurately inform what this will mean for longevity of permanent inhabitants of Mars. And then there is the concept of population growth on Mars as a result of humans breeding there. We have no clue what these conditions would mean for gestation and infant and childhood development.

But what exactly does this have to do with liberty? Under intense conditions such as these, where survival is crucially dependent upon elevated levels of cooperation and trust, people's demands for individual freedoms will necessarily recede when compared to the concept of liberty and freedom for people living in modern societies on Earth. Finding a few moments to be alone will be a treasure. One could think of being on board a highly technological ship that never comes to shore if seeking a comparison. But forget about the sea breeze and going fishing or swimming. But then, one could forget about highways plugged with commuters. Which leads to an interesting point.

Humans living in such a colony, for however long their lives may last, or however many generations they have been developing their own history, would very likely maintain a full-throated, high-broadband level of communication with the planet of their origin. And there would be subsequent landings of new immigrants from Earth to deal with. All of the constructs that modern civilizations must deal with, not just that of liberty, would require constant restructuring in each individual's mind. A fifth-generation Martian might be likely to completely ignore cultural news from Earth and become truly Martian (whatever that may be), while another would yearn wistfully for the air they had never breathed, and the

landscapes they had never personally witnessed, or the freedom to run around naked outside by a river (once they had developed enough muscle mass to stand upright). That person could easily resent their forebears who made an unbearable decision on their behalf. Just the freedom to decide to take a walk without getting suited up would be an impossibility. And someone who was newly arrived from Earth would have to carve out their own sense of liberty relative to both of those individuals. Liberty is something that one practices in relationship to other people. And each individual defines liberty for themselves.

There have been numerous writings in the form of memoirs by individuals in history who have served many years in prison. It is interesting to note a common theme for those writers—liberty is in the mind. You can take away all of someone's physical freedom, but you cannot take away the freedom of their thoughts. They may have to limit what the *other* knows of their thoughts, and those thoughts may be a lot about their relationship to the *other*, but no one can govern what their thoughts will be. This is the liberty with which a Martian colonizer will likely have to be satisfied. Their physical prison will be elaborate, and they can actually go outside to explore and work, but compared to common human experience on Earth, a prison it will be.

8.5 Interstellar Travel and Other World Habitation

It is difficult to compose a coherent thought about what liberty might mean for humans who, for whatever reason, might find themselves traveling, necessarily one-way when considering an individual, to another world in another stellar system that has (hopefully correctly) been determined to be habitable. For the sake of this thought experiment we will rely on the idea that this new world, when it has eventually been reached, is reasonably similar to Earth. If it turns out to be less than reasonably similar, one can just extrapolate to different results. The reason for the difficulty of describing a coherent sense of liberty in this situation is the rather impossible nature of actually getting to another stellar system. We shall ignore the glib solutions posited by science fiction, such as faster-than-light travel or technologically created artificial gravity.

As will be explained, such a mission will necessarily take many human generations in transit. As a result the vehicle will have to be enormous. It will have to be large enough to hold a population of a size that can be psychologically, physically and numerically self-sustaining—a large village or town. An appropriate level of gravity could only be provided by a ship of such a diameter if it is one that, once set to spinning, would keep the inhabitants comfortably glued to the inside of the shell. Imagining such a craft borders on ignoring the promise of ignoring glib solutions. And we haven't referred to propulsion yet.

Simply for the sake of example, imagine that a propulsion system for this enormous vessel could be found that would apply a force equivalent to 1 % of the force of gravity as experienced on the surface of the Earth. If that force could be

applied constantly for 10 years or so the vessel would have traveled about one half of one light year and attained a velocity (assuming starting from zero) of about 10 % of the speed of light (and now be traveling one light year every 10 years). We also need to assume that enough energy is left to reduce the speed back to zero in a reverse action commenced 10 years before arrival at the hoped-for habitable planet.

The nearest star to our own sun is Proxima Centauri, a mere 4.24 ly distant. Close neighbors, gravitationally bound Alpha Centauri A and B, are at 4.37 ly. Amazingly, a planet has been discovered around Alpha Centauri B (Alpha Centauri Bb, announced on October 16, 2012) which is only slightly larger than Earth. Unfortunately, it orbits so close to its star that its surface temperature is estimated to be 1,200 °C (about 1,500 K). We, of course, would not be so lucky as to find a friendly planet so close to the one we call home.

Instead let us assume that we are in fact lucky and eventually discover a planet that we feel confident we have accurately characterized as being acceptable for humans, somewhere in the extremely close neighborhood of the Sun—perhaps 200 ly. And considering that our Milky Way galaxy is upwards of 100,000 ly in diameter, 200 ly is pretty much next door. Assuming the velocity parameters of our imaginary ship as described earlier, with 10 years necessary to speed up to 10 % of the speed of light while traveling 0.5 ly, and an equivalent time and distance to slow down, we are left with 199 ly that must be crossed while coasting, yielding a total travel time, beginning to end, of 2,000 years. And now we can begin trying to consider a definition for liberty. Somehow *Liberty* would appear to be a bad name for the starship.

There are so many questions that cannot be answered. What technology could possibly exist that would allow this far flying village to survive—or even simply to maintain that technology? Would a most simple form of agrarian technology, a true agricultural village, be the most likely to survive? How many generations would pass before a group of utterly despondent and angry descendents blow the whole thing up as an act of liberty? Would a culture develop, bizarrely different than anything we can imagine, that would find peace and some purpose in going on? What kind of learning would survive, or find usefulness? What strange religion or religions would develop? What would philosophy be? And since liberty, as described in this essay, is defined as an active practice, what individual actions would fulfill that need? Would that need even exist or be recognized as being important?

As the distance from Earth grew, news from "home" would become bizarrely irrelevant. Ten generations out it would seem like mythological tales coming from Mount Olympus. What would even be the point of "phoning home" to someplace that was, in fact, not home? Perhaps communications would simply cease, except from the occasional individual who decided it was interesting or important for reasons that only they will know, and who had the wherewithal to figure out how to do it. It is hard to define such an act as a communication when a round-trip message could take longer than a human lifetime. Liberty, if such a concept existed in the minds of the individual members of this strange and minute civilization, would have to be something that only they could explain, and which we, most likely, here on Earth, could never know or understand.

And then after 2,000 years? Let's suppose the people on board this vessel, or the vessel itself, could turn around, slow down, and accurately enter orbit around the planet, and that it was actually good for humans. And then let's suppose that whatever technology was necessary for getting to the surface of the planet was available, and worked. One thing is certain, at this point we have defined 2,000 years of miraculous occurrences. Suddenly, liberty as humans know of it today in our own Earthly societies would be relevant once again. This, of course, assuming that there was not already a society or societies with definitions of liberty that were the natural inhabitant of this brave, new world (their old world). If that were the case we would be talking about an invasion. But regardless of what fate our human emissaries find, an attempt to describe human liberty becomes vastly easier.

These emissaries, if they could be called that, are about to begin living very human lives, lives that all of us would recognize from human history as we know it on Earth. Certainly there will be differences of experience and knowing, but all of those experiences stemming from gaining knowledge of a new place would somehow be comprehensible to us in our present moment here on Earth. Humans have had these kinds of experiences before. Liberty will grow and wane. Oppressions will occur. Freedom will be fought for. Philosophers will eventually write books, and people will read them, discuss them, argue about them. But at the beginning, and for some unknown period of time after getting their feet on real ground, liberty will be an explosive thing. Freedom will out. Culturally there is bound to be a very long period of time that we, in our present condition, would consider to be anthropologically archaic. It would be tribal. Liberty will be a few individuals moving over the next hill and into the next valley. Liberty will be a very active thing. It will be driven by an ever present human imagination.

Part II
The Policy and Practical Aspects of Extraterrestrial Liberty

Chapter 9
The Fate of Freedom of a Space Exploration Mission Encountering Life and the Liberty of the "Encountered" Extra-Terrestrial Beings

F. Javier Martín-Torres and María-Paz Zorzano

Abstract With the advent of new technologies and the flourishing of space travel and landing on other planets, the topic of finding life outside Earth has been attracting the attention of scientists. We are in the historical time where we must start posing and answering questions regarding the impact of discovering extra-terrestrial life in space missions. This chapter revolves around the freedom of announcing scientific discoveries if extra-terrestrial life is encountered; and it is an attempt to pose questions and alert the scientific community and international authorities of the firm need to answer them before life is discovered on another planet. Further to this, we highlight the point of the lack of a current procedure in place in the case of discovery of "life" and the rights and liberties of such "life" discoveries.

Keywords Space mission · Curiosity · Planetary protection · Extraterrestrial life · Encounter

> There I found very many islands filled with people without number, and all of them I have taken possession for their Highnesses. […]. As soon as I arrived in the Indies, on the first Island which I found, I took some of the natives by force in order that they might learn and might give me information on whatever there is in these parts.
> Christopher Columbus, Letter to King Ferdinand of Spain, describing the results of the first voyage, s. XV

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9.1 Introduction

From our planet Earth, orbiting a star like many others within a galaxy like so many others, in an immensity of dimensions, life seems extraordinary, unique, a phenomenon statistically so unlikely that its appearance borders on the miraculous and therefore unique. We only know that there is life on Earth. Nevertheless the possibility that there are other places in the universe capable of supporting life and that it actually exists is a question already firmly embedded in astronomy, a discipline that today looks decidedly exalted by space technology development and the firm conviction that our small planet is just one of many scattered in the vastness of a universe increasingly well understood. The task of clarifying the answer to this question has been taken up with interest and enthusiasm as a challenge worthy of substantial economic supplies and care of many of the brightest minds in human history.

Since the dawn of our culture voices have risen sporadically to either support or contradict this position, until finally, as in our day, has settled in science the idea that life can not be considered an exclusive Earth-event, but that might be normal in the Cosmos. Scientists are therefore starting to inquire about its extent and possible manifestations.

Moreover, the incessant finding of new forms of terrestrial life in extreme environments has greatly expanded the range of many parameters that demarcate the living conditions, and have ventured alternative to terrestrial biological models. Actually it is becoming generally accepted that any place meeting certain chemical and thermodynamic criteria would conduce to the emergence of processes that should be classified as life.

Despite the fact that for many people it could have been straightforward to imagine that other stars could host planets, the first evidence came only 21 years ago: in 1992, the first planet around a special type of stellar remnant, namely pulsars, was found (Wolszczan and Frail 1992), and in 1995, the first detection of a planet around a star of similar composition to the Sun, namely 51 Peg b, was reported (Mayor and Queloz 1995). The enormous progress in this field is reflected by the fact that, by the time that this paper is written (end of October 2013), 759 planetary systems, with 999 planets, are known. While most of these are gas giants like Jupiter and Saturn, several dozens of less than 10 Earth masses have already indicated that rocky planets with conditions considered suitable to harbour life are probably rather common. The discovery of Earth-like planets with suitable conditions for life, therefore seems to remain only a question of time.

Current technology allows us to return samples to Earth, with the advantage of being able to adapt analysis strategies to unexpected findings, or to land a robotic laboratory, the Mars Science Laboratory (http://mars.nasa.gov/msl/, http://www.jpl.nasa.gov/msl/), on Mars. A further opportunity to find alien life forms is given by the study of meteorites found on Earth, where it is now well established that some of them originate from Mars (Atreya et al. 2013). Although the exchange of biological material between Solar System bodies might also mean that such life is not

distinct from ours, but rather shares a common origin; even that encounter of life outside our planet would have an impact on Society, and most probably would occupy plenty of pages in journals and newspapers, as well as TV primetime.

New technologies, space travel and landing on other planets has made the topic of finding extra-terrestrial life a topic of scientific research. Many of the stories in Science fiction books are not longer just in the Paradise of imagination.

We are in that time in history where the detection of extra-terrestrial life is starting to look technically feasible, and, then we are in a time where one needs to address whether perceived societal benefits command us to search for it, or whether such an endeavour may rather turn out to be a threat to our own existence (Michaud 2006); or at least, to start questioning the impact of that encounter for us and for the "encountered" beings.

The detection and further study of extra-terrestrial life will fundamentally challenge our view of nature, including ourselves, and therefore the field of Science can hardly be isolated from its societal context, including philosophical, ethical, legal and theological perspectives.

As the light reaching a prism and decomposing it in colours, data coming from space in electromagnetic waves, like light, will open a colourful variety of implications for us. Under the prism of questioning the impact of such a discovery, this chapter would try to provide some insights about its impact on the Fate and Freedom of a Space Mission. We will distinguish between the different scenarios of extra-terrestrial life encounters and their impacts; and then we will analyse the hypothetical impact that they would have in a space exploration mission like the Mars Science Laboratory (MSL), a mission currently operating on Mars. Finally, we will highlight the point of the lack of a current procedure in place in the case of discovery of "life" and the rights and liberties of such "life" discoveries.

9.2 Different Impact from Different Scenarios

Through history, science fiction literature and films have portrayed different scenarios of encounters with extra-terrestrial beings that probably have created a collective established opinion about the impact of their discovery. These scenarios usually consider weird alien species invading Earth. Nevertheless, given that multicellular, and then intelligent, life is not likely on planets and satellites of our own Solar System; and that the distances to other Stellar Systems are enormous (our closest star, Proxima Centauri is 4.2 light-years away), the most likely detection scenarios will be either:

- The encounter of extra-terrestrial life (most probably multicellular) at a safe distance that prevents physical contact. This would be achieved through dedicated powerful space telescopes and/or ground-based radio-telescopes, like those in the Search for Extra-Terrestrial Intelligence (SETI) project, and the distances involved will be typically at light-years distance.

- The encounter of microorganisms, through in situ planetary exploration. This should be achieved for a science laboratory exploring another body of our Solar System. Based on our current understanding, a few planets and satellites in our Solar System (Mars, Europa, Enceladus, Titan) are the most promising places for finding life signatures.

There could be the possibility of the encounter of microorganisms invading our planet after entering our atmosphere and reaching the surface in meteorites, for example, but we will consider this possibility as remote, as the chance of an extra-terrestrial body containing organisms that additionally would survive the traumatic entry looks very small.

Obviously the impact of both types of encounters would be very different because in order for life (either multicellular or microbial) to be detected from light-years away, this should be discovered through its impact in the atmosphere (visible/infrared spectroscopic measurements) or/and by reception of electromagnetic waves emitted by the living beings in the planets (radio, TV emissions, …). On the other hand life accessible by planetary exploration missions in the next decades, i.e., within our Solar System, will be most probably microbial, otherwise we should have already detected it from the space exploration and the ground-based and space telescopes that have already screened the satellites and planets of our System.

In either case, the encounter does not look as traumatic as presented in many science fiction books and movies, although an encounter with microorganisms by an in situ space exploration mission would raise alerts and precaution mechanisms within the space mission, as we will present below.

9.3 The Freedom of the Scientist Participating in a Space Exploration Mission

Science missions, their operations and the freedom of scientist participating in a space exploration mission will be greatly influenced by the discovery of life outside Earth. In order to illustrate the impact of this discovery we briefly describe the internal functioning of a mission currently operating on Mars, the Mars Science Laboratory. As we will see these constraints, that could be considered a lack of freedom for scientists, are needed for a space mission like MSL involving many scientists and engineers and that has created many expectations between scientists and general public. In fact the MSL project's Curiosity rover was been shortlisted as *Time* magazine's Person of the Year 2012, with the sole non-human companion being the Higgs Boson particle.

We will explain briefly the constraints that scientists of MSL face during daily operations in order to rigorously disseminate the results from the mission. This will allow us to emphasize the impact that a hypothetical discovery of life by MSL would have in the freedom of scientist working in the mission.

9.4 A Practical Case: The Curiosity Rover

The Curiosity rover in the Mars Science Laboratory mission reached the surface of Mars in August 6, 2012. Curiosity was sent to explore a site located in Gale crater, where a broad diversity of materials was observed from orbit. Materials representing interactions with aqueous environments were targeted for study because of the emphasis on understanding habitable environments (Grotzinger 2013).

MSL is not a mission with the goal to find life in Mars but to find signs of habitability in Mars (Martín-Torres 2012); but, of course, it could find life directly (for example detecting it in a picture using any of its 17 cameras) or indirectly (for example through the detection of gases of univocal biological origin with one of its instruments, like the Sample Analysis at Mars (SAM)). Actually it delivered to Mars the most technically advanced geochemistry laboratory, and high-resolution cameras ever sent to the surface of another planet. What would happen if a mission like MSL finds life?

MSL is a complex mission involving daily operations. It is an interactive mission where, everyday, scientists and engineers in the project held several meetings at different levels to finally agree in a series of commands that are sent from earth to the Curiosity rover. Rover operations include:

- *traverse* of the rover in Mars, some dozens of meters per sol (Martian day) moving to the targets of interest, in order to take images, panoramic pictures, and perform chemical analysis;
- *recognition* of the areas of interest using remote sensing instruments, and performing chemical analysis and pictures;
- *approach* to particular targets at arm distance in order to perform chemical analysis, take images, and perform spectrometry studies;
- *contact* with selected targets to take measurements with instruments in the arm, and perform chemical analysis, take images, and perform spectrometry studies; and
- *sampling* and analysis after measurements with analytical laboratory to perform mineralogy, and isotopic composition studies.

Curiosity will be operating at least for 2 years, and probably for much longer. Actually the Spirit and Opportunity Mars Exploration Rovers (MERs) that had the goal to operate for 90 sols have been operating much longer (more than 6 years in the case of Spirit, and more than 9 years for Opportunity—still going on). For the interactive Curiosity operations to occur, every day since the beginning of the mission, 7 days a week and 16 h per day, scientists and engineers work in-person and remotely in a chain of meetings at different levels (from scientific to engineer and from pure scientific analysis to tactical and programming) to achieve these operations successfully. This involves more than 400 scientists and around the same number of engineers at different locations and local times participating in every day's Curiosity operations! Controlling information in a project like MSL is a very hard task.

9.5 Discovery and Speculation

Uncontrolled information could be a problem. Even when this information is controlled it is very easy to find communication problems. For example, in November 2012 the PI of the MSL mission, John Grotzinger, gave an interview in the National Public Radio that originated an internet buzz regarding the SAM experiment on the Curiosity rover.

In that interview he stated something that really was correct: that MSL will be viewed as a mission of historic proportion; but this sentence mixed with some comments about the success of acquiring SAM data during the course of operations, and that they looked great (really referring the quality and richness of the data), was like a flame exposed to an explosive gas; and right after the conference, media around the world and internet pages announced the discovery of methane by the Curiosity and then echoes of a plausible indirect evidence for life in Mars spread out. It was not true, of course, and actually the SAM experiment in Curiosity has found no methane on Mars (Webster et al. 2013). Lesson learned: even the simplest response might be disarticulated into fragments that are then reused by another reporter to almost tell a story about what's going—but one with essentially no useful content.

We live times where information reaches us at a frenetic pace, the internet is a sea where waves of news stick out and spread as rapidly as they dilute. For this reason, soon after the news were spread out, methane and life discovery by Curiosity was buried in layers of news that dissipated any impact in our society, that, on the other hand, unconsciously, and probably due to the whirl of information, does not assimilate news until it stays several days in the front-pages. A natural selection process of assimilation information: only news that survives long enough is really incorporated into the consciousness of society.

In a large mission like MSL, involving hundreds of people on the Team, and with many expectations between scientists and general public the scientific release of data needs to be done very carefully. Actually science news is protected by agreements of confidentiality such as Rules of the Road protocols, that everybody on the Team has to sign in order to be accepted as part of the Team. No tweets, Facebook, interviews, blogs, e-mails, even personal communications are allowed about unreleased data … but, of course, it is hard to keep everybody completely quiet in a group of people so large, specially when fascinating news arrive! How can that be avoided is difficult? Should it be legally punished? Can this be considered a lost of freedom? Is the confidentiality agreement within a space mission (or in any other mission) against the freedom of space scientists? Being part of a large Team, as being part in any other community or society, implies the need to follow some rules that we may like or not. Science cannot do away of these rules and, in principle, and in our opinion, everyone´s Freedom should end where Freedom from others start; but we begin moving into philosophical questions about benefiting collectives versus individualism, that should be debated in large legal, scientific, and international forums.

9.6 Planetary Protection

Planetary protection is an important issue for Space Exploration missions with implications for the Freedom of Research and Impact for hypothetical extra-terrestrial beings. As far as exploring other life forms is concerned, any strategy applied must exclude biological contamination—not only to protect us, but also to preserve any alien life discovered as part of an overall commitment to enhancing the richness and the diversity of life in the Universe.

From the point of view of the coercion of freedom Planetary protection is important for two main reasons:

- Forward contamination: planetary protection is currently applied during the phase of building, calibrating, implementing and testing instruments and spacecraft, and also during landing site selection. Planetary protection protocols should be reviewed to make sure that we do not cross-contaminate with terrestrial life forms. This implies that scientists in a planetary mission are always subject to following planetary protection protocols.
- Life protection: Planetary protection should have some immediate actions on operations after life is discovered. The mission would need to answer a question like: did the spacecraft perform some routines that exposed the life-form?. For instance, did the life form encountered appear after scratching, digging, movement of wheels? Was it in a protected environment (for sure this is the case on Mars) and may now die exposed to the ambient (UV radiation for instance)?

9.7 Freedom and Fear

Humanity is highly influenced by cultural and psychological factors. Therefore, the definition of Freedom will not necessarily be homogeneous for different countries and cultures. Even different political and religious beliefs or age will be factors to take into account; but in any case, whatever the definition of freedom is in a given society or culture, fear is its antagonist word.

In the case of a space mission, fear would limit its freedom for obvious reasons. It is not only the psychological fear of the unknown but also a practical fear of contamination. The fear of the effects of extra-terrestrial living beings, of unknown nature, on Earth's life would make an inhabited planet be seen from a different perspective. In particular, return missions from an inhabited planet or moon would be cancelled or postponed until full understanding about the potential "danger" and variety of life forms is achieved. Liberty to operate will be pressed by a fear of danger. Imagine that Martian microbes have D-chiral amino-acids and opposite handedness proteins, when on Earth, would they be lethal for terrestrial life forms?. What if they are viral forms?

All this would need to be understood before a free continuation of operations. If, as in the case of MSL, the mission is multi-instrumental, operations probably

should be restricted to those instruments that would provide the greatest information on the encountered life forms. Who decides that is something that should be clear from the first day of the encounter in order to avoid loss of time that could be vital for an appropriate and timely response. In particular, most probably priority should be given to operations focused on life-form classification and niche preservation.

Once the first impact of the discovery is surpassed, some (international?) organization should aim at constraining the conditions that define the niche of habitability of the life form (temperatures ranges, pressure ranges, radiation ranges, mineralogical resources, etc., …) and defining the most visible or apparent characteristic that define this being (size, colour, shape).

Features that should be described and understood are: what is the energy source of the metabolism of this life form? How does it adapt to the day-night and seasons cycles? What is the reproduction rate? Does it interchange gases with the environments? (CO_2/O_2 for instance, of methane).

This would become a priority within the mission, for sure lowering the priority of any other science of the instruments on board that is not directly related to this. A re-evaluation of the use of the spacecraft instruments as dangerous or not depending on its influence on the life form would be needed. For instance no laser shooting on the niche!

Principal investigators of other instruments in the mission or scientists interested in measurements from other instruments will lose their freedom to command or request measurements in the pursuit of the best possible knowledge of the discovered extra-terrestrial life.

9.8 The Liberty of the Encountered Living Beings

In the case of MSL, the PI of the mission has direct contact with NASA administrator and in turn with the US president. In case of discovery of life, NASA would activate its own protocols (as in the case of discovery of an incoming asteroid). For missions from other Space Agencies the protocol should be different. NASA is the space agency of a single country, but, the European Space Agency, for example, is an international organization. This would make it more difficult to take quick decisions, unless there is a supreme internal organisation, like the United Nations, that would take the lead as decision maker.

In 1989, the International Academy of Astronautics (IAA) approved a SETI post-detection protocol, which was developed by one of its committees (Tarter and Michaud 1990). Despite the fact that it has subsequently been endorsed by the International Institute of Space Law (IISL), the Committee on Space Research (COSPAR) of the International Council for Science (ICSU), the International Astronomical Union (IAU) and the International Union of Radio Science (URSI), the procedures laid out in that document are not legally enforceable.

This is really a problem. Not only for us, as citizens of the planet Earth, because some quick decision may need to be taken but also for the "encountered" beings. What their rights and Liberty are is unclear.

The implications of extra-terrestrial contact, particularly with a civilization far ahead of humanity technologically, have often been likened to the meeting of two vastly different human cultures on Earth. We have a good example with the arrival of Christopher Columbus to the American continent. Such meetings have generally led to the destruction of the "encountered" or "contacted" civilization receiving contact, and therefore destruction of human civilization is a possible result of extra-terrestrial contact. However, as the nature of extra-terrestrial civilizations is unknown and no conclusive contact with any has yet taken place, it is impossible to say with complete accuracy what the result of contact would be.

The discovery of extra-terrestrial life, particularly the finding of a new civilization, probably will help us to discover ourselves, take consciousness of our place in a Universe, and understand that our artificial borders do not make sense and that the real border is in the few molecules on the top of the exosphere of our planet that separate us from the rest of the Universe.

International laws, enforced by a supreme international organization, taking care for the rights and Liberty of the "encountered" extra-terrestrials, would be needed.

The question of the liberty of the encountered is something that should be debated in an appropriate Forum. Should we respect their rights at the expense of our own danger is something that will not be easily solved, and that can be topic of speculation depending on the ideologies of the society dealing with it.

9.9 Message in a Bottle: Questions to Be Solved in the Future

In the framework of the impact of the discovery of extra-terrestrial life on space exploration in general and on the space mission that discovers it, there are many questions that should be discussed. It is not the purpose of this chapter to answer them, as probably each of them would require more than a full book of discussion to be nearly answered. Our goal is to pose them and alert the scientific community and international authorities of the firm need to answer them before life is discovered in another planet.

Some questions that should be debated, probably in join scientific and legal forums, are:

- What should be the implications for a space exploration mission like MSL if life is encountered?
- How much freedom would the scientists and engineers working in the project lose?

- How should the flux of information should be controlled, both internally within the project and externally, in order to communicate the news to the public?
- What are the implications for the mission, for NASA, for the space program, for society?
- Within the mission, if one of suite instruments discover life, how that would affect the science of the whole mission, of the other instruments?
- What about all the operation plans that were programmed in advance?
- How is a mission to find habitability to be turned into a mission to explore life during operations on Mars?
- How the event would be transmitted to the society?
- Should Government authorities beyond NASA take the lead of the project?
- If the encounter turns out to be a threat to our own existence, what is the Liberty of the "encountered" Extraterrestrial beings, should these creatures be treated with the Earth rights? (Even occidental and oriental rights are different).
- What should the treatment be that we should confer to the "encountered"?

In our opinion while we cannot be prepared for the unpredictable, the careful development of an agenda alongside a response agenda becomes mandatory.

9.10 Discussion

While scientists are obliged to assess benefits and risks that relate to their research, the political responsibility for decisions arising following the detection of extra-terrestrial life cannot and should not rest with them. Any such decision will require a broad societal dialogue and a proper political mandate. If extra-terrestrial life happens to be detected, a coordinated response that takes into account all the related sensitivities should already be in place.

We would like to remark on a few messages:

- Most probably freedom will be lost by scientists in a space mission discovering life and control should be taken (most probably) by an International Board of experts.
- It is important to prepare *in advance* the road in order to take control of the situation and to execute procedures properly. Any irreversible step should be carefully thought through and contingency plans should be put forward previously, so that they can be activated when there is confusion and need for quick decisions.
- Planetary protection procedures should be revisited.
- Missions like MSL have showed that it is very hard to reach consensus in case of emergency, and that speculation will be hard to avoid.
- Regulations are necessary. In practice, if it remains a voluntary code of practice, it will probably be ignored in the event to which it should apply.

Will a suitable process based on expert advice from proper and responsible scientists arise at all, or will interests of power and opportunism more probably set the scene (Sagan 1985)?

A lack of coordination can be avoided by creating an overarching framework in a truly global effort governed by an international politically legitimated body. Member States of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) will need to place "supra-Earth affairs" on the agenda in order to take it further to the General Assembly, with the goal of establishing structures similar to those created for dealing with threats arising from potentially impacting near-Earth objects.

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Chapter 10
Astronaut Health—Planetary Exploration and the Limitations on Freedom

John R. Cain

Abstract This chapter examines the health of astronauts and how the provision of health care extra-terrestrially puts limitations on their freedom to act individually and as a group in particular as a result of planetary exploration. A brief outline of the chapter is given. This is followed by a discussion on what differentiates an astronaut from other space workers as it is expected that those categorised as astronauts will receive better health care because they are more highly valued. There is a brief discussion on the issues relating to planetary exploration and what constitutes liberty and freedom. The use of exposomes for the screening and selection of astronauts to work in extreme environments is discussed together with issues associated with quarantine where an astronaut's freedom will be restricted due to disease. A discussion of the enforcement of health and safety extra-terrestrially then follows and asks whether legislation can be fairly applied to all. The limitations on the freedom of choice due to health issues for astronauts and other extra-terrestrial workers is then discussed such as who will provide the finance for health care provision in planetary settlements, who will determine the programmes for medical research and how will education and training be organised? The chapter ends with a conclusion that summarises the main health issues relating to astronaut health and how their application can restrict liberty and freedom extra-terrestrially.

Keywords Astronaut health · Planetary exploration · Liberty and freedom · Health and safety · Exposomes · Quarantine · Enforcement

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10.1 Introduction

10.1.1 Background

Mankind has been fascinated with the need to conquer space for centuries. It became a reality over 50 years ago when Yuri Gagarin made his first spaceflight in 1961. In 1969, Neil Armstrong first set foot on the Moon. This was the start of the Apollo missions to the Moon. Over the subsequent decades there have been major advances in space technology and the human curiosity to live and work in space. Today, the International Space Station (ISS) which is a multi-national venture involving France, Germany and the United Kingdom circles the Earth's orbit with a crew of men and women astronauts that varies in number. It follows the Russian Salyut, Almaz and Mir space stations and America's Skylab.

Because of the size of the ISS, there are physical limitations on the number of astronauts that can live and work inside the space station. Importantly, there is a need to ensure that the astronauts' health and safety is maintained whilst in space so that their liberty is not restricted by developing a disease. For this reason, the crew are all regularly biomedically monitored. The results of the bio-monitoring may be used to limit how individuals live and work in the ISS and thereby restrict their freedom to act within the closed confines of the space station. As space travel becomes more commonplace, there will be more competition between the aims of various parties for resources. As space settlements are built on the planets such as Mars and on the Moon and there is a greater risk to health from exposure to various hazards, there will be increasing limitations on an astronauts' freedom to choose between one or more options due to health factors.

The development of commercial space tourism, the organised business exploration of both stellar and interstellar space for financial profit and the need for more space research with terrestrial applications will increase. This will see individuals and specific groups of individuals with an interest to venture into space increase rapidly over the next 40 years. The speed of this extra-terrestrial exploration of inner and outer space will relate to improvements in rocket propulsion systems, competition between nations, the need for minerals and the human desire to explore and discover.

When space and subsequent planetary exploration is routine and there are many people living and working extra-terrestrially, including the astronauts, many factors will limit the freedom of individuals to act independently or as a group. This will include health factors. There are also likely to be limitations on the range of people that can travel into space with those that are very old and sick or lack the finances being prevented. However, concerning space tourism, it may only be economic restraints that deter people from journeying into space.

10.1.2 Outline of Chapter

Today, all the specific highly trained and knowledgeable individuals that have left Earth to live and work in space have been known as astronauts. With the development of space travel, many other groups of people will want to explore space. There will therefore be a need to define what differentiates the astronaut from these other individuals e.g. space tourists, engineers, adventurers. The need to identify the various groups will have legal implications. Because they are more highly valued, those defined as astronauts are likely to have better health care provision than those other groups living and working extra-terrestrially. The astronauts will have limitations on the type of work they undertake that will not apply to other groups because of the costs relating to their training. This chapter will cover issues relating to this dichotomy.

The present definition of an astronaut is that of a highly trained, intelligent and fit individual who has spent many years preparing to live and work extra-terrestrially. Their individual health is regularly monitored by biomedical scientists and the hazard control within a spacecraft by astronautical hygienists. If an astronaut becomes unwell prior to being sent into space then their place may be taken by another individual; their health will have placed limitations on their freedom to take part in a space mission. The chapter will discuss how planetary and space exploration may affect an astronaut's health and how the risks of such activity may place limitations on their freedom to act in particular situations.

This will lead to a brief definition of the concepts of liberty and freedom as they apply extra-terrestrially and in relation to other space workers apart from the astronauts.

Three important extra-terrestrial examples of how health issues could limit the freedom of astronauts and other workers to live and work in space will be examined. These include:

- the use of exposome markers to screen astronauts for health effects and limit their movements if they are susceptible to certain hazardous substances to which they may be exposed during planetary exploration;
- the use of quarantine to restrict astronaut movement on a planetary settlement or in a spacecraft if they develop an infectious disease; and
- the role of health and safety legislation and enforcement to reduce the hazard exposure health risks by the need to comply with the law.

Furthermore, there will be a brief discussion of other health issues that could affect the liberty of an astronaut to act ethically and morally in specific situations. These will include the provision of universal health care in the space community. Will those highly trained astronauts be given better health provision than the support staff? Who will determine the inter-space medical and biomedical research programmes—public or private sectors? How will vaccination programmes be enforced? Who will finance the hospitals and training facilities; will there be restrictions on what will be taught? The conclusion will finish with a final examination of liberty, freedom and astronaut health during planetary exploration.

10.1.3 Definition of Health

The World Health Organisation (1948) defines terrestrial health as a state of complete physical, mental and sound well-being and not merely the absence of disease or infirmity. This is a succinct and concise definition and cannot be bettered. The definition will apply terrestrially as well as extra-terrestrially.

Astronauts are subjected to a range of hazards e.g. radiation, toxic substances, weightlessness, noise and microbes. Exposure to the numerous hazards encountered in space will increase the risks to health unless they are prevented or controlled by the implementation of appropriate measures (Cain 2011).

Both space medicine (including space biomedicine) and astronautical hygiene will be the two applied disciplines that will be employed to protect not only the astronauts but other persons living and working in space. Space medicine is applied to prevent and treat the symptoms of a disease. It has been by necessity and design predictive, preventative, participatory and personalised (Williams 2002). Astronautical hygiene is the application of science and technology to the identification of the hazard, for assessing the exposure health risks and then determining the measures to mitigate exposure during work in space. The space physician will treat the symptoms of a disease once it occurs in individual astronauts whereas the astronautical hygienist will design and implement measures to prevent or control hazard exposure for a specific astronaut "population" to reduce the health risks.

10.2 What Is an Astronaut: Definition and Its Importance to Health?

10.2.1 Astronaut Definition

An astronaut can be defined as a person who has been trained to carry out a spaceflight programme on behalf of a national body such as the European Space Agency (Esa) or the National Aeronautics and Space Administration (NASA). In Russia they are known as cosmonauts and in China as taikonauts but a similar definition will apply. Most astronauts have tended to be pilots, professional scientists, geologists and physicians but due to the complexities of the space programmes in particular on board the ISS most astronauts today are a combination of many talents (Musson and Helmreich 2005).

There have been changes in astronaut demographics over the years and this has seen an increase in the number of female astronauts and an increase in the average age (Longnecker et al. 2004). Because of the wide diversity of talent in the astronaut pool, it is necessary therefore to have a specific definition of an astronaut because there will be legal obligations for which they will have to comply in particular relating to health and safety and that will not apply to others.

