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Paulina Golinska
Marcin Hajdul *Editors*

Sustainable Transport

New Trends and Business Practices

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It aims to bring together academic, industry and government personnel from various countries to present and discuss the challenges for implementation of sustainable policy in the field of production and logistics.

Paulina Golinska · Marcin Hajdul
Editors

Sustainable Transport

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Preface

The transport is traditionally connected with the speed of economic growth. The European economy has been undergoing radical changes in recent years. The effects of the financial worldwide crisis and the slowing down of economies of many enterprises have become visible. Companies have faced the need to seek for new ways of costs reduction. It is worth remembering, that price of the finished product offered by manufactures or distributors depends also on the level of incurred logistics costs. Transport expenditures might constitute in many cases over the 50% of total logistics cost.

Frequent and prompt deliveries require more means of transport, whereas the absence of co-operation among companies and processes coordination results in involving many carriers. These actions cause the traffic, worsening of the road safety, or also a growth of harmful substances emission. Enterprises are part of the wider system. There is direct correlation between way of organizing transport processes and situation in the transport system of the region. Therefore it is necessary to take into account a strong correlation between the organization of transport processes in enterprises and the environment in which they operate.

Improvement of transport processes should be done using the concept of sustainable development. It is capable to meet current needs, in such a way that it does not eliminate the possibility of implementing the same or other purposes by the entity in the future. It involves balancing of three areas: economic, ecological and social development.

The aim of this monograph is to present the emerging environmental issues in organization and management of transport. The scope of book includes solutions which show the different stakeholders viewpoints on sustainability. It points out how the transport operations organized and conducted in the companies and regions might be consistent with the concept of sustainable development. The scope of monograph takes into consideration trade-off relations between actors directly and indirectly involved in transport networks. Therefore, authors present, in individual chapters, innovative approach to eco-friendly organization and coordination of transport processes, as well as management of transport networks.

In this monograph the emphasis is placed on four main areas:

1. shift from traditional transport to a sustainable one (on the way to sustainability in the transport sector);
2. collaboration models for sustainable transport;
3. information systems and information management supporting sustainable transport;
4. intermodal transport and models for CO_2 reduction.

The aim of the first chapter is to provide the review of current issues in European Transport Policy. The emphasis is placed on the development of the sustainable transport system. Authors identify main barriers for the sustainability of transport operations and describe main challenges for development of sustainable transport system.

The next chapter aims to overview of interconnectivity issues in the area of passenger transport in the context of sustainable transport development in the EU. At present the European Transport Networks' role as integrated international networks is compromised by poor interconnectivity. Authors present tools and solutions for improvement of interconnectivity.

The chapter "A structured approach for assessing sustainable best practices in supply chains" contains solutions for the evaluation process of select supply chain practices that can help to reduce the negative impact of transport, while improving long-term economic performance.

The final chapter in the first part focuses on sustainable development through implementation of logistics and spatial policy. Region EmiliaRomagna is presented as the case of successful implementation of such policy. Special attention has been paid to one of the tools of logistics and spatial policy of this region—Ecologically Equipped Industrial Areas.

The second part of the book presents models for coordination of transport processes especially within small and medium size companies. The emphasis is placed on the role of collaboration among companies in order to reduce the number of ineffective routes and to increase the load factor of particular vehicles.

Author in the chapter "Coordination model of transport processes based on sustainable development concept" presents new business model for vertical and horizontal cooperation between logistics services clients (consignees, consignors) and logistics services providers (SMEs). The aim of cooperation is to increase the load factor and to reduce transport costs. Moreover the model allows exploiting co-modality concept, understood as use of different modes separately and in combination, in order to obtain an optimal and sustainable utilization of resources. Author identifies interfaces between activities of enterprises and the transport system of the region, taking into account the economic, social and environmental impacts.

The idea of sustainable development emphasizes the rationalization of the demand for transport services. The key element in rationalization of freight transport is increased use of vehicle capacity. In the case of small and medium size enterprises, initiatives that aim to aggregate the demand for transport services are promoted. The chapter presents an information tool which facilitated integration of small and medium size enterprises to fulfil the goals of sustainable development policy.

Authors in subsequent chapter introduce the simulation approach in logistics as an effective work method. Then they describe the functionality of a running simulation tool, the variables it considers, the logic of the simulation algorithm, the quantitative indicators it produces.

The third part of the book focuses on the information technologies, which play an important role in transport management. The big number of different systems applied in particular European countries causes problems in interoperability and information exchange.

The opening chapter in this part presents the "one common framework" which allows interoperability between companies and communication to authorities and transportation network responsible. It supports better utilization of the available transportation infrastructure, provides appropriate security, and supports compliance requirements. The common framework approach lowers the cost for companies to electronically connect in transport and logistics.

In the next chapter authors addressed issues related to ICT support for intermodal transport chain development. The chapter describes approaches of intermodal transport chain development tools and gives an outlook about the necessary next steps.

The execution of UE Transport Policy requires the development of number of plans like e.g. the Sustainable Urban Mobility Plans. Authors of the successive chapter have proposed a standardized methodology to develop Sustainable Transportation Plan that includes an information system and decision support system. Also, a decision support system based on socio-economic indicators, mobility, energy and environmental indicators has been design and integrated to aid in the evaluation and strategies selections.

The last part of the monograph covers two important topics, namely development of the intermodal transport and CO_2 reduction. The intermodal transport is recently strongly promoted by European Commission. Therefore, the presentation of the best practices can be found in chapter entitled "Supporting intermodal transport solutions in selected European countries—case studies". Authors present the role of public authorities in creation of efficient transport infrastructure for intermodal haulages.

Chapter "Development of intermodal train concepts as a method for sustainable regional development" presents the problems which arise by establishment of the more environmental friendly freight transport solutions in order to address regional goals like accessibility, economic development and reducing emissions. Authors highlight the economical dimension and present a methodology how to design new, cost-effective freight train services.

The subsequent chapter examines innovative and alternative transport systems for freight transportation and benchmarks them in accordance to their fitness to application in ports and terminals. The chapter overviews new technologies and transport systems under development, which are not applied to practice yet. This chapter gives an overview of currently emerging innovative systems for freight transportation in port regions. All stages of development, from visions to market ready solutions have been researched. Technologies which are applicable for the usage in ports and terminals have been filtered and assessed against economic, social and environmental criteria in the benefit analysis.

The final chapter presents model for road traffic CO_2 emissions control by means of tradable permits. The chapter overviews the theoretical aspects of tradable permits, compares tradable permits and tax schemes and explains options of initial allocation systems. The opportunities and threats of the potential introduction of tradable permits for fuel at the micro- and macro-economic level are assessed. A model for road traffic emissions control by means of tradable permits is presented for the case of Slovenia.

This monograph provides a broad scope of current issues important for the development of the sustainable transport system in local, regional and international scale. Authors of individual chapters describe the practical examples of number of EC initiatives, mainly in the 6th and 7th Framework Programme. The advantage of this book is holistic approach to organization and management of sustainable transport systems.

Paulina Golinska
Marcin Hajdul

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Part III Information Systems and Information Management Supporting Sustainable Transport

Part IV Intermodal Transport and Models for CO2 Reduction

Part I
On the Way to Sustainability in the Transport Sector

European Union Policy for Sustainable Transport System: Challenges and Limitations

Paulina Golinska and Marcin Hajdul

Abstract Modern society is characterized by high mobility. Moreover globalization of trade stimulates growth of the international freight of goods between continents and countries. Changes in commerce and personal travel patterns have increased the importance of a reliable, efficient and environmental friendly transport system. The aim of this chapter is to provide the review of current issues in European Transport Policy. The emphasis is placed on the development of the sustainable transport system. Authors identify main barriers for the sustainability of transport operations. Authors describe main challenges for development of sustainable transport system, which are identified in the new 2011 White Paper on Transport Policy.

Keywords Transport policy · Sustainable development · Sustainable transport system

1 Introduction

Transport system is nowadays important factor for economic growth. It supports the peoples' everyday quality of life. Nowadays mobility is a must at every well-developed economy. Average mobility per person in the EU, measured in

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passenger-kilometre per inhabitant, had increased by 7% between 2000 and 2008. It is caused mainly through higher motorization levels, which is accompanied by the development of high-speed rail and the rise of cheap airlines. Over the last decade also freight transport demand has continued to grow by more than GDP. The only exception from this trend was the years of the crisis 2008 and 2009. The growth of freight is caused by new business practices like:

- concentration of production to reap economies of scale;
- off-shoring;
- just-in-time deliveries;
- development of reverse logistics (including growth of transport of waste recycling sites).

The transport industry accounts for about 7% of GDP and for over 5% of total employment in the EU of which 4.4% corresponds to transport services and the rest to transport equipment manufacturing, while 8.9 million jobs correspond to transport services and 3 million to transport equipment (Future of Transport 2009).

Transport comprises several elements like: infrastructure, transport vehicles and equipment, ICT applications, network services, and operational and administrative procedures. It is a very complex system that depends on many factors as:

- pattern of human settlements;
- consumption;
- location of production sites;
- availability of infrastructure.

The transport policy is performed in long-term periods, because it takes long time to build appropriate infrastructure and to stimulate new users' behaviour patterns. The European Union has made a big step since 1992 regarding development of the transport system. European Union Council of Ministers of Transport (2004) defined the sustainable transport system, features as:

- it allows the basic access and development needs of individuals, companies and society to be met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations;
- it is affordable, operates fairly and efficiently, offers a choice of transport mode and supports a competitive economy, as well as balanced regional development;
- it limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and uses non-renewable resources at or below the rates of development of renewable substitutes, while minimizing the impact on the use of land and the generation of noise.

The Renewed Sustainable Development Strategy of the European Union adopted by the European Council in June (2006) defines a sustainable transport as "a system that meets society's economic, social and environmental needs whilst minimizing its undesirable impacts on the economy, society and the environment" (RDS 2006). The undesirable effects are:

- congestion;
- oil dependence;
- accidents;
- emissions of GHG and of other pollutants;
- noise;
- land fragmentation caused by infrastructure.

The main goal of the transport policy is secure, safe and environmentally friendly mobility.

Since 2006 the concept of co-modality has been introduced, which requires efficient use of different modes on their own and in combination, resulting in an optimal and sustainable utilization of resources. This approach offers possibility to achieve at the same time a high level of both mobility and environmental protection. The challenge is still the integrated, technology led, user- and environment- friendly Single European Transport Area.

A number of document of the European Commission are published regarding the development of common transport. The most important among them are:

- White Papers of 1992, 2001, 2011 (2011);
- Keep Europe Moving (2006);
- Logistics: Keep Freight Moving (2007);
- Greening Transport (2008);
- Maritime Transport Strategy 2018 (2009);
- Future of transport (2009).