Under the special status provided by the Outer Space Treaty (1967) and other international regulations, an astronaut must be an object located in space, conducting activities in space for the benefits of all countries and act as an envoy of mankind. This definition of an astronaut was produced when space exploration was in its infancy and is a wide-sweeping definition. In the future as technology advances it could apply to automatons.

The Outer Space Treaty also defines astronauts as envoys of mankind and installs a code of mutual assistance in case of an emergency and this is linked to their national and registering state. Article 5 of the Outer Space Treaty states that this code does not apply to some space workers and space tourists.

10.2.2 Astronaut V Space Travellers—The Issues

As the exploration of space gathers pace there will be others who will venture extra-terrestrially including artists, space tourists, engineers and those workers (when planetary settlements are established) that will provide the services for the highly paid space adventurers and astronauts.

Living and working in space will become commercialised and there will be the industrial development of the Moon, Mars and asteroids for minerals. Man will eventually send manned missions beyond the Solar System. Space tourists will want to experience weightless conditions and see scenic sights on other worlds. Whatever situation develops in future extra-terrestrial societies, there will be discrimination between groups in particular in the provision of medical and related services that will be costly to provide in the harsh environment of space. Those classified as astronauts and who will be sponsored by nation states and agency funded and operated enterprises will require more of the health resources available.

The use of cheap propulsion systems to take Man into outer space and to colonise low Earth orbit will see an expansion in the range of people who will be identified as “astronauts”. Will all these people exploring space and have not been sponsored by national governments still be classified as astronauts? Will the same privileges that astronauts now have and are likely to have in the future apply to others? Will those defined as astronauts want additional rights so that they can remain and possibly extend their privileged position? A new definition of what an astronaut is will need to be developed and with it the legislation that will protect their rights and freedoms (Jakhu and Bhattacharya 2002).

If everyone that ventures into space is defined as an astronaut then in the ideal world all should have the same rights, privileges and status. This is not likely to occur in such a hostile and limitless environment as space where the “real” highly trained, skilled and intelligent astronauts will be in demand and therefore command a greater say in how the resources including health are distributed.

National space legislation is developing in many countries as governments discover the advantages associated with the use of space both commercially and scientifically. Because of the privileges and celebrity given to astronauts, there will

be disputes relating to their definition. Any disputes will likely be settled by a global space court based on the Articles of the Outer Space Treaty. One such major issue will include distinguishing the status of astronauts from others (Hashimoto 1993).

Another name for those not classified as an astronaut will need to be found because if the definition of an astronaut is applied to all in space then there will not be sufficient funding to grant all the same privileges such as the provision of healthcare. It is expected that in extra-terrestrial societies that the astronauts will have better healthcare because their skills will be necessary to ensure the survival of the settlement. It has been suggested by Smith and Uwe-Hörl (2003) that those other than astronauts such as technicians, teachers, journalists, space tourists, engineers etc. be termed "spaceflight participants"; their restricted rights would be protected by law.

However, whatever name is chosen for the disparate group of space explorers, industrialists, space tourists, there will be discrimination and segregation from the astronauts. This will interfere with an astronaut's freedom to act as individuals in particular in the exploration of the planets where their highly skilled and highly trained abilities will be necessary.

Because of the huge investment spent on astronaut selection and training, they will be provided with the best health care available unless legislation states otherwise. This is doubtful and their liberties based on elitism are likely to be extended.

During the exploration of space including the planets and the establishment of settlements, the definition of an astronaut as an individual part of a team acting for scientific and national security purposes on behalf of nations will continue. In contrast the "ordinary" space person will act for private or commercial reasons on behalf of themselves or the private sector (Ginsberg 1972) and be granted fewer rights.

10.3 Space Exploration and Limitations on Freedom Relating to Health

10.3.1 Planetary Exploration

Since Yuri Gagarin first went into space in 1961, man has been optimistic that the use of space-stations to explore Earth and the means to colonise the Moon, Mars and other worlds would be developed. However, it has been over 40 years since Man first landed on the Moon and so far it may be another 20 years before there are manned landings on the Moon and Mars. In the meantime there will be new technological developments in rocket propulsion systems, on improved communication systems but as importantly there will be a mental shift in how space is perceived and the need to colonise other worlds.

During all stages of extra-terrestrial exploration, the health of the astronauts will be paramount and there will be constant biomedical monitoring of the individual together with the need to assess the health risks on a spaceship or in a settlement. The providers of health care will face competition from the interests of various groups e.g. the national space agencies, private enterprise, space tourism, individual commercial ventures. The competing interests of these groups will at some stage restrict the freedom of action of the astronauts to carry out specific duties in relation to health issues for example, will health insurance premiums be higher for those astronauts involved in direct planetary exploration than from those working in a settlement (Daly and Frodeman 2007)?

Because of the destructive nature of mankind in particular as we have seen in the development of terrestrial environments, the explorers have been exposed to a number of hazards that have caused potential health problems such as viral diseases. There will therefore be a need for caution as the planets are explored. During planetary exploration, the astronauts will need to comply with health and safety regulations to ensure that extra-terrestrial environments do not become contaminated with microbes originating from Earth. Such contamination could destroy primitive life on a planet but also result in cross-contamination. Cockell and Horneck (2004) have argued that there will be acceptable risks not only for the astronauts exploring a planet but to the planetary environment itself.

The detection of extra-terrestrial life by an astronaut, will require policy strategies and risk management measures (i.e. planetary protection policy programmes) to ensure that the life is not only protected but that the astronauts are prevented from the affects of cross-contamination and the risks of developing an infectious disease. This will require obligations from the astronauts to comply with both their ethical and moral conscious needs (Hartman 1984). Initially, national governments will need to produce space treaties to safeguard extra-terrestrial life but this will be superseded by settlement society laws. The need to protect planetary life and hence the potential to cause disease following exposure, will restrict an astronauts' freedom to work in those select terrains as they would prefer (Marshall 1993).

10.3.2 Liberty and Freedom

An astronaut's health must be sustained during planetary and space exploration so as to safeguard a settlement or a space crew, but at what cost will this be in terms of a limitation on the freedom of the astronaut to live and work for the benefit of both the settlement and its society? Astronauts as individuals will have chosen their profession i.e. they would have had the freedom to choose between different kinds of professions (Arrow 1963). This freedom to choose would have been significant terrestrially.

In extra-terrestrial societies, this freedom may be limited because of the needs of all space explorers to work together on specific tasks so that all benefit and not just a few. All workers whether the astronauts or support personnel will be more

accountable for how they act because of the harsh environmental conditions in which they will live and work. A failure by one individual to carry out their duties, in particular the astronauts with their additional responsibilities could jeopardise a whole society or mission to outer space.

Protecting the health of the astronauts at all times will therefore, be an additional burden on their liberty. If an astronaut becomes seriously unwell in a planetary settlement where he/she lives and works or in a space ship during interstellar space travel, then because of the closed nature of these environments, the lack of replacement human resources, the limited access to Earth and the highly trained nature of the of the astronaut, then the whole society could be threatened.

What is freedom and what is liberty? Sen (2010) has defined freedom as the ability to choose from a range of priorities be they economic, career orientated or political to achieve specific goals however narrow that one has set oneself. This indicates that in a liberal society, astronauts will choose to live and work in space rather than pursue a terrestrial job and want the freedom to choose their own fields of research and planetary areas to explore with as little interference from others as possible. This will include as little interference as possible from those responsible for their health.

Liberty is the ability within the range of freedoms to prioritise ones needs. Both liberty and freedom are terms that are to most people interchangeable; in most circumstances they are (Anderson 1999). Extra-terrestrially, it is expected that the freedoms and liberties of the astronauts and others will be more restrictive because of the harsh conditions in which they will live and work. In these circumstances liberty and freedom will be interchangeable. The first true explorers of space and those that develop the first "designer" extra-terrestrial societies may appear at first to be free to act but this will not be the case. They will have less freedom of action in many areas such as in the provision of healthcare facilities, the supply of air (Cockell 2008) and food etc. which in most instances will be provided from Earth (Berlin 2002).

The financing of the exploration of both inner and outer space whether using money from the private or public sectors or by a combination of both will place additional limitations on the work carried out by the astronauts for example, on the ISS the astronauts are mainly sponsored by national governments but some have paid as individuals to work on the space-station. The restrictions that the national governments have set for their own astronauts are generally more limiting than those set for private individuals. This is because national governments have the expense of selecting an astronaut, they need to ensure that they remain fit and well and have to maintain the use of advanced training facilities for use before travelling into space. It is expected that Tim Peake, the UK's first astronaut will need to be kept in a state of fitness for over 2 years before he is sent to live and work on the ISS. During this time he will be subjected to intensive biomedical testing that will restrict his movement. Once aboard the spacecraft, the design of the ISS in particular the size will restrict the freedom of movement on the space station.

Once extra-terrestrial societies become established, the effects of allocating additional finance to protect the health and safety of the astronauts may cause

conflict unless a liberal culture prevails and Earth supports the settlement. In his latest book, Brian Aldiss (2013) writes "…..the whole Mars enterprise was funded by the UU. The settlement there remained ever dependent on terrestrial liberality. Liberality—Something else absorbed into the increasing terrestrial power struggle: a tap easily turned off.". In the early stages of space and planetary exploration, it will be necessary for the settlements to keep in good contact with Earth and vice versa otherwise there could be anarchy and an increase in ill health amongst all persons especially the astronauts who will be expected to lead and therefore put themselves at greater risk of harm (Rawls 1999).

The limitations on freedom relating to astronauts' health will be discussed below using three specific examples, namely, the use of exposomes and biological markers in astronaut selection, the need for quarantine restrictions in the event of a highly infectious disease with high mortality rates and the use of enforcement laws and regulations to protect the health and safety of astronauts during work. Other factors relating to limitations on freedom and the health of astronauts will be discussed such as, the possibility of providing universal health extra-terrestrially.

10.4 Use of Exposomes and Restrictions on the Freedom of Astronauts

10.4.1 Definition of Exposomes

The word exposome is a scientific concept with philosophical and ethical implications. The results of the use of exposome monitoring can be utilised to evaluate a persons exposure to environmental hazards over a lifetime and hence a persons susceptibility to one or more hazards. The results of exposome monitoring could therefore be used by a space agency to prejudice a susceptible astronaut from working in environments where there could be the potential for exposure to one or more hazards and whose exposure may cause severe health effects. The results of an exposome screen could be used to limit the freedom of an astronaut to work in a particular planetary environment.

During their lifetime, astronauts and others will be exposed to a variety of toxic substances found in their environmental surroundings both terrestrially and extra-terrestrially. There will also be changes to their genetic make-up due to lifestyle choices and to changes in their behaviour. The environmental exposures will include chemical exposures, the diet of the individual, the amount of physical activity undertaken, the affects of stress on the body, on the use of alcohol and tobacco. These factors will affect any pre-existing disease of a susceptible person to develop disease symptoms. Wild (2005) defined the exposome as encompassing all environmental exposures including those associated with diet, lifestyle and endogenous sources from conception onwards. The use of exposomes as an astronaut screening tool therefore could have major implications for their career choices.

10.4.2 Use of Exposomes

Chemical and other environmental exposures from all sources is included in the concept of the exposome i.e. a comprehensive measurement of all exposure events (exogenous and endogenous) from conception to death. In astronauts this will include all extra-terrestrial exposures for example, to radiation, to off-gases, to noise and to both those known unknowns and unknown unknowns that may cause the most damage. Screening astronauts both terrestrially and extra-terrestrially for the identification of exposomes relating to specific exposures and to which they may be susceptible could be used to restrict the work tasks of an individual or a group (Rappaport and Smith 2010). If exposome screening indicated that an astronaut was identified as at a high risk to a chemical during work in a space environment, would insurance be provided if a disease to which he/she developed? Would compensation be demanded from an astronaut that worked in an environment that screening indicated he/she was susceptible? Would insurance companies want additional payments from those working in harsh extra-terrestrial environments and with the risk of developing symptoms of disease?

During long interstellar space flights or during working inside a settlement, there will be need to identify and measure the affects of specific hazard exposure to assess potential exposure health risks and to identify those susceptible to develop a disease. The use of exposome screening and the measurement of selective biomarkers could be used to select those astronauts who are most unlikely to develop a disease following exposure to a specific hazard during for example, planetary exploration and thereby select them to take part in the exploration.

10.4.3 Exposomes—The Ethical Issues

A number of ethical questions may arise from the results of exposome monitoring used for screening astronauts for specific work tasks for example, if an astronaut who is a recognised expert in a field of space science was shown to be susceptible to develop disease if he/she worked in a particular environment, who would make the decision to limit his/her freedom to work? Would it be industry that was financially supporting him/her from an Earth base or would it be the leader of a settlement who was more capable of determining the risks? Would there be conflict between the two authorities? If an astronaut whose freedom of movement was limited to work inside a settlement due to screening, but would increase the financial and economic base of a settlement by undertaking high risk planetary exploration and decided to carry out the exploration. What would be the penalties? As the identification and measurement of exposomes via the use biological markers become more specific and sensitive, what form of legislation may be required to address the above issues?

Furthermore, if the use exposome biomarking indicated that certain races and sex orientations were more susceptible to specific extra-terrestrial hazards and

hence of developing a serious disease following exposure, would this lead to discrimination between groups? Could the social implications of a "positive" exposome screening result be that an autocratic society uses the results to further its own agendas?

Would there be a conflict between the capabilities of an individual and their obligations to the settlement population or space crew during a voyage in interstellar space (Rawls 2001). What if an astronaut refused to be subjected to screening? Would he/she be prosecuted and imprisoned especially if the survival of the settlement was at stake because of the refusal?

As the characteristics of the extra-terrestrial hazards are identified and the exposure health effects studied and controlled, it should be possible to select population groups for specific work tasks; those not suitable could be allocated other tasks or returned to Earth (Rappaport 2011).

As man colonises other worlds, more knowledge will be gained on exposomes and exposure (length of time of exposure, exposure routes), the distribution of specific extra-terrestrial exposomes over an astronauts' lifetime, on the affects of weightless conditions on the genome and on the measures to mitigate exposure and thereby reduce the health risks. The use of biomarkers for characterising human exposomes and measuring their diversity will become more important for those studying exposure, the health risks and disease associations e.g. astronautical hygienists.

During a long interstellar spaceflight or whilst living in isolation in a small planetary settlement, the people will be subjected to "psychological exposure" due to feelings of isolation. This will result in stress and the release of chemical stress hormones in the body in response to the stress. The findings of high levels of these chemicals in biomarker studies of the colony/space craft populations could be used to isolate susceptible individuals and treat them. During treatment there would be limitations on their freedom to work which some would object to and possibly cause conflict; those most vulnerable would be at greater risk.

New tools based on epigenetics and—omics e.g. proteomics will enable more sophisticated means for identifying high risk individuals in an extra-terrestrial environment in the name of health prevention. In the highly volatile politics of a space settlement this could have devastating effects on the population as a whole. Leaders would be able to control movement within a settlement based on hazard susceptibility and also use the results to limit privilege to their loyal supporters. Information from exposome screening will be stored on line, but who will have access to this data? Could the data be used to prejudice specific groups within a space craft or colony? Would legislation be required to limit the information to the individual alone? This seems unlikely in the confines of space and the need to utilise all resources in particular the human (National Academies 2010).

10.5 The Use of Quarantine to Limit Freedom

10.5.1 Quarantine Scenario i.e. Collection of Planetary Samples

Imagine a scenario where a group of astronauts decide to explore an area of scientific interest on the planet Mars where it is believed there may be evidence of primitive life similar to the extremophile organisms found in hostile environments on Earth i.e. *Archaea* (Landis 2001). Rock and surface dust samples are collected carefully for examination. However, small quantities of dust settle around the wrist connectors where the gloves are attached to the spacesuit. The astronauts return to the Martian surface explorer vehicle with the enclosed samples and then onto their nearby settlement. In the airlock they remove their spacesuits. Because of a significant reduction in the airlock air extraction rates and because procedures for the removal of the gloves are not adhered to, small amounts of the Martian dust containing the primitive organisms are released into the airlock. Two of the astronauts unfortunately inhale some of the dust and after a short incubation period develop an infection with unknown symptoms. Within days, a further 4 astronauts in the settlement develop similar symptoms. The antibiotics given fail to arrest the disease and they eventually need to go on life support. Most of them then die.

Prior to the planetary survey to collect the samples it is expected that the astronauts would have been trained on the safe handling of samples, in particular during their handling inside a safety cupboard where the risks of exposure were high. They would also have been expected to follow safe spacesuit removal techniques in the airlock so as to reduce airborne contamination and ensured that the air extractions rates were effective. Carrying out the procedures to reduce the health risks associated with the inhalation of the dust would have limited their actions but it would have reduced significantly their chances of developing symptoms of disease.

10.5.2 Ethical Considerations and Quarantine

Several ethical questions relating to the above scenario need to be addressed. When it was known that the astronauts were developing an infectious disease with unknown aetiology and symptomology, should the leader of the settlement have implemented quarantine regulations to restrict access to those with the disease only? Should the whole settlement have been quarantined and all persons prevented from leaving? Should the settlement have informed others of the disease and therefore the need to stay away until quarantine was ended? What if by informing others on Mars and those journeying from Earth it seriously affected the economic and social condition of the settlement; would this have prevented the leaders from informing others? What if there were no extra-terrestrial quarantine regulations and “well”

astronauts decided to leave the settlement? Who would have made the final decisions on when to end the quarantine and make social contact with others from outside? If persons from outside were in contact with astronauts before the infection began would they have felt ethically bound to self-quarantine to limit the spread of the disease? Would astronauts who had had contact with the settlement have been "hibernated" i.e. bodies shielded inside a protective environment until it was known that they didn't have the disease and they could be "awakened"? What if it was decided not to awaken them to minimise the infection risk? The imposing of quarantine regulations in a settlement or on board a spacecraft will significantly limit the freedom of choice for astronauts to live and work in the name of protecting not only themselves but their colleagues and others.

10.5.3 Quarantine Law Application

In 1969, a United States law was passed called "Extra-terrestrial Exposure Law". It stated that anyone exposed to extra-terrestrials could be quarantined under armed guard by a NASA administrator without a hearing. This law was to protect Earth from biological contamination resulting from the Apollo Space Program and other space exploration programmes and thereby prevent the spread of infection. The law was removed from statute in 1991 (Race 1996). Once the exploration of space is undertaken by many countries, similar laws will need to be applied in particular to address some of the issues discussed above.

Terrestrially, quarantine is used to separate and restrict the movement of well persons who may have been exposed to a communicable disease to see if they become ill. This will apply extra-terrestrially and may be more restrictive because of the potential estimates of the overall risk and the direct consequences for human health. In both instances, and by its very definition, quarantine will isolate and reduce the liberty and freedoms of those individual astronauts who are quarantined (ESF-ESSC Study Group 2012). It is expected that there will be the protection of civil and space liberties during quarantine, but in space and because the survival of a settlement may be at risk, this may not always be the case. However, extra-terrestrial societies must intervene where possible to ensure that quarantine is reasonable and effective.

With the risks of infection occurring in space and the potential need for astronauts and others to be quarantined, the microbiologists and astronautical hygienists will need to characterise the hazard, understand the modes of transmission of the organism including the exposure routes and also the symptoms of disease. These criteria will need to be assessed to enable the least restrictive form of quarantine to be implemented and to reduce the health risks. This may not be possible during interstellar travel on a space craft where space will be limited but the protection of the crew from disease will be paramount. In extra-terrestrial societies, the basic need to survive at all costs may be uppermost and the rights of individual astronauts who develop a deadly disease will be severely limited (Pope et al. 2011).

10.6 Extra-Terrestrial Health and Safety Enforcement

10.6.1 Introduction

In the terrestrial environment, health and safety laws have been legislated to reduce the health risks of both the worker and the public from exposure associated with various chemical, physical and biological hazards and to prevent accidents occurring due to negligence. Such health and safety laws have been implemented by almost all nation states. In Great Britain, the legislation is enforced by the Health and Safety Executive who employ HM Inspectors of Health and Safety including HM Specialist Inspectors of Occupational Hygiene to inspect industry and impose harsh penalties on those failing to comply with the appropriate laws.

NASA, the European Space Agency (Esa) and other space agencies have implemented a series of rules and regulations to protect the health and safety of those personnel living and working in space for example, the use of permissible standards to protect astronauts from excess radiation and chemical exposure on the ISS (Khan-Mayberry 2011). Similar rules and regulations will be required by NASA, Esa and others to protect their astronauts:

- during future space exploration of the Moon (Cain 2010);
- whilst colonising Mars;
- during work on asteroids; and
- during the exploration of outer space.

Specific laws etc. to prevent and control exposure to hazardous substances will also need to apply to commercial and tourist space explorers. By its very nature, such legislation will restrict the freedom of astronauts and others working and living extra-terrestrially, in particular in the "open" environment of a planetary settlement. The need for new laws will become more critical to deal with the prevention and control of exposure to newly discovered hazards.

NASA and other space agencies employ health professionals such as physicians, astronautical hygienists and others to safeguard the health and safety of astronauts while participating in their space programmes. The legislation in force is robust because of the hazardous nature of living and working in space and the potential risks to health. On the ISS for example, the risk assessments produced and related plans of work need to deal with all unexpected mishaps that could occur and which may result in loss of life or the aborting of a mission with a huge loss in prestige and finance. The ISS is a closed environment and the legislation can be more easily applied. However, whilst travelling in interstellar space or working in a planetary settlement with its more "open" environment, it may be difficult to comply with the health and safety legislation. This will reduce the limitations on the freedom to act in certain situations but it will also mean that the risks are higher.

10.6.2 Application of Health and Safety Legislation

Cockell (2013) has described the need for health and safety systems as "…….one of the most profound threats to liberty because it can be used both as an instrument of positive liberty by the state but at the same time as a means to coerce people into good behaviour by the false pretence of protecting them……..". This statement may or may not be true terrestrially and during extra-terrestrial exploration, it is still to be tested. In the harsh environments of outer space, in planetary settlements or during interstellar space travel, there may be a need for more restrictive health and safety legislation to ensure survival.

Restraint and limitations on freedom means broadly that restraint is taking place when the planned or unplanned conscious or unconscious actions of an enforcer prevent an astronaut or other space worker from doing what he or she wishes to do and is prevented by health and safety legislation from doing. The use of restraint by legislation can be dangerous and could lead to planetary conflict if it is not seen to be reasonably practical and applied fairly to all. Any legislation enforced extra-terrestrially should be used only as a "last resort" intervention. Health and safety legislation may be applied where there is absolutely no alternative that would reduce exposure to an identifiable hazard and thereby to a specified risk to those concerned and others who may be working in the vicinity. It may be that the interests of a space colony or those people travelling in a spacecraft may be more important than the outcomes of imposing restrictions on an individual.

Risk taking is a part of living and working in the weightless conditions of space though there may be greater risks to one or more individuals depending on the task being undertaken. If one important individual fails to comply with the legislation for example, fails to ensure that the life support systems on a spacecraft are well maintained at all times, then the justification for punishing this person for a failure to comply may not only restrict his/her freedom but may also affect the whole spacecraft population. Those making the judgement on whether to prosecute an individual will need to make a balanced judgement between the risks of causing harm if the astronaut's freedom is restricted and the correct form of intervention to deter others. Specific guidance drafted by terrestrial or extra-terrestrial legislators will be used to help make a judgement in most instances.

There will be circumstances where the application of health and safety laws and their compliance will be utilised where the risks are not understood by one or more astronauts. Nevertheless, in such instances the risks should be of such a degree that the intervention of appropriate health and safety legislation can be justified (HCHRs 1948). This may not always be clear cut.

Any health and safety system and associated legislation developed for use in outer space will need to be enforceable to all otherwise the law may be seen as a sham; this may be difficult because of the long distances involved. The system together with enforcement will also need to be seen to be protecting the health and safety of those at greater risk when working extra-terrestrially i.e. the astronauts who will be highly trained and well paid for the jobs done and those that service their needs.

A two tier system of health and safety legislation, with the top tier being more firmly applied and therefore giving better protection, will be seen as discriminatory if it is only seen to apply to protecting one specific group of workers at all times and not the others who are not well trained such as planetary settlement support staff. Any enforcement system will need to be fair but this may not be possible in an environment where "survival of the fittest" may apply in some settlements. For example, due to a lack of finance on a particular planetary settlement, any hazard control measures implemented to comply with legislation may need to be rationed so that only select groups of workers (i.e. the astronauts) get full protection. In such circumstances, a two tier legislative system may be the best alternative in particular to account for a shortage of resources in space. The first tier system will apply to protect the astronauts; compliance with the second tier will apply to support workers etc. The promulgation of liberty in space as a basic human right and developed over many decades may not be sufficient to prevent the law from becoming discriminatory, with the application of a two tier system, due to the costs associated with the universal application of the law.

10.6.3 Use of Permissible Exposure Standards

One important measure in any legislation is the use of permissible exposure standards (PESs) to protect astronauts and others from harmful exposures to a range of hazards encountered in space (Cain 2011). If the PESs set were exceeded because a space agency such as NASA or a large space mining industry failed to instigate appropriate measures to mitigate the exposure and thereby increased the exposure health risks then heavy penalties could ensue. Certain work carried out by astronauts may be limited if measures to control exposure to below a PES cannot be achieved (James 2007). However, if the work is necessary for survival e.g. maintaining life support systems outside a settlement, mining for ores on a planetary surface then there will be a balance between the risks of developing ill health and the needs of the extra-terrestrial society. Any disputes could be settled by arbitration but it is unlikely that a satisfactory result would be achieved that would suit all parties. I provide an example to illustrate the issue.

In an isolated area of Mars, there is a rich ore vein containing a highly valued mineral. Industry wants to mine the ore because of its profitability. However, the ore vein is situated in an area of Mars where alien life was detected. During the exploration of the area and the subsequent mining of the ore by astronauts and others, there would be the high risk that astronaut exposure to alien particles would exceed the levels set terrestrially by space legislators (WHO 2004). Would industry be granted a waver to mine or would the industrial backers mine without a waver and therefore fail to comply with set standards? What if the mineral ore was needed to ensure the survival of Martian settlements? Whatever the outcome, it is the freedom to act that would be in doubt and health and safety legislators would argue that they were limiting freedom to protect the health of the astronauts and others.

10.6.4 Drafting of Legislation

For health and safety regulations etc. to be complied with both terrestrially and extra-terrestrially there must be confidence in those that draft the laws and also in those that ratify the laws. It would appear logical that those who draft the legislation should have experience of the field in which they are expecting to legislate. For example, astronauts who live and work on planetary settlements should be directly involved with the drafting of laws for work in those settlements or take part in the consultative process. If they are not involved directly with the drafting of guidance, approved codes of practice or regulations or involved with the consultative process then the credibility of the legislation could be in doubt.

The leaders of individual settlements should also have the powers to set rules for issues that apply specifically to them e.g. rules to mitigate exposure to certain light and noise frequencies that occur in their settlements only. If there is not a regulated balance between the health and safety policy makers terrestrially and extra-terrestrially then over time there will be differences in interpretation of the law between individuals and the law enforcers that could limit or restrict the freedom to live and work as one chose (Siegrist et al. 2000).

Furthermore, the encouragement of terrestrially based industry to become more involved with the drafting of the legislation that will be applied extra-terrestrially will ensure more fair competition between what is required in safeguarding the health and safety of astronauts and others and their application. It will also provide a better understanding of those situations where the hazards likely to be encountered are unique to a particular environment and necessitate a quick response without the need for a long risk assessment (Slovic et al. 1979).

There will be some situations during the conquest and settlement of the Moon and Mars where off-the-cuff guidance and regulation will be required to protect astronauts when they encounter a new hazard or in the case of a journey to interstellar space when a star system is approached and there are intermittent bursts of radiation that were unpredictable and constitute a high risk to health. The use of such flexible health and safety legislation will at first take a blunder-bust approach to deal with all eventualities until it is refined. Until it is refined, the liberty of the astronauts and others may be restricted in some cases severely to protect their health from the unknown hazards.

10.6.5 Enforcement of Legislation

The enforcement of legislation extra-terrestrially will cover a vast area of space. There will therefore be a need for effective communication between the enforcers and those being enforced within both planetary settlements and spacecraft so that all are aware of the legislation and how it should be applied. New systems of communication (i.e. link geometries) will need to be developed so that there is effective

contact between terrestrial and extra-terrestrial parties. This may include the use of radio frequency with increased transmitter output power and transmitter antenna gain or the use of gravitational lens to improve the signal from a spacecraft or settlement (Galea 2012). Without effective communication it will be difficult if not impossible to respond to an accident in the deeper reaches of the Solar System.

It is expected that the enforcing of the health and safety legislation will require a large number of Inspectors who will be responsible for a large area of space and will need an appropriate back-up infrastructure to function efficiently and effectively. Because of the scale of enforcing involved, with each Inspector having backup staff who will be responsible for a designated territory and industry to inspect, there will probably be a number of policy headquarters each dealing with specific areas of health and safety expertise. The funding and management of a Space Inspectorate will probably be terrestrially run but as the size and diversity of planetary space settlements develop, it will be practicable for management to be delegated. The impact of such an Inspectorate and the provision of enforcement over a large area of space will be to limit the freedom of activity of some astronauts who may wish to explore specific planetary terrains but in doing so would increase their hazard exposure risks.

Each Inspector will have wide sweeping powers to inspect industrial complexes for example, plants involved with asteroid mining and also given the powers to ensure that businesses improve specific processes that may cause harm. This may include limiting exposure to planetary dust or prohibiting processes where serious harm could result if they continued such as working in high radiation environments without adequate protection. In either situation there would be limitations on the freedom of choice to protect the health of the astronauts and other workers.

10.6.6 Punishment for Failure to Comply

Penalties for a failure to comply with the legislation could be a heavy fine, imprisonment or a combination of both depending on the severity of the offence. Extra-terrestrially it may be difficult to impose such harsh penalties because of the shortage of experienced personnel required for specialised work in some industries. Less harsh penalties would therefore be more cost effective. Alternatively, it may be more appropriate for Inspectors to charge companies directly if there is a material breach of the legislation and they don't comply with health and safety legislation; but this could jeopardise an enterprise and restrict liberty if unfairly applied. Because of the nature of the organisation of businesses established in space, it is likely that they will want a major input into the drafting of health and safety legislation especially where the application of penalties are concerned. It would not be practicable for business to oversee the compliance of the legislation however, because there could be a conflict of interest that could lead to corruption.

A failure to comply with health and safety law in the harsh environments of inner and outer space could result in a high loss of life in particular if there is an

accident that could have been prevented and was due to negligence. Complying with the law may be a small price to pay in terms of a restriction on working practices and limiting the freedom of astronauts and others to choose.

10.7 Other Limitations on Astronaut Health

No one can predict the structure and organisation of the extra-terrestrial societies that will develop in space as mankind settles on other worlds. However, the health and safety of those living and working in the societies will be paramount if the societies are to continue to survive and even thrive. The provision of health will be by private or public means or a combination of the two. Because of the hazardous nature of space exploration, the provision of health including safe systems of work for the astronauts and others will be costly.

10.7.1 Astronauts V Others for Health Provision

The high costs both in terms of the treating and prevention of disease may mean that the better facilities are provided for the astronauts i.e. the services will need to be limited because the astronauts will be at the forefront of any exploration and therefore will require available resources to be directed at them. The space business community is unlikely to provide funding for space exploration unless it reaps both financial and economic dividends and also political influence. A two tier approach for providing health care will be less costly and therefore more favourable to the space business community. However, such an approach is likely to create segregation between the highly trained and knowledgeable astronauts including the scientists and those that provide the service support and ensure that the settlements are maintained to protect the health of the highly specialised astronauts.

Industrial complexes will not lay out high capital investments as part of health care provision to protect an "underclass" of workers that provide basic services such as catering, cleaning and maintenance. To ensure harmony within settlement populations, it is expected that healthcare for those other than astronauts will be provided by the public purse or its equivalent.

There will be sections of a population where it will be difficult to differentiate between groups of workers and it is here that conflict could occur and limitations placed on the freedom of choice and the range of work that certain workers can be involved with. The differentiation of the astronauts from the "others" may be further complicated by the provision of highly complex medical screening (i.e. exposomes) so that only those astronauts most able to undertake certain tasks will be selected. This subgroup may be provided with better medical treatment and astronautical hygiene hazard control measures to mitigate exposure. José Ortega y Gasset, a 20th century Spanish philosopher (1957) said that "Societies will always be composed of

a minority and a mass and the society will be healthy provided the masses are subservient to the ruling minority. Such societies will succumb to chaos if the masses refuse to behave as a mass.". This reflects human nature and will apply equally in space as on Earth unless there is a major culture change in the behaviour of society.

In an extra-terrestrial society, the "masses" will serve the astronauts unless there is the development of a political system that serves all. If not, then the astronauts will receive the better health care facilities. Unless a free open democratic society develops extra-terrestrially, there will be ethical issues associated with the differentiation between the astronauts and "others" and the provision of health care whether living and working in a settlement or travelling in a spaceship. For example, if ten non-astronauts are infected with an organism that requires costly treatment and if the treatment was scarce, would it be ethical to limit the treatment and save the remainder for the astronauts who may develop the disease? The problems of treatment allocation will become more acute if the treatment rationing appears to be unfair and sub-groups within the astronaut population need to compete for the treatment. In such situations which will become commonplace in space because of the extremity of the environment, who would make the decisions on who needed treatment? It is more than likely to be the leaders of the large industrial complexes whose interests will be served by the astronauts.

10.7.2 Pursuit of Research and Limitations on Freedom

A limitation on an astronauts' freedom to choose, will arise when decisions are made on which range of medical and biomedical research to pursue. The profitability and commercial practicality of the research chosen will dictate the scope of research to be carried out. There will possibly be conflict between the terrestrial private and public sectors as they decide on what type of cost effective research to conduct.

The production of roadmaps could help identify what are the space health risks to pursue and include several areas such as behavioural health performance, radiation health and human advanced support systems (Charles 2009). Collaboration between all interested parties including the biomedical community, academia, settlement laboratories and private investors could enable adequate finance to be made available for all relevant research and development (Beyster et al. 2013).

Planetary settlements will put forward proposals for research grants which will be aimed at controlling the hazards in the harsh environments in which they survive. In such settlements there will be competition for the brightest and the best to conduct research in a settlements interest. This will limit the range of work that some astronauts and their leaders would wish to pursue.

10.7.3 Vaccination and Choice

As more of the Solar system is explored with the discovery that life is fairly widespread albeit of primitive microbial like organisms similar to the *Archaea* bacteria on Earth that live in extreme environments, there will be the high risk that some of the microbes could mutate and cause disease in humans following exposure. The "open" communities of a settlement and those within a spacecraft would be additional factors in the potential rapid spread of the disease.

Where applicable, and to combat the spread of the disease, vaccination programmes would be implemented to limit the spread of infection in the environment, to protect the individual from infection following exposure and to treat the disease in the early stages of the disease. If individual astronauts and others had strong religious beliefs or doubted the efficacy of the vaccine to limit the spread of the disease, then they may refuse to be vaccinated. If so, will they face severe penalties such as restrictions of their movement within a settlement or spacecraft, quarantine or both? In either situation there will be limitations on freedom related to health factors i.e. protecting a population from disease. Furthermore, if those refusing to be vaccinated are influential persons within the extra-terrestrial society, then those in authority may need to decide whether the reasons for refusal are genuine or not. If the scientific evidence shows that they are not genuine but a large sector of the population believes that they are, then there may be dissidence within the community resulting in unrest.

10.7.4 Training and Education—Space State V Industry

The continued and sustained provision of medical and astronautical hygiene facilities in extra-terrestrial societies will require the training and education of its space citizens including the provision of health care in hospitals. Terrestrially, such space biomedicine training is conducted at Universities e.g. Kings College London, United Kingdom, with access to academic and health care provider personnel. Similar systems must be established in space (Bergman et al. 2010) to pool limited resources.

To ensure that the astronauts are kept up to date with recent scientific and technological advances, there will also be a need for continued professional development. This will be critical because as more of space is explored, there will be more hazards discovered and these will require knowledge on the characteristics of the hazard and suitable risk assessments to determine the measures to prevent or control exposure. Will the "space society" pay the costs to finance the system and provide the necessary resources to the educational establishments where select students will be educated? Or will industry in its own self interest provide the services? In those establishments where private industry provide most of the finance, will they also dictate the curriculum and what is taught and how it is to be

applied i.e. medical research and educational training will be aimed at preventing ill health in its own industry? A fine balance between public and private financing of education and what should be taught to benefit the space community as a whole will need to develop otherwise those in the private sector will be at a advantage in particular in dictating space health policy.

In the extra-terrestrial settlements that will become established on the Moon, Mars and other bodies, scientific, medical and technical knowledge and its application will be one safeguard of liberty. It will be necessary to ensure that the knowledge does not become the preserve of one particular interest such as industry or the space state alone. The provision of education for what will be a select few will foster a division between those that will be well educated i.e. the astronauts, and those that are not such as the "space underclass". Unless there are balances in the extra-terrestrial society to avoid the formation of social divisions, then there will be internal conflict and limitations on freedom for both parties. Education should not be in the hands of one single authority; it needs to be diverse to ensure that liberty can be achieved (Hayek 1960).

10.8 Conclusions

It has been seen that there will be limitations on the freedom of both the individual astronaut and on populations of astronauts to live and work extra-terrestrially based on their health. This will be important in the selection process where exposomes will be used to determine those most suitable to work in specific space extreme environments in particular during planetary exploration. Because of the high financial cost of providing health care and the need to allocate resources where there will be most cost benefit, it will be essential that those categorised as astronauts can be distinguished from other persons who have decided to live and work in space. The highly trained and knowledge based nature by which astronauts will be defined will place a higher value on them and hence the need for them to have better health provision. Ensuring their health will become a necessity if a settlement or the crew of a spaceship is to have the greater chance of survival.

The status given to an astronaut and the subsequent health care they will be provided will be more acute in a planetary settlement where a host of support staff such as cleaners, caterers and others will be needed to service the needs of the astronauts and other highly trained professionals. Because the maintenance of an astronaut's health care provision is primary in the hierarchy of the space working population, unless universal health care is supported by industry, it may not be possible to guarantee the status of the astronauts and unrest could develop. The potential for conflict between the private providers of health care and the public providers may generate a division between the various groups that could destabilise a planetary settlement or a spacecraft mission. Ideally a combination of health care provision by both the space industry and extra-terrestrial governments would provide the best overall health outcome especially if it is backed by insurance. It is

expected that there will be a heavy demand for medical treatment because of the hazardous nature of the space environment in which people will work and live. This will put a strain on both the biomedical staff and astronautical hygienists who will mainly provide the health services.

Limitations on the freedom of an astronaut to work and live in the space environment will be affected by the initial astronaut screening process using exposome studies. Those least genetically susceptible to the hazards to be encountered in space will be those that can travel into space. Once the selection process is complete and an astronaut is living and working in space, they will carry out planetary exploration.

During planetary exploration an astronaut could be contaminated with an alien micro-organism that causes an infectious disease. If the infection has a high mortality rate then there would be a need to instigate quarantine procedures to limit the spread of the disease; this would also limit the freedom of movement of those astronauts affected. The decision on when to end the quarantine restrictions would be a critical moment. It could be dictated by the financial needs of the space industry employing the astronauts to resume work rather than by the need to ensure that the infection had been contained. If quarantine was lifted too soon then the disease would not be contained and the survival of the planetary settlement would be jeopardised.

To ensure that the health and safety of astronauts and others are prevented or controlled effectively, there will need to be laws and regulations to which they have to comply during work. The need to comply with the legislation could limit the range of work that could be undertaken within a planetary settlement or on board a spacecraft for example, work could not be carried out inside an airlock if the permissible exposure standards set for exposure to dusts, to airborne microbes or to radiation were not controlled to below the limits.

The health and safety legislation including regulations, guidance and approved codes of practice will need to be enforced. This could be by the employment of Space Inspectors designated a specific territorial area to inspect e.g. Martian settlements north of Mons Olympus or a space industry such as ore mining or oxygen production. The Space Inspectors could use specialists to provide technical back-up in highly technical cases such as gas poisoning from a breakdown in life-support systems. Failure to comply with the legislation may incur a fine, prosecution or both. For specific areas of work carried out by astronauts in high risk areas, there may be a need for more stringent rules not only to protect an individuals' health but also that of others. Complying with the regulations in such instances would restrict their work and freedom to choose between hazardous high risk options.

Other factors could limit the freedom of astronauts working in extra-terrestrial environments in particular those associated with ethical issues and the provision of universal health care. For example, will discriminating between the astronauts and support staff lead to the development of a "two tier" system of health provision, the top tier for the astronauts and the lower tier for the support workers? If a vaccination programme is to be implemented in a space settlement to prevent the spread of an infectious disease, what will be the consequences of refusing to take part?

Who will decide on the type of medical research that should be undertaken and by whom? Will the production of roadmaps determine the correct research to pursue for the benefit of all and not just a select few? How will the training and education of astronauts be financed? The questions posed will be answered at some stage, but they should be debated now to try and understand the complexities that relate to ensuring the health of astronauts during space exploration and the limitations on their freedom.

No-one can predict how extra-terrestrial societies will develop and evolve over the coming centuries. Will the settlement societies follow a capitalist or Marxist system of space government or will it be one that is feudal in nature and where the space industrialists and entrepreneurs provide the finance to ensure a settlements' survival but expect subservience in return? Any social organisation will require health and safety provision for its astronauts and other workers. The need to ensure a healthy astronaut population that opens up the frontiers of space will place a limitation on their freedom to choose including how they live and work in the extreme environments of space.

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Chapter 11
Outrunning the Law: Extraterrestrial Liberty and Universal Colonisation

Stuart Armstrong, Anders Sandberg and Seán ÓhÉigeartaigh

Abstract In the depths of space, how will groups and individuals interact? What will the dynamics be when law enforcement is in pursuit of criminals, or when powerful groups try to constrain the activities of lesser ones? Using some very general assumptions, it is possible to paint a picture of how these dynamics could play out. The most likely options for competing groups are either an exodus at a significant fraction of the speed of light, in order to escape their pursuers, or a mass expansion to claim as many resources as possible. Such a mass expansion could also be used to preemptively prevent escape. This paper assumes that future humans are capable of 'recursive manufacturing' (expanding their manufacturing base to make full use of any new resources) and that they can copy and co-opt natural processes, including some of the mental processes. Then both expansion and escape will be relatively easy for any reasonably-sized space-faring group. The ultimate shape of human society in space may well depend on which groups expand first, and under which circumstances.

Keywords Cosmic escape and pursuit · Cosmic frontiers · Intergalactic · Fermi paradox · Space-faring

11.1 Introduction

> When a place gets crowded enough to require ID's, social collapse is not far away. It is time to go elsewhere. The best thing about space travel is that it made it possible to go elsewhere.
>
> Robert A. Heinlein

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> I don't believe in anarchy, because it will ultimately amount to the power of the bully, with weapons.
>
> John Lydon

Space is, famously, the final frontier—but frontiers are dangerous places, full of liberty, oppression, opportunity, and death. How concepts of liberty, government and law evolve will of course be influenced by political, social, and contingent factors—but they will also be strongly determined by practical considerations. As society, technology and the human environment have evolved, the possibility for liberty changed as well, sometimes dramatically—modern concepts of liberty would be unlikely to be feasible in a primitive agricultural society.

Human society may be poised on the brink of the biggest environmental change of all, as we extend our range into the new arena of space, reaching other planets and ultimately other solar systems.[1] In such a novel environment, many of the key assumptions that govern modern life on Earth will be overturned. Just to pick two examples, fast contact across the whole human race will be a thing of the past,[2] and cargo could be sent on very long trips just as easily as on short ones.[3]

In such an environment, predictions are both tempting and foolish. There are so many vivid scenarios that the mind could paint—science-fiction movies and books barely scratch the surface of the possibilities. But conversely there are few ways of determining which possibilities are likely to come to pass. Experts are terrible at some types of predictions, such as political developments (Tetlock 2005) and the possibility of Artificial Intelligence (AI) (Armstrong and Sotala 2012; Armstrong et al. 2014) both of which would be key for describing future society.

The best that can be hoped for in these circumstances is to lay out a few likely assumptions, and try and make general deductions from them. Before the airplane was invented, it was extremely difficult to predict its impact on politics, warfare, and society—but one could safely claim that it would improve long-range transport.

The first key assumption for this chapter will be that humans (or their machines) will have mastered recursive manufacturing. This is defined here to be manufacturing processes that can expand themselves (by building more factories and mines, for instance) to take advantage of any extra resources, and can continue to do so as long as extra resources are available. The second key assumption is that humans will be able to copy or co-opt natural processes, such as cell replication and reproduction. The last assumption will be the existence of efficient automation (such as an AI, though simpler, less intelligent systems might work as well) that would be up to the task of directing space-faring probes and replicating them upon arrival.

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[1] We will assume here that human civilization doesn't collapse in the meantime!

[2] This will be far from the current world, when a picture can get around the world in seconds and a military strike in a few hours. This need not make centralised authority impossible, but it does mean such an authority needs to allow local responses without consultation to the centre.

[3] Since the acceleration and deceleration are the key costs, with the middle section of the trip just being effortless coasting.

This chapter will use these assumptions to investigate the future of liberty and law in interstellar (and intergalactic) space. There are two kinds of freedom from involuntarily imposed constraint. One is freedom due the unenforceability of constraint, the other one is freedom due to a mutual agreement about what constraints to have (once an enforced agreement is reached, no *further* constraints should be forthcoming). There is less that can be said in general about the second kind of liberty because the possible goals of different human or alien societies (not to mention individuals) are nearly endless, and hence the kinds of agreements they might reach are similarly unbounded. Game theory might limit the space of stable agreements, but not by much: consider the diversity of human legal contract types. Liberty of the second type is however constrained by liberty of the first type. If it is possible to escape the agreements, then they cannot be made binding. Hence, in this paper we will focus more on the first kind, the freedom that comes from unenforceability.

Though liberty is primarily individual, groups are likely to be able to command much more resources than individuals, so this chapter will focus on the relationships between groups. Whether it is law enforcers chasing after criminals or powerful governments trying to control dissidents (and all the gradations between these), their interactions will be governed strongly by the difficulty of escaping or expanding across the sky. This determines whether rebels can escape and whether central authorities can constrain their escape—and hence whether any rules can be effectively enforced.

The somewhat surprising conclusion of this chapter and of a previous paper (Armstrong and Sandberg 2013) is that, given the assumptions, escape and expansion are very 'easy'. The key fact is that the amount of energy available in a typical solar system is much higher than what is needed to power an expansion. If this energy could be harvested (with Dyson spheres, for instance (Armstrong and Sandberg 2013), then, given efficient automation, waves of self-replicating probes could be launched to colonise the whole universe at high speed.

What this model shows is that, given the assumptions made, such colonisation projects become possible on relatively short timescales.[4] In a future where humanity is space-faring within the solar system, has mastered recursive manufacturing, and continues to have desire for energy or for expansion, some projects to fully harness the solar system's energy will be undertaken. Then over longer time scales, enough excess energy will be availble to power various colonisation projects.

It should also be noted that the counterintuitiveness of the result does not affect the likelyhood of the assumptions. In terms of probability theory, P(cosmic colonisation | recursive manufacturing)—which this chapter aims to demonstrate is high—does not affect P(recursive manufacturing), unless there is some independent evidence against cosmic colonisation.

One such source of evidence could come from the Fermi paradox, the puzzling absence of any visible alien activity: since crossing the void between galaxies is so

[4] On the cosmic scale, at least.

'easy', species that developed intelligence in nearby galaxies would have been perfectly capable of crossing across to ours. Thus their apparent absence is a mystery.

Applying the results about ease of expansion to human groups, this demonstrates that negotiations, flight or mass expansion are the only long-term viable outcomes to disagreements and conflicts. Any group that tried to remain confined to its own territory would quickly get overwhelmed by groups that didn't remain static.

Interestingly, the accelerating expansion of the universe allows for permanent escape. Ships launched at very high speed could slip away beyond the cosmic 'event horizon', ensuring they could never be caught. Conversely, a powerful group could attempt to preemptively seed the universe with their own 'police probes', preventing any such escape attempt. The future of human development could depend on the tension between these two possibilities.

11.2 Law, Enforcement and Conflict

There are myriads of legal systems and legal philosophies. But without the ability to enforce its rulings, a legal system is only a legal fiction. Enforcement need not be with coercion or violence; social pressure or persuasion have proven very effective at enforcing rules in many circumstances (Hackman 1992). But this ability is strongly determined by the relative power and abilities of the enforce or enforce. The dynamics between them could cause both to want to expand into the universe.

11.2.1 Expansion by the Weaker Party

Consider the following scenario: in the vastness of space, group A wishes to inflict some sort of penalty on a weaker group B. This may be a police force wishing to impose a legal penalty, a government cracking down on dissidents, or two groups with some disagreement over morals or resources. Group B has a variety of options available to it[5]:

- Negotiate.
- Hide.
- Flee.

[5] This list has some similarities to the work of Albert O. Hirschman, who analysed conflicts in organisations or societies in terms of "exit" (hiding or fleeing), "voice" (negotiating an agreement) or "loyalty" (staying put and accepting the status quo) (Hirschman 1970) One interesting aspect is that if exit is easy, the scope for voice is reduced—dissenters or resource-rich parties will preferentially escape, leaving a more loyal core depleted of reformers. In fact, some powers might encourage exit as long as they do not have any reason to fear subsequent retaliation by the exiles. However, some of the technologies discussed in this chapter, such as recursive manufacturing, do make interstellar exiles potentially dangerous.

- Bunker-up: put defensive measure into place.
- Build up a larger military.

Negotiations in all their possible permutations will probably be the most common outcome, as space warfare could potentially be extremely destructive. But the other options will strongly affect the negotiations simply by being possibilities: threats, deals, and brinkmanships will be articulated around the other options. So analysing these other options is key, as they will certainly be very different from their Earth based equivalents.

But how can we predict the course of future space conflict, any better than George Lucas or Isaac Asimov? There are good reasons to suspect that as soon as space becomes available for colonization, fleeing may be relatively doable. As noted by Iain M. Banks, ships and habitats in space need to be self-sufficient and are often mobile, making control harder for centralized powers. While they are more vulnerable than planet-bound habitats, this only enables easy destruction, not effective occupation. Exiles need only one successful escape in order to reach their goal, while the central power needs to succeed in stopping them every time (Banks 1994). The lightspeed limit also reduces the potential for some types of remote coordination, possibly fragmenting large scale civilizations.

Beyond that, a detailed analysis is impossible to do with any rigour: we can speculate about the courses of future technological developments, but we are still likely to be very wrong in our speculations, and even more so in how these technological developments will be applied to the field of warfare. However, it is possible to paint a very informative picture, based on a single assumption: that of recursive manufacturing.

11.2.1.1 Recursive Manufacturing

Recursive manufacturing (see also 'exponential assembly' Freitas and Merkle 2004) is defined to be a process by which manufacturing tools are capable of efficiently transforming basic resources into further manufacturing tools. This is a more general concept than self-replicating machines: it requires that the entire manufacturing base be capable some degree of self-replication, not that any part of it be capable of building identical copies of itself. Crucially, this recursive manufacturing could continue indefinitely, as long as resources were available. So a group of self-replicating robots would not be capable of self-replication, if each needed a human controller: extra humans cannot be so efficiently created.

How likely is it that recursive manufacturing will be possible? A sufficient condition would be the construction a true artificial intelligence (AI). If the AI had human-level skills, a sufficient knowledge base, and multi-purposes tools and manipulators, it could create extra copies of its tools and its computer system, and copy itself into those. But that kind of operation does not require full human intelligence, just a certain degree of flexibility and the ability to solve certain specific problems repeatedly. Humans have been good at copying or co-opting

natural processes, and at automating them. It would therefore be a fair supposition that our descendants could automate this replication process, possibly by using and modifying the intelligences of other animals, or simply by clever coding—NASA had a design for a self-replicating lunar factory in 1980 (Freitas and Zachary 1981), and we hope future generations to be able to surpass 1980s NASA! Lack of mental capital does seem to be the only limiting factor that could prevent recursive manufacturing: by assumption, all other needed resources (energy, materials) will be available to the process.

The key assumption is the possibility of recursive manufacturing. From it, most of the results follow. Without it, the future world will be very different to the one described here

11.2.1.2 Applying Recursive Manufacturing to Interstellar Confrontation

Given the development of recursive manufacturing, 'hide' will no longer be a viable strategy. If group A even suspects that group B may be hiding in some locality, it can leave behind a small manufacturing base (manned if needed) that will eventually expand to absorb all the local resources, inevitably revealing group B or compelling them to react.

Defensive measures will be similarly ineffectual. As long as group B remains confined to some limited zone, it will have access to limited resources. Meanwhile group A will be free to expand across the rest of the solar system/galaxy/universe, acquiring all its resources, ready to hit back at group B at some later time with overwhelming strength.[6]

Thus it seems the two most viable options are to flee or to amass sufficient power to balance against the other group's (or credibly threaten to do so). Both of these require aggressive rapid expansion, though of a different type. Flight only needs expansion in a few directions, aiming to put the maximum distance between the two groups, and ensuring that most/some of the escaping group can't be caught. Amassing power would be a much more thorough process, with group B grabbing every resource they could find, expanding their own recursive manufacturing base as much as possible to keep up with group A's own expansion. A mixture between the two strategies is also possible, with group B locally acquiring enough resources to drag out the potential conflict, providing cover for other parts of the group to flee.

Thus there are strong reasons for a weaker group to want to expand into space.

[6] To pick an example, if group B remained confined to a solar system while group A claimed the galaxy, then group A could eventually crash half a dozen stars into group B's system without denting their own resources. More likely, they could saturate group B's domain with fast moving projectiles or destructive energy pulses.

11.2.2 Expansion by the Stronger Party

In the previous hypothetical scenario, group A would also have strong incentives to expand. If group B wanted to challenge their power, they could counter this by grabbing all the resources beforehand. If they did so efficiently enough, this might preclude group B from challenging them in the first place. And there is no need for them to wait for any particular group B: it is always in group A's advantage to claim as many spare resources as possible, as insurance against rebellion or challenge from groups inside or out.

These outside groups may not include just humans. There are over 4 billion galaxies in the reachable universe, each with hundreds of billions of stars, with planets being quite common (Lineweaver 2001). Though they currently *appear* devoid of life—which is the puzzling 'Fermi Paradox' (Brin 1983)—there is no guarantee that the sky is as empty as it seems. Even if alien life is unlikely, a space-faring human civilization could probably not afford to ignore the possibility. And though humans might be content not to grab the entire reachable resources of the universe, we'd be unlikely to allow other (potential) beings to do so. Preemptive grabbing of all unclaimed resources would be the most prudent option. This might be the "Prisoner's dilemma" of interstellar colonisation.

Finally, the larger and more spread-out a civilization becomes, the more resilient it is to internal collapse or to natural phenomena. A single-planet civilization is vulnerable to meteor impacts; a single-system one to stellar incidents; a multi-system one to nearby supernovas or gamma ray bursts. But once a civilization is spread across a galaxy (or more) it remains vulnerable only to the most extreme events, such as false vacuum collapse (Turner and Wilczek 1982).

Thus there are compelling reasons for a stronger group to want to expand into space.

11.3 Expansion, Realism and Extreme Models

We have shown that the interactions between future human polities is likely to be dictated by the ease of expansion across the cosmos, and the remainder of the paper will be devoted to analysing this question. There are several scenarios that should be considered here, differentiated mainly by how easy it is to expand.[7]

[7] We will lay aside the possibility of faster than light expansion, using some as yet unknown loophole in physics. This would enable both escape anywhere, but also presumably catching anyone. It also makes the Fermi paradox far more problematic—FTL drives would allow visits from aliens even beyond the cosmic event horizon. In the end, there is very little that can be said about such an unconstrained case, which—according to our current understanding of physics—would permit time travel.

The approach used here is exploratory engineering: analysing what technologies are compatible with known physics and could hence possibly be reached by future human (or alien) engineers (Drexler 1992). This gives an outer boundary of possibility, even if these possibilities are very extreme by current standards. We will be making three key assumptions here:

1. Recursive manufacturing.
2. Copying of natural processes.
3. Artificial minds of some sort.

Recursive manufacturing has already been defined. Humans have proven adept at copying natural processes or co-opting them. Therefore the second assumption this paper makes will be that we can do continue to so with any natural process. This means that replicating cells and similar will be within our capacities.

The third assumption is that that copying or co-opting extends to mental processes as well—that we'll be able to copy some of the skills of intelligence. Thus we will assume that humans are capable of either creating de novo artificial intelligences, 'uploading' human minds as whole brain emulations (WBE) (Sandberg and Bostrom 2008), or creating or modifying biological minds so they are capable of performing the tasks required for colonisation. Whole brain emulations are perhaps the most interesting possibility: human minds copied and instantiated in a computer (Sandberg and Bostrom 2008). These minds can be stored extremely efficiently and are easily copied. Most interestingly, they allow the possibility for humans to send themselves into the expansion, and not rely on automated probes to do the jobs for them.

In a sense, all three assumptions could be reduced to an extreme version of 'copying of natural processes', giving recursive manufacturing (since natural self-constructing systems exist), and artificial minds (since natural brains exist). The assumptions are kept separate, as they play different roles: recursive manufacturing is absolutely key, copying nature is necessary to allow colonisation with 'dumb' probes, and artificial intelligence is needed to do so efficiently with smart minds.

As shall be seen in the next sections, under these assumptions, expansion into space will be extremely efficient and rapid—far more so than conventionally imagined by science-fiction. Colonisation will proceed in all directions, aimed simultaneous at every galaxy, only slightly below the speed of light.

There are a number of reasons to focus on this extreme scenario, which this paper will be doing. First of all, it gives an upper bound on the possible expansion speed (and it suggests that less extreme scenarios could allow much faster expansion than generally imagined). Even if future humans couldn't expand at breakneck-speed themselves, they could be able to design artificial agents capable of doing the expansion on their behalf, allowing them to control extra resources indirectly.

As a hypothetical possibility—or a threat—extreme expansion will remain relevant even in more standard situations. Even if WBEs didn't exist, there would always remain the possibility that they could be developed at some point, instantly changing the expansion game, and causing various groups to act to preclude or prepare for such possibilities.

Finally, it should be noted than even flesh and blood humans should be able to maintain an extremely fast expansion speed. Technologies such as suspended animation or cryonics could allow relatively efficient long voyages. The acceleration and deceleration phases are very short as compared with the journey time, which could stretch over millions or billions of years. Thus even standard human reproduction could be enough to maintain expansion at an exponential rate over these timescales. This would likely require orders of magnitude more energy that a WBE-based expansion, but since that has such low requirements (see Sect. 11.6) this less efficient possibility could be perfectly viable.

It should also be noted that escape scenarios, which don't need to colonise whole swathes of the universe, can proceed very fast without assuming WBE or even suspended animation. Even something as inefficient as a 'generation ship' (Caroti 2011) (a huge ship with a self-contained ecosystem and a reproducing population) could be accelerated to very high speeds at relatively low energy cost, if only a few of them need to be sent out.

11.3.1 (Much) Faster Than a Speeding Bullet

The scenarios presented in the next section involve expansion at a significant fraction of the speed of light (50, 80 and 99 % of c). The acceleration phase will be extremely brief, as compared with the voyage, which can last thousands, millions, or even billions of years for the most distant galaxies. Hence, except for the closest of destinations, it is advantageous to delay one's departure to wait for better technologies to get a slight speed increase. This seems to give an advantage to the most powerful group, allowing them to prevent escape: even if their targets shoot away at ultra high speed, they can take their time, develop better technology, and eventually catch up.

But this ignores the exponentially increasing expansion of the universe (Peebles and Ratra 2003; Gott et al. 2005) (see Fig. 11.1 which shows the scale factor of the

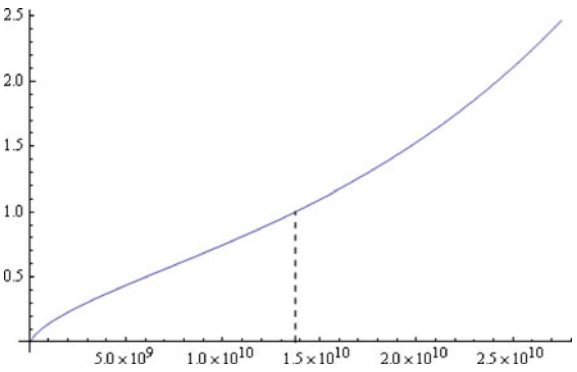

Fig. 11.1 Scale factor of the universe as a function of age (years), showing future exponential expansion

universe, normalised to one at the current era). Galaxies are receding from us, slipping permanently beyond our grasp, as the relative speed between us increases above the speed of light. This allows for an unusual escape technique: if an escaping entity aims for the cosmic horizon at speeds *very* close to the speed of light (99.999999 %*c*, for instance), then if the pursuer lets too much time pass (even as low as a few years) then it will become absolutely impossible for them to catch up before the pursued slips out of reach forever. If the escapees launch from a distance away from their pursuers (a few light years, say), they may be effectively out of reach before the pursuers even realise an escape has been attempted. Ships moving at those speeds would need novel ways of shielding themselves from intergalactic collisions and would require huge amounts of energy. It would likely not be be possible to launch a cosmic colonisation project at these speeds, but it could be feasible for a few escape ships. Hence this dynamic favours the escaping group rather than the pursuer, especially if the direction of launch can be concealed. The only likely counter is for the stronger group to launch preemptively in all directions to occupy all surrounding space.

11.4 Launching the Colonisation Project

The ease or difficulty of cosmic expansion is relevant to many situations for future humans and potential aliens. Humans could attempt a cosmic expansion from many different technological bases and from many different situations—still on one planet, spread across a few asteroids, occupying the whole solar system, or spread across a few star systems. Potential aliens could start from an even more diverse set of circumstances.

Nevertheless, we will begin by considering a single situation: that of the human race, still in our own solar system, with some technological improvements, and access to recursive manufacturing. If fast expansion is possible in that situation, it will be possible for a more advanced humanity, or one already spread out across the stars. And any alien species in an analogous situation could also achieve this feat.

The easiest source of energy is the sun itself, with its 3.8×10^{26} Watts of power; this could be collected by various hypothetical methods such as Dyson spheres (Dyson 1960; Sandberg 2006; Suffern 1977).[8] But the details of such a scenario are unimportant: the key fact is that the energy contained within a solar system is much higher than what is required to expand.

[8] See paper Armstrong and Sandberg (2013) for more details on one possible scenario.

11.4.1 The Launch System

The energy collected can be used to launch probes to distant destinations. Rockets are highly inefficient, so it would be best to avoid them for acceleration and use some sort of fixed launch system instead.

Coilguns are one example of such a system, as are quenchguns. Both these devices have a theoretical efficiency close to 1 (Sung 2008; Kolm et al. 1979; Graneau 1980), so could have high efficiency in practice. Alternatively, to avoid the large barrels of these guns, the probes could be launched from a distance using laser propulsion (Landis 1999) or particle beam propulsion (Nordley 1993).

Because practical efficiency never reaches the theoretical limit, we'll assume that the launch system has an efficiency of at least 50 %.

11.5 What to Send…

The previous section delved into how energy could be harnessed to allow the launching of probes. But what probes, and where would they be launched?

It would be ruinously difficult to reach every planet in the universe with a colonisation fleet. Fortunately, this is not necessary: a much better approach is to send over a smaller probe that could then build all that was necessary, gathering resources for a second round of colonisation. This is the concept of von Neumann probes: entities capable of constructing copies of themselves from the resources they find (Freitas 1980; Bracewell 1960).

Thus the colonisation project could proceed in stages: a first wave spread out to distant targets, that creates the second wave that creates the third, etc. The most effective replicator, size-wise, would be an artificial intelligence of some type, either capable of human-level decisions (such as a whole brain emulation Sandberg and Bostrom 2008), or at least capable of piloting a probe to its destination in another galaxy, collecting energy at its destination, and overseeing a second wave of launches to individual stars. As mentioned above, scenarios with humans in suspended animation or even generation ships are slower alternatives, but this paper will assume artificial intelligence is possible.[9] Of course, if whole brain emulations/uploads are also possible, then colonisation makes more sense: we'd be sending actual human beings to the stars, rather than simply having non-human entities claim vast amounts of resources for their human masters.

We'll consider only the first stage of the process: probes targeted at each galaxy individually, which will arrive in a single solar system of that galaxy. The next stages would be the colonisation of that galaxy, which would proceed at a pace and in a number of stages appropriate for the particular replicator used.

[9] This is a stronger assumption that recursive manufacturing. Artificial intelligence would be sufficient for recursive manufacturing, but not necessary.

11.5.1 Replicators

The replicators will be tasked with building more of themselves, to continue the second phase of the colonisation project. More generally, we would want them to be universal constructors: capable of constructing many things, including other universal constructors (which need not be identical to the initial replicators). We'll designate this universal constructor as the 'replicator', distinguishing it from the 'probe' which is the object actually launched through space (which consists of the replicator and the means of decelerating, maneuvering, and shielding it).

A spaceship with a variety of human couples, life support systems, large databases and an onboard factory would count as a von Neumann probe, capable of building more copies of itself through manufacturing and reproduction. So von Neumann probes are certainly possible. What would be a more efficient design using AI or WBE?

11.5.1.1 The Size of Mindspace

To set aside one issue, data storage space should not be a limiting factor. The most compact method of data storage reasonably imaginable would be a diamond constructed of carbon 12 and 13, with the two types of atoms serving as bits. This would have a storage capacity of 5×10^{22} bits per gram. By comparison, the total amount of data in the human world has been estimated at 2.4×10^{21} bits (Hilbert and López 2011). If human brains could be instantiated inside a computer WBE, then 100 Terabytes is a reasonable estimate for the number of connections in a human brain, meaning one gram of diamond could contain about all the world's data and the (uncompressed) population of Britain.

A more physically plausible data storage level would be that of DNA, which averages one bit per 1.10×10^{-24} kg, or 9.13×10^{20} bits per gram. Storage of 5.27 megabits at a density of 6×10^{20} bits per gram has been demonstrated (Church et al. 2012).

Given continued exponential progress in storage capacity (Walter 2005), data storage is therefore unlikely to be a limiting factor for the replicator. The AI or WBE need not take up more than a few grams.

11.5.1.2 How Big?

Project Daedalus (Bond and Martin 1978) was one of the great achievements of the British Interplanetary Society: a design for an unmanned probe, using near future technologies (such as fusion rockets) that could reach nearby stars. In 1980, Freitas extended the design, adding ideas from NASA's self-replicating lunar factory (Freitas and Zachary 1981), in order to produce a 500 ton self-replicator (Freitas 1980). It required basic AI, but in all other ways was extremely conservative in design, taking a good 500 years for self-replication.

This 500 tons represents a useful upper bound on the replicator. If we disallow advanced AI but do allow cryonics, then 500 tons could be a reasonable estimate as well for a ship carrying a small population in suspended animation and the machines to maintain them (recall that this 500 ton figure does not include propellant).

If generation ships are needed, then the weight requirements go much higher than this. On short timescales, generation ships seem better designed for escape than for mass colonisation.

11.5.1.3 How Small?

Not content with designing one of the largest self replicating design, Freitas (along with Merkle) also designed the smallest known one: the Merkle-Freitas HC molecular assembler, which had a total mass of 3.91×10^{-18} kg (Freitas and Merkle 2004).

This can only be taken as a lower bound, as there is no engineering pathway to building such a device.

11.5.1.4 All-Natural Replicators

Our second assumptions states that humans will be able to co-opt or copy any natural process. So how do natural replicators compare? Some terrestrial replicators (Freitas and Merkle 2004) are presented in Table 11.1 (again due to Freitas). These all lie comfortably between the upper and lower bounds established above. In a general environment, vibrio comma is the smallest replicator. *E.* coli is very robust as a replicator. Seeds are interesting, as they can assemble a plant, which is a macroscopic structure much larger than themselves. The smallest seed has a mass of a millionth of a gram. Finally, acorns can range all the way down to a gram, while being essentially a macroscopic building machine powered by the sun, using resources from its environment.

A replicator on an asteroid (the most common landing target) would not be in as hospitable an environment as these replicators would be on Earth. But nature has demonstrated that living organisms can survive in extreme conditions, such as the (well-named) extremophiles (Rampelotto 2010). So simple survival is possible for

Table 11.1 Selected natural self-replicators

Description	Size	Properties
Vibrio comma	10^{-16} kg	General environment replicator
E. coli	5×10^{-16} kg	Robust replicator
Smallest seed	10^{-9} kg	Creates macroscopic structure
Smallest acorn	1 g	Creates large structure

such a replicator. Moreover the natural world has provided many approaches that would allow the replicator to move about and leach all sorts of materials from its surroundings. Unlike natural replicators, this one would carry advanced technology, initial fuel, initial solar panels, and a detailed knowledge of physics and chemistry, allowing it to quickly build itself up to a sustainable level. Once it is sustainable, it will start expanding, and, given recursive manufacturing, will make use of all the resources in the system it ended up in, so as to power a second wave of probes.

All in all, it does not seem unreasonable to assume a final replicator with a mass of 30 grams, including the AI and the manipulators. This will be taken as the model, though the upper limit of 500 tons should be kept in mind as well.

11.5.2 Deceleration

When arriving into a galaxy, the probe has to reduce its speed so it can land on planet or asteroid to get the raw materials it needs for the next phase: creating more probes to claim the entire galaxy. Thus deceleration is important, and puts real constraints on the maximum speed of the probe. If it lacks the means to decelerate efficiently, it will either be too huge to launch, or will only be able to travel at slower speeds. There are potential exotic ways of decelerating, such as magnetic sails (Winglee et al. 2000) or Bussard ramjets (Whitmire 1975), but we will focus here on the least efficient deceleration method: using rockets.

A full probe consists of a replicator, along with the means of decelerating, and possibly some ways of shielding itself from collisions with interstellar dust (see Sect. 5.1).

11.5.2.1 Rockets

At relativistic speeds, rocket deceleration is given by the relativistic rocket equation

$$\Delta v = c \tanh\left(\frac{I_{sp}}{c} \ln \frac{m_0}{m_1}\right), \tag{11.1}$$

where Δv is the difference in velocity, m_0 is the initial mass of the probe, m_1 the final mass of the replicator and the I_{sp}/c term denotes the specific impulse of the fuel burning process. The I_{sp}/c term can be derived from η, the proportion of fuel transformed into energy during the burning process, $I_{sp}/c = \sqrt{2\eta - \eta^2}$ (Forward 1995).