Ex post evaluation of the White Papers 2001 undertaken by the Commission, has shown that, efficiency, safety and security of transport system has improved a lot. The main problem is still the high dependency on fossil fuels and the dominance of road transport (both in freight and passengers). The experts announce a significant need for shift in the current transport paradigm in order to reduce unsustainable trends:

- growing GHG emissions;
- oil dependency;
- growing congestion.

In the next section authors describe in detail the main problems in the development of sustainable transport system in Europe, as well as the root causes of current situation.

2 Barriers to the Development of Sustainable Transport

The current policy of the European Commission requires that transport system should be able to develop without serious negative consequences in the form of environmental, economic and social costs. There are still obstacles on the way to

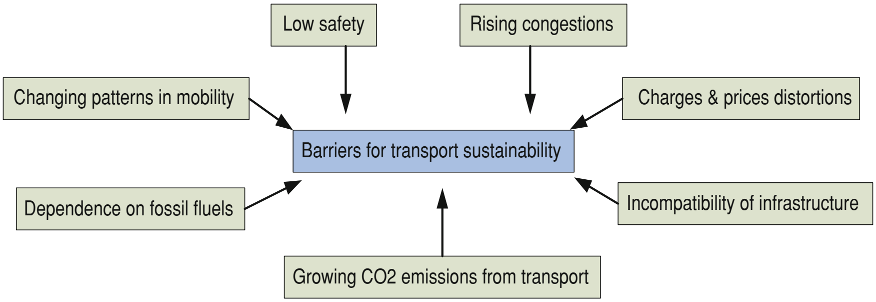

Fig. 1 Barriers for transport sustainability

the creation of the efficient sustainable transport system, main of them are presented in the Fig. 1.

Incompatible infrastructure—most of the existing transport infrastructure has been designed to serve national rather than European economy. The effects of these historical limitations are cross border bottlenecks that constrain the EU economy integration. Still existing problem is the lack of comprehensive standards on infrastructure design, power supplies, traffic management and data exchange. In last decade the application of Cohesion Fund and European Regional Development Fund has helped to developed Trans-European transport networks (TEN-T). About one third of the necessary investments counted for EUR 400 billion in the TEN-T have been made. There is still need for additional investment in the infrastructure in order to create co-modal logistics chains which optimize the use of the different modes. The main shortages appear in the following infrastructure:

- transalpine tunnels;
- rail corridors, intermodal nodes for rail and sea or air transport;
- IT infrastructure supporting intermodal transport.

The efficient transport system requires integration and interoperability of the individual parts of the network within Europe. Moreover also interconnections between different modes of transport are needed. Crucial in achieving this result are the logistics centres which play the role of the network's nodes. Nowadays there is still scarcity of intermodal and transhipment platforms which can consolidate and optimize passenger and/or freight flows in the urban areas in order to avoid frictions. A big problem regarding the development of Trans-European infrastructure is disconnected planning at national and EU level. Due to the lack of international cooperation following inefficiencies appear (Impact Assessment 2010, pp. 23–24):

- lack of joint traffic forecasts leading to differing investment plans;
- disconnected or even contradictory timelines;
- lack of joint investment calculation and joint financial structures;

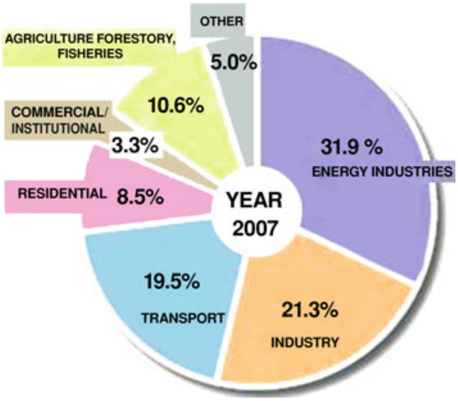

Fig. 2 GHG Emissions by Sector—EU-27 Million tonnes $CO_{2.}$ (Source: Statistical pocket book 2010 EU Energy and Transport in figures)

- incompatible technical characteristics;
- inadequate joint management of cross-border infrastructure projects.

Still one of main problems by design and execution of infrastructure projects is lack of network-oriented approach.

Growing CO_2 emissions from transport—since 1990 transport sector has greatly increased its activity. At the same time the reduction of its energy and GHG intensity has been insufficient. There is no other sector which has the growth rate of GHG emissions as high as in transport comparing to early nineties. As presented in Fig. 2 in year 2007 according to data from the European Environment Agency, transport is accounted for close 20% of total GHG emissions 19,5 and 23,1% of total CO_2 emissions in the EU-27. Railways, maritime and inland transport have better CO_2 performances for long-haul shipments. Maritime transport is the most energy-efficient mode of transport because of its large loading capacity.

The growth of transport activities raises concern for its environmental sustainability. The energy efficiency of transport is increasing, but the improvements have not been enough to outweigh the larger transport volumes. Introduction of EURO emission standards supports the standardization and upgrade of new cars. Still the pace of improvements is not sufficient to create sustainable transport system in Europe.

Dependence on fossil fuels—transport does not reduce significantly its GHG intensity by switching to cleaner energy sources and is still 97% dependent on fossil fuels. A binding target of a 10% share of renewable energy sources in transport by 2020 (Directive 2009, pp. 16–62) have been adopted recently as part of the climate and energy package by European Union. This situation is a crucial barrier for development of sustainable transport system in Europe.

Low safety—the 2001 White Paper included the objective to halve casualties in road transport by 2010. This goal has not been achieved although different actions had been taken in many Member States. In the other modes of transport the situation has improved. EU has established one of the most advanced regulatory frameworks for safety and for pollution prevention in maritime sector. In aviation sector was been implemented a set of common, uniform and mandatory legislation covering all the key safety elements:

- aircraft maintenance;
- airports management;
- operations of air traffic management systems.

Rising congestion—the road transport is the main mode for the bulk of passengers and goods movement. According to the European Commission the share of road transport in total freight is at the level of 76,9%.[1] At the same time the share of rail is only 17.6%. The current capacity of transport networks is not able to meet the growing demand, what causes congestion in urban areas and on the key transit roads. Also some airports are very congested. Therefore effective organization of the transport processes is becoming increasingly difficult. It causes situation that journey times lengthen and reliability suffers. The problem of increasing congestion is trying to solve the European Commission. One of the first ideas, published in the 2001 White Paper on European Transport Policy, was to reduce the congestion by moving traffic from the road onto rail, inland waterways or short-sea shipping. Strong emphasis was also placed on the use of intermodal transport, i.e. the movement of cargo using different modes of transport. Examples include road-rail transport, where on the main part of distance is used rail transport, while road transport is used only for cargo delivery from rail siding to the final recipient.

Moreover the road transport itself need to be greener and more efficient too. New vehicle technologies, improve infrastructure, fuel efficiency and "eco-driving" are needed. Also intelligent mobility and transport demand management solutions might help to lower the congestion. There is still lack of the cooperative systems based on vehicle-to-vehicle and vehicle-to-infrastructure-communications that might in the longer term improve considerably the efficiency of traffic management and alleviate congestion.

Current mobility patterns—the progress in shifting from road transport to other modes is still very limited. Unfortunately, the European Commission, despite the enormous efforts, was unable to convince companies to change the organization of logistic processes and take into account when planning the impact on the environment and society. One of the main reasons for this situation was little consideration of the factors affecting the choice of transport modes. Entrepreneurs, without strong arguments concerning the improvement of their financial results, were not interested in using alternatives to road freight transport. International road freight transport grows twice as fast as domestic road freight transport and 30% of total road freight is international.[2] The factors which shall be taken in consideration by the company during the selection of modes of transport are presented in Fig. 3.

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[1] http://epp.eurostat.ec.europa.eu, for EU-27.

[2] Source: Road Freight Transport Vademecum, N°2, March (2009).

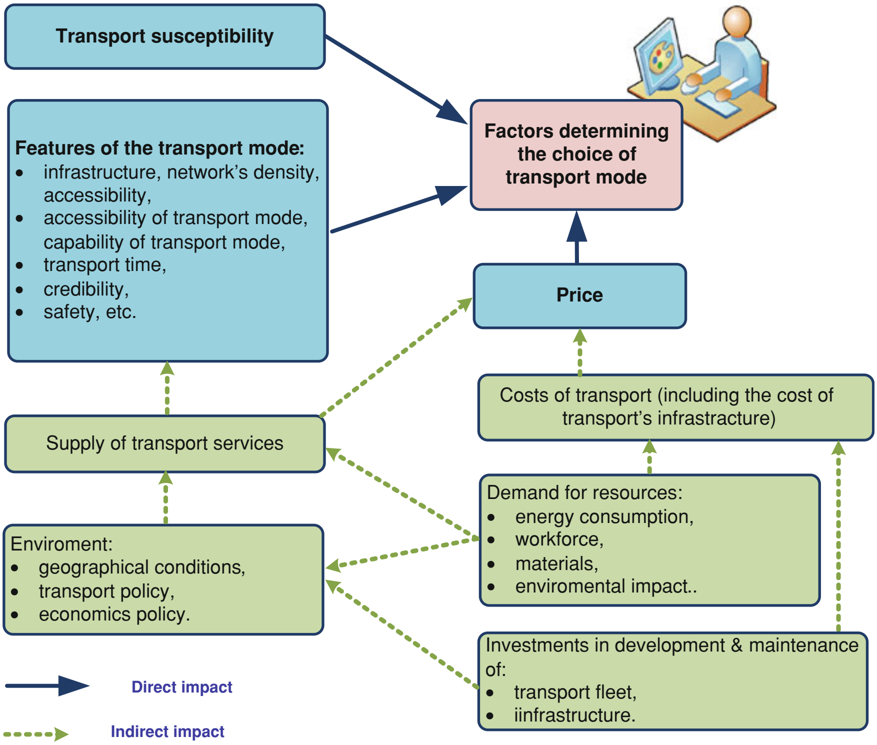

Fig. 3 Factors determining the choice of transport mode

Therefore, it is worth to note that the choice of modes of transport directly affects a number of factors such as price, the susceptibility of the cargo and the characteristics of the transport modes. Therefore, in many cases, the use of rail transport, inland waterway or intermodal is simply impossible. A better exploitation of the network's capacity and of the strengths of each transport mode could contribute significantly to reducing congestion, emissions, pollution and accidents.

In connection with the facts set out above, the European Commission has decided to revise its policy for logistics and transport. Focuses on supporting the process of rationalization of logistics enterprises based on the concept of sustainable development. The main problem is lack of the optimization and operation of the multimodal network as a single entity. Nowadays even within the same transport mode there is a lack of integration between countries.