We will consider three energy sources for the deceleration, from the speculative to the currently possible: antimatter-matter annihilation, nuclear fusion, and nuclear fission. Antimatter rockets could in theory have an I_{sp}/c of 1; in practice, we turn to the results presented in (Westmoreland 2010; Vulpetti 1985), which give an I_{sp}/c of

Table 11.2 I_{sp}/c of different types of rockets

	Matter-antimatter	Fusion	Fission
I_{sp}/c	0.567	0.0843	0.0397

Table 11.3 Initial masses needed for decelerating from various speeds

Δv (% c)	Matter-antimatter (kg)	Fusion (kg)	Fission (kg)
50	0.0791	20.2	31,100
80	0.208	13, 600	3.23×10^{10}
99	3.20	1.28×10^{12}	2.90×10^{27}

0.58, and an efficiency of $\eta = 0.185$. For nuclear fusion the efficiency is 0.00375, and for nuclear fission it is 0.000828 (Armstrong and Sandberg 2013). But the rocket does not consist of pure fuel; the reactors and other components must be included as well. Since the rocket will be optimised for maximal efficiency, we assume that 95 % of the rocket mass will be fuel, the remaining 5 % being infrastructure, and that the infrastructure is gradually cannibalised to serve as reaction mass. Hence the real efficiencies are 95 % of the above, giving actual efficiencies[10] of 0.176, 0.00356, and 0.000787, and consequently the I_{sp}/c's as given in Table 11.2.

We can combine these numbers with the final replicator mass of 30 g, and Δv's of 50, 80 and 99 %c. The relativistic rocket Eq. (11.1) then gives the initial mass needed for the probe, as listed in Table 11.3.

The values in bold are those we will be considering in this paper, rounding them up: matter-antimatter probes of total launch mass 5 kg launched at 99 %c, fusion-powered probes of mass 15 t launched at 80 %c, and fission-powered probes of mass 35 t launched at 50 %c.[11]

11.6 …and Where to Go

In the popular imagination (and even in some more serious papers Hanson 1998) space exploration is over-analogised to past Earth exploration. It is imagined to be a slow and gradual process, starting close by and expanding gradually, with colonies

[10] The calculation of these efficiencies is where this approach is most vulnerable to small errors: small loses of efficiency mean dramatically more material needed for deceleration. But the total energy requirements are so low that this does not change the main point on the ease of expansion, though this expansion may end up being slightly slower than envisaged here.

[11] In fact, the expansion of the universe creates a 'Hubble drag' (Peacock 1999; Bertschinger 1995) that slows probes down relative to their destinations. For the most distant of the galaxies—those barely reachable at all—the probes will arrive with practically no velocity. Thus we will also consider a fourth scenario, that of probes launched at 99 %c with no major deceleration capabilities.

planted at key points to serve as nexuses for further expansion into new territory. But in the (essentially) frictionless environment of space, there is no need for such gradual expansions. If the probe is to stay inert during the trip (which would be the case of AI/WBE powered probes or some designs carrying humans in suspended animation), then a distant galaxy is as easy a target as close one: the trip will take longer, but won't present any extra difficulties besides potentially impacting more dust along the way.

Adopting a gradual approach—colonising a star, then moving to the next, then moving to the next, then moving to the next…—amounts to adopting a zig-zag course across the cosmos. Another group which had decided to go straight to the final star would have got there well in advance, claiming its resources for themselves. The next section will demonstrate that the resources needed to shoot off at high speed are relatively small: there is no need to leap-frog from star to star. A better approach is to send probes directly to each and every galaxy that could be reached. Once there, the replicators could build a second generation of probes that would claim every star in that galaxy in one (or at most two) stages.

The possibility of such a 'high fan-out' approach is what makes it conceivable for certain groups to colonise the universe rapidly enough to prevent any possibility of escape.

11.6.1 Dust as a Limit

At relativistic speed the slightest collision with interstellar dust would be explosive, potentially destroying the probe. Various ways of shielding can be considered (for example, expendable low mass shields traveling ahead, shaped to deflect debris to the sides) but we will make the conservative assumption that the probes are hardened against impacts up to a certain mass, and beyond that just rely on strength in numbers to reach their destination.

A probe of cross-sectional area A traveling a distance d will sweep out a volume Ad, and if the density of particles larger than the critical mass is ρ, the probability of encountering none in this volume is $\exp(-dA\rho)$. The redundancy needed to guarantee an expectation of at least one probe reaching its destination is on the order of $\exp(dA\rho)$: it goes up exponentially with traveled distance, and above $d_{limit} = 1/A\rho$ the need to launch large numbers quickly overwhelms any local resources.

Assuming the probes can handle a 800 kj hit (≈a grenade blast) and that lesser damage can be repaired, for 99 %c the destructive particle mass is 1.46×10^{-12} kg. Fortunately, intergalactic space is fairly empty; assuming a power-law distributed density of intergalactic dust the necessary redundancy over 4.09 Mpc is $R < 40$ (Armstrong and Sandberg 2013) at 99 %c (at the slower speeds of 50 and 80 %c, a redundancy of two is sufficient).

However, withing a galactic disk, the larger density reduces d_{limit} by up to 8 magnitudes, reducing it to less than a parsec. Slower and thinner probes can reach

further (at 80 %*c* the range is 5 times greater), but expansion distances (and hence useful fan-out) will be limited inside dense galactic areas, requiring building staging points and a slower overall expansion.

11.6.2 The Friedmann Metric's Geodesics: Our Maximum Range

The Friedmann metrics can be used to approximate the future evolution of the universe, under the assumption of homogeneity and isotropy (which is the case for our universe, on the large scale). Our universe is expanding at an accelerating rate, which will become approximately de Sitter (Peebles and Ratra 2003) in the far future. Even before that happens, galaxies will recede from us: not every galaxy we can see is one we can reach. A previous paper used the data from (Gott et al. 2005) to solve the geodesic equations for rockets starting around our current time and position, and shooting out into the universe with initial speeds of 50, 80 and 99 % *c*. The results are plotted in the graph of Fig. 11.2 for these speeds, and, for comparison purposes, *c* itself. These show how far these probes can reach into the universe; the distance is given in Parsecs in current comoving coordinates.

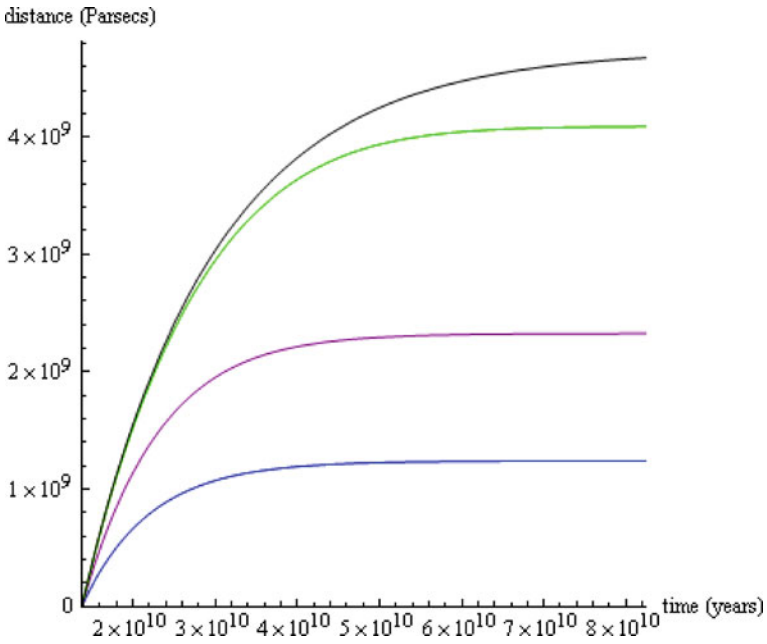

Fig. 11.2 Distance reached by probes with speeds of 50, 80, 99 %*c* and *c*, in comoving coordinates

Table 11.4 Table of maximal reachable distance (in Parsecs) and approximate maximal number of galaxies reachable, at various launch speeds

Speed	50 %c	80 %c	99 %c
Maximum distance	1.24×10^9	2.33×10^9	4.09×10^9
Galaxies reached	1.16×10^8	7.62×10^8	4.13×10^9

In order to estimate how many galaxies are within reach, we need to know the density of galaxies in the reachable universe. The observable universe is of approximate volume 1.3×10^{31} cubic Parsecs (Bars and Terning 2009), and has about 1.7×10^{11} 'bright' galaxies (Gott et al. 2005). This gives the figures in Table 11.4 on the (approximated) number of galaxies reachable at the various speeds—hence the minimum number of probes that need to be sent out, to colonise all galaxies reachable at that speed.

Is it even feasible to construct so many probes? Put quite simply, yes. The Earth itself has enough uranium to provide over 350 tons per probe. And uranium is the rarest naturally occurring element in the solar system, which should provide more than enough resources to create all needed fuel.

11.7 Total Energy and Time Requirements

Recall the assumptions for colonisation: the probes will be carrying either fission rockets, fusion rockets, matter-antimatter rockets, or no rockets at all. They will have masses of 35, 15 t, 5 and 1 kg respectively. The first two will be launched at speeds of 50 %c (aimed at 1.16×10^8 galaxies) and 80 %c (aimed at 7.62×10^8), with a redundancy of 2. The last two will be launched at 99 %c (aimed at 4.13×10^9 galaxies), with a redundancy of 40.

Then Table 11.5 gives the full energy cost of sending probes to every reachable galaxy. For comparison with the energy available in the solar system, the last two rows give the time required for the sun to generate that amount of energy, for both the 30 gram replicator (maximum of 2 h) and the 500 ton one (maximum of 3800 years). All these durations are insignificant on the cosmic scale. These energy requirements should be met, many times over, for any advanced star-spanning civilization that survives for more than a few centuries.[12]

[12] The initial paper in this project (Armstrong and Sandberg 2013) was focused on the Fermi paradox: the idea was not to plot the future course of a human cosmic civilization, but to illustrate the ease with which alien species could cross the void between galaxies, and thus worsen the Fermi paradox: life could have reached us from many galaxies with ease, so their absence is puzzling.

The Earth is not among the oldest of terrestrial planets. About 75 % of the planets that could have habitable life on them in our Milky Way are older than the sun (Lineweaver et al. 2004). If we look back 5 billion years (a timespan in which its likely that intelligent life could have evolved on Earth-like planets), then 7.69×10^7 galaxies could have reached us at the slow pace of 50 %c, considerably worsening the Fermi paradox.

Table 11.5 Time and energy requirements for universal colonisation

Rocket type:	Fission	Fusion	Antimatter	No rocket
Probe mass (kg)	35,000 kg	15,000 kg	5 kg	1 kg
Velocity (%*c*)	50	80	99	99
Kinetic energy	4.87×10^{20}	8.99×10^{20}	2.74×10^{18}	5.47×10^{17}
Fuel energy	≈0	≈0	4.49×10^{17}	0
Number of probes	2.31×10^{8}	1.52×10^{9}	1.65×10^{11}	1.65×10^{11}
Total energy	1.13×10^{29}	1.37×10^{30}	5.27×10^{29}	9.05×10^{28}
Solar time required, 30 g replicator (s)	*593*	*7,200*	*2,770*	*477*
*Solar time required, 500 t rep*licator (years)	*313*	*3,800*	*1,463*	*251*

11.8 Constraints on Escape

This scenario can be modified to some extent by various external limitations.

If the starting environment is dusty (such as deep inside a galaxy), fast long-range expansion is not effective, and expansion will occur in smaller hops with delays at each staging point. A central power with resources to expend could send a large number of probes to catch up with earlier escapees. It would be costly but feasible, at least until the escapees reached outside the galactic disk. A race towards the edge, played with ever faster launches of ever thinner probes, might be the result.

There could also exist speed limitations, for example due to physical limits on how well deceleration rockets could function or the survivability of fast probes. In the speed limited case escape beyond the cosmic horizon will not be feasible, and at some point escapees will have to stop and either hide or build up their defensive resources.

There might be technological limitations of how well automation, AI or replication can be done. But even factories and spacecraft crewed by humans are enough to perform a small-scale slow version of our scenario. It has been argued that self-replicating or autonomous intelligent systems are too dangerous to create; some civilizations might wish to avoid them. However, if a breakaway or outside group takes the risk the only feasible response is to do the same: the only way of beating exponentially growing opponent power is to have faster exponential growth.

11.9 Conclusion

The model presented in this chapter should not be taken literally. The point is to illustrate how relatively ‘easy’ such scenarios are. A future humanity that has built orbiting solar captors, or has spread across several solar systems, would find the

energy and time demands of universal expansion well within their long-term capabilities. This means that small scale expansions are lightly to be attempted, at the very least. Since this allows the acquisition of resources for further expansion, the process would most likely become exponential on time-scales which may be long by human standards, but are cosmically insignificant.[13]

Thus even if mass expansion had not yet have started at a given stage, its possibility will be very present in human consciousness, and would influence how space-faring human groups interact with each other, what kind of legal system they could design, and what kinds of freedom they may experience. 'Splendid isolation' will never be possible: no group will have the luxury of staying put within their domain of control, and ignoring the dynamics going on around them. They will have to put into action plans to expand or to escape, or negotiate long-term agreements with the other powers around them.

At this point it's hard to imagine what dynamics and relationships may play out in the future—it's perfectly possible that humanity may be an integrated single state by then, or alternatively that colonies on other planets or solar systems will further fragment human polities. But it appears likely that negotiations, and some way of reaching binding agreements[14] will be a key feature of the interstellar legal landscape.

This is because mass expansion, though easy to commence, is extremely hard to stop. And once one group commences expansion, the others are strongly pressured into following suit. Therefore future scenarios without such mass expansion must have some other ways or restraining the expansionistic urge and allowing groups to deal with each other: effective negotiations are a must.

Conversely once expansion has started, it is likely to be extremely uneven: the groups that expand first, and most especially those that expand the fastest, will tower over their rivals. It is not unlikely that the fast-movers will acquire millions or billions of times more resources than their slower counterparts. Thus weak groups will no doubt have to surrender to the stronger ones. Any conflicts are likely to be exceedingly one-sided (Sandberg and Armstrong 2013).

Escape, though, will remain a possibility, and will no doubt be a key option in inter-group rivalries. The major uncertainties are whether escaping groups will be able to expand at speeds such that pursuit becomes impossible, by exploiting the continuing expansion of the universe to put themselves permanently out of reach. To prevent such escapes, more powerful groups may be tempted to expand first, in every possible direction, claiming the universe for themselves to prevent escapees—or potential alien species—from doing so. How easy this is to accomplish will depend

[13] A few million years is a rounding error for most cosmic phenomena.

[14] This might be as simple as improved transparency, allowing all groups to spy on each other, or may be the result of new technology, such as applying workable lie detection to leaders of the various factions.

on what technologies are available at the time; such an expansion is easier using advanced AI[15] than it would be using humans in suspended animation, which is much easier again than if generation ships are needed.

Thus the future of the human race may well depend on a race of another kind.

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[15] Or whole brain emulations.

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Chapter 12
The Lethality of Interplanetary Warfare: A Fundamental Constraint on Extraterrestrial Liberty

Ian A. Crawford and Stephen Baxter

Abstract Elsewhere in this volume Charles Cockell points out that because of the confinement and necessary centralisation of fundamental life-supporting facilities to be expected in near-future extraterrestrial settlements, a revolution against a tyrannous government in such a settlement, analogous to the 1776 American Revolution, would be hazardous, if not impossible. But if such a revolution were nevertheless to be attempted, could there be future analogues to the US Revolutionary War? We argue that so huge are the energies wielded by interplanetary cultures that any such war would be catastrophically lethal. An interplanetary 'war of liberation' could not be waged without threatening the survival of the human species itself. It is therefore essential that an interplanetary political framework is established that guarantees colonial liberty without recourse to conflict.

Keywords Interplanetary warfare · Kinetic energy · Extraterrestrial liberty · American Revolution · Existential threat

12.1 Introduction

In the future, will humans living in extraterrestrial colonies strive for political independence? And if so, how will such independence be won or lost?

An often-cited historical precedent for future struggles for human liberty is the American Revolution of 1776, in which the colonists of the thirteen states seized control of their territories from the British government. This was followed by the

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Revolutionary War waged between the self-declared independent colonies and the British imperial forces. Elsewhere in this volume and in (Cockell 2013), Charles Cockell has pointed out that because of the confinement and necessary centralisation of fundamental life-supporting facilities to be expected in near-future extraterrestrial settlements, a revolution against a tyrannous government in such a settlement would be hazardous, if not impossible. But if such a revolution were nevertheless to be attempted, could there be future analogues to the US Revolutionary War?

In this paper we explore the prospects for war waged by cultures capable of large-scale interplanetary travel, an obvious necessary condition for extraterrestrial settlement. We cite science-fiction visions of such wars, and use kinetic energy (KE) as a proxy to estimate the energies wielded by interplanetary cultures. The core of our argument is that so huge are these energies that any such war would be catastrophically lethal, even compared to our modern capability of all-out nuclear war. Put simply, an interplanetary war could not be waged without threatening the survival of the human species itself.

So again the analogy with the historical American experience breaks down in the extraterrestrial context. Even if extraterrestrial colonists could overthrow a tyrannous local controller, an interplanetary war against a central government on Earth would likely wreck both civilisations if not exterminate the warring populations entirely. Thus, despite Earthbound historical precedents, it will simply not be practical, and certainly not desirable, for extraterrestrial colonies to 'liberate' themselves from Earth's dominance through revolutionary war.

It is therefore essential that an interplanetary political framework is established that guarantees colonial liberty without recourse to conflict.

12.2 Interplanetary War in Science Fiction

Interplanetary conflict has been explored in science fiction at least since the Martian invasion depicted by Wells in *The War of the Worlds* (1898). Indeed, the landing on Earth of the cylinders fired by Wells' Martians, apparently arriving at interplanetary velocities, caused significant damage, even before the cylinders opened to release the fighting machines to wage a more conventional ground war with their 'Heat-Ray' and 'Black Smoke'. Wells' journalist narrator (p. 16) describes an 'enormous hole' dug into Horsell Common, Surrey, with heaps of debris visible a mile and a half away, and with the heather set ablaze. The Martians could have surely have smashed Victorian England and the rest of the human world from space using solely the kinetic energy of their travelling cylinders; but theirs was a war of colonisation, terraforming and enslavement, not destruction.

Robert Heinlein's *The Moon is a Harsh Mistress* (1966), set in the year 2276, contains a detailed depiction of a rebellion by a penal lunar colony against the Earth, and illustrates the extraordinary fragility of both Earth and extraterrestrial colonies in the face of the purposeful deployment of interplanetary energies. With the authority on the moon overthrown, conflict begins with Earth. The 'loonie'

rebels, miners and farmers, recognise the advantage of their position: 'Luna had [no weapons]. But weapons… turned out to be engines for manipulating energy—and energy Luna has plenty. Solar flux alone is good for about 1 KW/m^2 of surface at lunar noon… But Luna also has energy of position; she sits at top of gravity well eleven kilometres per second deep.' (p. 80). The rebels prepare to use a solar-powered mass-driver, intended to deliver wheat exports to the Earth, to bombard targets on Earth with rocks: 'The concussion of a hundred-tonne mass on Terra approaches the yield of a 2 kT atomic bomb' (p. 80).

When conflict begins, the loonies' first assault prioritises military targets (Chap. 25). A second salvo contains near-misses designed to exhaust Earth's limited supply of interceptor missiles: 'Boston gets one in her harbour. New York gets one in Long Island Sound…' (p. 269). Collateral casualties are inevitable. The final stage of the conflict looms. Population centres on Earth could be targeted directly by the moon rocks, but on the other hand the fragility of the lunar colony is well understood; to destroy the warrens would require just 'one ship, six [hydrogen] bombs' (p. 205). However political unity on Earth is lost, the moon is granted its freedom, and these dreadful final steps are not taken.

Footfall by Niven and Pournelle (Niven and Pournelle 1985) gives a detailed vision of an attack on modern-day Earth from space using only near-future technology, further illustrating the vulnerability of the planet to such an assault. The *fithp*, would-be colonists from a planet of Alpha Centauri, arrive at Earth with their mile-long mother ship pushing the 'Foot', an ice fragment from the Saturn system. Aggression begins immediately. A high-altitude nuclear detonation causes an electromagnetic pulse to eliminate humanity's space assets (p. 161). A precision bombardment from space of humanity's infrastructure begins—targets include dams, rail depots, ports, road junctions. Humans fight back with nuclear weapons, but ICBMs are barely capable of reaching space (Chap. 12), and any site that launches a missile is struck by an impactor from orbit. The next phase of the invasion is a landing of *fithp* paratroopers in Kansas (Chap. 18). Orbital surveillance is total; any human assets in motion are hit by small targeted kinetic weapons which are compared in the text to a real-world study to which Pournelle contributed called Project Thor (p. 321) (for discussion see next section).

In an attempt finally to subdue mankind, the *fithp* push the Foot onto an intercept course with Earth: '"Must the Foot fall?"… "Stop them. Show our might"' (p. 365). The Foot is a mass of ice and rock some 2 km long (p. 234) massing $\sim$27 billion tonnes and travelling at $\sim$25 km/s (p. 420). The fall is in the Indian Ocean, an impact estimated at 4,000 Mt (p. 454). A quarter of a billion tons of seawater boils (p. 449) and tsunamis devastate coasts from Africa to Australia. Billions must have died; India for example is inundated (p. 464). Humans understand clearly the advantage held by the *fithp*: 'We'll never beat them while they control space… one Dinosaur Killer after another' (p. 318). Humanity's final roll of the dice is a successful assault on the *fithp*'s spaceborne mother ship using an immense warship driven by a nuclear-pulse 'Project Orion' drive (Dyson 2002).

While *Footfall* depicts the vulnerability of Earth to attack from space, Robinson's *Red Mars* (1992) exemplifies the equal vulnerability of planetary colonies.

Four decades after the landing of the first colonists on Mars, the discovery of precious metals on Mars begins a 'gold rush' (p. 324) by Earth nations and corporations. But there is a growing reaction on Mars against the Terran exploitation. When revolution is declared, the Martian rebels do attempt one strike against Earth, by diverting an asteroid called Nemesis, but this is destroyed. The Martians themselves, however, are much more vulnerable: 'It was not hard to destroy Martian towns. No harder than breaking a window, or popping a balloon' (p. 558). In one ghastly trick, a colony's air is given high oxygen levels so that humans within can be flash-incinerated while leaving the infrastructure largely intact (p. 557).

As the war accelerates, each side attacks the infrastructure on Mars, and increasingly destructive blows are struck. Aquifers are cracked, releasing floods not seen since the Noachian era (p. 565). Phobos is used as a surveillance and attack station (p. 585); the rebels find a way to bring the moon crashing down to Mars (p. 610). In the end a space elevator is cut from its orbital anchor; the cable wraps around the planet in a spectacular disaster (p. 589). Mars is won back by Earth, but Mars itself has been tremendously damaged: 'Red Mars was gone' (p. 643).

The notion of a massive KE strike from space used for military purposes continues to be used in fiction today (Yancey 2013). Perhaps the most extreme vision of spaceborne kinetic-energy weapons described in science fiction is the 'relativistic kill vehicle', as depicted for example in a novel by Pellegrino and Zebrowski called *The Killing Star* (1995), in which civilisation across a settled solar system is exterminated by a hail of alien missiles travelling at 92 % of lightspeed and targeted at the inhabited worlds. These missiles are described (p. 28) as pods of ceramic ~ 2 m across. If one missile weighs a tonne, say, its kinetic energy would be $\sim 10^{20}$ J.

But it is striking that much more primitive spacegoing technologies are capable of immense devastation. In Baxter's *Titan* (Baxter 1997), conflict between China and the US in the early twenty-first century leads the Chinese to attempt to target an asteroid impact on US territory. But the Chinese miscalculate: 'We think they intended some kind of glancing blow… A Tunguska rock on New York. A Meteor Crater where Washington is… But 2002OA is too large. Instead, we may be looking at some kind of Cretaceous-Tertiary boundary impact' (p. 533). After an ocean strike, clouds cover a devastated Earth, leaving it 'a twin of scorched Venus' (p. 565).

12.3 The Energetics of Interplanetary War

12.3.1 Energies and Warfare

What of the future reality?

It is hard to predict the weapons technologies of future ages. However we argue here that a consideration of kinetic energies alone is sufficient to make an order-of-magnitude argument.

After all, as the fictional illustrations above show, kinetic energy can itself be used as a weapon, and the idea of attacking a planetary surface with an inert projectile whose destructive force comes solely from its kinetic energy has been studied in military circles. Science fiction writer Jerry Pournelle seems to have originated one concept in the 1950s, while working for Boeing, known as 'Project Thor'; the impactors would be slender cylinders of solid tungsten ~9 m long and ~60 cm in diameter fired down from orbit at targets on the ground, hitting with a velocity of ~3,000 m/s; the KE released would have been 2.3×10^{11} J, about equivalent to 58 t of TNT (Shainin 2006). The concept is revisited periodically, for instance in a 2003 USAF review of future technologies (USAF 2003).

Meanwhile, in an intrinsically high-energy society like our own, the kinetic and other energies contained in our transportation systems may be subverted or weaponised. In the attacks of September 11 2001, the crash of a Boeing 767-223R aircraft, American Airlines Flight 11, caused the destruction of the North Tower of New York's World Trade Center (Boeing 2013). The plane's kinetic energy alone would have delivered $\sim 10^9$ J, and the chemical energy of a full fuel load (~100,000 L of aviation fuel) would be $\sim 10^{12}$ J (Air BP 2013)—that is, the equivalent of 1 kT of TNT.

The similar subversion of space technology would be still more devastating. As we saw, in Heinlein's novel *The Moon is a Harsh Mistress* (1966) rebellious lunar colonists throw moon rocks into Earth's gravity well, using a mass driver system intended for the peaceful transport of wheat crops. Indeed it may be easy to weaponise other aspects of interplanetary travel systems, such as high-energy drives based on fusion, or high-intensity beam systems intended to drive light sails. This is not to say that an interplanetary war would necessarily be fought with such weapons; more advanced technologies may be deployed. Alternatively the simple nudge of an Earth-crossing asteroid onto a collision course with the planet may be seen as a less costly yet effective stratagem by extraterrestrial aggressors.

Following this argument, kinetic energy estimates can be considered an estimate of the lower bound of the weapons capability of a culture—just as in the modern day a crashing aeroplane yields less energy than did the earliest of our nuclear weapons.

Here, our study of the consequences of interplanetary war centres on a comparison in Table 12.1 energies released by natural disasters and various human weapons systems with the estimated kinetic energies (KE) of advanced interplanetary spacecraft, and the overall energies wielded by advanced cultures.

12.3.2 Natural Disasters and Modern Weaponry

Damaging natural phenomena have been extensively studied in terms of their distribution in time and their effects (McGuire 1999). Here we make a rough categorisation: *city-scale events* (10^{14} J or more); *global-scale events* (10^{17} J or more); *extinction-level events* (10^{22} J or more).

Table 12.1 A comparison of energies of natural phenomena with human technologies

Energy (T of TNT)	Energy (J)	Natural phenomena	Weapons systems	Technology
1 T	4×10^9		Boeing 767 (KE) Boeing (2013)	
10 T	4×10^{10}	Earthquake Dallas 2012, Richter 3.5 USGS (2013a)		
100 T	4×10^{11}		Project Thor KE weapon Shainin (2006)	
1 kT	4×10^{12}		Boeing 767 (fuel load) Boeing (2013)	ISS (KE) NASA (2013a)
10 kT	4×10^{13}		Minor scale conventional explosion Tech Reps (1986)	
100 kT	4×10^{14} City-scale events:	Earthquake Kentucky 2012, Richter 4.3 USGS (2013a); Urals meteorite 2013, Moskvitch (2013)	Hiroshima bomb Malik (1985)	
1 MT	4×10^{15}			Vista—Mars transport (KE) Orth (1990)
10 MT	4×10^{16}	Volcano Mt St Helens 1980, VEI 5 USGS (2013b); earthquake San Francisco 1906, Richter 8.0 USGS (2013a)		
100 MT	4×10^9		Tsar Bomba Nuclear Weapons Archive (2013)	
1 GT	4×10^{17} Global-scale events:	Volcano Toba, VEI 8 USGS (2013b); earthquake Chile 1960, Richter 9.5 USGS (2013a)	12-hour nuclear war Simmons (1990)	
10 GT	4×10^{18}			Vista—Neptune transport (KE) Orth (1990)

(continued)

Table 12.1 (continued)

Energy (T of TNT)	Energy (J)	Natural phenomena	Weapons systems	Technology
100 GT	4×10^{19}	250 m-diameter asteroid strike Hartmann (1977), hurricane NOAA (2013)		
1,000 GT	4×10^{20}			Daedalus interstellar probe (KE) Bond et al. (1978)
10^4 GT	4×10^{21}			C21 Earth annual energy usage Simmons (1990)
10^5 GT	4×10^{22} Extinction events:	Chicxulub impact Hartmann (1977), Alvarez et al. (1980)		
10^6 GT	4×10^{23}			
10^7 GT	4×10^{24}			Type K-1 civilisation annual energy usage Shklovskii and Sagan (1966)
…				
10^{14} GT	4×10^{31}			
10^{15} GT	4×10^{32}	Late Bombardment Dyson (1996)		
10^{16} GT	4×10^{33}			
10^{16} GT	4×10^{34}			Type K-2 civilisation annual energy usage Shklovskii and Sagan (1966)

As the table indicates, the energies of major destructive natural phenomena which an individual human being is likely to encounter in an average lifetime begin at order 10^{10} J, equivalent to the detonation of $\sim$10 t of TNT. Such energies characterise relatively minor earthquakes (Richter 3.5) (USGS 2013a).

The Volcanic Explosivity Index (VEI) (Newhall and Self 1982) was devised by geologists to provide a comparative measure of volcanic eruptions. Eruptions in recent history (VEI 5 or less) such as Mount St Helens in 1980 (USGS 2013b) can deliver energies of 10^{16} J, equivalent to 10 MT of TNT. A Richter 8 earthquake can deliver energies of a similar order of magnitude (USGS 2013a). As the example of San Francisco in 1906 showed, such events can inflict damage on the scale of a city (or a space colony). The most devastating earthquakes, such as that which struck Chile in 1960, and the most massive volcanic events, such as the VEI 8 event at Toba 75,000 years ago, can be two orders of magnitude more energetic, and can have global effects.

Hurricanes (NOAA 2013) are heat engines which can expend in a day as much energy as the strike of a 250 m-wide asteroid (Hartmann 1977). Impacts of extraterrestrial bodies however can dwarf in energy other natural terrestrial phenomena. In June 2013, the well-recorded explosion of a stony asteroid at an altitude of $\sim$20 km over the Chelyabinsk region in the Urals felled trees and buildings, blew out windows and injured $\sim$1,700 people. The energy release is estimated at $\sim$400 kT of TNT; the object is estimated to have massed 10,000 t and was $\sim$18 m in diameter (Moskvitch 2013). On a much larger scale the end-Cretaceous Chicxulub impact event, which hastened the extinction of the dinosaurs, delivered some 10^{22} J (Alvarez et al. 1980). This extinction-level event saw the destruction of a significant fraction of the Earth's biomass.

The Earth-moon system was born from a process of still more dramatic collisions between primordial bodies. One measure of this is Earth's gravitational binding energy (Dyson 1996) which, roughly speaking, is the energy that would be required to lift all of the planet's mass out of its gravity well—that is, to dismantle the Earth. Perhaps this is an upper bound on the energy that it is worth delivering by any weapon directed at a planet.

Current human energy consumption, at $\sim 10^{21}$ J annually (Simmons 1990), is impressive on these scales, and is reflected in the global-scale modifications humans make to the planet's topography, through construction work, mining, etc., and to the composition of its atmosphere, through industrial and agricultural emissions.

Our current weapons systems too can deliver energies comparable to some natural phenomena. The first atomic bomb used in warfare in 1945 (Malik 1985) delivered energies comparable to earthquakes of order $\sim$4 on the Richter scale. Of a similar order of magnitude was Minor Scale, a test in 1985 by the US Defence Nuclear Agency, described as the largest planned conventional explosion in history; it released $\sim$4.2 kT of TNT equivalent (Tech Reps 1986). The largest nuclear detonation was of the USSR's 'Tsar' bomb in 1961, at 50 MT (Nuclear Weapons Archive 2013).

As the table indicates the use of individual weapons of this kind can cause devastation on the scale of a city. By comparison it is estimated that a 12-hour

all-out nuclear war would release energies in excess of ∼1 GT, a catastrophe on a global scale comparable to the energy released by the largest volcano (Simmons 1990). We may not yet, however, be capable of inflicting on the Earth an extinction-level event such as was inflicted by the Chicxulub impact (Alvarez et al. 1980).

12.3.3 Future Weaponry

Moving away from the Earth, even our current presence in space requires an energy investment on a significant scale. The largest structure yet assembled in space is the International Space Station, currently massing some 419 tonnes (NASA 2013a); the kinetic energy due to its orbital velocity is equivalent to ∼3 kT of TNT.

This energy will be dwarfed by the kinetic energies of the interplanetary craft of the future. VISTA (Orth 1990) was a 1998 study by the Lawrence Livermore National Laboratory, US, of a manned interplanetary transport using an inertial confinement fusion propulsion system. It was quoted as being capable of a round trip to Mars in ∼130 days, and to Jupiter in ∼402 days—an average velocity of ∼40 km/s. With a dry mass of ∼1,800 t the KE involved represents an order of magnitude more than the Hiroshima bomb. A more advanced interplanetary craft of similar dry mass but capable of 1 % of the speed of light, ∼3,000 km/s, and thus able to make a round trip to the outermost planet Neptune in ∼35 days, would have a KE equivalent to an order of magnitude more than the energy released in an all-out nuclear war. Looking beyond the solar system, the 1970s 'Daedalus' design study (Bond et al. 1978) described a one-way unmanned interstellar probe using a similar fusion propulsion system to VISTA's; the probe would accelerate a payload of ∼450 t to a velocity of 12 % of lightspeed, a KE two orders of magnitude greater than VISTA to Neptune.

It can be seen that a VISTA-like Mars transport could be used to destroy a city on Earth, or a domed colony on Mars or the moon, with an energy equivalent of a nuclear weapon of power ∼1 MT by simply being crashed onto the settlement. Similarly the crash of an outer solar system transport could inflict global damage on the Earth.

Even the energies of relatively near future interplanetary craft, however, pale into insignificance compared to what may be possible for truly advanced space-faring civilisations. Kardashev (Shklovskii and Sagan 1966) gave a useful classification of hypothetical civilisations based on their energy usage. A Kardashev Type K-1 'planetary' culture would be capable of capturing the total solar flux incident upon its world. On Earth the flux at the top of the atmosphere (Simmons 1990) is 175,000 TW. (Our modern energy usage falls orders of magnitude short of this, at a mere 30 TW.) Table 12.1 indicates that this is two orders of magnitude more than the energy delivered by the end-Cretaceous killer impact (Alvarez et al. 1980). That is, it would require only the equivalent of a few days' energy supply for such a culture to inflict an extinction event on a planet.

Looking even further ahead, a Type K-2 culture would be capable of capturing the entire output energy of a star. This perhaps represents the upper bound of the energy usage of an interplanetary culture. It would require only 12 days of the sun's energy output (NASA 2013b) to dismantle Earth entirely (Dyson 1996).

12.4 Discussion and Conclusions

The huge energies routinely deployed by a culture capable of interplanetary travel on a large scale would make war potentially hugely damaging. The KE of a Mars transport craft would be equivalent to a 1 MT nuclear weapon, and presumably would be capable of inflicting great damage on a surface colony on a world like the moon or Mars, or indeed on a space habitat of the O'Neill kind. A craft capable of fast transport to the outer planets would acquire a KE comparable to a major nuclear war, or to a significant asteroid strike, and could inflict global damage on the Earth. The upper bound of the energy usage of an interplanetary culture is the capture of all the sun's output energy; to such a culture it would be trivial to inflict an extinction event.

A planet robustified against natural disasters may to some extent be relatively resilient to disasters of a similar magnitude inflicted artificially, through such means as deep-buried communications systems, distributed command nodes and stores, heavily backed up information systems, and transport systems with built-in redundancy. There have been studies of the use of space-based resources to mitigate such disasters (Hempsell 2004). It may in fact be possible to protect planet Earth to some extent against attacks from space by an extension of such systems as asteroid deflection systems—although an attack coming from beyond the plane of the ecliptic could well evade counter-measures positioned to deflect or destroy natural impactors.