In the passengers transport the main problems that need to be faced are:

- aging society—older drivers are not so flexible on changing to new vehicles technologies;
- low utilization rate of individual transport modes (c.a. 1,25 passenger/car);
- growth of urban areas resulting in forced mobility (every day long trips work-home);

- insufficient (unreliable and unsafe) public transport;
- outermost regions suffer from a strong accessibility deficit.

Charges and prices distortions—at present charges do not fully reflect the societal costs of transport. There are inconsistent taxation rules between transport modes and fuels. Some solutions between and within Member States might cause situation where tax systems subsidize environmentally unsustainable choices.

In order to achieve the goal of sustainability it is important to internalize the transport externalities. The economic efficiency of transport cannot be reached unless the prices reflect all internal and external costs caused by the users. The prices are not combined with the scarcity of infrastructure or services. The differentiation of prices for the use of the road in peak versus off-peak hours is very seldom. There is no incentives policy for usage of more silent vehicles, safer and more environment friendly modes of transport. Moreover the congestion charges, which represent the cost of infrastructure scarcity, are not often imposed.

On the other hand transport brings about positive externalities to society by connecting the isolated regions and stimulating by easier accessibility their economic growth. Moreover transport system generates revenues for public budget including:

- energy taxes (c.a. 1.9% of GDP) coming from fuel taxes on road transport and the private cars;
- vehicle taxes (c.a. 0.6% of GDP[3]);
- tolls and charges for infrastructure use.

Despite already paid by users a significant amounts, the price often bears little connection to the real costs of transport on society. The principle "polluter pays" is not respected in all cases. The costs imposed on transport users do not reflect expenses for infrastructure development and maintenance. Moreover the pricing system fails to steer the demand for most efficient and sustainable mobility choices.

3 Fundaments of Transport Policy

In March 2011 the European Commission has published new White Paper on Transport which highlights main goals of policy in order to create a Single European Transport Area. The sustainability issues play a very important role in this document. The paper includes a roadmap of 40 concrete initiatives for the next decade to build a competitive and sustainable transport system which will:

[3] Eurostat, Taxation trends in the European Union (2008) edition. European Commission, 'Excise duty tables, tax receipts—Energy products and electricity', July 2008.

- increase mobility;
- remove legislative major barriers in key areas;
- protect employment;
- optimize usage of fuels.

3.1 Reference Scenario: As is State

In the process of preparation of the 2011 White Paper on Transport a number of simulations were performed. Results show that, in a "no policy change" scenario, the unsustainable features of the EU transport system are likely to worsen because of growing demand for transport. Total transport activity is expected to continue to grow. Total passenger transport activity would increase by 51% between 2005 and 2050 while freight transport activity would go up by 82% (Impact assessment 2010). Final energy demand by transport is forecasted to increase by 5% by 2030 and an additional 1% by 2050, driven mainly by aviation and road freight transport. At the same time the energy use of passenger cars would drop by 11% between 2005 and 2030 due to the implementation of the Regulation (EC) No 443/2009 setting emission performance standards for new passenger cars. The share of CO_2 emissions from transport would increase to 38% of total CO_2 emissions by 2030 and almost 50% by 2050. Overall, CO_2 emissions from transport would still be 31% higher than their 1990 level by 2030 and 35% higher by 2050 (Impact assessment 2010). Additionally aviation and maritime would contribute an increasing share of emissions.

External costs of transport would growth because of increasing mobility. It is forecasted about 20 billion € increase of noise-related external costs by 2050 and external cost of accidents would be about 60 billion € higher. The external cost of accidents in urban areas would increase by some 40%. Only the external costs related to air pollutants would decrease by 60% by 2050. Congestion costs are estimated to increase by about 50%, to nearly 200 billion € annually (Impact assessment 2010).

In order to avoid the above mentioned negative consequences it is clear that new tools must be implemented by the European Commission to stop the present unsustainable trends. Without well planned actions the transport system is not able to adjust to the climate change, infrastructure constrains and fossil fuels scarcity.

3.2 Main Goals of New Strategy

The objective of the White Paper on Transport Policy contributes to the objectives laid down in the EU 2020 Strategy "Resource efficient Europe". This strategy aims to support the shift towards low carbon economy through the reduction of CO_2 emissions and energy security. Within the transport sector the implementation

Fig. 4 Goals of new transport strategy

of resource efficient policy requires reduction of energy consumption, introduction of cleaner energy and better utilization of the infrastructure. The benchmark is creation of de-carbonized transport system. The important requirement for all new policy tools should not prevent that "current and future generations have access to safe, secure, reliable and affordable mobility resources to meet their own needs and aspirations".[4]

The new element of the strategy comparing to 2001 White Paper on Transport Policy is focus on urban mobility. The strategy proposes different course of actions for transport within the cities, between cities, and long- hauls. The main goals are presented in Fig. 4.

The first goal of new transport policy is to keep the transport growing and supporting mobility while achieving the goal of 60% GHG emission reduction by 2050 comparing to 1990 level.

In order to achieve this goal the European Commission has defined ten goals for a competitive and resource efficient transport system which benchmarks for achieving the 60% GHG emission reduction target. The following action should be taken (2011 White Paper, pp. 9–10):

- Halve the use of 'conventionally-fuelled' cars in urban transport by 2030; phase them out in cities by 2050; achieve essentially CO_2-free city logistics in major urban centres by 2030;
- Low-carbon sustainable fuels in aviation to reach 40% by 2050; also by 2050 reduce EU CO_2 emissions from maritime bunker fuels by 40% (if feasible 50%);
- 30% of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050, facilitated by efficient and green freight corridors. To meet this goal will also require appropriate infrastructure to be developed;
- By 2050, complete a European high-speed rail network. Triple the length of the existing high-speed rail network by 2030 and maintain a dense railway network in all Member States. By 2050 the majority of medium-distance passenger transport should go by rail;

[4] SEC(2010) 1606 final (14 December 2010) Commission Staff Working Document, "A European Strategy for Clean and Energy Efficient Vehicles–Rolling Plan".

- A fully functional and EU-wide multimodal TEN-T 'core network' by 2030, with a high quality and capacity network by 2050 and a corresponding set of information services;
- By 2050, connect all core network airports to the rail network, preferably high-speed; ensure that all core seaports are sufficiently connected to the rail freight and, where possible, inland waterway system;
- Deployment of the modernized air traffic management infrastructure (SESAR) in Europe by 2020 and completion of the European Common Aviation Area; Deployment of equivalent land and waterborne transport management systems (ERTMS—European Rail Traffic Management System, ITS—Intelligent Transport Systems for road transport, RIS—River Information Services, SSN—the EU's maritime information systems SafeSeaNet and LRIT—Long Range Identification and Tracking of vessels). Deployment of the European Global Navigation Satellite System (Galileo);
- By 2020, establish the framework for a European multimodal transport information, management and payment system;
- By 2050, move close to zero fatalities in road transport. In line with this goal, the EU aims at halving road casualties by 2020. EU should be a world leader in safety and security of transport in all modes of transport.
- Move towards full application of "user pays" and "polluter pays" principles and private sector engagement to eliminate distortions, including harmful subsidies, generate revenues and ensure financing for future transport investments.

The above mentioned actions are reflecting three main areas that are important for development of logistics and transport operations, namely:

- developing and implementing of new and sustainable fuels and propulsion systems,
- optimizing the performance of multimodal logistic chains,
- increasing the efficiency of transport services and infrastructure's utilization with information systems and market-based incentives.

The next goal namely, efficient core network for multimodal intercity travel and transport requires the consolidation of large volumes for transfers over long distances. This implies greater use of buses and coaches, rail and air transport for passengers and, for freight, multimodal solutions relying on waterborne and rail modes for long-hauls. Integration of network should result in linking of airports, ports, railway, metro and bus stations. The physical infrastructure will be connected to online information and electronic booking and payment systems in order to facilitate multimodal travel. It is assumed that in 2050 perspective freight shipments over short and medium distances (below some 300 km) will be transported mainly by trucks. The new technologies for green vehicles are crucial, regarding the short design-to-market introduction of new engines and cleaner fuels. For long-haul freight de-carbonization goal should be achieved by making the multimodal transport economically attractive for shippers. The benchmarks are specially developed, fully functional and EU-wide core network of transport corridors. These corridors should be optimized in terms of energy use and emissions, reliable with low operating and administrative costs. The challenge is to improve the economical attractiveness and service quality for maritime, inland and rail transport in order to take a significantly greater proportion of medium and long distance freight. By 2050, all core airports should be connected to the rail network (high-speed if possible) and all core seaports should be sufficiently connected to the rail freight and, where possible, inland waterway system. For freight transport, an intelligent and integrated logistics system must be deployed, where ports and intermodal terminals will be key element.

The next goal is to achieve the global level-playing field for long-distance travel and intercontinental freight. Europe should in the next decades play a role of global hub**.** For long-distance travel and intercontinental freight, air travel and ships will continue to dominate. New engines, fuels and traffic management systems will increase efficiency and reduce emissions (Future of Transport 2009)**.** It is important to create tools for sustainable aviation management, which are able to face growing demand for travel to and from third countries and areas of Europe. The increase of demand is forecast to double of EU air transport activities by 2050. In order to avoid increase in aviation congestion high-speed rail should absorb much medium distance traffic. By 2050, the majority of medium-distance passenger transport should be operated by rail.

Clean urban transport and commuting requires gradual elimination of more conventionally-fuelled cars from the cities. This goal should be achieved in three steps:

- halve the use of conventionally fuelled cars by 2030;
- achieve essentially CO_2-free movement of goods in major urban centres by 2030;
- eliminate the traditional vehicles by 2050.

Congested urban area caused higher utilization of fuels than on the outer roads. Reduction of GHG emission within urban areas will contribute to sustainability. Shift to greener cars will require the development of appropriate fuelling/charging infrastructure for new vehicles. Also growth in the share of travel by collective transport is crucial. The improvements are required which will allow increasing the density, frequency and quality of public transport service. Also walking and cycling zones should become an integral part of urban mobility. The use of electric, hydrogen and hybrid technologies should be promoted among public transport companies.

Another important element of building CO_2-free movement of goods in major urban centres is deployment of the interface between long distance and last-mile freight transport. The reduction of the individual deliveries is need, due to the fact that they are the most inefficient part of the journey.