Recently however Robinson, in the novel *2312* (Robinson 2012) has suggested that with sufficient computational power even the most elaborate of planetary defences might be evaded. In the year 2312, there are tensions between a post-scarcity space culture and an impoverished, post-climate-collapse Earth (p. 307). However, 'there's never been… a war in space. We've managed without them' (p. 224). Now, however, a colonised asteroid is cracked open by an evidently purposeful impact (p. 218), and a mobile city on the surface of Mercury is attacked—but without apparent evidence of an incoming impactor, which if detected might have been deflected or avoided (p. 135). In the end it emerges that rebellious AIs called 'qubes', intent on deflecting human history, have found a way to assemble virtual impactors by sending swarms of pebble-sized rocks, each below detection level, on long trajectories across the solar system, their orbits carefully calculated to combine at the impact point: 'So ten thousand little rocks [are] thrown downstream, over a matter of months or years, with such directions and velocities that they all arrive at one spot at the same time' (p. 221).

However, such is the ease of inflicting enormous damage through an attack from space, and such is the short-term fragility of the biosphere of Earth to disasters of such magnitude, as the historic, geological, fossil and other records show, it is hard to imagine that the planet and its cargo of life, including the human, could ever be adequately protected in the event of an interplanetary war. Colonies in space and on other worlds would be still more vulnerable to attacks from space.

Our conclusion is that human affairs in an extraterrestrial context cannot be conducted through warfare, which is more likely to destroy the contending cultures and perhaps extinguish mankind altogether than to lead to any desirable political outcome. Therefore, although wars of revolution have historically been a means of rebellion by cultures in search of liberty on the Earth, they will not be feasible or desirable in an interplanetary context. It follows that an interplanetary political framework that guarantees colonial liberty without recourse to conflict needs to be established. One possibility might be an interplanetary federal system, that incorporates Earth colonies into a future federal world government on Earth ((Crawford 1995), see also Chap. 10 in this volume). Although this might be seen as an additional constraint on extraterrestrial liberty, it seems that something along these lines will be required if a technological civilisation is to persist in the solar system.

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Chapter 13
Interplanetary Federalism: Maximising the Chances of Extraterrestrial Peace, Diversity and Liberty

Ian A. Crawford

Abstract I propose that a federal system of government, able to implement the principle of subsidiarity on interplanetary scales, will be the most appropriate form of political organisation to guide the future colonisation of the Solar System. Only a federal system will simultaneously satisfy the three key criteria of (1) accommodating and protecting social and cultural diversity among Solar System colonies; (2) minimising the risk of conflict between these diverse colonies and with the Earth; and (3) protecting the rights and liberties of individual human beings throughout the Solar System. No other form of political organisation is likely to leave humanity in a better position to exploit the opportunities, and minimise the risks, associated with building a Solar System-wide civilisation.

Keywords Federalism · World government · Interplanetary government · Interplanetary peace · Extraterrestrial liberty

> *Governments and States are provisional things, and they can be and must be modified to meet the change and expansion of human needs.*
> H.G. Wells (1922, p. 308)

> *Since society is essentially federal in nature, the body which seeks to impose the necessary unities must be so built that the diversities have a place therein.*
> Harold Laski (1967, p. 270)

13.1 Introduction

Baring a major catastrophe in the near future, it appears likely that in the coming centuries humanity will gradually expand outwards from Earth into the Solar System. Among many other considerations, it follows that it will become

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increasingly important to identify the forms of political organisation able to maximise the opportunities, and minimise the risks, that will be presented by human activities in this new environment. Key political objectives include encouraging cultural diversity among human colonies throughout the Solar System, while at the same time minimising the risk of military conflict between them, and protecting the rights and liberties of individual colonists. With regard to the latter point, Cockell (2009, 2010) has drawn attention to the risk that extraterrestrial settlements may inexorably slide into (at least locally) totalitarian forms of government. It is very important, both for the future well-being of humans living in space and for the general peace of the Solar System as a whole, that this tendency be countered by a strong (and necessarily Solar System-wide) liberal-democratic political framework.

In this Chapter I will argue that the principle of federalism, as pioneered by the eighteenth century founders of the United States of America, provides the most viable long-term political solution to the problem of peaceably combining cultural diversity with individual liberty over large spatial scales. Liberal-democratic federal forms of government have already been demonstrated to function efficiently on continental scales (e.g. in the United States, Canada, India, and increasingly, although not yet completely, in Europe), and I will argue that the concept is inherently (and probably uniquely) expandable to planetary and inter-planetary scales. As such, federalism appears to be the most appropriate form of political organisation for a Solar System-wide civilisation.

13.2 The Nature of Federalism

In his influential discourse on political institutions, *The Spirit of the Laws*, Montesquieu (1748, p. 131) defined federalism thus:

> This form of government is an agreement by which many political bodies consent to become citizens of the larger state that they want to form. It is a *society of societies* that make a new one, which can be enlarged by new associates that unite with it (My italics).

As defined here, it is left ambiguous as to whether the 'citizens' of a federation are the pre-existing 'political bodies' acting in a corporate capacity, or the actual, individual, human citizens of these constituent bodies. In modern usage we would now strictly identify the former arrangement, made between essentially sovereign states, as a *confederation*. Examples include the 'Articles of Confederation and Perpetual Union' under which the 13 original American states (formerly colonies) organised themselves between 1781 and 1789, the League of Nations (1919–1946), and today's United Nations (established 1945). On the other hand, the term *federation* is now usually reserved to describe political systems where sovereignty is divided between both state and central governments, and where, following the

democratic imperative identified by Locke (1689),[1] individual citizens are represented in both. The competencies of the two (or more) levels of government are usually specified in a written constitution, as a modern definition of federalism (Miller 1987, p. 131) makes clear:

> A constitutional system of government is federal if law-making powers are divided between a central legislative body and legislatures in the states or territorial units making up the federation. Citizens are thus subject for different purposes to two different bodies of law …. The allocation of powers derives from the constitution and cannot be unilaterally changed by either set of legislators.

The present constitution of the United States of America (adopted in 1789, but developed by the constitutional convention held in Philadelphia over the summer of 1787) is the archetypal federal constitution in this sense. As James Madison (1751–1836), one of the constitution's founding fathers, and later the 4th President of the United States, made clear at the time:

> The federal and State governments are in fact but different agents and trustees of the people, constituted with different powers and designed for different purposes (Madison 1788a, p. 294).

As usually understood today, federalism is also closely associated with the *principle of subsidiarity*, i.e. that "a central authority should have a subsidiary function, performing only those tasks which cannot be performed effectively at a more immediate or local level" (OED 2013). That is, the 'different purposes' of the different levels of government identified by Madison are defined such that decisions are taken at the most effective and appropriate level, with local decisions being taken locally, state-wide decisions being taken at state level, and only decisions that affect all the member states being taken by the federal government. Again, the precise division of powers will be specified in a written constitution.

Despite the evolution of the concept of federalism that has occurred since Montesquieu's day, one aspect of his original definition remains highly relevant to the present discussion—federations are inherently *expandable*. This intrinsic property of federalism is shown very clearly by the expansion of the US federal government from the original 13 states, all clinging to the eastern seaboard of North America, to include 35 new states established in the interior of the continent as the frontier of American colonisation moved westwards to the Pacific. Then in 1959 the US federation was extended to include two new states, Alaska and Hawaii, that are not contiguous with the other 48, and one of which, Hawaii, is not even part of the North American continent.

This potential for growth, and the importance of designing a constitution able to accommodate it, was recognized in the original framing of the US constitution. This was made clear by James Wilson (1742–1798), a Pennsylvanian delegate to the

[1] For example *Second Treatise of Government*, Paragraph 212: "When any one, or more, shall take upon them to make laws, whom the people have not appointed so to do, they make laws without authority, which the people are not therefore bound to obey."

federal convention, and later a US Supreme Court judge, speaking at Pennsylvania's ratifying convention in November 1787:

> …the task entrusted to the federal convention, whose prospects were not only to 13 independent and sovereign states, some of which in territorial jurisdiction, population, and resource equal the most respectable nations of Europe, but likewise to innumerable states yet unformed, and to myriads of citizens who in future ages shall inhabit the vast uncultivated regions of the continent. The duties of that body therefore were not limited to local or partial considerations, but to the formation of a plan commensurate with a great and valuable portion of the globe (Wilson 1787, p. 138).

Although the idea would doubtless have astonished James Wilson, in the present context it is worth pointing out that his observation regarding the territorial expandability of the federal constitution can be extrapolated off the 'globe' of the Earth altogether. As far as the operation of the federal government is concerned, the state of Hawaii could just as easily be a US colony on the Moon or Mars as a group of islands in the middle of the Pacific Ocean (we will return to the implications of this perspective in Sect. 13.5).

Wilson's speech to the Pennsylvania ratifying convention also highlights something else of importance when considering the development of new federal constitutions. To the framers of the US constitution the original 13 members were "independent and sovereign states" that, in order to ensure a more efficient government among themselves, voluntarily ceded part (but only a limited and carefully defined part) of their sovereignty to the newly formed federal government. Today, as the US federal government has gradually evolved into something approaching a unitary national government such as we are familiar with in Europe, it is easy to lose sight of the importance of this key political innovation. But this ability to unite proud and independent political entities into a common, and inherently expandable, political structure for the common good is a key aspect of federalism. As Wells (1922) observed in his inspirational and insightful *A Short History of the World*:

> We call the United States a country just as we call France or Holland a country. But the two things are as different as an automobile and a one-horse shay … The United States in scale and possibility is halfway between a European state and a United States of all the world….

As Wells foresaw, by eventually placing the resources of a continent-sized landmass under the control of a single political authority, the federal principle has enabled the United States to undertake projects that are utterly beyond the capabilities of small, European-style, nation-states. Indeed, everything that the US has achieved as a superpower (including of course its space programme) ultimately rests on the federal constitution worked out at Philadelphia in 1787. Moreover, and this is especially important in the context of this book, the federal principle has allowed the US to reach its present level of global economic and political dominance while maintaining a democratic form of government which actively protects the political freedom of its citizens. By any standards this was, and is, a remarkable political achievement. Indeed, the success of US federalism, as a solution to the problem of governing large and diverse areas while maintaining democratic governance, is further demonstrated by the 'copycat' development of other continental-

sized federations. The most notable examples being those of Canada (established 1867), Australia (1901), India (1950), and most recently, but perhaps less happily from a democratic standpoint, Russia (1993).

Perhaps the biggest missed opportunity in the history of federalism to-date was the failure of the Spanish and Portuguese colonies in South America to federate along the lines of the US model, despite apparently having much in common as regards colonial history, language, and religion (the latter, at least, being more homogeneous in South than in North America during colonial times). It seems clear that South America would be better off today, and would have had a happier history regarding the rights and freedoms of those who live there, had a democratic South American federation been achieved. Probably the failure of South America to federate can be put down to the fact that the constituent states were already too large, and too geographically dispersed over the continent, for unified political action to be possible at the time of decolonisation. Still, the South American example contains several important lessons. Firstly it acts as a mirror to show what North America might look like today had the US federal constitution not been ratified in 1789 (with enormous, and as far I can see entirely negative, implications for subsequent world history); secondly, it shows that, despite clear economic and political benefits, there is nothing inevitable about federalism, even in areas sharing a similar culture and historical experience—federations have instead to be actively created through the application of political will; and, thirdly, timing is crucial—if the requisite political will is not applied at the beginning, before the constituent states evolve too far down their individual paths towards political independence, achieving federation will become increasingly difficult regardless of manifest political and economic advantages. This last consideration is likely to be especially important in the context of interplanetary federalism, as discussed in Sect. 13.5.

Before leaving this historical discussion of federalism, and moving on to future possibilities, it is necessary to consider the significance of federal innovations currently taking place in Western Europe. Over the centuries, the presence of so many independent nation-states existing within so small an area has cause nothing but trouble for Europe, and it has long been recognized that the continent would benefit from some kind of unified government (Heater 1992). Following the Second World War, through the vision of Jean Monnet (1888–1979), Robert Schuman (1886–1963), Konrad Adenauer (1876–1967), Paul-Henri Spaak (1899–1972), Altiero Spinelli (1907–1986) and many others, and through the gradual evolution of pan-European institutions from the European Coal and Steel Community (1952), the European Economic Community (1958) and the European Union (1993), Europe has been gradually inching towards a federal solution to problems caused by its historical disunity.

The European Union is of course not (yet) a federal United States of Europe on the US model, having more a confederal than a federal structure with national governments mostly represented in their corporate capacities. Nevertheless, the existence of a written constitution (currently the Lisbon Treaty which entered into force in 2009) specifying the division of powers between the decision-making institutions of the Union and the member states, the explicit recognition of the

principle of subsidiarity (in Article 3(b) of the Treaty[2]), a single currency (albeit one that several member states have so far chosen not to join) and, especially, the establishment of a directly elected European Parliament, have all introduced some genuinely federal aspects into its organisation.

This is important because, while the US experience demonstrated that federalism can unite large geographical areas given a relatively homogeneous starting population, Europe has the potential to demonstrate that a federal form of government can also unite many different nations, speaking many different languages, and having a long history of conflict. Indeed, if federalism can be shown to work in Europe, where the modern nation-state was invented (in the aftermath of the collapse of the Roman Empire), there is every reason to believe that it can work anywhere.

13.3 Federalism as a Protector of Peace, Diversity and Liberty

The greater the number independent sovereign states occupying a given area (be it a continent, a planet, or even, in the context of this book, a planetary system), with each state pursuing its own perceived self-interest and acting as judge in its own cause, the greater will be the likelihood of conflict occurring between them. Preventing future military conflict between the recently independent American states was therefore a key consideration in the framing of US federal constitution, as Hamilton (1788a, p. 54) makes clear in *The Federalist Papers.*:

> A man must be far gone in Utopian speculations who can seriously doubt that if these States should either be disunited, or only united in partial confederacies, the subdivisions into which they might be thrown would have frequent and violent contests with each other. … To look for a continuation of harmony between a number of independent, unconnected sovereignties situated in the same neighbourhood would be to disregard the uniform course of human events, and to set at defiance the accumulated experience of ages.

Federal forms of government therefore promote peace by integrating previously independent sovereignties into a single political framework within which political differences can be addressed by legal and constitutional means rather than through military conflict. The contrast between the internal histories of the federated United States of America (and also Canada) with the un-federated nations of South America is again instructive in this regard. In the post-colonial period the latter have been racked by more than twenty-five inter-state and civil wars (Wikipedia 2013),

[2] Treaty of Lisbon (2009), Article 3(b), Paragraph 3: "Under the principle of subsidiarity, in areas which do not fall within its exclusive competence, the Union shall act only if and insofar as the objectives of the proposed action cannot be sufficiently achieved by the Member States, either at central level or at regional and local level, but can rather, by reason of the scale or effects of the proposed action, be better achieved at Union level." http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1408652989843&uri=CELEX:C2007/306/01

while the United States has suffered only one (albeit almost catastrophic) civil war over an issue that was left unresolved by the constitution. And the bloody history of the continent of Europe speaks for itself, and is a major reason why moves towards European political integration are so important.

The principal topic of this book, however, concerns liberty rather than peace per se, and here again one of the principal benefits of federalism becomes apparent: it is the only known political system which is able to accommodate both cultural diversity and individual political liberty under a single government. As we have seen, federal forms of government are able to accommodate diversity by integrating pre-existing political units (e.g. colonies, states, nations), each possibly having a distinctive culture, into a political union operating according to the principle of subsidiarity. They are able to protect liberty by ensuring that individual citizens are directly represented in *both* the federal and the state (and often also local) governments. Moreover, federal governments generally operate according to a written constitution which explicitly guarantees individual political freedoms, and which also instigates checks and balances between the different levels and organs of government so as to minimise the risk of usurpation by illiberal and non-democratic forces (e.g. Mayerfeld 2011).

Again the US federal constitution provides an example, because preserving the liberty of individual citizens was a major preoccupation of the drafters of that document. Initially it was felt that, as each member state already had a 'republican' form of government (which was as democratic as things got in the eighteenth century), all that was necessary was for the federal constitution to ensure continued republican government in the states. Thus, Article IV, Sect. 4, of the US Constitution states that:

> The United States shall guarantee to every State in this Union a republican form of Government, and shall protect each of them against invasion; and …. against domestic [i.e. intra-state] violence.

Shortly thereafter, however, it was realised that this formulation may not have gone far enough to protect the rights of individual citizens, and in 1791 the first ten amendments (the so-called 'Bill of Rights') were ratified, of which the first famously states:

> Congress shall make no law respecting an establishment of religion, or prohibiting the free exercise thereof; or abridging the freedom of speech, or of the press; or the right of the people peaceably to assemble, or to petition the Government for a redress of grievances.

In Europe similar liberties are protected by the European Convention on Human Rights, which was established by the Council of Europe in 1950 and entered into force in 1953. While not originally a component of European political integration (having been signed by many more European nation-states than are currently members of the EU), the European Convention on Human Rights nevertheless

become a key guarantor of individual rights within the European Union following ratification of the Lisbon Treaty in 2009.[3]

Thus, by providing legal underpinning for the protection of basic freedoms, federal systems of government make enforcement of such freedoms easier than would be possible through treaties between independent states, which ultimately are not enforceable without military conflict. This is not to say that such constitutional rights are always upheld even within well-functioning constitutional democracies,[4] only that civil rights are better protected by the existence of such constitutional protections than they would be without them.

13.4 World Federalism

Given the inherently expandable nature of federalism, and the demonstrable practical and political benefits it has conferred on continental scales, and before moving on to consider even larger extraterrestrial scales, it is worth pausing to consider if the federal principle might be extended to include the Earth as a whole. Would a federal *world government* be possible or desirable?

There are in fact many compelling reasons for believing that some form of world government is indeed desirable, and the idea has long been discussed by historians, statesmen and political philosophers (e.g. Kant 1795; Russell 1916; Wells 1922; Reves 1946; Laski 1967; Toynbee 1972; Kerr 1990; Converse 2010; Cabrera 2011; a scholarly historical discussion is given by Heater 1996). The desirability of world government stems primarily from the fact that Planet Earth has many problems that can only be effectively addressed at a global level. Examples include: (i) an essentially anarchic international environment where heavily armed nation-states act as judges in their own cause (making military confrontation and the attendant waste of lives and resources all but inevitable); (ii) global environmental pollution

[3] Treaty of Lisbon (2009), Article 6, Paragraph 2: "The Union shall accede to the European Convention for the Protection of Human Rights and Fundamental Freedoms." And Paragraph 3: "Fundamental rights, as guaranteed by the European Convention for the Protection of Human Rights and Fundamental Freedoms and as they result from the constitutional traditions common to the Member States, shall constitute general principles of the Union's law".

[4] Recent revelations that the US National Security Agency has been indiscriminately harvesting telephone and internet records of millions of US citizens imply that constitutional protections of privacy, or at least the *spirit* of those protections, are currently being ignored by the executive branch of the federal government. The 4th Amendment clearly states that: "The right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated, and no Warrants shall issue, but upon probable cause, supported by Oath or affirmation, and particularly describing the place to be searched, and the persons or things to be seized." Hopefully, the checks and balances built into the US federal system will ensure that the protections guaranteed by the 4th Amendment are soon restored, as this will demonstrate the proper functioning of the federal constitution as envisaged by its founders. The alternative would presage a slide into totalitarianism by the world's oldest constitutional democracy, and does not bear thinking about.

(including man-made contributions to climate change); (iii) global habitat destruction and loss of biodiversity; (iv) large-scale global threats (such as the risks of global pandemics, mega-volcanoes and asteroid impacts); (v) long-term development challenges (including the provision of sufficient food and water, and the satisfaction of legitimate aspirations for higher living standards, for a growing world population; and (vi) inefficient, and often irresponsible, management of the global commons, including the resources of the seas (both fisheries and seabed resources), the Antarctic continent, and, especially relevant to the topic of this book, outer space.

Attempted solutions to these problems based on voluntary agreements between independent nation-states have proved to be largely ineffective, for the simple reason that the perceived self-interests of these independent sovereignties are in conflict. Therefore, as Heater (1996, p. 205) succinctly puts it:

> Individual states are at best powerless to prevent wars and environmental degradation, at worst they are the cause of these disasters. Only effective world government can protect mankind from these hazards.

But if the world needs a government it remains necessary to determine the *form* of government that would be best matched to its needs. While there is a powerful case for a global government that can deal with global problems at a global level, it would be unnecessary (and indeed unwise) to disrupt existing, and generally well-functioning, government at national and local levels. Moreover, given the extent to which the (I would argue pernicious) ethos of nationalism dominates global politics, it would be quite impractical (and in fact counter-productive) to dissolve existing national governments in favour of a world government. Therefore, the best we could realistically hope for would be the establishment a *federal* world government, built from the agreement of the existing nation-states, and operating in accordance with the principle of subsidiarity extended to the global stage. This is the essence of the concept of *world federalism*, which seeks to:

> invest legal and political authority in world institutions to deal with problems which can only be treated at the global level, while affirming the sovereignty of the nation-state in matters which are essentially internal. (WFM 2005).

It is notable that Madison (1788b, p. 277), reflecting on the wider implications of the US constitution, came close to advocating just such a federal solution to the world's political disunity when, writing in *The Federalist Papers*, he expressed the opinion that:

> Happy would it be if such a remedy …. could be enjoyed by all free governments; if a project equally effectual could be established for the universal peace of mankind!

And, just a few years later, Immanuel Kant (1795, p. 117) made the case more explicitly:

> Reason can provide related nations with no other means for emerging from the state of lawlessness, which consists solely in war, than that they give up their savage (lawless) freedom …. and, by accommodating themselves to the constraints of common law,

> establish a *nation of peoples* (*civitas gentium*) that (continually growing) will finally include all the people of the earth (Kant's italics).

The technical practicality of such a world federation is not in doubt—given modern communications and transport capabilities Planet Earth is, in any meaningful practical sense, already far smaller than the area united by the US constitution in 1789. Whether or not such a global federation is *politically* possible in the near future is of course more doubtful. As noted above, much depends on the outcome of the European experiment—if federalism can be shown to work in Europe, with its multitude of nations, languages, and history of internecine conflict, then there is hope that it might be extended to global scales. On the other hand, if the European experiment fails there would be grounds for pessimism concerning our ability to develop international government on any significant scale. This in turn would leave the human race without the political tools to deal effectively with the serious global challenges that we will face in the future.

Daunting though the political obstacles to world federalism undoubtedly are, there may nevertheless be grounds for optimism in the context of a future which includes a significant element of space exploration and development. There are several reasons for this, but perhaps the most important is simply the psychological impact of a growing 'cosmicization' of world views. A society that is rigorously exploring the Solar System, and building colonies on the Moon, Mars, and asteroids (which is the societal backdrop on which the topic of this book is predicated), can hardly fail to be aware that the Earth is a very small planet when viewed in its cosmic setting. This is a perspective that astronauts have often mentioned, and it is worth quoting one here (Schweickart 1977):

> You look down there and you can't imagine how many borders and boundaries you cross, again and again and again, and you don't even see them. There you are—hundreds of people in the Mid-East killing each other over some imaginary line that you're not even aware of …. And from where you see it the thing is a whole, and it's so beautiful. You wish you could take one in each hand, one from each side in the various conflicts, and say, 'Look. Look at it from this perspective…'.

The greater the number of people who go into space, and who know people who live and work in space, and the more commonplace images of Earth from space become, from ever greater distances, the wider this perspective must diffuse through global society. One may expect that increasing awareness of this cosmic perspective will gradually gnaw at the minds of political leaders, and those whom they represent, and lead to the (in part purely emotional) realisation that in some sense Planet Earth *ought* to be politically unified.

Moreover, there are also very real practical considerations. For one thing, space development will require the establishment of legal and political mechanisms for the management of extraterrestrial raw materials and, as we have seen above, these naturally fall into the category of global 'commons' that are beyond the competence of individual national governments to manage. Even more seriously, any significant programme of space exploration and colonisation will inevitably require the use of energy sources (e.g. nuclear power and propulsion), and very likely the ability to

manipulate the orbits of asteroids, that will be potentially dangerous to Earth's inhabitants. It seems most unlikely that these technologies could safely be deployed in space in the absence of a global legal and political regime capable of ensuring that they are not misused, and in particular that they cannot become military tools for one or more nation-states to threaten others. A world government able to effectively regulate the use of potentially dangerous space technologies would maximise humanity's safety in this respect. Last but not least, it is possible that only a politically united world, one that no longer has to spend a significant fraction of its wealth arming itself against itself, would be able to afford a large scale programme of space exploration and development in the first place.

For these reasons, I have suggested elsewhere (Crawford 1993, 1995a) that a symbiotic (strictly mutualistic) relationship may ultimately develop between space development and world government. On the one hand, a world government may need space development to provide the cosmic perspective on which part of its psychological legitimacy may rest, and also the space resources on which the world economy may increasingly come to depend (e.g. Martin 1985; Lewis et al. 1993), while on the other hand space exploration may need the funding and security that only a world government could provide. In this context it is also worth reflecting on the 'Golden Rule of Space Exploration' advocated by Hartmann et al. (1984, p. 182), viz:

> Space Exploration must be carried out in a way so as to reduce, not aggravate, tensions in human society. Each decision, each policy, must be tested against this principle.

If the development of the Solar System can indeed be carried out in this enlightened manner, aided by appropriate legal and political institutions, then it cannot but help the wider cause of human integration. As we have seen, there are multiple reasons why Planet Earth would benefit from an (ideally federal) world government quite unrelated to space exploration, but the socio-political implications of space development, and especially an increasing global awareness of the cosmic perspective, may in the future help tip the balance of the arguments in its favour.

13.5 Interplanetary Federalism

The initial phases of human colonisation of the Solar System will probably consist of establishing small scientific research stations on the Moon and Mars, commercially-driven activities around near-Earth and Main-Belt asteroids, and facilities in space (and possibly also on the surfaces of Moon and Mars) designed to cater for space tourism. Even in these early stages it will be necessary to develop a legal framework governing the activities of these outposts, and protecting the well-being of people living and working in them. We have argued above that dealing with extraterrestrial affairs on behalf of humanity as a whole would be a logical task for a future federal world government. However, even in the most optimistic view, it appears unlikely that a world government will exist during the earliest phases of

Solar System colonisation (i.e. over the next several decades), so the near-future regulatory regime will presumably have to be based on international treaties.[5]

Over time these small outposts are likely to grow into self-supporting colonies and the question of their governance will become increasingly important. It is however important to realise that the likely timescale for the evolution of extra-terrestrial outposts into self-sufficient colonies (probably a century or more) is of the same order of magnitude as that which we may expect for the gradual evolution of Earth's own political integration along federal lines. Indeed, one can foresee a situation in which the two strands of political evolution, terrestrial and extraterrestrial, proceed in parallel, and where, as noted above (see also Crawford 1993, 1995a), they co-evolve in a mutualistic manner towards a federal form of organisation able to encompass both Earth *and* her colonies. An intermediate stage in such a co-evolution between space activities and global governance might include the United Nations taking on more responsibility for space activities, while at the same time implementing a more federal form of international decision making (for example by the addition to, or replacement of, the existing UN General Assembly by a directly elected parliamentary assembly; e.g. Crawford 1994; UNPA 2013). One way in which a strengthened UN could play a significant role in space activities would be through the formation of a World Space Agency to coordinate space development on behalf of humanity as a whole (e.g., Crawford 1981; Katz 1985). Already, space exploration is becomingly increasingly internationalized (see the extensive recent review by Ehrenfreund et al. 2012), and the recently formulated Global Exploration Strategy (GES 2007) and Global Exploration Roadmap (International Space Exploration Coordination Group (ISECG) 2013) could perhaps form the basis of a genuinely global world space programme.

We have already noted that the principle of federalism is expandable to large spatial scales. It could certainly encompass the whole Solar System, across which

[5] Currently international activities in space are governed by the United Nations Outer Space Treaty (strictly the 'Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and other Celestial Bodies'), which entered into force in October 1967. Currently this treaty has 102 states parties, including all major space powers. Although it has served the international community well for much of the space age to-date, it is inadequate for dealing with issues that will soon be upon us. These include the exploitation of extraterrestrial raw materials; the regulation of space tourism; and, in the context of this book, the rights and liberties of the inhabitants of space colonies (which needless-to-say were not considered at the time the Treaty was formulated). Attempts to extend the reach of the 1967 Treaty (e.g. the 'Treaty Governing the Activities of States on the Moon and Other Celestial Bodies' of 1979, the so-called Moon Treaty) have not been very successful (the Moon Treaty has not been ratified by *any* major space power). It is therefore clear that there is a large area of international space law that will need to be developed if space activities in the first part of the 21st century are to be properly regulated (see, e.g., the thoughtful discussion by Goldman 1985). That such activities will need to be regulated can hardly be doubted, given the risk that some of them (e.g. changing the orbits of asteroids to better facilitate resource extraction) may pose a serious risk to Earth's inhabitants, and the more mundane consideration that private companies are unlikely to invest in space (either for resource exploitation or tourism) unless their investments are protected by an appropriate legal framework.

the communication timescale is at most a few hours, and where (depending on the transportation technology available in the future) the physical transit times might be only weeks or months—still effectively no larger, and in some senses smaller, than was the continent of North America in 1789. We have already noted that, as far as the functioning of the US federal government is concerned, the state of Hawaii could just as easily be a colony on another planet as a group of islands in the Pacific Ocean. Thus the technical feasibility of a Solar System-wide federal government, just as for a planet-wide federal government on Earth, can hardly be doubted. Moreover, a plausible evolutionary route towards such an outcome can be identified in a political context within which Earth itself evolves towards a federal form of organisation over the same timescale.

The *desirability* of a federal Solar System is of course a separate matter, and in my view rests on a straightforward extrapolation of the arguments for a federal Earth. Specifically, that only a federal solution will simultaneously satisfy the three criteria of (i) accommodating and protecting social and cultural diversity; (ii) minimising the risk of conflict between these diverse elements; and (iii) maximising the chances of individual and political liberty within the individual colonies. There are many potential forms of political organisation, ranging from anarchy to dictatorship, that could accomplish one or other of these objectives, but it seems to me that only a federal form of organisation could achieve all three at the same time, as we now discuss.

13.5.1 Accommodating Interplanetary Diversity

One of the potential societal benefits resulting from an expansion of humanity into space will be increased opportunities for the diversification of human culture, what John Stuart Mill (1859, p. 120) termed "different experiments of living", that may not occur on an increasingly culturally homogeneous Earth. Indeed, this was recognized by the philosopher Olaf Stapledon (1948) a decade before the space age had even begun, when, in a lecture to the British Interplanetary Society, he argued that:

> The goal for the solar system would seem to be that it should become an interplanetary community of very diverse worlds each inhabited by its appropriate race of intelligent beings, its characteristic "humanity"….. Through the pooling of this wealth of experience, through this 'commonwealth of worlds' new levels of mental and spiritual development should become possible, levels at present quite inconceivable to man.

Not unrelated, and certainly an additional cultural benefit of space exploration and colonisation, will be the increased opportunities for scientific discovery and intellectual stimuli of multiple kinds compared to what we could hope to experience by remaining on our home planet. This may go some way towards preventing the kind of intellectual stagnation predicted for 'the end of history' by the American political philosopher Francis Fukuyama (1992; see also Crawford 1993).

One might initially be tempted to argue that if maximising diversity is the principal social benefit to be expected from space colonisation then one should not seek to impose external political constraints of any kind on extraterrestrial colonies. However, a moment's thought will reveal that such interplanetary anarchy is not desirable; without some unifying political framework the disparate Solar System colonies could easily come to resemble Hamilton's (1788b, p. 73) nightmare vision of the thirteen American colonies in the absence of the federal constitution, i.e. split.

> into an infinity of little, jealous, clashing, tumultuous commonwealths, the wretched nurseries of unceasing discord and the miserable objects of universal pity and contempt.

Such an environment is unlikely to provide the kind of environment within which human intellectual and cultural potential would be maximised. Moreover, leaving aside the fact that numerous independent 'jealous, clashing, tumultuous' colonies would significantly increase the risk of interplanetary conflict (the implications of which are discussed separately below), if humanity as a whole is to benefit from the fruits of interplanetary diversity then some form of interplanetary organisation will be required to integrate all these different experiences. This led Stapledon (1948) to propose his concept of a 'commonwealth of worlds'. Stapledon did not explicitly address the political organisation of this 'commonwealth', but a federal arrangement that applies the principle of subsidiarity on interplanetary scales, and thereby explicitly protects colonial diversity, would appear to be the most appropriate arrangement (see also Crawford 2012).

13.5.2 Preventing Interplanetary War

Although interplanetary cultural diversity is desirable, interplanetary anarchy and conflict are not. As discussed by Baxter and Crawford elsewhere in this volume, the energies available to a spacefaring civilisation (even considering only the kinetic energies of space vehicles and of small asteroids whose orbits may be manipulated) are such that, if used aggressively, the continued habitability of the Earth, and the very survival of its colonies, would be at stake. It therefore follows that interplanetary cultural diversity will need to be managed within some kind of appropriate political structure that minimises the risk of conflict.

Again, there are a number of potential political arrangements that might achieve this objective, of which the most secure might be a totalitarian control of space activities by Earth-bound institutions (e.g. by a future world government). However, a totalitarian, essentially imperial, model is not a desirable solution to the problem of interplanetary peace, for at least three reasons: (i) such a model is unlikely to permit the kind of colonial cultural diversity that we have already identified as desirable; (ii) it will by definition limit the extent of personal and political freedoms enjoyed by the individual colonists, which is something we wish to promote; and (iii) for this very reason it is likely to promote a colonial backlash against the central government and thereby increase the risk of conflict.

We have already seen (Sect. 13.3) that minimising the possibility of war is one of the key benefits of federal forms of government. This is achieved because federations both reduce the number of independent sovereign states, and thereby the opportunities for conflict between them, *and* provide legal and constitutional mechanisms to resolve differences without the perceived need to resort to violence. This will be as true on interplanetary scales as it is on planetary and sub-planetary scales. However, there is an important lesson from Earth history: if the risk of wars of independence is to be avoided it will be important to establish a framework for interplanetary federation *before* the colonies become self-sufficient and begin to see themselves as potentially independent political entities. Had Great Britain managed to create a (necessarily federal) political union with its American colonies prior to 1776 (such that there *was* representation regarding colonial taxation, for example) then the US Revolutionary War might have been avoided. Similarly, had South America managed to adopt a federal form of government on the US model before its newly independent nation-states diverged too far for this to be practical, then its post-colonial history would probably have been happier and its economy far stronger. Therefore timing is important, and the groundwork for interplanetary federalism will need to be developed in parallel with the earliest phases of Solar System colonisation.

Just to reinforce this latter point, it is instructive to imagine what the Solar System may be like if we fail to develop appropriate unifying political institutions at an early stage. The science fiction author Kim Stanley Robinson has envisaged just such a Solar System-wide society of the 24th Century and reflects on the (fictional) historical observation that:

> One mistake was that no generally agreed-upon system of governance in space was ever established. That repeated the situation on Earth, where no world government ever emerged. Balkanization became universal; and one aspect of balkanization was a reversion to tribalism, notorious for defining those not in the tribe as not human, sometimes with terrible results. It was not a good structure of feeling for a civilisation spanning the Solar System and wielding ever-greater [power] (Robinson, 2012, p. 337).

13.5.3 Maximising Interplanetary Liberty

We turn now to the main theme of this book. Historically, discussions regarding the colonisation of other planets have tended to assume that the process would enhance human liberty by allowing minority or persecuted groups on Earth to escape and build new lives elsewhere in the Solar System. The non-conformist colony established by the Pilgrim Fathers in 1620 at present-day Plymouth, Massachusetts, is an oft-cited example. Indeed, building on this example, and referring to the work of O'Neill (1976) on self-supporting space colonies, Dyson (1979, p. 126) articulates this vision thus:

> O'Neill and I have a dream, that one day there will be a free expansion of small groups of private citizens all over the solar system and beyond.

At first sight this appears to be a noble dream, until we recall Hamilton's (1788b) warning, quoted above, about the dangers of colonial anarchy. Indeed, in this context, it is appropriate to reflect on the fact that today the good citizens of Plymouth, Massachusetts, are infinitely better off securely embedded within the federal constitution that was devised 150 years after their colony was founded than they would be had the state of Massachusetts chosen to remain outside it.

Moreover, as Cockell (2009, 2010) has pointed out, the dream of colonial 'freedom' could easily turn into a nightmare if the socio-political arrangements are not handled with care. This is because, at least for the foreseeable future, the physical environment of space colonies (small, cramped, and entirely dependent on life support equipment) will naturally lend itself to totalitarian forms of governance. Not only will the ability to switch life support machinery on and off at will give the governors of these colonies (whether individuals or groups) immediate power over life and death, but the vulnerability of the survival of such colonies to potentially harmful unauthorised activities of multiple kinds will in certain respects *demand* authoritarian forms of governance.

The prospect for personal liberty in isolated space colonies therefore appears rather bleak. Even if established on liberal democratic principles, if left to their own devices colonies could easily slip into totalitarianism. However, as Converse (2010), in his study of the lessons of the US constitution for world federalism, has rightly pointed out:

> the liberty of any given society of people depends, to a great degree, upon the institutions that exist, or they create, to protect it.

Getting the legal and political institutions right is therefore essential. The simplest institutional way to minimise the risk of a slide into totalitarianism would be to ensure that all such colonies are, *from the start*, embedded in a larger political framework that guarantees individual rights and liberties in a manner that the local governors of these colonies would find hard to overturn. As we have seen above (Sect. 13.3), this is something that federal forms of government are naturally able to do for their constituent states, and it was a key consideration in the framing of the US constitution (and the subsequent ratification of the Bill of Rights[6]). By way of analogy, consider that, even though geographically isolated from the other states of the Union, it would today be politically impossible for the state of Hawaii to implement policies that violate to the First Amendment. There is no reason why a suitably constituted interplanetary federation could not guarantee similar rights for its members.

[6] Especially Amendments I and IV through X; clearly, Amendment II would not be helpful in an interplanetary context, and Amendment III seems hardly relevant. Of course, any actual interplanetary Bill of Rights would have to be constructed so as to be relevant to the particular social and physical conditions within which individual rights are to be protected.

Cockell (2010) has given a lot of thought to minimising the risk of extraterrestrial tyranny, and has come to essentially the same solution. Thus he writes:

> Eventually the link between the Earth and other settlements, as well as the relationship between those settlements, might be governed by some kind of League of Worlds …. Such an organisation would promulgate the general philosophy of liberty-seeking, *whilst still allowing each planetary body or place in space to work on the emergence of its own brand of liberty, under its own specific set of challenges.* By nurturing links between all settlements and the Earth, it would serve many political and economic purposes….. (Cockell 2010; my italics).

This is of course an essentially a federal solution, where the phrase I have italicised above implies the operation of the principle of subsidiarity on interplanetary scales. If properly constituted, in addition to helping to maximise extraterrestrial liberty such a 'League of Worlds' could indeed 'serve many political and economic purposes', not least minimising the risk of interplanetary war (Sect. 13.5.2) and maximising the cultural benefits of interplanetary diversity (Sect. 13.5.1; in which context it would fulfil the role already envisaged by Stapledon's 'Commonwealth of Worlds').

However, in order to maximise all these socio-political benefits, it is important that the phrase 'League of Worlds' be interpreted as a true federal government (in the sense described in Sect. 13.2). What the Solar System does not need, and what all experience tells us would ultimately prove to be disastrous, is a weak *confederal* structure along the lines of the ill-fated League of Nations. History has taught us that these are not effective (other failed examples include the US Articles of Confederation (1781–89) and, it has to be said, the United Nations since 1945). Only a democratic federal government, with constitutional provision for appropriate implementation of the principle of subsidiarity, is likely to be sufficiently robust to be both long-lasting and effective.

13.6 Conclusions

As Aristotle (350 BCE) pointed out long ago "man is by nature a political animal", and we regulate our affairs through our political institutions. It follows that, as humanity moves out into the Solar System, we will have to design and implement political institutions appropriate to our operations and well-being in this new environment. Foremost among these institutions will be forms of government able to simultaneously maximise the opportunities for peace, diversity and liberty within the extraterrestrial realm. I have argued here that only a democratic federal form of government, constitutionally applying the principle of subsidiarity on interplanetary scales, will be able to simultaneously satisfy all three of these requirements. I have further suggested that such an interplanetary federation may grow out of, and perhaps co-evolve with, a federal world government on Earth for which strong arguments can also be identified.

It is important to realise that federalism is not a panacea for human happiness, either on Earth or beyond. Forms of government can only go so far in that respect, and much will in any case depend on the particular constitutional arrangements adopted. Moreover, there can be no guarantee that even well constituted federations will never fail. All I would argue is that, when compared with other political arrangements that might be applied to humanity's operations beyond Earth, an appropriately constituted federal government, which incorporates both Earth and her colonies, will maximise the opportunities for interplanetary diversity while minimising the risk of conflict and tyranny. But, in the nature of things, there can be no guarantees. As Madison pointed out in *The Federalist Papers*:

> It is a sufficient recommendation of the federal Constitution that it *diminishes the risk* of [calamities] for which no possible constitution can provide a cure…. (Madison 1788b, p. 277; my italics).

Finally, it is worth pointing out that a human civilisation occupying a large part of the Solar System, and politically united by a single (federal) form of government, will have enormous intellectual, physical, and technological resources at its disposal. It is in this societal and political context that plans for interstellar exploration and colonisation are likely to become feasible. The scientific and cultural benefits of interstellar exploration are potentially enormous (see discussion by Crawford 2014, and references therein), but it will pose fundamental problems for legal and political institutions. Indeed, although appropriate and desirable on interplanetary scales, the time delays imposed by the finite speed of light imply that federal forms of government (or any other form of government) are less likely to work (and may in fact be impossible[7]) on interstellar scales.

It follows that the kind of unrestrained colonial 'freedom' (or 'anarchy' depending on one's point of view), advocated by Dyson (1979) and by many others, may yet come to pass in the context of *interstellar* colonisation. However, the basic political problems of avoiding conflict between independent sovereign entities, while at the same time maximising the opportunities for diversity and liberty, will still remain. Therefore, even if interstellar federations prove to be impractical, it seems that a future interstellar humanity (or post-humanity) may nevertheless opt for the establishment of local, planetary system-scale, federations in each colonised star system. It would be interesting to know what the eighteenth century pioneers of federalism would have made of that prospect!

[7] As discussed by Crawford (1995b), if faster-than-light travel or communication proves to be possible then it *would* be possible to establish interstellar political institutions, including interstellar federations. However there are at present no reasons to believe that faster-than-light travel could ever be technologically feasible, even if, given certain assumptions, it appears that it may be theoretically possible within the framework of General Relativity.

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Chapter 14
Education and Liberty in Space

Janet de Vigne

Abstract A colony that is successful must raise children to carry the flame. How might the principles of liberty apply to them? And more specifically, what kind of education will be necessary in an off planet school room? This essay aims to discuss the problem of raising children in an extra-terrestrial context and issues such as their freedom of choice, the practical considerations of control in an artificial environment, ways of fostering social accountability and the type of expertise needed by educators in this strangest of situations. A critical approach is suggested, one which through constant questioning could at worst inculcate an illusion of freedom (some would argue no different from 21st century practice) in the young but which at best could encourage a teaching and learning utopia.

Keywords Education in space · Extra-terrestrial teaching and learning · Liberty in education

> Educate and inform the whole mass of the people… they are the only sure reliance for the preservation of our liberty. (Thomas Jefferson)

The problem of education in space lifts its head when we consider that a colony anywhere must reproduce in order to survive. The question then of children being raised in 'cages' (Cockell 2013), albeit the cage in which their parents also live; where the tiniest unintentional exposure to hazard might endanger everyone (think of a 2 year old throwing a tantrum, or a curious 5 year old pressing the big red button she was told not to touch), becomes more complex: how might children become part of an eco-system that cannot 'carry' any non or mis-functional elements? How might an education be provided ensuring the safety and longevity of the colonials, while maintaining the liberty of children? Does liberty exist for the 21st century child anyway? These are questions which this essay will attempt to address, while examining the role of the teacher, learning and education in such a

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confined space. To date, no proposition has been put forward to include 'teachers' among the members of a space travelling colony—does this imply that the 'teacher' role will be subsumed into the identities of the other members, astrophysicists, engineers, biologists? Might there be a nasty surprise in store for those who assume they can 'just do it' with no awareness of the theory or practice of such a skill? It would not take much of a leap of the imagination to a place where behaviourist approaches in the classroom might result in such a uniform denial of liberty that the creative spirit, perhaps the very humanity of the children might be quashed and thence their ability, not only to survive in such a 'cage' but to become 'useful', diminished if not negated. Could we therefore describe a second generation of automata, rather than fully rounded, psychologically balanced humans, as truly free? In this, as in every discussion about liberty, we walk the tightrope of the balance of power—one slip and liberty is gone (and then lost forever, for Thomas Jefferson) to a totalitarian regime that enforces obedience to the necessary annihilation of the disobedient (too risky to have around).

The essay will assume the general familiarity of the reader with concepts of liberty, namely the social contract (Hobbes, Locke, Mill etc.) and positive and negative liberty, in an attempt to explore these in the microcosm of an extra-terrestrial classroom. How children's rights might be observed and how the students might be encouraged to develop to their fullest potential will inform areas of discussion relating to current educational theory and practice.

> For to be free is not merely to cast off one's chains, but to live in a way that respects and enhances the freedom of others. Nelson Mandela

Is liberty a social or individual construct? This is the fundamental question that needs to be addressed. If it is individual, then Benjamin Franklin's statement 'they who can give up essential liberty to obtain a little temporary safety deserve neither liberty nor safety' might completely negate the concept of extra-terrestrial liberty, if the object of space travel were to ensure the survival of the species (Cockell 2013). In Helvetian terms, if liberty is 'the freedom from being terrorised like a slave by the fear of punishment' our colonists are not free—they will be living with the constant fear of being wiped out at one stroke. When children arrive on the scene, this fear can only intensify. If instead, as Mandela seems to imply, liberty is social —the selfless giving of one to another to enable the other's liberty—then freedom of choice might encourage each element to look to the stability of the whole. In the West, our thinking in these matters has been mostly individualistic, in the East, the concept might be described as less self-focused. If we were to explore the awareness of and importance of the social contract (Hobbes, Locke, Montesquieu—see Cockell 2013) that must then exist in space, how might this function in the extra-terrestrial classroom? Less, perhaps, a question of protection from a potential tyrant, and more a network of protective cohesion maintained by all, severally and equally.

Most of the explorations of liberty have of course been thought through as a response to tyranny. Some might argue that nowhere is tyranny more apparent than in a classroom. Concepts of liberty might then be said to have been forged in rather negative circumstances—to be reactive, in the sense of reacting against a theoretical

imposition. What might we then want and need to impose on a child that would hinder her exercise of freedom and rights in an extra-terrestrial community?

'Give me a child until he is seven and I will show you the man.' (attributed to St Francis Xavier) So spoke the Jesuit educational expert. Can we then, if not assume, hope, that an education that engenders less a sense of individuality and more and sense of responsibility to the family will be more suitable in space? If freedom is about choices, then choices that are informed as to the wellbeing of the others will be essential. Do we then risk breeding a second generation of innocents —of children unaware of the massive human potential for disaster—very similar to the Savage in Brave New World? How then will we educate children in a colony—what shall we teach them? For this becomes a much greater problem than specialist training in a discipline that will ensure the mechanical, chemical and physical function of their 'caged' environment. Freedom of choice will be exercised how? In a celebration of the GCSE or Standard grade options available? Freedom of choice in this respect is of course contained even on earth in each individual country's educational system. It seems then that a truly international and holistic educational practice will have to be developed, an integrated curriculum balancing emotional, academic and technical literacy.

What will the children learn, and how will they learn?

Let us for a moment imagine the unthinkable—that the children of the colonists become the last remaining humans in the universe. Plenty of sci-fi blockbusters exist to indicate that such a scenario is alive and thriving in the popular consciousness. The children then become the sole repositories of the great and the glorious aspects of human history. Should they know about the dreadful and the disastrous? How valuable will it be to understand the development of the internal combustion engine and the process that led (!) to nuclear fusion? Will it be considered necessary to build defences—and will the history of wars and weapons be necessary in order to understand fully the principles of tactics and strategy? If this were omitted, what are the chances that a child might invent a gun anyway? The point here is to consider what socio-political and cultural ideologies we might impose in education, and how much of an infringement of liberty this imposition might be considered to be. What is good? What is bad? There is much to discuss here, and we have touched on only one subject—history. Where might the arts fit in? How valuable are they to a child's intellectual and creative development? Some would say essential. Some would say that the concept of liberty might be internalised by the practice of art, so that the internal space becomes greater than the cage in which they are confined, and that this alone might ensure a better balanced mentality. Having said that, which composers do we choose? Do they learn about the construction of a symphony as distinct from a song, and do we take all the instruments into space with the colony not just for their use but for their identification. It seems unthinkable to me that a child might grow into and adult not being able to recognise the musical instrument that he or she is listening to. So the decisions here will impact heavily on what someone deems to be the most important elements of being human. Who will that someone be? Who will make the decisions and draw up the plan?

Arguably children develop and learn through their own curiosity about the world and themselves. Arousing and stimulating curiosity is acknowledged by theorists to be an effective inroad into learning—it ensures motivation, persistence and achievement. Allowing a child's natural curiosity to flourish is an idea that goes back to Rousseau and the exercise of such curiosity might be considered a liberty essential to true human development. Therefore, the problem of stimulating this and permitting it to develop in a highly controlled environment will be critical. Vygotsky's theories that learning is social, that we need each other and that a zone of proximal development be provided by a knowing other is entirely possible BUT hugely time and resource consuming. A model other than the one that presently exists will be necessary in space, but whether true liberty therein will remain a happy illusion is up for discussion.

> Disobedience is the true foundation of liberty. The obedient must be slaves.
> Henri David Thoreau

In his Essay on Civil Disobedience of 1850, Thoreau takes a stand in the development of the rights on man and the lengthy process of constitutional reform in the USA. But these rules cannot apply in space—an act of disobedience might spell disaster for the individual or for the colony, or both—depending on the status of the individual. How then can the impression of slavery and oppression, where necessity is the driving force, be thrown to the winds in order to preserve some kind of liberty?

> Everybody is a genius. But if you judge a fish by its ability to climb a ladder, it will spend its entire life believing it is stupid.

The quotation above, popularly and sadly spuriously attributed to Einstein, still has something of relevance to the liberty of children in education. Do children have the right to an education that will allow them to explore and achieve their potential? The next question, and again the issue that impacts on the question of liberty will be 'and does this matter, if the consequences might be too dangerous to the rest?'

Educational theory and children's rights have a long and contentious history. On the earth of the 21st century the demands we make on our children are vastly different from those imposed in Victorian times. We no longer educate to enable children to operate machinery, to be able to function in factories where a smattering of numeracy and literacy might suffice. Instead, some (at least) are looking to the new 'Knowledge Economy' and wondering how to re-instil creativity in education. In the words of Sir Ken Robinson (2006): 'Our education system has mined our minds in the way that we strip-mine the earth: for a particular commodity' and deliberately, in putting the arts to the bottom of the academic attainment pile, quashed their creativity:

> If you were an alien from another planet visiting Earth and you asked yourself what public education here is for, you'd have to conclude, if you look at the output—who really succeeds, who does everything that they should, who gets all the brownie points, who are the winners—that its whole purpose, throughout the world, is to produce university professors. (Robinson 2006)

Robinson is clear that university professors are valuable indeed—but how valuable will they be in space? What, in other words, do we really need the children of a colony to be able to do? What would happen if, among the academic and physiologically elite chosen to be 'the colony', all the children wanted to be conductors? Dancers? What would happen if there were 57 chemists and no physicists? This is where an education must develop an understanding and willingness to contribute to societal cohesion. It is unlikely that a child gazing out of the window of a classroom in a cage would really be thinking about running across the boiling desert sands. 'Escape' becomes an impossible construct and one which again would endanger if the colony even if it could occur. Within the paradigm of the arts though, such an escape might be possible, even if just for a few hours—and internally, rather than externally. True liberty might therefore consist in being able to be a chemist and a conductor, a physicist and a dancer, recognizing the value of each both to the individual and to their wider society. Might some kind of life satisfaction then be an essential part of the construction of educational liberty in space?

In acknowledging a kinesthetic element to education, freedom of movement could be considered an element of liberty. Touching on work done by Gardner in theories of multiple intelligences and multiple learning styles, the 21st century teacher now knows how to engage the widest variety of students, enabling them to become autonomous learners through converting their extrinsic motivation to intrinsic. In the theory of self-determination (Ryan et al. 2006) it has been shown that attempts at extrinsic motivation (such as a bribe) has a detrimental effect on learning outcomes. By contrast, praise delivered verbally (but not in a controlling way) can have an amazing and measurable effect. If a child needs to move in order to think things through, then he must not only be allowed to move, but encouraged to do so; if a child needs to draw to enable herself to work something out, then she must be allowed to draw. Motivation, it would appear, is a key element of autonomous learning. Autonomous learning is the goal of the teacher—to encourage the child to take control, giving the learner power, in other words, over their own learning. The use and abuse of power here will also be of relevance in the debate on liberty in extra-terrestrial education, particularly in issues involving assessment—whether this be the relative suitability of a child for a task, or an attempt to stream children who might attain to leadership.

In the heyday of the psychometric and behaviorist eras, it was generally believed that intelligence was a single entity that was inherited; and that human beings—initially a blank slate—could be trained to learn anything, provided that it was presented in an appropriate way. Nowadays an increasing number of researchers believe precisely the opposite; that there exists a multitude of intelligences, quite independent of each other; that each intelligence has its own strengths and constraints; that the mind is far from unencumbered at birth; and that it is unexpectedly difficult to teach things that go against early 'naive' theories that challenge the natural lines of force within an intelligence and its matching domains (Gardner 1984).

During the development of this theory (ongoing), Gardner challenged the ideas that underpin much of Western educational thought. The Swiss psychologist Jean Piaget's concept that a child's development proceeds along a certain path with each

stage encompassing a cohesive whole has been shattered. It seems that children may develop very quickly in one area of intelligence—and be slow in others—development may occur in 'spurts'. Differentiated teaching then, becomes ever more necessary as a method of working with each child's capacities in the best possible way to achieve the best outcomes for the child. The Vygotskyian principle of the Zone of Proximal Development becomes an essential tool—the Knowing Other is alongside to help, guide and encourage. This is the point at which the child is functioning at the height of her ability to achieve things that are just out of reach. This theory is profoundly social—children learn from interaction with other people, by doing, with informed aid. How best to supply this kind of support in a cage? How many children will there be, and how many teachers?

We come then, to the next and arguably most crucial debate in education. What is literacy? And this question must encompass some solution to the problem of how to define literacy as an act of liberty in space.

In the 21st century an earth based observer will see, in many primary classrooms, small children gathered together for 'circle time'. Sitting around the teacher in the non-hierarchical circle gives an opportunity for many issues to be explored, but the aim is to promote articulacy and emotional literacy. The benefits of singing together are experienced—oxygenation and breathing, learning repeated verses, memorization and articulating happiness or sadness very simply. The process aids in socialization and makes the children aware of each other, thus, it is hoped, helping to develop their Theory of Mind. I would like to argue that, in an enclosed and vulnerable societal group such as a colony, the systematic development of Theory of Mind will be an essential component of emotional literacy and societal cohesion. I refer to Theory of Mind as the ability to conceive the 'other', of recognizing that another person has thoughts, desires and feelings that are different from yours. Humans have the potential to develop learning in this area, there is no doubt, but it is possible to suggest that the learning process can take years and may be achieved to a greater or lesser degree. In a small community where there is no 'away', an understanding of 'the other' in this context could be construed as a vital societal function and an essential element of the practice of a selfless liberty (in the sense articulated by Nelson Mandela).

Assuming that literacy might function then only at the basic levels of numbers and letters would be folly. But encouraging awareness and skills in other areas would have to be managed so as to maximize the benefit to society as a whole and not just to the individual. The encouragement then of critical literacy might at first seem to be a dangerous idea, with its emphasis on questioning everything and challenging the possession and function of power. However, it is possible that this could work to the benefit of the colony and in fact provide the means whereby liberty is preserved, not just in education but with a rippling effect out to the entire community. Critical literacy was developed with social justice in mind, but in space such issues may not exist, at least not during the honeymoon period of the establishment of the colony. However, this element need not mean that its ideas cannot be applied to a society in such a refined and artificial context.

> Human beings are, because they are in a situation. And they will be more the more they not only critically reflect upon their existence but critically act upon it. (Freire 1970)

Freire takes Descartes to a different level here, so relevant to the concept of the cage within a cage of a classroom. Although his aim was to put power back into the hands of the marginalized and dehumanized, the power and appropriateness of his words to the concept of extra-terrestrial liberty are more than clear. If this statement were taken to inform a pedagogical model, then the children would be living constantly confronted with the absurd nature of their condition—that they simply cannot 'get out'. Critical reflection on this issue might produce very positive results —new inventions that better the life of the community, rather than reducing the colony to the madness apparent in, for example, Space 2001, where the simplest procedures are keeping the doomed sane.

Education as the practice of freedom—as opposed to education as the practice of domination—denies that man is abstract, isolated, independent and unattached to the world; it also denies that the world exists as a reality apart from other people (Freire 1970).

One might therefore conclude that true freedom is relational, certainly we have already mentioned the social aspect of education. If this is the case then this element cannot be excluded from any educational system in space. We create then a type of 'functional liberty' which is not at heart dishonest or paradoxical. The reality of the situation is not denied, but awareness of it is key. Reflection on it, both at individual and societal level, is not taken as an aggressive confrontational act, but instead as a motivational factor for improvement and change. It might be entirely possible for a new consciousness to be encouraged, where creativity is celebrated and given room to develop and an integrated curriculum crossing traditional subject boundaries devised. There is no reason why the children themselves could not drive the curriculum while accepting that they do not know what needs to be covered but being clear that they want guidance. An approach similar to this has been researched by Vasquez (2004), whose work with 3–5 year olds in challenging the status quo has demonstrated remarkable results in terms of young children's ability to reflect critically on the world around them. In space, such reflection will be essential—it could prevent accidents, ensure responsible behaviour, encourage real and useful communication between members of the community and serve as a tool in conflict resolution.

> Oh brave new world! That hath such people in it…
> (Shakespeare, the Tempest)

By encouraging critical awareness and reflection, then, we might avoid the production of innocents and/or automata that other non-self-aware systems of education might cause.

> Education either functions as an instrument which is used to facilitate integration of the younger generation into the logic of the present system and bring about conformity or it becomes the practice of freedom, the means by which men and women deal critically and creatively with reality and discover how to participate in the transformation of their world. (Freire 1970)

Freire undoubtedly meant this in a more revolutionary sense, but there is no reason to suppose that an enclosed society, such as that under discussion in space, might benefit hugely from such a practice. To conclude, to fear that liberty might be under threat in the extra-terrestrial classroom is to hold a very narrow view of what 21st century education can offer. So much more is understood now concerning the way children learn and the benefits of true honesty regarding their circumstances. It is becoming clear that even the youngest children have opinions on what is fair and just, and that harnessing these feelings to the benefit of the community and showing the children how to manage them might produce unforeseeable advantages in the communities of the future. Surely these benefits might be construed as the products of the practice of liberty?

There is so much more to be said from an ethnographic perspective on the way that society might function, on heading off potential problems and resolving others, of managing in an organizational development sense a group whose common goal will be survival for at least the first few 100 years. It is to be hoped that such thinking might go hand in hand with the practical ideas of how to access space and build colonies robust enough to manage without contact with the earth. The human element in this must be acknowledged for such projects to truly succeed and this is where the true value of the social sciences will flourish. Liberty will then become a cherished construct where informed choices are made in a collaborative, negotiated space; where the whole will become greater than the sum of its parts and the possibility of tyranny recede into the farthest corners of the universe, as the colony's second and third generation manage themselves and their environment to the mutual benefit of all.

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Chapter 15
Liberty, Freedom and Democracy: Paradox for an Extraterrestrial Society

David Baker

Abstract Human society is built on an evolving set of structures and is therefore cradled within a range of imperatives largely independent of design—the way humans interact is dependent on the circumstances at each phase of its evolution, with the determinates set by the particular set of interactions prevalent at specific points in the chronological evolution of humans. The interrelationship of physical and social evolution is traditionally explained within the separate fields of physical and social anthropology. It is the premise here that humans will react according to their relative stages of evolution and that reactions at one stage cannot be a pre-requisite for reactions at another: while the physical evolution of a Greek of the 5th century BC was every bit as developed as that in a modern Greek, the evolving social anthropological model meant that the Greek today would not respond in the way she or he would 2,500 years ago. The fully developed *Homo sapiens* brain is capable of reforming according to the influences of a continuously evolving social structure and this will play a vital role in any extraterrestrial society. The author proposes that we are unable to predict how liberty, freedom and democracy will feature in an extraterrestrial society because we cannot know how these bedrocks of civilization will be regarded in the future time when such a society will be formed. It is assumed that not for at least 100 years will humans create such a society. Here, an extraterrestrial society is one assumed to be completely separate from Earth societies in both contact and accessibility and therefore unique—without precedent or parallel. The conclusion of this thesis is that an extraterrestrial society may choose not to limit itself to the accepted norms of liberty, freedom and democracy as defined by humans in societies on Earth. It may feel that the various interpretations of their application are lessons to be learned by way of avoiding what it may view as irrational methods of collective agreement, much less a basis for governing a more balanced society. Or, it may choose to redefine the meaning of liberty, freedom and democracy, as humans on Earth have done for millennia.

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It may be several decades before humans visit worlds beyond our bi-planetary Earth-Moon system and some decades beyond that before permanent bases of scientific exploration are set up on Mars or one of its two moons. It could well be several centuries before people from Earth make journeys to the outer reaches of the solar system. However, this paper is concerned with societies that are dissociated from Earth and who choose to establish a community beyond Earth and out of reach of people living on this planet. In effect, groups who choose to leave Earth behind and, devoid of contact with the birth-planet, set up new societies far away in space.

This departure, if it ever happens, would not be unique to human evolution. There are precedents for isolated communities who deliberately choose, without coercion or pressure, to separate themselves from the rest of humanity. It has been this way for several thousand years at least and may have been a more common event in the distant past than we would imagine so today. Such communities are usually found to be stagnant, existing in a phase of stasis and without growth or decline, achieving a measure of subsistence that engages with the natural resources of the Earth in a state of integration with their surroundings rather than exploitation of its possibilities.

Physical anthropologists point to the separated enclaves of different species of *homo* that adapt uniquely to the conditions and the environment of their chosen habitat. In the distant past in human history, this has spurred evolutionary development and is displayed through physical adaptation into the four classic '*races*': Mongol, Caucasian, African and Australasian. While that took several tens of thousands of years to establish, the convergence of this former heterogeneity into the homogenised gene pool that is the modern human has brought physical evolution to a halt.

In seeking to establish an extraterrestrial society independent of Earth, humans would re-set the evolutionary clock and in establishing a completely separate and disassociated community elsewhere in space would, in effect, be opening the evolutionary prospect of a new sub-species of human. With all the implications for a physical adaptation to changes in environmental factors, such as a changed gravity level, different atmospheric makeup and restructured use of cognitive function, that this would imply, a new cosmocentric human condition is possible.

And while physical anthropological changes may force new evolutionary development, the cognitive development of the brain, reflected through the mind, will change too.

In searching for a standard of governance in our ETS, we will first examine what we mean by standards of *liberty, freedom and democracy* (A), then we will discuss how cognitive evolution of the mind could influence the form of administrative control likely to emerge (B), and then we will observe the options these two former deliberations open for our extraterrestrial society (C).

15.1 A0 Definitions

In searching for a base upon which to establish the rationales of a society living off-planet it is first necessary to understand the language of the argument. Without an agreed definition we are unable to mobilise concepts and draw conclusions, random and subjective interpretations being too chaotic to find a fixed base.

Beyond that it is necessary to establish 'zones of detachment', defined as dis-association from Earth-based societies by time and distance; does it influence the structure of the ETS if it is positioned within observable distance of the Earth or not, does it change the way the ETS is organised as to whether it is within the solar system or beyond?

After those issues are incorporated, are we to assume that ETS's are likely to be constructed differently because of the evolutionary nature of the human mind within the brain, given that it may be several centuries before the first autonomous ETS is developed? These are the prime issues discussed in this paper, where we are not concerned with extensions of Earth-based activity out to the Moon or Mars but rather the complete and autonomous survival of a community permanently detached far from Earth at a distant place in or beyond the solar system.

15.2 A1 The Meaning of Words

We live in times in which the interpretation of words and phrases is open to challenge on a scale reminiscent of the Middle Ages, where the meaning of 'liberty', 'freedom' and 'democracy' was defined in different ways and for different purposes. And because the interpretation of these words has been changed by world events it is crucial to discover why and how that might influence decisions about our ETS.

Prior to the age of the great revolutions (in France and North America at the end of the 18th century, in Europe in 1848 and in Russia early in the 20th century) these words were adopted by revolutionary bodies seeking independence from authoritarian governance and oppression. Previously, they were the mantra of individuals seeking severance from ownership by a Baronial overlord or tied employment. Now they are words restructured by those same elements in society who parade the cult of individualism—'I don't like the way the State is controlling me therefore I am going to overthrow the ruling administration', even if that means the minority becoming the new ruling elite which, de facto, will have to become the authoritarians they seek to replace with an assumption of egalitarianism in flagrant contravention of their actions.

These words are open to re-definition to suit different points of view and various causes. It is entirely appropriate, therefore, that in looking at the structure of extraterrestrial societies we examine what we actually mean by these words and phrases. Not to do so exposes us to a diverging range of comparators—the mis-understanding of what is meant and implied.

What is the nature of liberty, freedom and democracy? We need to know in order to progress the debate, because false assumptions lead to flawed definitions. In the past, assumptions have played havoc with intentions. What a word holds dear for one is anathema to another.

The Chambers English Dictionary (2011) defines *liberty* as 'freedom from constraint, captivity, slavery or tyranny; freedom to do as one pleases'. This is dangerously close to the same dictionary definition of anarchy: 'complete absence of law of government'. But does it really mean that? How can *freedom* be associated with control if it is to liberate the individual from *constraint*—which is surely the function of government to impose, if it is to prevent that other dictionary adjunct to the definition of anarchy: 'chaos, utter lawlessness, complete disorder'?

And what of *freedom*, what does the dictionary say about that? Chambers defines it as 'not strict, or bound by rules, not under arbitrary government', yet to invoke a sense of liberty is to appeal for a standard against which that liberty can be measured—a structure to society belied by the definition of freedom: '*to do as one pleases'*. Freedom exists within a system where there are constraints on the ability of a ruling system, or systems, to police the actions of the State which is itself empowered only by the *liberty* of the individual to make choices.

Democracy is a difficult one because, more than *liberty* or *freedom*, the interpretation shifts more stridently with time. Reference to 'democratic principles' has to be aligned with the definition current in the period quoted. Currently, Chambers says that democracy is 'a form of government in which the supreme power is vested in the people collectively; a state of society characterised by recognition of equality of rights and privileges for all people'. This will have difficulties for us when contemplating the kind of ETS we might expect in our varied scenarios.

15.3 A2 Vertical Integration

All of these definitions speak to a *lateral-democracy*, where the purest definitions of freedom and liberty define a state of governance where majorities overwhelm the views of the minority, until the former oppresses the latter through 'political correctness' or ostracism. It is, after all, the way modern 'democratic' governments on Earth work, by achieving power through the acquiescence of the majority (proponents) at the cost of the minority (opponents). It is not a way to sort out what is best for the society as a whole but merely a means to appeal to the electorate on grounds of patronage, to provide a system where responsibility can be transferred to a hired adjudicator, or manager, without recourse to accountability. Earth-based societies have not matured beyond this level and are no model for an ETS.

Just for the sake of comparison, but discussed in more detail later, is the alternative *vertical-democracy*, where a set of agreed principles unrelated to liberty, freedom or democracy, sets standards agreed to by the participants according to what is determined to be good for the group rather than what appeals to idealistic concepts. These are passed along to their successors as a code of structural

conformity to ensure safety of the group, goal-orientation, cooperative behaviour and benevolence.

Currently, on Earth, politicians impose constraints upon themselves when they assume the role of 'manager', transferring to the electorate responsibility for decisions they claim are made at the ballot box. In this way they absolve themselves of responsibility for unpopular decisions (management). This is an example where *lateral-democracy* infests the political establishment, securing a bail-out clause for seemingly unpopular decisions ('you have a choice at the ballot box' cry to the people). Contrary to this assumption, a 'leader' gains the confidence of the group by proposing solutions outside those appealed for by the electorate, presenting roadmaps entirely new and outside the range of previously proposed pathways.

One classic example of this is the transfer of the premiership from Neville Chamberlain to Winston Churchill on 10 May 1940. Chamberlain 'managed' the country after war broke out by attempting to find a solution to fit all problems and failed to gain the support of Parliament due to a series of 'feel good' speeches often exposed as lies and obfuscation. Parliamentarians exposed a tissue of fabricated 'good news' stories that were exposed as diversions.

Churchill promised nothing good ('I can promise nothing but blood, toil, tears and sweat' (Churchill 1940)) and thereby gained the support of the majority of the British people—whether they liked him or not—by his sheer honesty. When things got better he said they were, and because he was accepted for his honesty the population believed him. That is leadership; not to seek approval at a level which seeks to exonerate the manager, but to impose a solution. The true leader must be both inspirational and pragmatic and not seek to be liked. Respect being far superior to adoration, the difference between Churchill and Hitler. These are important functional duties which are crucial to the effective operation of an ETS.

While making note only in passing, since it is outside the scope of this paper, the functions of 'manager' and 'leader' are fudged today where power-play is taught and a simplified role of control accepted. It will, however, be the determination of this thesis that neither lateral-democracy nor the presently defined principles of *liberty* or *freedom* are wise in an ETS.

15.4 B0 The Evolving Mind

If we are to rationally consider an off-planet society we must accept that we are incapable of accurately predicting the development of the human mind far in the future. Self-sustaining ETSs severed from Earth are at least two centuries in the future. The human mind has changed markedly over the evolution of our species, even over the last century, and the rate is likely to accelerate. It is now necessary to consider in what way we can learn from our evolution as a prerequisite to extrapolation about future societies.

The purpose here is not merely academic but rather to ask challenging questions which are all too frequently ignored by space technologists and will be fundamental

to the structured running of an ETS: will the innate selfishness of *Homo sapiens* (mitigated by the blocking logic of cooperative action being beneficial to the individual and encouraged through gregariousness) prevail; is the sometime human desire to serve fellow Earth creatures in a benevolent manner (expressed by recourse to saving species, hugging a tree and feeding birds) likely to emerge as the dominant gene; is Homo Sapiens likely to ignore either path and collapse into a purely individualistic culture where pragmatism overrides moral and ethical choices? Only by deciding which, can we make sensible extrapolations.