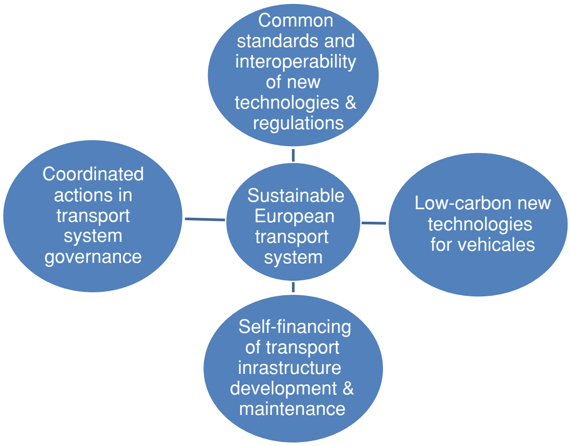

Fig. 5 Challenges for development of sustainable transport in Europe

4 Challenges for the Future

The main challenges for the development of sustainable transport system in Europe are presented in Fig. 5.

The traditional transport infrastructure is designed for both passenger and freight. The new challenge might be to provide dedicated transport corridors in order to obtain more efficiency when users have similar volumes and speeds. The other options might be setting the 'smart' priority rules in order to lower congestions in the most crowded transport corridors. The powerful tool for the development of sustainable transport system will be setting of the open standard for the design of new infrastructure, vehicles, and necessary devices.

The adequate infrastructure is a key element of the Single Transport Area in Europe. The emphasis should be placed on eliminating the residual barriers between modes and national systems in order to speed up the process of integration. In EU 27 still exist large divergences in transport infrastructure between eastern and western Member States. The core network should cover efficient multimodal connections between the capitals, main cities, ports, industrial centres, main airports, maritime and inland ports, as well as border crossing of key importance. The emphasis should be placed on mounting the existing infrastructure's gaps and increasing throughput of the bottlenecks. The cost of EU infrastructure development to match the demand for transport has been estimated at over € 1.5 trillion for 2010–2030. The completion of the TEN-T network requires about € 550 billion until 2020 out of which some € 215 billion can be allocated to the removal of the main bottlenecks (based on data from 2011 White Paper). The above mentioned numbers exclude the cost of expenditures needed for investments in vehicles, equipment and charging infrastructure. In simulations performed by elaboration of the new 2011 White Paper these costs have been estimated for an additional trillion to achieve the emission reduction goals for the transport system.

The bottlenecks are most visible in the internal market for rail services. There are still many administrative, regulatory and infrastructural obstacles on the way to Single European Railway Area. The harmonisation and supervision of safety certification are essential in this field. For maritime transport, a “Blue Belt” in the seas around Europe shall simplify the formalities for ships travelling between EU ports. Essential is also the development of the suitable framework for the improvement of the inland waterway transport in European Union (2011White Paper). The important role to play in the investments process should have not only regional and national governances but also multinational and multimodal logistics operators.

New emerging technologies should be interoperable, safe and user-friendly. The internet technologies open new perspective for open exchange of information among stakeholders of the transport system. Easy access to information over routing, travelling times is necessary for improvement of door-to-door mobility of both passengers and freight. Information technology tools should be widely applied to simplify administrative procedures, cargo tracking and tracing activities, as well as to optimise schedules and traffic flows (e-Freight).

The changes in regulatory framework conditions are crucial for the development of sustainable and innovative transport’s services. Main concern should be standardisation and interoperability requirements that will avoid technological fragmentation and enable companies to fully benefit from the entire EU transport market, as well as will provide access to global market opportunities. Smart intermodal ticketing, with common EU standards that respect EU competition rules is very important (2011 White Paper). Another challenge for IT systems is the better electronic route planning across modes, adapted legal environment (inter-modal freight documentation, insurance, liability) and real time delivery information also for smaller consignments is needed.

‘Growing out of oil’ will not be possible relying on a single technological solution (2011White Paper). In order to lower the dependency on fossil fuels a new concept of mobility is needed. This new concept should be supported by new technologies. The most promising technologies should be promoted in order to achieve a faster and cheaper transition. This approach includes both already existing and the emerging technologies, such as:

- fuel-cell power trains;
- hydrogen cars;
- electric cars;
- alternative fuels: bio-ethanol, methanol, algae’s fuel, bio-diesel, solar energy, ect.;
- new materials: composite materials (e.g. organic, carbon, aramid), very light materials (e.g. aluminium, magnesium), nanomaterials;
- biodegradable vehicles.

Through new engines, materials and design, as well as cleaner fuels can be achieved more environmental friendly traffic, especially in the urban areas. The problem of the “charging infrastructure” must be solved for green vehicles which consume the electricity from renewable sources or hydrogen. It is necessary to reach compatibility in all the Member States. Moreover new technologies are now in the most of the cases not cost-effective. This cost-competitiveness gap should be mounted. The development of clean technologies should be supported with a systems' approach. The holistic approach should include infrastructure, regulatory requirements, as well as mechanism for coordination of multiple actors. The European Commission will compile an innovation and deployment strategy for the transport sector, in close cooperation with the Strategic Energy Technology Plan (SET-plan) identifying appropriate governance and financing instruments, in order to ensure a rapid deployment of research results (2011 White Paper).

The coordinated governance is needed to link the infrastructure development and land-planning at local and European level. Outermost regions will need to exploit the potential of regional airports and maritime connections. The need for integrated logistics systems should be monitored by public policies enabling the co- modality, standardisation and interoperability across modes. Development of the transhipment hubs will be an important part of sustainable transport policy. Large logistics multimodal operators might be included in co-financing of new infrastructure within public—private partnership (PPP) projects.

A new challenge is the diversification of the financing sources for big investments in the infrastructure. Additional sources of funding should include schemes for the internalisation of external costs and infrastructure use charges. The cost of externalities like: noise, air pollution and congestion could be internalised through charging for the utilization of infrastructure. This approach could create additional revenue streams making infrastructure investments more attractive to private capital (2011) White Paper. In its Communication on the Strategy for the internalisation of external costs SEC (2008)2207, the European Commission has laid down a common methodology to charge all external costs in the transport sector. The new regulatory rules are unlocking the potential of private finances for participating in the investments' costs of the infrastructure development.

The improvement of charges and taxation system within transport sector should contribute to self-financing of the infrastructure maintenance and deployment. Moreover the reform of prices and taxes system should allow full application of "user pays" and "polluter pays" principles. The changes in so-called 'Eurovignette Directive' will result in a higher degree of internalisation of costs generated by heavy goods vehicles. The planned step-by-step approach will lead to a mandatory harmonised internalisation system for commercial vehicles both in urban and outer areas.

5 Conclusions

Authors in this chapter have presented the review of current issues in European Transport Policy. The emphasis is placed on the development of the sustainable transport system. The chapter overviews the main problems and challenges on the way of building the sustainable transport system in Europe. The future actions

Table 1 Future actions to be taken

	Barriers for sustainability	Actions to be taken
1	Incompatible infrastructure	Joined investments plans, coordinated land planning; further development of TEN-T network; open standards for design of infrastructure; open standards for information exchange systems
2	Growing GHG emissions	Green technologies, electric cars; promoting of walking and cycling, better public transportation network, phasing out traditional vehicles from urban areas, low carbon aviation and maritime transport
3	Dependence on fossil fuels	Development of alternative fuelling/charging infrastructure; focus on research in cost-effective renewable fuels, shorter design-to-market cycles for green technologies
4	Low safety	To separate cargo and passengers corridors; improvement of the signalling systems; implementation of new vehicles safety systems.
5	Congestion	Development of high-speed rail; increase in density of rail networks; efficient and green freight corridors; development of intermodal hubs; intermodal integration of transport services
6	Mobility patterns	Promoting of co-modality; incentives for usage of public transport; creating platforms connecting airports and ports with efficient rail services; establishing the framework for a European multimodal transport information, management and payment system attractive frequencies, comfort; easy access, reliability of services; smart intermodal ticketing, with common EU standards
7	Prices and taxes distortions	Connecting prices and taxes with sustainability; self-financing of maintenance and development of infrastructure, incentives for companies for usage of intermodal transport, full application of “user pays” and “polluter pays” principles, elimination of the harmful subsidies; regulatory framework and innovative financial instruments for unlocking the potential of private sector in co-financing infrastructure’s deployment and maintenances

which should be taken in order to overcome the existing barriers for the sustainable transport development are summarised in Table 1.

The existing European Commission’s documents on Transport Policy provide the road map for needed actions to create a system which will be friendly for the natural environment and the citizens of the Member States. The fulfilment of the defined goals will however, require a coordinated cooperation of local, regional and international stakeholders. The progress which has been performed in the last decade is big but still a number of obstacles exist. In order to provide sustainable transport services are needed new investments, shift in mobility patterns and further technological development.

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Passenger Transport Interconnectivity as a Stimulator of Sustainable Transport Development in the European Union

Monika Bak, Przemyslaw Borkowski and Barbara Pawlowska

Abstract The aim of this chapter is to provide the overview of interconnectivity issues in the area of passenger transport in the context of sustainable transport development in the EU. At present the European Transport Networks' role as integrated international networks is compromised by poor interconnectivity. A realistic assessment of intermodal opportunities is a key ingredient to future policy development. In this part the tools and solutions for improvement interconnectivity are also discussed.

Keywords Passenger transport interconnectivity · Interconnection · Sustainable transport

1 Introduction to Passenger Transport Interconnectivity

Effective integration of passenger transport systems requires good interconnection which cannot be guaranteed without the provision of integrated networks and services which are attractive to potential users.

There are no universally accepted official definitions of the terms used for describing the transport of passengers using more than one transport mode;

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however in current literature the words “multi-modality” and “intermodality” are most often used to define a “characteristic of a transport system that allows at least two different modes to be used in an integrated manner in a door-to-door transport chain”. Distinction between those two terms is often made in case of goods transport with “multi-modal” indicating possibility of transport unit change whereas “intermodal” addresses transport chains utilizing the same transport unit (but still more than one mode of transport). In passenger transport the rigid distinction between these terms does not exist, but the former term is generally applied.

Consequently, a trip may be defined as being “multi-modal” or “inter-modal” where it uses at least two different modes from origin to destination. Both multi-modality and inter-modality have to consider the existence of connections that allow transfers between different transport modes. In this sense the definition on interconnectivity comes straightforward: interconnectivity is a characteristic of a transport network that allows multi-modal or inter-modal transport. Consequently interconnections are the connections between the infrastructures of the various transport networks (de Stasio et al. 2009).

The topic has particular relevance at the European level because the European Transport Networks’ role as integrated international networks is compromised by poor interconnectivity and because the next generation of European transport policies will have to be sensitive to the differences between short, medium and long-term transport markets and the market advantages of each transport mode. In this context, a realistic assessment of intermodal opportunities is a key ingredient to future policy development.

The chapter is based on the results of the project realised in the EU funded 7 Framework Programme—INTERCONNECT (Interconnection between short- and long-distance transport networks) by the team of the University of Gdansk together with partners from five EU countries.

Integrated in the work of the project were the following scientific and technical objectives (Thisgaard et al. 2011):

- To produce quantitative evidence on the current and likely future extent and impacts of poor interconnectivity between long-distance (more than 100 km) and local/regional travel in Europe;
- To provide evidence on key stakeholders perceptions of the underlying causes of the problems and of the applicability of specified solutions;
- To identify and investigate gaps and apparent inconsistencies in the European and national strategic planning concerning interconnection;
- To provide an analysis of evidence on the nature and seriousness of identified barriers to effective interconnectivity;
- To provide an assessment of the effectiveness of available analytical tools for the assessment of problems and solutions in this domain;
- To provide an assessment of the performance of selected policy interventions designed to improve interconnectivity in specific situations;

- To provide evidence on the potential impact of improved interconnectivity on a European scale in particular, though not only, on:
- Decongesting overcrowded transport corridors,
- Encouraging a shift towards the more sustainable transport modes,
- Reduction of Green House Gas (GHG) emissions;
- To provide policy guidance on good practice in implementation of improved interconnectivity;
- To disseminate project findings widely to policy-makers.

In this chapter some results in the mentioned above areas are summarized.

2 Interconnectivity and Sustainable Transport Objectives in EU Transport Policy

Nowadays it is widely acknowledged that facilitating connectivity among modes is crucial for (Sitran et al. 2011):

- Making better use of the existing transport infrastructures;
- Relieving congestion;
- Improving the environmental performance;
- Improving the overall quality of transport operations, thus increasing mobility and influencing passengers' choice.

The optimal and sustainable combination of different transport modes is the basis of the recently introduced concept of co-modality. This is the reason why interconnectivity (and is related term interoperability) is a core theme in the development of the EU transport policy. Together with multimodality and sustainability, interconnectivity is a key word in the design of a comprehensive EU transport policy which is supposed to ensure adequate and efficient accessibility at different levels, that is not only across Member States but also at regional and local level.

The main objective of the INTERCONNECT project was to recommend the solutions aiming for greater efficiency and reduced environmental impact of passenger transport by judicious encouragement of integration, co-operation and, where appropriate, competition in the provision of local connections, paying attention to land, air and maritime modes.

The current part of this chapter gives an overview of EU policy objectives in the field of improving intermodality and interconnectivity of passenger transport in the context of sustainable transport development. For this purpose, those EU policy documents—mainly issued within the last ten years—have been analysed, whose policy objectives or policy measures have a direct impact on passenger intermodality, interconnectivity and sustainability.

The European Commission has put forward in several policy documents the concept of interconnectivity. The policy objectives have been addressed by the EU through an array of measures, including for instance regulations, funding, standardisation, research or the exchange of best practice. In Table 1 the overview of strategic transport policy documents is presented.

The 1990s saw a gradual but significant development of the interconnectivity issue, which evolved into a major policy goal as stated by the Green Paper on the impact of transport on the environment of 1992 which stressed the need to improve the linkage between the different components of urban journeys (Green Paper on the impact of Transport on the Environment 1992).

A later key development in this respect was marked by the Green Paper on the citizen's network of 1995, where the Commission acknowledged that public transport had to be become more flexible and better suited to the needs of passengers (Green Paper 1995).

A breakthrough in setting the course of the European transport policy occurred in 2001 with the release of the White Paper: European Transport policy for 2010: time to decide of 2001. Interconnectivity and intermodality are viewed as priority aspects for easing travelling conditions and modal transfers, as travellers encounter serious impediments when using different modes of transport for single journeys, namely when the latter involve several transport companies or different means of transport. Moreover, the White Paper also concludes that transferring from one mode to another can be complicated by inadequate infrastructure. Within this framework, the White Paper identified a number of key issues to be addressed, such as (White Paper 2001):

- Integrated ticketing, e.g. encouraging the introduction of integrated systems between modes of transport (air–coach–ferry–public transport–car parks), which may also ensure a greater transparency of fares;
- Baggage handling, e.g. making it easier to check in luggage directly in a station without holding it during transfers to/from the airports;
- Continuity of journeys, which requires integration in land-use and transport planning.

Later, both the Mid-term review of the White Paper of 2006 and the Communication "A sustainable future for transport" of 2009 have stressed the need to further encourage and coordinate actions and investments for making the EU transport systems more cooperative, co-modal and to ensure a better interconnection (Keep Europe moving 2006).

On the one hand, the mid-term review of the White Paper emphasises the structural developments that occurred at EU institutional level with the 2004 enlargement. The enlargement shaped as ever the EU dimension, and the extension of the TEN-T network emerges as valuable and strong determinant in creating more corridors and in linking Europe to its neighbours, while ensuring a Europe-wide internal transport market (Green Paper 2009).

On the other hand, the Communication: A sustainable future for transport emphasises that the optimal functioning of the transport system requires full integration and interoperability of the individual parts of the network, as well as

Table 1 Overview of EU contribution to the interconnectivity and sustainability issue

Document	Editor	Year of publication
The Green paper on the impact of transport on the environment	European commission	1992
The Green paper on the citizen's network	European commission	1995
Interoperable electronic fee collection systems in Europe	European commission	1998
Directive on the interoperability of the trans-European conventional rail system	EU parliament and council	2001
White Paper—European transport policy for 2010: time to decide	European commission,	2001
Trans-European transport network: TEN-T priority axes and projects	European commission	2005
Facilitating the movement of locomotives across the European Union	European commission	2006
Keep Europe moving—sustainable mobility for our continent	European commission	2006
Regulation on rail passengers' rights and obligations	EU parliament and council	2007
Trans-European networks: towards an integrated approach	European commission	2007
Green Paper: towards a new culture for urban mobility	European commission	2007
An action plan for airport capacity, efficiency and safety in Europe	European commission	2007
Directive on the interoperability of the rail system within the Community	EU parliament and council	2008
Proposal for a regulation on the rights of passengers in bus and coach transport	European commission	2008
Community guidelines for the development of the trans-European transport network	European commission	2008
TEN-T: implementation of the priority projects progress report	European commission	2008
Action plan on urban mobility	European commission	2009
Green paper: TEN-T: a policy review	European commission	2009
A sustainable future for transport—towards an integrated, technology-led and user-friendly system	European commission	2009
White paper: roadmap to a single european transport area—towards a competitive and resource efficient transport system	European commission	2011

Note: References to the strategic documents are given in the literature items: (A sustainable future for transport 2009; Action Plan on Urban Mobility 2009; Commission working document 2010; Green Paper on the impact of Transport on the Environment 1992; Green Paper 1995, 2007, 2009; Keep Europe moving 2006; Strengthening passenger rights within the European Union COM 2005; White Paper 2001, 2011)
Source: (Sitran et al. 2011)

interconnection between different (modal) networks. Creating the ideal conditions for making interchanges easier and more accessible is here crucial. This applies to both passenger and freight transport, but it is with respect of the passenger side that the need for better integrating the different modes to make seamless journeys possible emerges with utmost importance (A sustainable future for transport 2009).

A more holistic approach to the achievement of a single, interconnected and efficient transport system has been lined up by the EC in the new White Paper on transport policy released in March 2011. Specifically for the issue related to interconnectivity, in the staff working document accompanying the White Paper, the European Commission stresses that

> The modal mix has to be better adapted to the particular needs of each journey and, in the case of passengers, to the overall travel experience. This will only be possible in a system that is highly integrated, and that is based on a continuous and ubiquitous exchange of information. The use of information technology to optimise all aspects of personal travel and freight transport is likely to become one of the most distinctive traits of future transport systems

(Commission staff working document 2011).

Within the project at the national level 67 policy documents has been reviewed and there has been identified 40 documents, which mentions areas relevant to the intermodality and interconnectivity of passenger transport issues (Sitran et al. 2011). Most of the documents reviewed are from the year 2000 and onwards, and large part of the documents concerning the new member states (NMS). In these NMS documents the mentioning of interconnections are only at a general level and not related to access and egress or to any special modes or terminals/stations. The general picture shows that there is little or close to no focus on interconnections in the policy documents. This lack of focus on interconnections in policy can have some negative effects on the passenger transport between neighbouring states and European wide passenger transport. Missing interconnections between different modes of transport and different layers of transport networks level this would not only have a negative impact on people's ability to access local/regional destinations, but it would also reduce access to European and intercontinental destinations and it would have similar effects for people coming from higher levels of transport networks trying to access local/regional destinations.

This lack of accessibility can potentially have negative effects on the economy and social cohesion, both at local/regional level and at the EU level.

3 Tools for Improvement Interconnectivity

In order to analyse solutions for improvement of the interconnectivity one has to identify the key problems of poor connectivity. They can be enumerated as follows (Bonsall et al. 2010):

- Non provision (or inadequate standard) of the infrastructure for local links;
- Poor design, maintenance or operation of modal interchange points;

- Inefficient procedures for interchange (e.g. delays while waiting for luggage);
- Inadequate provision of local transport services (e.g. no fast public transport from an airport to city centre);
- Local transport services exist but do not serve the needs of connecting long-distance travellers (e.g. time tables are uncoordinated, nearest bus stop requires a long walk);
- Inadequate provision of information;
- Unavailability of integrated tickets (covering the local as well as the long distance parts of the journey).

In the INTERCONNECT project the toolkit is one of the major result of the project. This toolkit refers to 94 potential solutions to the problems of poor interconnectivity experienced by long distance travellers whose journeys require them to use short distance "local" mode(s) to commence and/or complete their journeys. The toolkit comprises[1]:

- A list of 94 potential solutions;
- A brief description of the problems of interconnectivity;
- A discussion of the criteria by which to judge the usefulness of different;
- Text descriptions of each of seven categories of solution;
- Matrices summarising the usefulness of the 94 identified solutions;
- Text descriptions of each of the 94 identified solutions, including examples of their application, references and links to more detailed case studies and sources of information.

A set of assessment matrices which summarise each category of solutions in matrix form, has been developed and the assessment criteria is as follows:

- Indicative cost of implementing the solution;
- Technical feasibility;
- Financial feasibility;
- Organisational/legal feasibility;
- Acceptance by users;
- Other aspects of political acceptability (in addition to expected acceptance by users);
- Impact on users door to door travel time;
- Impact on users door to door travel cost;
- Initial impact on comfort or convenience of the users' journey;
- Any detectable increase in users' safety;
- Any detectable increase in users' personal security;
- Any detectable increased access for people with reduced mobility.

[1] For more detailed information please visit the INTERCONNECT website: http://www.interconnect-project.eu/.

For each solution a rating score is given for each of the assessment criteria. In this way the reader is able to absorb the key characteristics of the solutions in a time effective way.