An ETS is not a colony on the Moon or Mars, nor is it a permanently manned space station, all of which are subservient to Earth governments and subject to national laws and determinations of host States. Permanent bases on Mars will not be completely independent of, and severed from, administrative control from Earth. Perhaps they should, for this could be the route by which we develop truly different and completely autonomous ETSs. Yet talk of one-way trips to Mars and successive generations living and dying on the Red Planet is premature.

The technical, financial, medical and management issues of such a venture are incapable of being satisfied without further research in near-Earth orbit (NEO). For the predictable future, humans will explore Mars and set up bases but this is more likely to be a logical extension of the International Space Station, learning to transition from a community based on supplies from Earth to one able to survive indigenously—and that will be the transition point for severed societies in a truly autonomous context.

Yet it is inevitable that humans will, if they survive in a state which permits extra-mural activities, desire to explore and settle beyond NEO and to defeat the obstacles presently inhibiting such adventure. These base camps will evolve into autonomous springboards to a new kind of society and a start will have been made on severing all dependence on, or consultation with, Earth-based legal or societal infrastructure. But at what point will people engaged in the exploration of other worlds decide they no longer wish to return to Earth?

The practical challenges of such a transition would bring enormous problems, not least because the manufactured facilities for human habitation in such alien environments are, to us, almost insurmountable. Comparative analysis of people spending months at Antarctic research stations and equivalent periods aboard the International Space Station is not encouraging for those who wish to believe it is a natural progression. We relate to our home because humans are tied empathetically to their origins and to the place they regard as the foundation of their identity.

Yet, just as humans learn over time to regard their home as a place from which to embark upon new adventures, establishing a new base elsewhere, so too may humankind come to regard the Earth as a place from which to depart. This may be as important a step for the evolution of humans as the emergence from Africa—first to put *Homo habilis* in Europe and Asia and then to place modern humans on a global march (Gamble 1993). There is a link between the motivation to move and the desire to experiment with and exploit technological advances that stem from new challenges. In other words, we must first understand why we would want to go.

To understand that we must revisit the evolution of our identification with ideas that established the first philosophical principles of how we see ourselves and how we define the parameters of collective behaviour.

15.5 B1 Cerebral Evolution

The story of the way we have evolved cerebrally involves a journey of the human mind which is still in progress and this is reflected in the way various people, at different times, have defined the words we have been examining. Only by accepting the transitional state of the human mind early in the 21st century can we hope to extrapolate to the time when an ESP can emerge.

In the previous section we examined what we mean by liberty, freedom and democracy and found in-built flaws—illogical interpretations that are conflicting and contradictory. Summed as an integral model for governance and the administration of humans, their interpretations have no valid meaning. Now we must look again at those words to see why an ETS would probably not choose to adopt these principles of societal control. Instead of merely examining the definition of the words, we must relate them to examples.

To the Roman slave, liberty meant something completely different than it did to the French peasant in the late 18th century, and again to the founders of the American nation early in the 19th century. To the Roman, liberty was a legal and binding conduit to progressive stages where personal welfare increased according to the level acceded to the individual. To the Roman Senate it was a token gifted to an individual on merit, who would then exchange it for access—to position, wealth or influence. That is very different to how we define liberty today. Although in other places in the world that word has a completely different meaning.

Freedom has had an equally tortuous path. Freedom for the individual to decide his or her path in life through a series of decisions based on non-intervention is different to that sought by a group intent on overthrowing an established or entrenched society through direct action. One man's freedom-fighter is another man's terrorist. Freedom from want and freedom from oppression are two completely different things. Like 'liberty', 'freedom' is a concept that offers a little of something—sufficient to get the majority prepared to compromise on its demands—while providing nothing of substance because it's very imposition calls for a denial of 'freedom'.

Freedom is often defined as the ability to act as one wants and sometimes the freedom to 'impose' rather than the freedom to 'deny'. The freedom expressed by a loud partygoer returning home to the annoyance of his or her neighbour is a freedom few would recognize as socially cohesive. While the freedom of roaming can annoy landowners and the 'free will' to walk along proscribed paths becomes a trespass.

Democracy too is as varied and amorphous as the struggles within the Roman Senate for definition of an ideal—Democracy or Republicanism. So it is today,

where democracy for a voter in Western middle-class society is as different as it can be for a guerrilla fighter in a despotic state who seeks to impose his or her will on the rest of the population.

It is said that both are justified by an asserted higher moral virtue which in reality does not exist. Yet both call it democracy. It is different again to the citizen of a country restructured following rebellion and the overthrow of autocracy but who decides that the will of the majority is not their own will and is therefore, in their estimation, undemocratic. How do we deal with those issues in our extraterrestrial civilization if we are to merely pack up the same baggage?

The formulation of these social standards and their movement through our social history is possible only because it is directly the result of the way our minds have evolved within the human brain. For the two are separate and distinct. Think that the 'brain' is the hardware and the mind the 'software' in a deterministic process constrained only by the level of evolutionary progress over time. Definition of that state depends upon which model of the mind is adopted. It is time to look at the alternative interpretations.

15.6 B2 Models and Methods

The STANDARDIZED SOCIAL SCIENCE model (Mithen 1996) is considered by social psychologists to be a description of the mind as a general-purpose learning mechanism initially free of content. It is known as the GENERALIZED MENTALITY model (Mithen 1996). At birth the mind is a blank slate, it says. Our knowledge of the world is acquired from our culture. This then will define our view of liberty, freedom and democracy. We are sculpted by the experiences of nurture and human contact plus absorption techniques through learning. Psychologists Tooby and Cosmides (2000) defined this model eloquently.

This model is one most frequently used by society and its psychologists to accept compromising situations that if left unattended, or unanswered, can result in a sense of guilt, depression and morbidity. One example in 21st century society is the conflict between nurturing and abdication of parental responsibility for a purpose more applicable to the desires of the adult than the requirements of the child. Going out to work, or staying at home to fulfil the evolutionary role of nurturing. The GENERALIZED MENTALITY MODEL alleviates our sense of guilt: our offspring are blank slates upon whose surface anyone can write the equations for personal development—parents, per se, not needed.

THE EVOLUTIONARY PSYCHOLOGY model, however, says the mind works according to our evolutionary makeup and is the product of our ancestral lineage. According to this model, our biological code has a big part to play in *what* we think and *how* we think. This is known as the SPECIALIZED MENTALITY MODEL. In it a series of cognitive processes are each dedicated to a specific type of behaviour and a particular way of thinking. Much like the separate blades of a Swiss army knife, each part has a pre-formed structure and views the information it

receives according to a pre-structured algorithm, the nature of which is a cognitive construct formed from the sum of all of our predecessors.

In the developed world, the SPECIALIZED MENTALITY MODEL finds itself in conflict with 21st century middle-class society because it requires a refocusing of attention through a linear path from ancestor to progeny. No abdication clause is allowed: parents are necessary because the personalised traits, cerebral connections and behavioural characteristics come not from a proxy minder writing on a blank slate but rather from a member of the same genetic base. This elevates the role of the parent but shifts the focus of responsibility from the personal desires of the adult to the cognitive needs of the progeny.

Which model better fits the cognitive evolution of humans? Is the Medieval mind the same as the post-Modern mind? Can cognitive instincts and gender-related focus-loyalties (train spotting, playing with guns or making plastic spaceships) demonstrate that we are indeed the sum total not only of our parts but of our past? Perhaps so, but we have also evolved to a GENERALIZED MENTALITY model as well. The Swiss army knife has developed a cognitive fluidity which gives humans the ability to design complex tools, create art, for some of us to believe in religious ideologies and for all of us to be able to anticipate and plan for a socio-economic structure which we have yet to test.

But how did we get this way? It appears this may have been through a sequence of evolving behavioural, nutritional and cognitive paths that presented a route along which humans have evolved over several million years of competitive co-existence with higher primates. Why is it so important to understand this before we can effectively reset the clocks on human civilization in an extraterrestrial context? And, how precise can we be that we do in fact know how the mind has evolved? After all, the consequences of getting it wrong, or of merely stumbling forward blindly, are to court disaster and unsettle any conclusions. And perhaps the most disturbing aspect is that the tool used for diagnosis in the subject of that diagnosis itself—the human mind.

Three major steps characterise the development of the human brain to its present capacity: meat eating; tool-making; and the industrious use of planetary resources, for farming, urbanisation and technology. It is because we are still evolving that this is relevant to our considerations of what we will be when we develop the first ETS off planet.

The transition from root-eating to meat-eating caused the first major increase in nutritional value that set the human brain on a curve of expansion more than 4 million years ago (Mithen 2003). The first stone tools are more than 2.5 million years old, made by the first meat-eating proto-humans (Australopithecines) with a cranial capacity of $\sim$650 cc. A significant increase to $\sim$ 800 cc occurred less than 2 million years ago with the emerge of *Homo habilis*, and then *Homo erectus* around 1.5 million years ago with a brain of $\sim$1,000 cc. Finally, <0.5 million years ago, after a period of making fire to cook food, *Homo neanderthalensis* and *Homo sapiens* grew the cranial capacity to 1,400 cc.

The transitional state of the brain from increased size to the redistribution of cranial convolutions has defined the modern human, exemplified by the slightly

smaller size, but a significantly enhanced cognitive adaptation, in the last 150,000 years. And that evolution is still taking place at ever increasing rates. Consider this:

a. It took 2 million years to get from the first stone tool to the first piece of carved bone, 90,000 years ago.
b. All of aesthetic and technological creativity has been expressed in just the last 90,000 years.
c. First use of ceramics 40,000 years ago.
d. First carved figurines 26,000 years ago.
e. First farming and domestication of animals 10,000 years ago.
f. First writing 5,000 years ago.
g. First metal smelting 4,000 years ago.
h. It took 20,000 years to get from the bow and arrow to the atomic bomb.
i. It took 6,000 years to get from the first wheeled vehicle to spacecraft.

The accelerated pace of human progress is indicative of an evolving mind. Both physical and social anthropologists testify to finding this in a growing volume of work that relates to the way the mind is a product of human behaviour as well as of ancestral learning. Studies in this field are dangerously close to the much criticised idea of 'morphic resonance' (Sheldrake 1988), which has deterred some scientists from investigating human behaviour which gets close to that.

Inherited awareness is a maligned interpretation of how we have come so far so quickly. In the judgement of the author, it is because we are unable to accept patterns of interrelated connections that we fail to see the way human development is reshaping the way the brain itself is changing. Physical anthropologists make valid connections between the shape and the internal contours of the skull and the shifting balance between various convolutions of the brain driven by shifting prioritisation of the mind (Reader 2011).

In a remarkable link between social and physical anthropologists, there is agreement that while the soft-tissue brain will not survive decay, the skull itself is a good indicator of the way the brain is changing over time. As various convolutions reflect changing priorities of neural connections, they impose a shifting pattern of indentations in the skull. This occurs gradually over several generations but is indicative that the mind—and the shifting patterns of thought in successive generations—is changing the way the brain itself is evolving.

15.7 B3 The Cosmoanthropocene

How can this accelerated pace of capabilities be explained? In setting the platform for determining how we are to construct our social determinates, where should we begin? And what should we leave out? Are they to be a product of our mores (as with customs and traditions of thinking among intelligent people) or are they to be from a new slate—rewritten on a blank sheet for a new society altogether, as

Konstantin Tsiolkovsky envisaged for the Bolsheviks when he laid down the basis for his own extraterrestrial civilization more than 100 years ago (Tsiolkovsky 1903)?

This event is so seminal that it is nothing less than the next stage in the evolution of the anthropocene—what we can call the cosmoanthropocene. The time when we set up extra-terrestrial societies and civilizations—defined by, organized by and managed by civil law; accorded and adhered to by administrators and citizens alike. And the constructs of that law will depend upon our conception of what cosmo-anthropocenic humans should adhere to in writing the books of words, defining liberty, freedom and democracy.

In considering the cosmoanthropocene we are asked to judge whether we are defined as decision-makers by The Standardized Social Science model, where we are born fresh and new, influenced solely by nurture, or whether we are defined by the Evolutionary Psychology Model where supra-generational influences build pre-knowledge. I suggest the latter—the evolutionary model.

We are defined as we head to the cosmos, to some extent, by the cultural 'big bang' that exploded into human activity between 60,000 and 30,000 years ago. The surge in our creativity and imagination has fuelled every expression of what it is to be human. The mind of the hunter-gatherer is different to that of the modern human. To make art and to do science the mind has merged a specialized with a generalized structure. In doing so it has lost some innate sensory capabilities and acquired others.

So how does this affect the way we view liberty, freedom and democracy in our extraterrestrial civilization? The first primates appeared 40–50 million years ago. Now, in relative and on cosmological timescales, we are about to embark—or perish—on the greatest adventure life has bequeathed since then. Humans now have the capacity to liberate themselves from the umbilical of Mother Earth and begin the next journey in evolution, the cosmoanthropic existence beyond our planetary womb. We will become pioneers, and therein lies a danger.

In this circumstance of reinventing society and civilization, how are we to consider the three defining structures of liberty, freedom and democracy? When asked what he thought about Western Civilization, Ghandi said that he thought it would be a very good idea (Brown 1994). While mischievous in his answer, he was making us aware how primitive and how fragile that lofty concept is and how it can be so easily picked up to cloak guilt or hide abuse from our own consciences.

Even recent history tells us that there is danger in defining a structured purpose for a pioneering people. The damage and savage brutality executed in the name of 'manifest destiny' (Miller 2006) has left the pages of North American history tainted with the blood of 25 million Native Americans in the surge for land-grabbing access to that great continent in the 1800s. And let us not forget that the primary motivation for that rush was the search for mineral resources to acquire wealth.

As a defining embrace of the pioneering ethos in the mid-19th century and as a torch for wagon trains heading west, numerous artists depicted the assault on the frontier as a noble and empowering activity. Overhung in John Gast's painting with

the beautiful female form of *Columbia*, the personification of the United States representing youth and fertility, appeared as if in angelic form to give a God-given right to conquest and colonization, sweeping aside the heathen and diminished tribes who had first set foot upon that land more than 20,000 years before.

It spoke of the 'special powers' of the American people, of their need to redeem the world in the model of America, and to remake it in the form of the United States, to undo the wrongs of privilege and to strip away prejudice and power for a true and defining rule of liberty, freedom and democracy. All three terms were used to explain how the New World would wash away the sins of the old. It sets light today to how some Americans view the rest of the world, how 'old Europe' is defined as nationalistic and simmering toward conflict, while 'new Europe' looks to a homogenised and united continent; shades here of 'redeeming the world in the model of America.'

It is a terrible warning of how bold a noble ideal can seem to be that it veils the way it can be taken by foul despots and turned to a depraved and inhuman activity; less than 80 years after the painting by John Gast showing the lightly clad figure of Columbia appearing like an angel in the sky to hard-pressed pioneers burned by desert and lashed by storms, Reichsfeuhrer Heinrich Himmler was teaching his young SS officers that 'freedom' for the German people would be achieved only by undoing the wrongs of generations of Germans by annihilating an entire people in the name of progress to rid the world of 'old Europe' and its stagnant slaves. Yet that same word was used with utter conviction, just as we use it today to justify acts of aggressions and genocide.

And in the same year, Adolf Hitler too was using the example of the American pioneers to attack his detractors. Concerned at how history would regard the invasion of the Soviet Union in 1941, so as to prepare large tracts of land in Eastern Europe for colonization by the professional classes, he quoted the expansion of American pioneers and the elimination of Native Americans as precedent for genocide in the East. Even the British control over several million people on the Indian subcontinent with a tiny minority of military and government officials inspired him, as he watched films of Britain's colonial prowess for evening entertainment.

Liberty and freedom are nebulous terms, only as profound as the moral standing of the source. Konstantin Tsiolkovsky wrote that space flight will liberate and 'make free' the oppressed masses of the industrialized world. Weightlessness, which knows no ups or downs, gives everyone the same ability to float to different heights, he said. Space will give liberty to the individual and freedom to society.

Democracy is much, much harder to agree upon. Yet it is in the definition of these words upon which must rest the viability of our concept, that they are the pillars of a decent and structured society. When Roman politicians discussed the future as the Republic became an Empire, Senators asked 'What shall we have? Republicanism or democracy?'. And the answer came: 'democracy if you can keep it!' Because the two are mutually exclusive, with democracy the undefined loose cannon in our arsenal of civilised options.

15.8 B4 Leadership

Democracy was defined by Cleisthenes (Hignett 1952) in the 6th century BC when Athenians were given the right to equality under the law and where each citizen had a 'voice' in deciding whom should represent them. Not 'who leads them' or 'who decides on their behalf', but who 'represents' them. As we saw earlier, today managers have adopted the title 'leader' while in truth a manager stays on the fringe, observes quietly and unobtrusively and gentle tweaks the rudder when rocks loom on the horizon.

A leader is a person who inspires, provides a polarizing focus for all within the group and lays down objectives outside the routine management of agreed activities —and he or she may be (usually is!) a poor manager. In fact, a leader delegates to those who are expert in crucial, enabling facets of the group. People can be trained to be managers but no one can be trained to be a leader.

Yet countless 'motivational' movements have adopted, even short-circuited, the true definition of these two very different roles, propelling inadequate and incompetent 'managers' into a false sense of authority. For both exude a level of power and are desired by those who in reality fill neither role and are frequently incapable of justifying the roles they assume for themselves.

So how are we to choose managers between leaders, or different styles of management and leadership, in our ETS? If we can train managers, who in turn can be organised and assigned appropriate places within society, how does our ETS obtain leaders, especially in a democracy which can stifle both talented managers and gifted leaders?

While managers gather, collate and assess information from parameters that already exist, leaders originate new concepts, modes or pathways and stimulate analytical evaluation. To inspire they must synthesise alternatives, make selections among options and transfer a sense of functional purpose to those who will carry out the objectives.

In a space-faring society rooted on Earth but extending far beyond low Earth orbit, these issues are taken care of by the communities that send expeditions to do their bidding. For space-sailing societies roaming the solar system, either on gravitationally anchored planets or free-flying platforms (space colonies, artificial planetoids or interstellar world ships) the problem of organising a separate and distinct community must address these issues before the journey starts.

Such structures are not born of evolution but rather of a deterministic approach bound by the rigour of practicality and pragmatic lines of constraint. A transformation in planning a space-faring society is essential for agreement among the participants and for tight disciplinary controls on action. Only in this way can the community survive and retain the function for which it was engaged.

In this context, a space faring ETS will be limited in scope if the traditional interpretations of liberty, freedom and democracy are bound into the operating protocols. If Earth-based concepts of societal interactions, acquiescence to a power base with only tenuous hold on acceptance by a majority and unfettered

interpretations of freedom are the base for our space-based society, it will be incapable of fulfilling the aspirations of its population. Liberty, freedom and democracy will have no place here.

Such views will be challenged by those who believe in the nebulous principles of so-called democracies and imagine them to be irrefutable and permanent starting points for our new society. But to understand the functionality of new space-faring societies we must be prepared to ask the question: how are we to determine whether we need democracy at all in our extraterrestrial society?

At NASA we discussed this issue at a special conference held in Falmouth, Massachusetts in 1965. We wrestled with just what democracy is and what it is not. As we have discovered, over time definitions have changed and the meaning of the word has adapted to the fluctuating expectations of individuals. We hear it thrown at detractors when violent opposition to questionable governments flares into firebombing official buildings, the perpetrators defined as 'revolutionaries'. But there is a transferability of that definition anchored in the history of US-Soviet relations during the Cold War.

When NASA had a group of people in Moscow during early July 1974 preparing for the joint docking flight with the Russians, drink flowed a little too freely (Ezell and Ezell 1978). Some of the Americans decided to let off fireworks for a 4th July celebration alongside the walls of the Kremlin, a police van quickly arriving on the scene. As they were about to be bundled into the van, not knowing who the Americans were, incarceration was avoided when they told their would-be captors that it was a 4th of July tradition to celebrate their revolution. The Russians understood fully—and helped them light off the rest of the fireworks! But revolution to an American is very different to revolution for a Russian.

And so it is with democracy. In western societies, the leadership has been subsumed under the blanket of management. Now, a British prime minister—a functional office less than 180 years old, at least in present form—is the leader of the majority political party. He has 'freedom' to act without direct recourse to the electorate, wielding power through threats, cajoling members into a fixed line of endorsement and introducing bills to the legislature far removed from the party manifesto.

Is this the form of democracy the ETS community will wish for? Do they want a system where elected 'representatives' do what the community wants them to do, or people who make decisions out of specialised access or experience—sometimes against the will of the majority? Do they, in electing through 'democratic' ballot, seek a manager for their own individual decisions, or a leader who provides new ideas outside the range presented to him or her? These issues are vital for extraterrestrial societies. It is the question asked by the Roman, 2,000 years ago.

15.9 B5 Challenges

While arguing the definition of freedom, liberty and democracy and the nuanced interpretations of their meaning, one thing is certain: the challenges faced by an ETS will require fundamentally different ways of organising society. At the beginning of the 21st century, societies are so narrowly focused around optional paths for defining their regulation that systems are polarised around two opposing structures: big government or small government; control by the state in an authoritarian structure controlling the activities of its citizens, leaving little room for 'freedom', or a free-market where the individual has little 'liberty' to benefit from an altruistic or egalitarian state heavily taxing its citizens for revenue essential to welfare support for the under-privileged.

Will our ETS decide on either—or neither? The development of fully autonomous and independent ETSs is unlikely to come about by a decision made by a particular group. It is more likely to evolve in stages from outposts already established but controlled by laws and regulatory standards set by the country paying for the venture. The aspiration to set up home completely independent of Earth is already there in the mindset of certain people, however. The Mars One organization has set impossible targets for a one-way flow of people, materiel and resource replenishment that at the very least would cost several billion dollars per year. Yet it has received wide acclaim and support from a host of volunteers.

But these are not the people who will settle the first off-planet community. Very few would want a one-way trip and even fewer would have the appropriate psychological profile for carrying out such a venture. There has yet to be one human among the more than 500 who have experienced space flight who does not identify strongly with the Earth or the need to get back to it—eventually.

It is much more likely that off-planet communities will grow through two-way flows that send and replace scientists, technologists, engineers and research workers to the distant outpost for stays of one or two years at most. The need to develop indigenous means of support through atmospheric gases, protection from radiation, food and water raised in situ and not through expensive, heavy-laden freighters replenishing the reducing stocks on a rotational basis will be necessary before any degree of autonomy can be established.

'Living off the land' will be an early prerequisite for sustained human activity on other worlds. This is something Mars One advocates are unable to provide. The volume of food and water per individual would bankrupt any organization hauling all these supplies from Earth. In attempting to test artificial ecospheres duplicating isolated communities in alien environments, experimenters have had to abandon their efforts as the delicate eco-balance of environmental control and nourishment fails. But autonomous groups setting up permanent base camps, presumably from where expeditionary excursions depart for extensive field trips, will be the first to develop techniques for self-sufficiency.

It is self-sufficiency in staples for life support and a sustainable infrastructure for medical and health requirements that will precede fully autonomous communities.

Until then, they are expatriated workers assigned by a nation state on Earth. As such they will be subject to the same laws. We are not concerned in this paper with the mechanisms that will trigger an autonomous ETS or the way in which it will come about, but when it does the separation from Earth-based precedent could be profound, causing the cosmocentric humans to adopt completely different guidelines for structuring and organising their society.

15.10 C0 Options for the Extraterrestrial Society

Confining our evaluation to completely detached and autonomous societies in some place on another world or within a space-traversing habitat, the options available to the new cosmocentric citizens are as wide as human imagination. But the constraints of rational thinking and a presumed awareness of former governmental and administrative systems on Earth will give the inhabitants a new perspective on how to organise their community and with what rules to populate their society.

We have already seen that the definitions of liberty, freedom and democracy are incapable of providing characterisations which fit the expectations of the users. They may be considered archaic concepts more appropriate to the loose language of Magna Carta than the sophisticated ground rules for human behaviour in an extraterrestrial context. And yet, in reality, they are one and the same: a code for human behaviour with controls for the good of the community and the interaction of that community with its environment rather than the self-serving and frequently pompous purposes to which those words are usually attached.

We have decided that humans are a continually evolving organic structure with their true potential far into the future and whether they can survive long enough to achieve that potential being the only questionable caveat on that goal being reached. Liberty, freedom and democracy favours the majority at the cost of the minority and cosmocentric humans may decide that there should be a better and more egalitarian way of defining principles for their guidance.

15.11 C1 The Reasons to Go

Humans have evolved on Earth in both physical and cerebral contexts with a seemingly pre-ordained belief in their exploitation of planetary resources and ‘management’ of the Earth. If it fails, we are to blame, if it is in danger we need to ‘save it’. But cosmocentic humans may see it in an entirely different way. Instead of exploiting their host, they may wish to stabilise their own communities within its own finite provisions and resources.

This is just one in a series of reasons why the ETS could be very different to our preconceptions based on Earth-like societal systems. The big question here is whether the separated community sees in its migration similar reasons to go as did

our ancestors when they left homes and families behind to migrate to new lands. The conditions surrounding the establishment of an ETS are so different from our analogues, however, that similarities may be superficial at best and there may be no precedent at all for the real reasons to set up an ETS.

An example from relatively recent history is in the mass migration of Europeans to the North American continent during the second half of the 19th century. In that period, from 1850 to 1900 the population of the United States increased by 53 million, growing from 23 million to 76 million, of which 25 million were immigrants from Europe. In the American myth, actually taught in US schools today, they came to escape the tyranny of European monarchs and to seek a better life. In reality, they came to escape tyrannical governments, oppressive controls, lack of opportunity and crowded urban complexes.

It could just be that our ETS settlers will wish to escape Earth for similar reasons, which could include dissatisfaction with entrenched and stagnant political and administrative systems, disapproval of privilege and restrictive practices within archaic 'democracies', or simply a desire to move to the next stage on which to play out their lives and those of their offspring. More than any other, these motivations will probably decide the nature of our extraterrestrial society. Of one thing we can be certain. Right now, we do not know what those triggering motivations will be so we must consider a hypothetical desire to re-set the clocks on human civilization.

15.12 C2 A System of Governance

As we have seen, ideas of 'liberty', 'freedom' and 'democracy' (LFD) are open to challenge, a challenge difficult for many because of entrenched beliefs that somehow these are connected to attitudes of human behaviour defined by ethical standards, morality, benevolence, altruism, egalitarianism, etc. They are not. LFD are concepts for systems of governance and have been used wisely, misused, abused and scandalised in equal measure at various times over the last 2,500 years. Human behaviour is distinctly separate from the way groups, communities and states run themselves and it often bears no relationship to the precepts of government.

As we have seen, 'liberty' can be interpreted as free-will against the interests of the majority, 'freedom' as licence to persecute those who do not conform, and 'democracy' as the consensus of the masses against the freedom of the individual. These are extreme interpretations and do not apply to societies who agree to conform to the will of the majority. The failure in LFD is where it is used to 'sell' power in return for acquiescence to the majority view and is a demonstration of the innate selfishness in some advocates.

Our extraterrestrial society may wish to restructure governance around the pooled talent of specialist and expert opinion present among its number, conformity then becoming logical acceptance of their greater experience. Instead of picking unskilled, inexperienced representatives without specialist knowledge, our ETS

may instead choose the concept of absolute logic upon which to build the next evolutionary step for the mind and for cosmocentric society.

Instead of everyone getting a vote in decisions crucial to the running of the society, they may defer to those with specialist knowledge and act on their recommendations. They may agree that by applying the talented values of the individual to make decisions, they each contribute directly rather than defer to an inexperienced individual who plays no other part in society than to mouth the collective voice of the community. They may decide that the executive should be disassociated from the legislature and the executive, being merely a managerial function, should not assume for itself the role of leadership.

There is precedent for this in some administrative systems on Earth, those where critical decisions vital for the safety and well-being of large numbers of people in defined communities are made not by 'democratic' means but by expert analysis, judgement and decision: large business corporations and military armed forces.

15.13 C2 Democratic Dictatorships

The notion that businesses, corporations, industrial production facilities and manufacturing installations can be democratic is likely to raise a few eyebrows in those organisations. As too is the notion that police forces, security organs and the armed services can be democratic. As too is the idea that ambulance and fire services, care and health services, welfare services and rescue organisations called in after natural disasters can be democratic institutions. So it is not, after all, so absurd, that all of society can only maximise the efficiency and well-oiled running of day-to-day activities through what could be said to be, not undemocratic but non-democratic means.

What at one level seems an appeal for autocracy and dictatorial power is in fact the rationalisation of needs with means. The needs of an ETS are stability, cohesiveness, collective commitment and purpose. Each of these can only be achieved through the same vertical integration that comes from a command and control function based not on democratic consensus but on rules, regulations and a structural certainty that stems from selfless commitment. Remove the institution of law and recklessness ensues ahead of chaos.

As has been shown, classical concepts of 'democracy' among Earth-based societies breed increasingly aggressive splinter groups demanding their own form of 'liberty' and 'freedom'. This is not a basis on which ETSs can perform with functionality or sustained equilibrium essential to survival. It is difficult to see how divergent claims to systems of governance could be productive under such circumstances and whether the values of the whole could be conserved while allowing diverging challenges to law and order.

In a nascent state, the extraterrestrial society will have only one driving imperative—to establish and preserve a high state of stability to meet challenges brought about by operating in a new environment. The level to which the society

itself can relax and search for permanent ways of governance will be proportional to the degree of certainty within the community. Families will want that security and be more concerned with that than with esoteric concept of Earth-based legacy systems built around 'democracy'.

But there is another reason for maintaining a tightly structured order in our extraterrestrial society: the possibility of encounter(s) with extraterrestrials from other places in the galaxy and all that ensues from that.

15.14 C3 When ETS Meets ET

The structure of an ETS will determine its survivability. By definition, it will be remote from any assistance and truly autonomous both in operation and the way it can effectively mobilise a defence against threat. That threat can come from indigenous flaws, failings or accident within its systems, or it can come from the inability of the inhabitants to respond effectively to challenge or confrontation. Science fiction is replete with examples of dysfunctional alien life forms intent on destroying, consuming or absorbing Earth beings in grotesque forms of genocide and destruction.

By far the more dangerous for humans are alien beings that manifest themselves in identifiable forms and seem to pose no challenge or threat. Because humans need enemies to justify extreme actions, if none are available from natural surroundings their encounters with other intelligent beings will likely spark a desire to assume the worst. In much the same way that those closest to war and extreme conflict are least likely to provoke it, a strong sense of military-style discipline would mitigate the danger of over-reaction.

To some extent, the way humans respond to threat is determined by their training and by the procedures used to teach defensive and offensive tactics. An example of this can be seen in the different conflict strategies taught at the United States Military Academy at West Point in the USA and at the Royal Military Academy Sandhurst in the UK. Renowned for its *Schwerpunkt* battle tactics, the US Army has a history of tactical methods closely akin to those employed by the Prussians while the British Army adheres quite closely to the teachings of *Sun Tzu* (2005) and those are one of gradual erosion by consuming the enemy's ability to fight.

The American way would be to contain and roll back the threat; the British way would be to observe, analyse and deploy a strategy proportionate to the perceived threat. Thus would the inherent cultural heritage of each group determine the outcome of a meeting between humans and intelligent beings from other worlds. In these differences may hinge the survival or not of brief or protracted encounters and the reluctance to engage may be equally important as the desire to subdue or obliterate.

15.15 C4 A Multitude of Threats

The cerebral preparation of an extraterrestrial society to meet natural and induced challenges to various levels of threat leaves little reason to employ 'democratic' governance. Expert and professional responses to a wide range of situations leaves no room for the amateur, the serving citizen of the Greek '*polis*' or Rome's '*civitas*' or the '*politician*' of today.

To integrate the desires on the part of the extraterrestrial society into a cohesive plan for establishing rules of governance it is only necessary to implement the rationales of scientific test. This has been articulated by Karl Popper (1994) in the equation: $PS1 \rightarrow TT1 \rightarrow EE1 \rightarrow PS2$, where PS1 is a range of possibilities reduced through theories of probability (TT1) subject to an elimination of plausible errors in probability to a 3-Σ value which delivers PS2, the culmination for the next set of probabilities. This 'probabilistic' test produces solutions which are devoid of random selection (such as 'liberty', 'freedom' and 'democracy') and delivers a product—or decision—which is similar to the survival of competing species in evolution.

It may well be that the ability of our extraterrestrial society to manage itself in a cohesive and rational way will be to jettison this Earth-based irrational lip-service to egalitarianism and adopt a pattern of evolutionary-tree analysis for governance and community decisions based on biological theory. Thus would the cerebral flow of constructional thought align with the very mechanisms that produced humans as an upper primate through evolutionary biology.

It was Karl Popper who defined the irrationality of an overly tolerant society: *'Unlimited tolerance must lead to the disappearance of tolerance. If we extend unlimited tolerance even to those who are intolerant, if we are not prepared to defend a tolerant society against the onslaught of the intolerant, then the tolerant will be destroyed, and tolerance with them'*. This can be applied to the LFD argument as defined in earlier subsections.

From this it may be assumed that our ETS, if operating on a platform of rationality, above the plain of nuanced attachment to political concepts, can be both tolerant to the notions of 'liberty', freedom' and 'democracy' while intolerant to the destabilising forces of misplaced logic. Whether faced with problems as enticing as technical challenges to survival and habitability, or to the mundane disassociation of malcontents within the community, a more elevated way of dealing with these will not be to repeat the mistakes of Earthlings but to engage with rationality that is itself intolerant of digression. To do so would be a collapse into the fuddled thinking and lurching incompetence that would already have inspired the notion of a new societal structure, as far from Earth as possible.

15.16 C5 The Choice

Designing an extraterrestrial society from scratch would be implausible, selective amnesia being the prerequisite for that. But the fact that lessons and models from the past on Earth could be brought into play would give advantage to the new community. Not for them the mistakes and the protracted conflicts that on Earth had wrought death and destruction across the millennia. Not for them the enforcement of the majority upon the minority and the adoption of laws to prevent collective opinion having power over individual choice.

If, having decided that moral, ethical and benevolent principles were superior to idealistic dreams of 'liberty', 'freedom' and 'democracy', our extraterrestrial society decided to align the advancing cerebral evolution of 'mind' over the material environment, new possibilities would emerge. Possibilities that could ensure not only compatibility with unfamiliar surroundings in alien environments far removed from the birth-planet, but compatibility with the principles of evolution. For the first time this could free the human mind of clutter brought about by false constructs on the planet from which they came.

Issues such as 'liberty', 'freedom' and 'democracy' would be classroom subjects for society's offspring, learning about why their elders chose a different path as the underpinning principles upon which to base a level field. Where the only vertical hierarchies are structural principles of common human decency and logic, conforming to the universal principles of evolution for both mind as well as body, for this society there would be a truly unique beginning. Philosophers and sages have for decades argued the opportunities for wiping clean the slate of history and starting over. Our extraterrestrial society may choose to do this in a more radical manner than any have been prepared to accept thus far.

15.17 Beyond the Extraterrestrial Society

There is direct evidence that we are still evolving and probably have several million more years to go before we reach our full potential. We are such new forms of life on this planet that when in however many centuries we become truly celestial citizens of the cosmoanthropocene, we will be very different to what we are now. The 'hardware' that is our brain will have adjusted to the advancing sophistication of its 'software', our mind, and perhaps only then will we be able to recognize and to communicate with other forms of intelligent life that might be out there for us to be challenged by.

Until then, there are grave doubts that in our fragile and intensely primitive state, we are in any shape to even ask the age-old question: 'is there anyone out there?' It is a defining aspect of our naivety that we assume we are sociologically equipped to handle such an encounter. For the time being, it is vital that we begin the discussion now for while we are on the verge of being able to understand technologically how

we might take our place among the stars the sociological constructs in the world today are in no fit state to serve as a model for that journey.