The toolkit's 94 solutions are organised in the following seven solution categories (as included in Table 2).

The **local link infrastructure** category includes those solutions which seek to address the problem of inadequate infrastructure for the link between an interchange (such as an airport) and the centre of the city which it serves. The question of financial feasibility is very important for many of these solutions. The initial investment by government (local, regional, national or supranational, a special purpose authority, or the private sector, will generally be recouped by usage charges which are met, directly or otherwise, by end users. The assessment of overall financial feasibility is based on a judgement as to whether the initial and ongoing costs could be recouped in this way.

The l**ocal transport services** category includes those solutions which concern improvements to the organisation of local transport services which could be achieved without major investment in new infrastructure.

The category labelled **improvements at the interchange point** includes those solutions which address problems experienced at the modal interchange point (e.g. within airports or at major rail stations or ports). It includes improvements to infrastructure which will facilitate movement within the interchange facility, design details which should make movement easier and quicker, and other interventions designed to make the time spent within the interchange more pleasant or productive. Some of these solutions, e.g. car parks and traveller facilities, may generate revenues, but most do not—except indirectly in so far as they might contribute to the attractiveness of the interchange. Their financial feasibility may thus be an issue.

A special category is included for solutions which concern **check-in and luggage transfer**. Although primarily procedural, all will require some investment in infrastructure and information technology. Even where they do not directly generate additional revenue, the financial case for them may be based on the fact that they may attract additional passengers. Note that, as stated in the introduction, changes to procedures and facilities associated with the long-distance leg of the journey are beyond the scope of this document.

Ticketing and pricing solutions concern the provision of integrated pricing and/or ticketing for the individual components of long distance journeys. The idea being that this will make a multi-leg journey easier to understand, plan and execute. The general justification for providing "seamless" journeys is that it would reduce the effort involved in making such journeys.

A distinct group of solutions involving **marketing, information and sales** was identified and includes branding, the provision of information and new sales channels. The idea being that this will make a multi-leg journey easier to plan and execute and will help users identify and access the most appropriate options for their journey.

Table 2 List of solutions improved interconnectivity

Types of solutions	Solutions indentified
Local link infrastructure	Ferry link
	Maglev link
	Link into general HSR system
	Dedicated HSR link
	Link into heavy rail system
	Metro/s-Bahn link
	Tram link
	Monorail/people mover
	Motorway link
	Park and ride facilities
	Tramtrain or traintram
	Guided bus link
	Segregated bus lanes
	In-road bus lanes
	HOV lanes
	Cycle path
	Improved maintenance and earlier replacement of public transport infrastructure
	Vehicle or service upgrade for increased comfort and convenience
Local transport services	Robust schedules
	Integrated timetabling
	Regular interval timetabling
	Creating hub-and-spoke schedules by adding short ‘spokes’
	Increased service frequency or capacity
	Service re-routing
	Direct (shuttle or express) services by rail or bus
	Addition of intermediate stops
	Demand-responsive bus service
	Provision of dedicated shared-ride taxi services
	Link into general bus lines
	Shuttle bus links between different interchange points provision of short feeder flights
Improvements at the interchange point	Additional, conveniently located, car parks
	Convenient positioning of local transport services
	Convenient positioning of taxi services
	Moving walkways
	Elevators and escalators
	Level access to trains and buses
	Visibility axis between modes
	Direct, un-interrupted, logical paths
	Provision of assistance for travellers with reduced mobility
	Tactile guidance systems for disabled
	Improved lighting
	Increase space and comfort at waiting areas
	Provision of services for travellers

(continued)

Table 2 (continued)

Types of solutions	Solutions indentified
	Train information/tickets at baggage claim area of airports
	Multilingual or pictogram information
	Increased provision of staff
	Provision of monitoring cameras
	Cycle facilities at modal interchanges
	Use of charges and subsidies to reduce congestion at the interchange
	Multi-modal information and ticketing booths
Check-in and luggage transfer	At-station passenger check-in for flights
	In-train passenger check-in for flights
	Full check-in and luggage-drop point at airport stations
	Door-to-door luggage transport
	Flight luggage check-in at train station
	Early issue of luggage labels
	Post-flight luggage collection from local train station
	Rfid tagging for luggage
	Self-service luggage check-in and drop-off
Ticketing and pricing	Pre-paid tickets or cards allowing unlimited local travel
	Simple tariff structure for local transport services
	Provision of integrated tickets for local journeys
	Competitive pricing of integrated tickets
	Integrated ticketing for air and rail and within mode
	Pre-booked ticket for parking and public transport
	Integrated ticketing for long-distance rail & local public transport
	Inclusion of local taxi journeys in rail or air tickets
	Smart cards
	Payment via mobile telephone text messages
	Virtual tickets on smart phones
Marketing, information and sales	Common information design guidelines across operators
	Uniform branding and marketing across operators
	Pre-trip marketing of connecting services
	En-route marketing of connecting services
	Pre-journey information about interchanges
	'one stop shop' multi-modal journey planner—national
	'one stop shop' multi-modal journey planne—international
	Local transport ticket sales via internet
	Pricing information and payment systems for international travellers
	Smart phone applications
Enabling solutions	Single strategic authority
	Voluntary partnerships
	Intermodal agreements
	Relaxation of antitrust laws
	Increase competition where little or none exists

(continued)

Table 2 (continued)

Types of solutions	Solutions indentified
	Strengthened independent regulation
	Tendering/franchising/concessioning
	Serial motorway concessions en route to major ports/airports
	Joint management of car parks and serial transport services
	Price regulation for serial rail concessions
	Coordination between local public transport operators and long distance rail providers
	Coordinated policy for management of an interchange's access modes
	System for fair distribution of ticket revenue

Source: (Bonsall et al. 2010)

A final, rather different, category of interventions was identified comprising **enabling solutions** which, while not providing a complete solution to problems affecting end users, seek to facilitate the implementation of more specific solutions by reforming aspects of the operating environment. Many of the impacts of these solutions would come about only indirectly—because some other development is facilitated. These enabling solutions generally involved regulatory or organisational changes.

4 Modelling Interconnectivity

Interconnections between modes could also be analysed in quantitative manner through investigation of the modelling of interconnectivity. Models allow for integration of disperse knowledge that has been gathered through case studies in a systematic way—quantitative whenever feasible—to assess the impact of improving key local and modal interconnections at European level.

The model for interconnectivity assessment calibration is based on using as input data generalised costs obtained from TRANSTOOLS[2] for the different modes and refining these costs based on the knowledge gathered from INTERCONNECT case studies.

Testing of applicability of modelling tools in different situations for number of key nodal points in Europe and at various levels of integration—including different modes of transport allows for creation of meta-model. This final tool indicates what could be the impact on the relative modal shares, if adjusted costs (including interconnectivity issues) were considered. The concept of meta-modelling differs

[2] TRANS-TOOLS ("TOOLS for TRansport Forecasting ANd Scenario testing") is a European transport network model that has been developed in collaborative projects funded by the European Commission Joint Research Centre's Institute for Prospective Technological Studies (IPTS) and DG TREN for purpose of model ling transport systems.

from traditional TRANSTOOLS used widely in transport research and policy making. Traditional transportation modelling approaches are not oriented to deal with interconnectivity and multimodality. Often the definition of "multimodal model" is adopted if the model just covers more than one transport mode, regardless of its capability of dealing with trips composed of different transport modes on multimodal paths. At a general level, the recommended framework to enable the proper modelling—which could been used to determine interconnectivity in multimodal passenger transport has to encompass:(Ulied et al. 2011)

- The use of a network-based representation of alternative routes and modes within the transport model;
- The transport model should employ some form of choice model which estimates the demand on each mode combination/route based on the generalised costs of the different alternatives;
- The generalised cost formulation used in the transport model should include an explicit representation of costs of modal transfer.

The interconnectivity indicators defined and computed by the meta-model fulfil those criteria. The list of 15 indicators used in INTERCONNECT includes (Ulied et al. 2011): respective percentages of uni-modal itineraries, multi-modal itineraries, road uni-modal itineraries, rail uni-modal itineraries, air uni-modal itineraries, road-rail multi-modal itineraries, road–air multi-modal itineraries, rail–air multi-modal itineraries, road–rail–air multi-modal itineraries. Also used are multimodality rate, defined as the number of different modes used in an itinerary, intermodality rate, defined as the number of shifts between different modes in an itinerary.

Interconnectivity rate, defined as the number of shifts between different modes or between different services in the same mode, diversity rate, defined as the total length of road, rail and air used in an itinerary aggregated according to an entropy formulation. It reflects the diversity of modes used, has a minimum value of 0 when only one mode is used, and a maximum value of 1 when all modes are used in the same proportion (33%; 33%; 33%). Other indicators are: travel cost, defined as the cost in EUR of an itinerary (dependent on the length of the itinerary, the modes used, the geographic location of the links used and the value of time of users), percentage of travel cost spent in interconnections (city connectors and network connectors) with respect to total travel cost.

Indicators are computed for NUTS3 (counties/districts level), NUTS0 (country level) and globally for Europe. They are determined in relation to itineraries between different NUTS3, reflecting the geographic notion of travel opportunities; they are also calculated in relation to trips in Europe; and they are measured in relation to trip-kilometres. Indicators can be calculated for all trips and for specific travel purposes: business trips, private trips, commuter trips and holiday trips. They can also be calculated for different trip length ranges.

5 Interconnectivity in Europe in the Future

In Europe long-distance travel represents less than 10% of all passenger trips. But if one counts overall distance travelled than those long distance trips rise to almost 30% share. At the same time only 7% of trips use modal combinations of more than one mode, but those trips represent as much as 20% of the total amount of kilometres travelled. Thus multi-modal trips have much higher impact on transport system than uni-modal trips. The pattern of use of different modes shows predominance of road transport with complimentary role of air mode and very limited role of rail. The uni- versus multimodal behaviours are strongly influenced by location. Opportunities for uni-modal trips are lower in the periphery than in central areas. Itineraries from the periphery to all other regions in Europe have to cope with a relatively larger amount of interruptions (interconnections inter mode or intra mode) than itineraries originated in core regions. The important question is how this situation will evolve in the future?

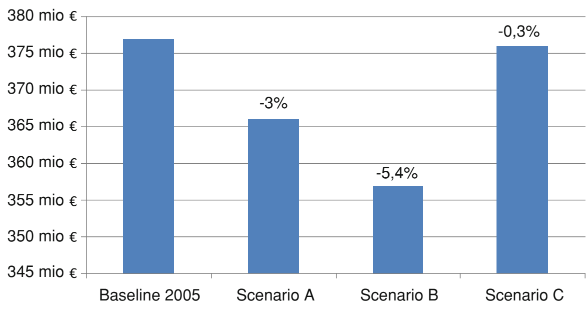
The results of both qualitative and quantitative modelling allow for formulation of possible future scenarios for development in Europe. Three alternative scenarios based on reducing interconnectivity costs could be tested using tools developer within INTERCONNECT. The baseline scenario represents current situation. Scenario A assumes that the cost of all interconnections will be lowered by 50% of today's values. This reduction affects all connections between all transport modes, regardless of the modes (rail connections to airports, road access to airports and rail stations, road access to cities and rail access to cities). Scenario B lowers the cost of all interconnections to zero and Scenario C lowers only the costs of access and egress to rail terminals to zero. The first two aim to measure the overall impact of reducing all interconnectivity costs in Europe, while the third represents an effort to procure modal shift towards more environmentally friendly rail mode. The impacts could be observed on overall EU level, on individual user level and in regard to modal structure of the transport system.

On the EU level overall forecasted costs of passenger transport under those three different approaches produce savings as given in Fig. 1. It is noticeable that while reductions have been achieved in all cases, the rail enhanced scenario does not guarantee substantial savings.

The effects on individuals could be best summarized by changes in trip costs per person. Figure 2 presents modelled results of price change in regard to all three scenarios in division into trip purpose. The most significant changes are observed on vacation trips but also on daily commuter travels. Again rail enhancement only slightly improves overall situation of individual transport user as compared to two other scenarios.

Impact on modal split is simulated on Fig. 3. If costs of travelling are reduced equally the most benefits go to air sector. Also difference between scenario A and B shows that when interconnection cost reductions are higher the positive effect on air is more than proportional.

Fig. 1 Evolution of transport costs under different scenarios, *Source*: (Ulied et al. 2011)



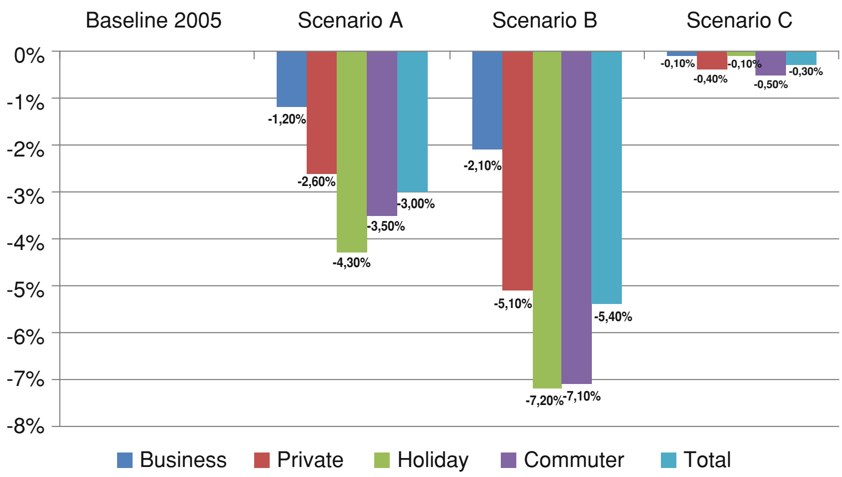


Fig. 2 Cost variations by trip purpose, *Source*: (Ulied et al. 2011)

The relative low value of rail enhanced scenario (from travel cost perspective) is offset by huge reduction of environmental costs under this scenario (see Fig. 4). The results present difficult dilemma for policy makers –improving interchanges only at key rail nodes delivers clean transport and reduces environmental costs but keeps overall transport costs high.

Pursuing balanced improvements of interchanges gives significant savings for users and societies in terms of transport costs but very limited in terms of emissions.

Finally the impact on multimodal travel could be compared to the impact of uni-modal travels. Figure 5 shows evolution of multimodal versus uni-modal share under different scenarios (top figure). Impacts of different scenarios on shifts in modal shares for uni-modal systems (middle figure) could be compared to impacts on multimodal systems (down figure).

When analysing the share of the different transport chains (in terms of trip-kilometres), the number of multi-modal trips increases in all scenarios. Compared

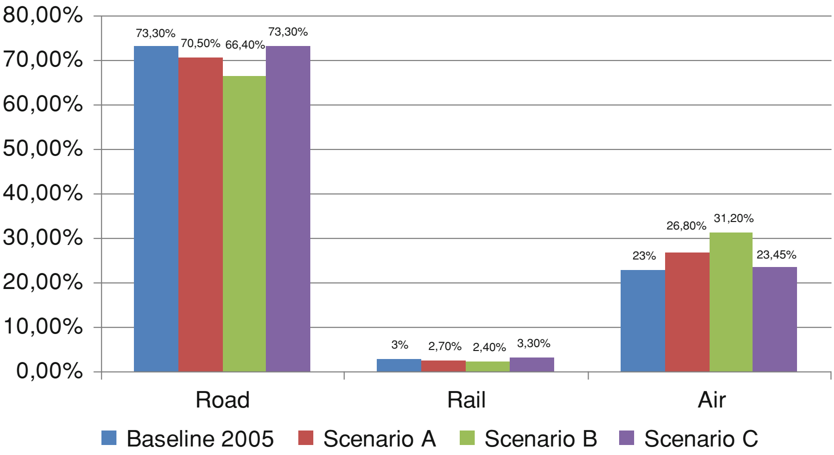
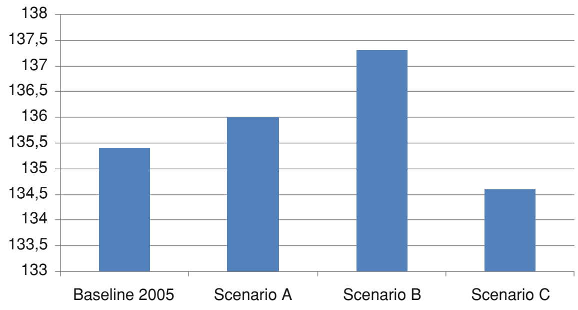


Fig. 3 Impact on modal split (per trip-km), *Source*: (Ulied et al. 2011)

Fig. 4 Impact on GHC emissions (yearly released million tons of CO_2), *Source*: (Ulied et al. 2011)



to base, scenario A produces a 1% increase in the multi-modal trips, scenario B a 2% and scenario C in a 3% growth. This confirms the assumption that making interconnections cheaper results in increasing shares of multimodal travel. Different results apply to the uni-modal trips. In this case both scenarios involving absolute cost reductions (A and B) result in increases of the air uni-modal trips (2 and 4% respectively) and reductions of the road uni-modal trips. The special case—rail scenario (C) gives a 1% increase of the rail uni-modal trips, a 1% increase of the road uni-modal trips and a 2% air decrease. Within the multi-modal trips, for scenarios A and B there is a clear trend towards reduction of the road–rail multi-modal chain, but an increase on all others, in particular on the air–road multi-modal chain but also of the air–rail multi-modal chain. For scenario C, the most significant change is an increase of the tri-modal chains (road–rail–air). The global increase of trips by air mode is a consequence of reducing the higher cost of access/egress to airports, which are more significant than costs of accessing the rail and road networks.

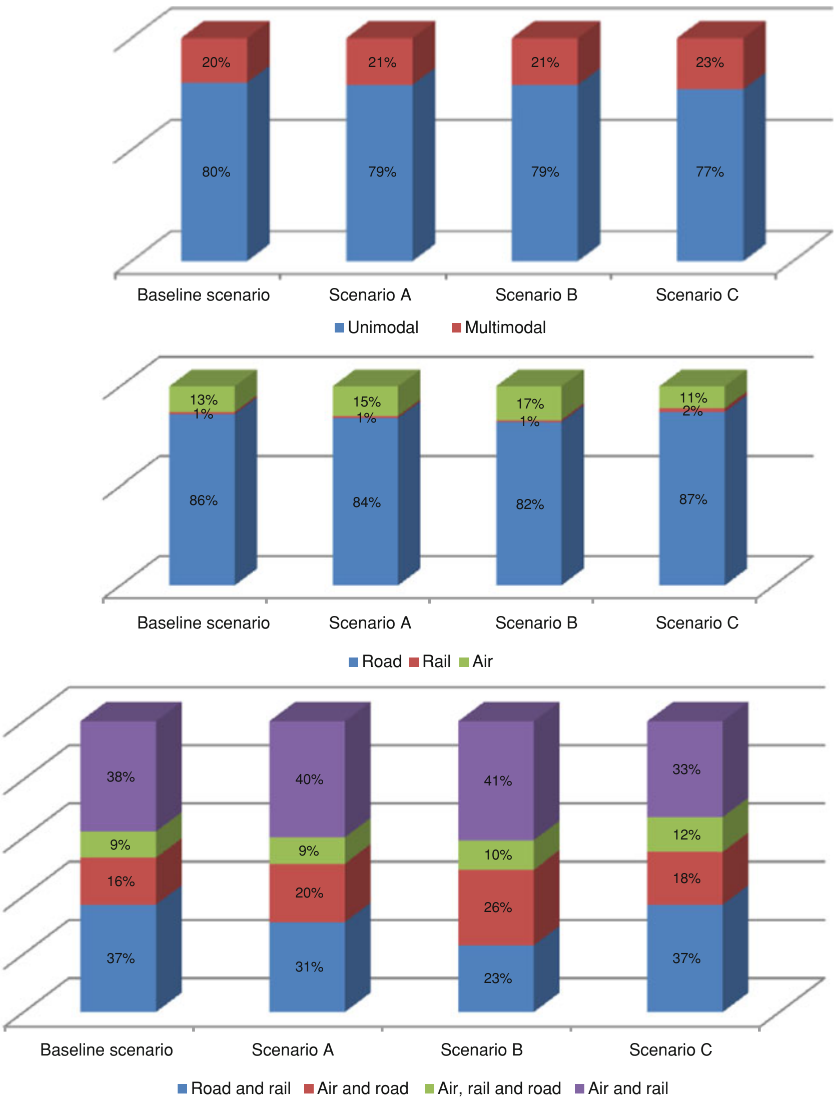


Fig. 5 Modal shifts under interchange cost reduction scenarios. *Source*: (Ulied et al. 2011)

6 Conclusions and Recommendations

The results of the INTERCONNECT project have highlighted the possibilities for the EU to function as a driver for the development of interconnectivity at very different scales. At the strategic level the analysis has revealed that on interconnectivity there is an overall lack of focus in national strategic policies documents, and that the actual EU strategic policy issues concerning passenger intermodality and interconnections call for a more active role of the EU, and highlight the potential for more formal and authoritative strategic policy decisions binding for the member states, in order to ensure a coherent and cross-national strategic EU policy in passenger interconnections, safeguarding the integration and development of the EU, and ensuring the mobility needs of the EU citizens.