Eventually, we must leave this planet. To do that humanity will have to survive the next several centuries until we find a way to manage ourselves. When that happens, we can then look back, draw together all the collective experiences of liberty, freedom and democracy we have devised, and decide what we want to become. But we must begin that debate now, and be in the vanguard of such an endeavour. And in so doing we may just make this world a better place along the way and if we fail in our ultimate goal we may succeed in our efforts to live better and more harmoniously together on this planet. And that would be no mean achievement in itself.

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Chapter 16
Human Space Colonies: Towards a Governance Architecture

Rick Wylie

Abstract The subject of this chapter is a maybe not-too-distant future when humankind reaches out from the Earth to colonise new worlds. Its' focus is the development of a general framework to create the basics of a governance architecture which engages a possibly disparate group of colonists in a manner which creates a legitimate, robust and equitable basis for policy and governance. It is argued that the rights of colonists, and their freedoms, could be strongly influenced by the resourcing package and consequent mission profile, and that the process of developing such an architecture will begin on Earth well before any colonising mission begins its long and perilous journey to a new human home. Drawing upon the experience of institutions on Earth the Institutional Analysis and Development Framework is used to highlight the importance of a framework of rules and responsibilities, and the key role of a sense of community in shaping the human experience in an off-world colony.

Keywords Governance · Institutions · Community · Commercialisation · Policy

This chapter focuses upon the governance of a human colony in space. Given the pioneering nature of such a project, the chapter advances a general approach to developing a governance architecture for a colony based upon the creation of an institution centred around the development of a sense of community accommodating the interests, activities and aspirations of future space colonists.

To establish the current institutional context, we begin by looking at changes in space policy over 6 decades of space activity and how they reveal the increasing democratisation, internationalisation and commercialisation of space policy. We speculate that, given the scope and scale of future space exploration and colonisation, these trends may become even more pronounced, and that this could have significant implications for the freedom of individuals and colonies in space.

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Then, following a discussion of issues in the human colonisation of space, some key issues and themes which a future colonisation may have to address are explored. The Institutional Analysis and Development (IAD) framework is used to suggest how the governance of space colonies could, in the fullness of time, evolve from an Earth-bound beginning to a self-determining polity in space.

This chapter is, of course, speculative: mankind has not yet established colonies in space, though the popularity of space colonies as an idea is well documented in popular science fiction and the focus of this chapter is possibly one of humankind's most significant ventures, describing something that humankind has no experience of—the purposive colonisation of space. It is true that missions have been sent to the moon and to the International Space Station (ISS) for relatively long durations, but these are categorically different missions to those envisaged as the topic of this chapter which is a project to establish space colonies.

The aim of this chapter is to consider some of the key issues confronting the development of a space colonisation project, and to suggest a policy framework for its realisation. Given the constellation of possibilities in respect of the scope and scale of such a venture and the range of potential destinations, resource packages, mission profiles and durations, it is only possible to address the policy and governance processes in the most general way in this discussion. Given this, a framework approach is used to develop a governance 'model' which respects the rights and freedoms of colonists which may be generalizable across a range of colony projects.

The colonisation of space with human beings settling for long periods, perhaps permanently, on other heavenly bodies raises significant governance issues centred upon the independence of the space colony and the relationship between that community, its funders and the wider human community. Already, there are hints as to some key issues which will affect the future and freedom of those individuals who travel beyond the earth for an extended duration visit and which will need to be addressed and accommodated in a lengthy process.

Space policy today appears to be at a moment of transition, in which the colonisation of space has transitioned from the national interests of an elite group of nations to a wider group of organisations many of whom are commercial and have a very different agenda and funding criterion from those that drove Apollo and Soyuz in the 1950s. This activity also highlights some new issues confronting contemporary society as it develops new structures to cope with increasingly complex and rescaled issues seen in the glare of an assertive, commercially driven global mass media.

Focusing initially upon these changes in the character, context and content of space policy, this chapter explores issues in public policy and governance which are seen as significant in space colonisation reflecting the wider constellation of the uses of space today. These envisaged colonisations are categorically different in character and duration than Low Earth Orbit missions manned by astronauts and mission specialists. They are also categorically different to the transient journeys into space such as the pioneering Apollo missions of the 1960 and 1970s.

What is envisaged are missions lasting years, decades or, ultimately, generations. The extended timescale of these missions, in which even the journey to a destination may take years, is the context of this chapter. Space colonisation represents the transition of mankind to becoming a space faring species. It may be that the first steps towards the establishment of space colonies will need to take place on earth before any colonising trip to space is undertaken.

In the early years space policy and the use of space was focussed upon the national interest. President Kennedy's 'we choose to go to the moon' speech galvanised a generation of scientists and ultimately half a million Americans worked on Apollo, but in those early days the policy was technocratic, secretive and was made by an elite of scientists and politicians. During the Cold War, space and the moon were seen as places to project national interest and technology and policy was based upon the push of national prestige as much as the pull of exploration and exploring the unknown.

In those early days, space policy was made at a high level, with decisions made at the level of political or technocratic elites. However, since the 1960s we have seen a number of changes in the context of space policy with the democratisation of the benefits of space through the implementation of satellite technology, delivering mass benefits in the form of communications, weather and climate observation and navigation.

This discussion of policy in the vacuum of space takes place at a particular moment in human space exploration. Since the days of Mercury and Gemini, space policy has become 'normalised' with the implication that space activity needed to make a return on its investment, both politically and economically. America still had men (and women) in space, but their missions were largely for terrestrial purposes. At a national level, space activities are often seen in respect of their contribution to areas of national policy like industrial or science policy. In short, there is an 'earth-centerdness' in space policy. At the same time, as with so much of policy, there have been globalising dynamics as international collaborations result in bilateral and multilateral basis and structure to much of policy.

In parallel with globalisation has been the privatisation and commercialisation of space programmes which have moved the science, technology and resourcing into the scope of international consortia. For example, following the end of the STS (Space Transportaion System) programme, private sector space organisations now resupply the ISS. These themes, normalisation, commercialisation and globalisation all have a bearing upon future policy in respect of space colonies and have potentially significant implications for the freedom of colonists who require a policy space in this new arena which will guarantee their freedoms, as well as to encourage policy learning in this new arena.

In the colonisation of space, there will be a need for a new model of governance, as Buckerfield de la Roche argues "… the last frontier space is transnational, borderless, and essentially ungoverned…" (Buckerfield de la Roche 2013. p. 1). Like many new arenas of policy, space colonisation is at a disjuncture in which problems and their solution do not correspond with the borders of extant actors and sovereign states. In space there are not (yet) sovereign bodies and, following Hajer:

> *…there are no clear rules and norms according to which politics is to be conducted and policy measures are to be agreed upon.* To be more precise, there are *no generally accepted* rules and norms according to which policy making and politics is to be conducted. (Hajer 2003, p. 175 emphasis as in the original).

The notion of an institutional void implies that, to be legitimate, policy making in these new arenas should involve new configurations of actors, issues, and policy processes and structures. In this new context it is argued that policy and the actual process of policy making itself should be be shaped by discursive practices (Hajer 2003, p. 176) with deliberation about both policy issues as well as the policy process itself. This has clear implications for future colonists in space, especially in the context of a community in which, following McMillain and Chavis (1986) political participation is an important aspect. Indeed, as Suedfeld and Steel (2000) argue, drawing upon capsule environment analogues such as overwintering on Antarctica, one of the most significant aspects of a successful future colony in space are the relational aspects of being a member of a group. Indeed, it has been argued that the psychological and sociological aspects of living in an off-world colony are at least as important as technological aspects (Pass 2006).

There is then the question of the status of the colonists themselves. We cannot assume that these individuals are mission specialists and astronauts in the employ of a nation state with rights of rescue and support (Lyall 2010). It may be that their status could be as private individuals who will, ultimately, become citizens of a new state in space, though they may remain 'citizens' of a nation state on Earth.

Undoubtedly the funding package and motives of the 'mission' will determine the selection criteria and whether mission specialists and non-specialists will be eligible to apply. Moreover it may be that the type of individual volunteering for a pioneer colony could itself create significant pressures on the policy and governance process. Writing about capsule environments, an oft-used analogue for space habitation, Suedfeld and Steel argue that:

> …most volunteers… tend to be high on the need for personal control and autonomy. They find that capsule life is in fact controlled by environmental requirements and organisational regulations. They go on to suggest that "…In most capsules, the crew has very circumscribed spheres of free choice of activities, companions, or behaviour settings" (Suedfeld and Steel 2000, p. 242).

Given the nature of the individuals potentially involved in a colony project, the space pioneers, there could well be an enhanced requirement for participation and for the articulation of colonists' interests throughout the development of such a project. The potential scope, scale and complexity of such an endeavour create the possibility for a range of decisions and inputs into the design and details of the mission, which will also provide an opportunity for inputs from colonists, as well as opportunities for colonists to shape the design and detail of the hardware and software of the project.

The resourcing requirements of such a venture will be a massive issue. It has been suggested that the cost of a colony on Mars may be in excess of $150 billion (Joseph 2010, p. 4068) and the technologies required to successfully realise such a

project may be at the leading edge of scientific and technical understanding and engineering. Whatever the source of funding, the outlay will be very significant and the level of support realistically required for such a venture would probably be well beyond the resources of a single state, agency, organisation or individual. Moreover, the wider resources package will involve a potentially massive range of actors whose input will determine, among many other things, mission duration, trip profile, habitat environment and landing site—all decisions (and there will be thousands of others) which will affect the experience and wellbeing of colonists.

Clearly, resource decisions will have a significant impact upon the colony and the colonists. Considering the overarching mission funding package very broadly highlights this potential. Two sources of funding come to mind firstly, the global media. The funding of $150 billion over a decade could come, it has been suggested (Joseph 2010, pp. 4068–4080) from creative marketing and television rights. But what would be televised? One could foresee the demand for a 24 h 'reality' TV show broadcast live from space around the world. Clearly, there could be massive implications for colonists' freedom and civil liberties at the whim of the requirements of programme editors and viewers curiosities.

A second obvious source of private sector funding appears even less appealing. One of the principal reasons given for the exploration and colonisation of planets and asteroids is the extraction of minerals. In such films as Moon (2009) Total Recall (1990) and Outland (1981) a hellish vision is created in which the principal *raison d'etre* of the colony is the extraction of valuable minerals or materials, and that colony is organised entirely around the pulse and processes of an extractive industry to which all will contribute, rather than a minority here on earth (Fowles 1978, p. 368).

Simplifying to make the point, it may be that if the funding is a commercial venture in pursuit of valuable commodities, such as Helium 3, perhaps, then the ability of colonists to work in a factory environment may be a deciding factor in their recruitment and selection as colonists. It is interesting that a number of science-fiction films (Outland, Moon and Total Recall) envision a space colony in a rather hellish world of commercial mining with the colony totally focussed on the extraction of ores. Alternatively, it may be that the funders could be broadcast media with the project becoming a type of TV Reality show, with the colonists themselves being the resources.

Clearly, the selection criteria between these two future scenarios will be very different. Other scenarios present themselves, with a colony having a variety of missions where some individuals being 'productive' in the sense of a mining or extraction with others less productive or, for some mission profiles, being merely 'tourists' paying to be there for a specified duration. This diversity of status has significant implications for the decision making process in a colony: does more pay mean more say in decision making and who decides this, and when? This vision paints a gloomy prospect of a space colony which, Fowles argues, conspire to create a world in which commercial sponsors shape the governance and policy of the colony and where "…the menace of the environment and the impositions of a supremely industrialised regimen are likely to create great stress" (Fowles 1978, p. 369).

Indeed, the entire issue of freedom of the colonists may well be very problematic and a colony could be ultimately a very oppressive place and not just in respect of the production requirements and imperatives of a mining and extraction facility. Actually, the very day-to-day existence on such a colony could put great stress on individual colonists as the technical issues of living on a hostile world will require great discipline in order for life to be sustained and constant attention to procedure and protocols in all aspects of living and environmental safety.

Neither source of funding or future scenario- a TV reality show, or an industrial mining colony—appears to offer a robust future for the development of a space colony. What is clear, however, that there may be very significant policy issues affecting the freedom and liberty of individuals living in such a colony for which careful thought and preparation will be required so as to protect the freedom of individual colonists.

In the early days of a colonisation project there will probably be a phase where the colony is being established in an off-world setting and are totally dependent on resources from Earth, and it may be that in the early phase the policy focus of the colonists remains part of a polity which includes the Earth. There then may be an intermediate phase where the colonists, though still reliant upon the Earth for resources, come to establish a polity of their own in their new location and come to see the colony itself as their home and themselves as 'Spacelings', rather than the project as a mission and themselves as 'Earthlings'.

In this early stage, it may be that the space colony is seen as a community, as an outpost of Earth, which could, in the fullness of time, develop into a new society. This perspective suggests the transience of an initial space colony project. Certainly, if the initial resources of a project come from Earth-bound institutions, then those institutions may legitimately have some claim on their acquisition and allocation. However, gradually, the colony could create its own society in space and that may be a constitutional goal of the colony project from the outset.

Very obviously, space colonisation represents a new area of human activity and a new sphere for policy. Following Hajer (2003) the long-term colonisation of the vacuum of space represents an institutional void in which there are no established players or processes. Colonies represent a completely new arena for policy which, though initially rooted in terrestrial actors and activities, open up a new political space which will emerge to address the problems associated with off-world habitation which are of a scope, scale and complexity well beyond the capacity and capabilities of any one actor or, probably, nation state.

Clearly, whatever the configuration of a space mission, a new policy structure will be required: this will be a pioneering venture in many respects, including policy and governance. Funding could come from a range of sources, each with its own specific requirements, conditions and agenda and this funding package could shape the actual technology of the project, which may come from a range of sources and itself shape the motives behind the mission, the choice of destination, and place significant constraints upon the colonists. Moreover, as the technology required will be shaped by the choice of destination and landing site which may, in turn, be shaped by knowledge and science, much of it held in space agencies and

universities around the world, all of which will affect the resources required for the undertaking and it may be that these changes will affect the governance of the project through changing the influence of actors involved.

Perhaps the most crucial aspect of policy in space, with special reference to space colonies, is that this is a new venture. It is unlike anything mankind has undertaken before. Space colonisation is longer than a mission to the moon, which lasted just a few days and more remote than an extended stay in the International Space Station in Earth orbit. Ultimately, a colonisation may be of a potentially permanent duration. Moreover, the scope and scale of current space activities, resources and technologies suggests that a future colonisation project will involve a range of organisations from a range of countries. This will be a new coalition involving multiple actors, organisations, cultures and sectors. Policy making in the vacuum of space is very much making policy in an institutional void in which there are no structures, norms or case examples which may be drawn upon. In this new policy space the boundaries of the project don't map or match the capacities, capabilities or jurisdictions of existing actors or institutions in the policy process. In this new policy space, it is argued that the interests of colonists themselves, and the community they create in the early years, should be seen as the institutional basis of the colony project.

An institutional perspective is perhaps the most useful framework in this discussion. Following Imperial (1999) we define an institution as "An enduring regularity of human action structured by rules…" (including policies) "…norms or shared strategies and the realities of the physical and biological world" (p. 453). Institutions include government agencies and most organisations, including structures such as families. We suggest that, in the institutional void of a space colony project, the colony as a community should form the institutional focus of a space project and, drawing upon the strength of the community concept on Earth, this should form the institutional basis and focus of a governance architecture for a space colony project which provides a framework for respecting the freedom of the colonists.

Given the range of possible configurations of a colony project, the Institutional Analysis and Development (IAD) framework has a number of features relevant to this discussion of policy and governance in the development, design and delivery of a space colony project. Firstly, perhaps, is the level of specificity and its generalizability to a range of configurations of a space colony project. The IAD framework is "… a meta theoretical device… that helps provide a general language for describing relationships at multiple levels and scales" (Ostrom 2010, p. 659). IAD is essentially about the rules a group of organisations or individuals use to resolve a problem (Imperial 1999 p. 454). Given the possibly long-term development of a space colony project prior to its launch, the range and diversity and plurality of actors in the policy process, and a massive range of configurations of the science package, the mission's duration and destination, and the background, role and status of colonists, we can only suggest some quite broad parameters for policy at this time. Here, the IAD framework is especially apposite as it operates at a level of analysis and insight above that of a theory or a model. Indeed, one of its key features is that it is "…intended to contain the most general set of variables that an

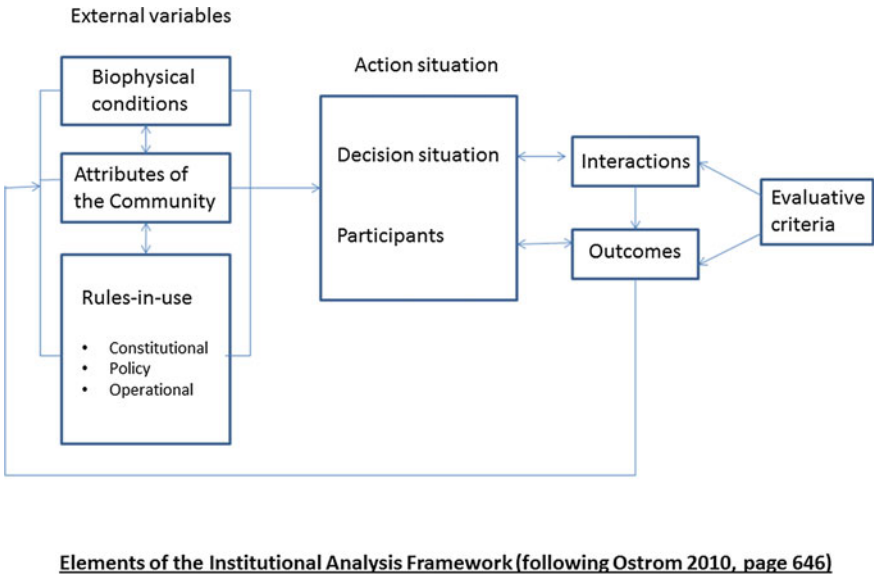

Fig. 16.1 The IAD framework

institutional analyst may want to use to examine a diversity of institutional settings…" (Ostrom 2010, p. 646).

Essentially the use of IAD provides an overarching conceptual framework centred on an action situation which allows us to locate the actors and issues—and the sources of rules and policies—in wider settings. The key unit of analysis of IAD is an action situation which is located within a wider context of external variables as shown on the diagram below. An 'action situation' has been defined as "the social spaces where individuals interact, exchange goods and services, solve problems, dominate one another, or fight (among the many things that individuals do in action situations)" (Ostrom 2011, p. 11). Figure 16.1 shows the key elements of the IAD framework. Essentially, the IAD framework unpacks factors bearing upon governance and of special interest in this discussion are three sets of external variables bearing upon the 'action situation'. These are:

- biophysical conditions, in this case the harsh environment of space;
- attributes of a community; and crucially,
- rules in use (including policies) in a hierarchy from operational, through collective to constitutional levels.

However, and of special relevance to this discussion of policy relating to space colonies, the recognition that these action situations may be connected and related into a series of nested, linked contexts is a key insight relevant to a space colony project which may be envisaged initially as action situations based purely upon the material and physical setting. Firstly, an Earth-bound set-up stage of the project and

then, ultimately, a second entirely space-bound setting in which the actual colony itself, remote from Earth as a self-contained colony, makes its own policies within its own structure of rules and policies, though it may be that this framework of rules will be created and agreed on Earth prior to a mission.

Rules are a key element in the IAD framework within which they are "…an implicit or explicit attempt to achieve order and predictability among humans" (Imperial 1999, citing Ostrom 1986). Rules can be formal, like policies, or they can be informal, like behavioural norms (Imperial 1999, p. 454). Following Imperial (1999, p. 455) rules may be identified at three levels of analysis, from constitutional, through collective choice, to the operational implementation. In more detail these rules are:

- constitutional level rules—determine eligibility to participate in the development of the constitutional framework which shapes the rules and policies at the following levels;
- collective choice level rules—at the level of policy making and management decisions—these focus on how the operational rules may be changed and who can participate in this process; and
- operational level rules—the day-to-day provision, appropriation, monitoring and enforcement occurs at this level.

For the purposes of a space colony venture, what is especially useful with the IAD framework is its flexibility. For example (see Fig. 16.2) it may be that activities at a constitutional level could be envisaged as an action situation in its own right whose output decisions set the rule context at the next lower level, in this case the collective choice level which, in turn, bear upon decisions at the operational level that directly impact upon and bear upon actions and activities at an operational level (Sabatier 1991, p. 152). At each level of rule making one could envisage the 'action

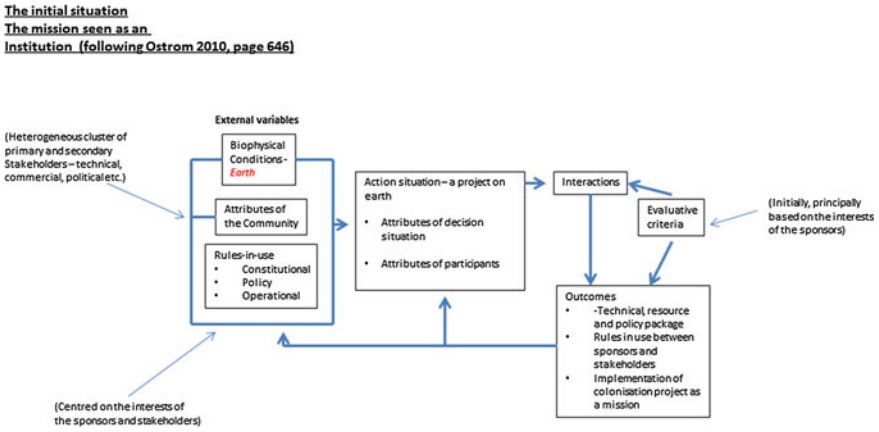

Fig. 16.2 The initial situation—the mission seen as an institution

situation so defined' becoming narrower as the initially, possibly global, project becomes narrowed down to a small group of colonists taking a very big step.

The IAD framework also accommodates changes which occur in an action situation over time as actions in the initial stages of a project begin to shape activities in subsequent stages (Ostrom 2011, p. 11). This dynamism and sequencing of an institutional development provides an important dimension to a policy framework for a space colony as it takes into account developments and decisions in the material, technical and physical environment which shape the project from outside, and the community and sociological dynamic of the community of colonists which shape the project from within. These colonists (or their interests) could also evaluate the outcomes of the process giving them a degree of freedom in what may be a confined and constrained setting.

By foregrounding the participants in an action situation, and the context of the community the IAD framework provides a powerful insight to developing a dynamic and multi-level approach to accommodate complex policy and governance arrangements such as those envisaged in the development and settlement of a colony in space far from the Earth.

As the previous discussion has suggested, policy in the vacuum of space has been, for the past 50 years, set on Earth within wider policy contexts, as much of space policy has been related to terrestrial and national considerations and national state-centred policy arenas. What is envisaged in terms of space colonies requires the development of a new locus for policy—the colony itself. The way the IAD framework foregrounds the community may take on a wider significance in space colonies, reflecting the importance of the sense of community and the community dynamic in the structure, fabric and longevity of a long-stay space colony mission. It may be that, as mankind moves outward away from Earth, policy will need to take account of the interests and dynamics of the community itself, in order to secure the freedom of the space colonists themselves. Moreover, the space colony project will begin well before the mission, and will probably involve many actors, agendas and resources—and require many choices to be made to package the technology, mission and destination: the colonists interests clearly require input at all stages of the process.

The IAD framework highlights the role of the community in shaping the context of the action situation at all levels and at all stages of the colony project. Given the importance of the community dynamic to the success of a colonisation mission, and its ultimate longevity, the creation and nurturing of this community dynamic will need to inform policy at all levels. Both in the early stages of the colonisation project and in its ultimate journey and establishment the community interest may prove to be an essential 'force' (McMillain and Chavis 1986) and focus for policy which gives the colony project a locus based upon the interests of the colonists as members of a functioning collective entity, a community beyond the interests and agendas of sponsors.

The interests of the colonists will be paramount in the colonisation mission, special efforts will need to be made to foster commonalities, communications and a cultural dynamic which is related to the colony and the place itself. In this regard,

the role of the community in shaping the dynamics of the community itself will be vital. This is especially the case if a mission involves nationals from different countries and from various walks of life, who do not have a mission-specialism and whose role is, essentially, to be colonists and to create a colony with an appeal to current and future colonists whose rights, responsibilities, interests, freedoms and identities as colonists can be accommodated and addresses through the concept of community.

It is easy to foresee a community dynamic of some sort evolving on a distant planet. Especially in a situation where there is a significant isolation from the Earth and particularly where there may be in the short term no chance return to Earth the place of destination will come to mean something as a 'place' in the sociological, human sense.

What the sequencing of the IAD process highlights is the requirement for input at all levels of rules or policies in the creation of an institutional framework, at constitutional, collective choice and operational levels: these rules provide the fundamental framework for the colony as an institution. Moreover, the interests of the colonists as an institution, as a community, will need to be taken into account in the early stages of the colony project in order that the interests of individuals as a community, and the social and political space they will create and occupy on some far off place, can be fostered.

Figure 16.3 below gives a simplified view of a potential initial situation in respect of the design of a space colony mission.

We can see how at all levels of the process, there will be space in the contextual rules to incorporate the interests and aspirations of individuals who will form the space colony. The community dynamic will come to be a key element of the success of a colony mission, and that dynamic requires a significant role for members of the community in the decision making surrounding the community. It also requires that the community's own particular interests are reflected in the policy process.

Ultimately therefore, a space colony will come to make and take many if not most of the operational level decisions—especially in a remote setting—on behalf of the community. In this context, given the importance of the community dynamic it will be essential that their interests become identified and articulated at all levels —operational, collective choice and, ultimately, the constitutional level, though the latter may be many years down the road. In the institutional and political vacuum of space void deliberative decisions about how policy is made may be almost as important as what policy decisions are made. However, the initial 'action situation' of a space colony project (as depicted in Fig. 16.2) will be on Earth. As with current policy this action situation will comprise many actors' organisations and institutions. Clearly, rules, policies and decisions could be made by a diverse range of actors across different countries, specialisms and sectors as power and decision making will be polycentric with a constellation of actors making contributions to an overall mission plan and package.

In the early days of the development of a colony project, therefore, the policy and decision making may take place without the colonists. Possibly the key part of

that project will be to recruit colonists, and it is impossible to speculate who they could be. It may be that initially they are mission specialists trained to undertake particular activities and employed with the status of 'astronauts' rather than as private individuals or space tourists. However, this status may change with a transition to a larger space community with individuals ultimately travelling as *colonists* rather than as employees of a national space organisation, or as employees or paying customers of a commercial organisation.

Of course, in the early days (or decades?) of a colonisation mission resources for the colony may all come from Earth. It may be only gradually that the colony will establish processes to create its own resources. Moreover, in the short term, someone on earth will probably own those resources and it is fairly clear from current space activity is that it is more than likely that these resources will come from many sources and there will probably be a coalition of countries, companies and actors involved in the development of one of the most complex and risky activities mankind has ever undertaken. In all of this complexity and diversity it will be necessary to keep sight of the interests of the colony as a community and to use that as a focus for the interests of the individual colonists.

McMillan and Chavis argue that there are four sets of elements which create a community experience and which, they argue, exists as a force in human life (1986, p. 3). A sense of community, they argue, is "a feeling that members have of belonging, a feeling that members matter to one another and to the group, and a shared faith that members' needs will be met through their commitment to be together".

These four elements are;

- **Membership**—feelings of belonging and personal relatedness (affective)
- **Influence**—a sense of empowerment (political)
- **Fulfilment of needs**—both instrumental (economic) and safety (physical) needs
- **Shared emotional connection**—a shared sense of place

Each of these elements has a profound bearing upon the sociological and psychological sense of community and context of a colony. Indeed, the strength of these dynamics could strongly influence the success, quality and effectiveness of a colony project, especially one many miles from Earth—and may be out of sight of the home planet, with no chance of return to Earth, at least in the short term, and with a diversity of individuals in a new 'place' creating something out of a simple habitation, which connects individual colonists with the place, each other, and with the project itself.

Returning to the IAD framework allows us to appreciate the dynamic nature of the colony as a project with activities in the early years creating a set of rules (including policies and a constitution) which could accommodate the interest and input of colonists as they become recruited and develop an interest in and influence over the space colony in respect of the rules-in-use at all levels, from constitutional to operational levels. In order for the colony to accommodate the ultimate interests of colonists Fig. 16.3 shows an idealised and simplified institutional arrangement in the form of a self-governing colony, an independent institution in an unspecified

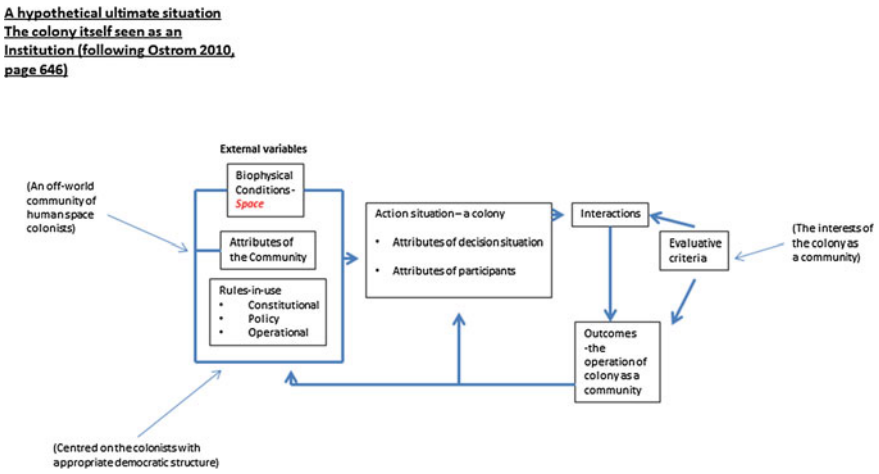

Fig. 16.3 The colony itself seen as an institution

future having made a transition from dependence on Earth to independence in the future as a human society in space.

From the perspective of freedom, it may be that the promulgation of a community spirit and dynamic provides a fundamental driver towards legitimate policy making in the vacuum of space, and that the policy process could be based upon creating the feelings of belonging and membership of the colony, a process which could be begun on Earth, as could the degree of influence and empowerment the colonists come to enjoy as members of a fully-fledged community.

16.1 Conclusion

The development of human colonies in space will represent a massive step for mankind. Nothing like it has been undertaken before and policy for the long-term habitation of space represents an uncharted institutional void. Though this issue will raise many technological and scientific challenges and it may be that technologies are extant for a mission to Mars or a long-term return to the Moon, the policy and governance of such a venture raises very important issues about the freedom of colonists based potentially millions of miles away from Earth in an extremely hostile environment.

Given the broad range of possible destinations and colonisation mission profiles and resource packages it is difficult to be too specific about the form and structure of the governance of a space colony. What is proposed here is an approach based upon the development of a community in space as an institution begun early in the mission planning phase and long before departure. In this structure, the interests of colonists are appreciated and accommodated as members of a community at an

early stage of a colonisation mission and the community element of a space colony becomes established at an early stage of the mission planning and has input into all stages of the operation. This engages colonists in the mission and embeds their interests in its design and implementation.

Looking at the evidence of current space activity reveals that the scope and scale of such a colonisation may be beyond the capacities of any single organisation or nation state. It is likely that such a venture will involve a range of organisations, and a range of nationals in an international project. Crucially, these organisations may have not worked together and they will have essentially Earth-bound resource and cultural contexts. Moreover, though the science and technology may largely exist, it has not been packaged together in the form used on a colony mission. On Mars lander missions, for example, we see a range of different teams undertaking complex tasks in their specialist areas, vehicle construction, science modules, delivery, operation, guidance to name but a few. All are highly specialist areas requiring input from dedicated specialist teams from separate institutions.

The idea of a manned mission with human-rated systems, possibly without the availability of return at least in the short term, is a categorically different undertaking than a lengthy mission on ISS or an Apollo mission—the mission is also distinct from terrestrial analogues like an over-wintering mission in Antarctica, though that has revealed the importance of the social environment bearing on the effectiveness of the colony.

The cultural differences could be enormous, not least in respect of language and religion. Moreover, with a colony, will there be mission objectives other than the establishment of a colony itself? Who will be eligible to go? From which nations will they come? What will the status of the colonists be—will they be 'astronauts' or 'settlers'? All of these things will, most probably, have a significant effect on the dynamics of the colony as a functioning entity. If the current activities in space are anything to go by, there could well be a large range of nationals (and cultures) involved in the establishment of a colony.

There are potentially many issues which will bear upon the freedom of space colonists, from the demands of commercial sponsors, to the harshness of the environment, cramped living conditions, lack of facilities for exercise and the requirement of an exercise regime, and a monotonous and limited diet. In this chapter, it has been argued that the most significant issues will be human, given the availability of the science and technology. And yet, in many discussions of space colonies there is little consideration given to the human, psychological and sociological elements of a colony mission.

Perhaps the most difficult aspect of this is the difference of this type of project to that which has gone before. This cannot be understated and yet there are so many possible configurations to a colonisation project which, if successful, will change forever the lives of a few, though it may not, for the foreseeable future, affect the lives of the majority of humankind.

To date, space missions are national or multinational or corporate endeavours. They have earth-bound agendas, exploration, and resources from 'sponsors' (be they governments or corporations) who expect a return. Perhaps the biggest

challenge facing a colonisation mission is that these resources will be spent to address an essentially off-world agenda—with the establishment of a colony being an object in itself.

It may be, though, that real commercial issues will become a key driver of the colony project—or at least elements of it. Television rights of how the colonists live and function, or resource rights for mineral deposits, or perhaps some manufacturing process which requires a low-gravity environment. Clearly, these have implications for the freedom of the colonists whose interests and aspirations need to be accommodated in an overarching framework within which the policy and governance of a colony can develop.

In order to accommodate the various interests and drivers bearing upon the colony project, and reflect and respect the freedoms of colonists the IAD framework seems to offer a useful and very flexible approach to the development of a colony project. Respecting the rights and responsibilities of a range of actors, especially the colonists this framework allows us to envisage a colony as the development of an institution over possibly many years and in a number of iterations. Following the IAD theory the notion of institution accommodates both formal and informal structures and embraces written rules and policies and normative behaviour and practices. It is a conceptual framework which may be applied flexibly and which is centred upon rules in use in a variety of contexts.

The IAD framework allows us to appreciate the dynamic nature of the colony as a project with activities in the early years creating a set of rules (including policies and a constitution) which could accommodate the interest and input of colonists as they become recruited with, ultimately a self-governing institution off-Earth in an unspecified future and transition from dependence on Earth to independence in the future as a human society in space.

This three stage institutional project as envisaged reflects the dynamic and multifactorial nature of the colony project. Focused upon the interests of colonists through the notion of community, It involves an initial set-up institutional stage resulting in the output of a scientific and technical package with express mechanisms for colonists' interests and engagement. This second stage would involve colonists in the establishment of a technical, scientific and political package leading to a community in space as the key driver of the project. The IAD framework, by locating an institution in its social and environmental context, foregrounds the importance of community in the development of a colony project and its presence at constitutional, collective choice and operational levels. It has been speculated that a sense of community could be a centripetal, socially unifying, dynamic for the institutional setting of a space colony project, giving coherence to a complex project otherwise lacking in an institutional and human focus or centre. Begun in the early stages of the development of a colony mission, the essential insight provided by an institutional framework approach is that the colony should be considered as a *community* and as a key focus policy relating to the colony, both in respects of the process of policy as well as its substance, this to foreground the colonists interests and give shape to a new human institution in space.

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