The modelling exercise shows that reduction of costs of interconnection increases the share of multi-modal trips, as expected but the increase is relatively small: But real effect is seen in global transport costs savings. With reductions of 50 and 100% in interconnection costs, transport costs may decrease 3,0 and 5,4% respectively, which translates to a € 11,000 million and € 20,000 million saving per year. Moreover users that capture more benefits from reducing the costs of interconnection are those with lower values of time, like tourists. The reduction of costs of interconnections provides reductions in the global volume of trip-kilometres travelled, implying that more efficient routes are globally chosen. With reductions of 50 and 100% in interconnection costs, volumes of traffic decrease 2,2 and 1.1% respectively. This is a total of 2,600 and 13,000 million passenger-kilometres respectively.

But this overall positive impact on travel costs is offset by increasing environmental burden. The reduction of costs of interconnection causes long-distance traffic CO_2 emissions to increase up to 0,9% (1,9 million tones CO_2) in scenarios with simultaneous reductions of costs of all interconnections, and to decrease 0.5% in scenarios favouring rail.

In general, the present gap between formal and authoritative strategic policy decisions, and the actual EU strategic policy issues concerning passenger intermodality and interconnections highlight the need for an overall and formal strategic EU policy in three strategic areas (Nielsen et al. 2011):

- Physical infrastructure (especially intermodal terminals). There are substantial differences in the quality of the passenger infrastructure in the EU. A terminal for intermodal exchange of passenger cannot be isolated from the development of passenger transport modes, and visa versa. In general an EU policy driving the development of infrastructure and the related intermodality could be a driver for the integration of EU.
- Technology facilitating passenger intermodality. An example is the success of computer reservation systems of the airline industry.
- A similar system covering several or preferably all inter-EU passenger transport modes would be a substantial advantage.
- Policy and legal frameworks facilitating intermodal cooperation. An example is the creation of common EU standards to facilitate technological development and preventing the development of national suboptimal standards, especially concerning passenger ticket, passenger information and passenger reservation systems. Another example is to set-up minimum standards for the intermodal connection terminals important to cross-national passenger movements, and

secondly for interconnections of national importance, thereby creating a feeder system facilitating international passenger mobility.

The INTERCONECT project has documented the need for further research and development on several issues. A few of the most interesting and most promising areas for such endeavours are mentioned in the following (Thisgaard et al. 2011).

Infrastructure planning plays a significant role in the development of interconnections. However, the present tools and knowledge available cannot answer questions on how infrastructure planning as a process in a political system could contribute to an improved interconnection.

Organisational issues have proved to be of importance in the development of interconnection, sometimes leading to success and in other examples leading to failure. A better understanding of organisational behaviour and the structural elements in organising interconnections in complex political and economical structures is needed.

Financial and economic issues have been found to often interact with organisational issues and to create complicated barriers to improved interconnection, as problems at different political, organisational and economic levels need to be solved by actors with conflicting interests. Possibly, a better understanding of such situations could lead to guidance and/or general solutions or models, which could be implemented in the EU.

Intelligent Transport Systems (ITS) and overall the possibilities of using new information technology, mobile- and smart-phones as an active element supporting interconnection, holds a promising potential to become a driver for the development of interconnection. Research and development in this area also has potential for the ITS and IT industry in Europe to develop new products and/or systems to be used and exploited as business opportunities in the rest of the world.

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A Structured Approach for Assessing Sustainable Best Practices in Supply Chains

Wojciech Piotrowicz and Richard Cuthbertson

Abstract This book chapter presents a structured approach to assess supply chain practices. The proposed solution incorporates sustainability dimensions into the evaluation process—considering social, economic and environmental impacts—and can be applied to select supply chain practices that can help to reduce the negative impact of transport, while improving long-term economic performance. Although there is no universal practice that can be applied across all business and national contexts, based on the extensive analysis of various supply chain practices across Europe, the most common 'generic' solutions used to improve supply chain are presented. The analysis of each 'generic' practice includes its social, economic and environmental impact, as well as its drivers and limitations, which should be considered when new implementation takes place.

Keywords Supply chain assessment · Best practices · Sustainable development · Supply chain performance

1 Introduction

This chapter presents a structured approach for best practice assessment that incorporates sustainability dimensions (social, economic and environmental). The approach presented in the following sections can be applied to select supply chain

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practices, which can help to reduce the negative impact of transport, while improving long-term economic performance. The proposed solution allows the comparison of various practices in a supply chain to identify those that could be potentially applied by an organisation, albeit under certain contextual limitations. This is an important issue, as there are various solutions promoted as the 'best practice' that could green the supply chain, or make it more sustainable. However, it should be acknowledged that some practices may deliver good results only in certain social, economic, political and environmental settings, so their transferability could be limited by external and internal factors. At the same time, positive impacts are not always obvious when a long-term view is taken; moreover, some results that are perceived as positive in one national or regional context can be negative in another. The selection of the wrong practice, which initially may look as promising, could result not only in a waste of company resources and unnecessary reorganisation, but also in lower customer service levels and lower financial performance. Problems relating to best practices in supply chains, and their evaluation and transferability, were covered by the European Commission-financed project BestLog (Best Practices in Logistics: www.bestlog.org) that was completed in 2010. A cross-European team worked on the topic, with selected findings presented in the Springer publication *Sustainable Supply Chain Management: Practical Ideas for Moving Towards Best Practice* (Cetinkaya et al. 2011). In this chapter we would like to present the approach that was developed and tested during the BestLog project and was used to assess supply chain practices across Europe. The chapter is based on the project deliverables and earlier publications (see: Cuthbertson and Piotrowicz 2008; Piotrowicz 2008; Piotrowicz et al. 2007; Cuthbertson and Piotrowicz 2009; Cetinkaya et al. 2011; BestLog 2007).

The chapter structure is as follows: firstly, issues related to sustainability in supply chains and logistics are discussed; then the research design is presented. The main part of this chapter presents an approach that proposes to evaluate supply chain practices: namely, validation, positioning and evaluation. This is followed by a discussion of what we can learn from supply chain practices analysed using this approach. Such 'generic' practices are clustered among common themes; then drivers, transferability limitations and impacts are presented. Finally, conclusions and recommendations are listed.

2 Green, Socially Responsible, or Sustainable?

There is plethora of initiatives labelled as green, socially responsible or sustainable; but how many of them are sustainable, and what does this really mean? Is the 'best' solution always 'best'? We argue that to create long-term green initiatives, there is a need to look beyond just the 'green' element—it is important to consider three sustainability dimensions: economic, social and environmental. This approach is supported by the European Commission's definition of sustainability

(EC 2007), where sustainable development is a *progress that integrates immediate and longer-term needs, local and global needs, and regards social, economic and environmental needs as inseparable and interdependent components of human progress*. Economic, social and environmental dimensions also are identified as necessary for being included in transport and logistics activities (EC 2006a, b). Without a positive impact on the economic performance of an organisation, 'green' or 'sustainable' practices could not be sustainable over a longer period, and could be used as short-term marketing and public relations tools only. When they negatively influence long-term economic performance, they could not be sustained over time. Similarly, practices that could have a positive impact on the environment might have a negative social impact, in some cases in different tiers of the supply chain, such as in developing countries. There is also a danger that instead of delivering positive impacts, practices in certain conditions will deliver unintended negative outcomes in the short- or long-term. Thus, to select practices for implementation, there is a need for a balanced view that will include all sustainability dimensions, and will consider the context in which the original practice was developed, and the context in which it is going to be implemented. The framework proposed in this paper provides guidelines for the assessment of supply chain and logistics practices, including their impact on sustainability. This should help managers to understand how certain practices work in their original context, and to assess their potential impact after their transfer into new organisational and national settings. It could also help academics to design case studies in a format that could capture contextual factors, as well as the complex impact of certain practices.

3 Research Design: Framework Creation

The approach presented in this chapter was developed through a literature review, the analysis of existing case studies, and fieldwork (a series of case studies completed in several countries), and was supported by input from a focus group. Our goal was to create a framework for the assessment of sustainable practices in supply chains, allowing benchmarking practices from various supply chain areas, industries and countries. This research answered three main questions:

- What criteria and metrics should be used for best practice assessment?
- What should the process of such an assessment look like?
- What are the limitations for transferring best practices?

During the BestLog project, we aimed to create an approach that could be used by managers and companies, but which could at the same time be informed by recent academic literature, policy and practice. The research results needed to be relevant to current managerial practices, and thus had to consider the current limitations of existing performance measurement systems, measurement standards

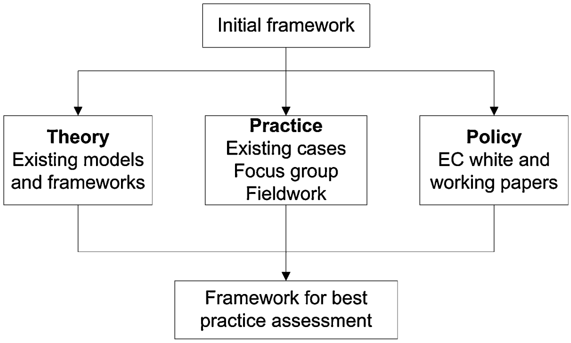

Fig. 1 Elements incorporated into the framework

and metrics used by companies, as well as acknowledging differences between sectors, countries and access to resources. The work was informed by the literature from the operations management, and operational research and logistics disciplines, as they are strongly related to the supply chain management (SCM) field (see: BestLog 2007). A starting point for the research was the framework developed during an initial project workshop; this framework was modified during further work, and the analysis of existing published case studies, pilot fieldwork and full fieldwork, according to the structured case method (Carroll and Swatman 2000). During the research, several working versions were created (see: Piotrowicz et al. 2007), before the final version presented in this paper was developed. The research in progress was presented to the focus group—the project Advisory and Communication Board (ACB)—which was composed of CEOs and senior managers from the transport and logistics sector, leaders of logistics and transport associations, and policymakers from national and European Commission levels, as well as representatives from the USA and Turkey. The working versions of the framework were presented to ACB members, and their feedback was collected and incorporated to assure that this approach would work in practice. Additionally, we ran several workshops where aspects related to the framework were discussed. To create this approach for best practice assessment, theoretical concepts, practices used in the industry, and European policies were all analysed (Fig. 1). The analysis of best practices from various sectors, countries and supply chain functions allowed us to test this approach in different settings (see: Cetinkaya et al. 2011 for selected case studies).

4 Framework for Best Practice Assessment

The following section presents the main elements of the process of best practice assessment; the process is based upon three main steps: validation, positioning and evaluation (Fig. 2).

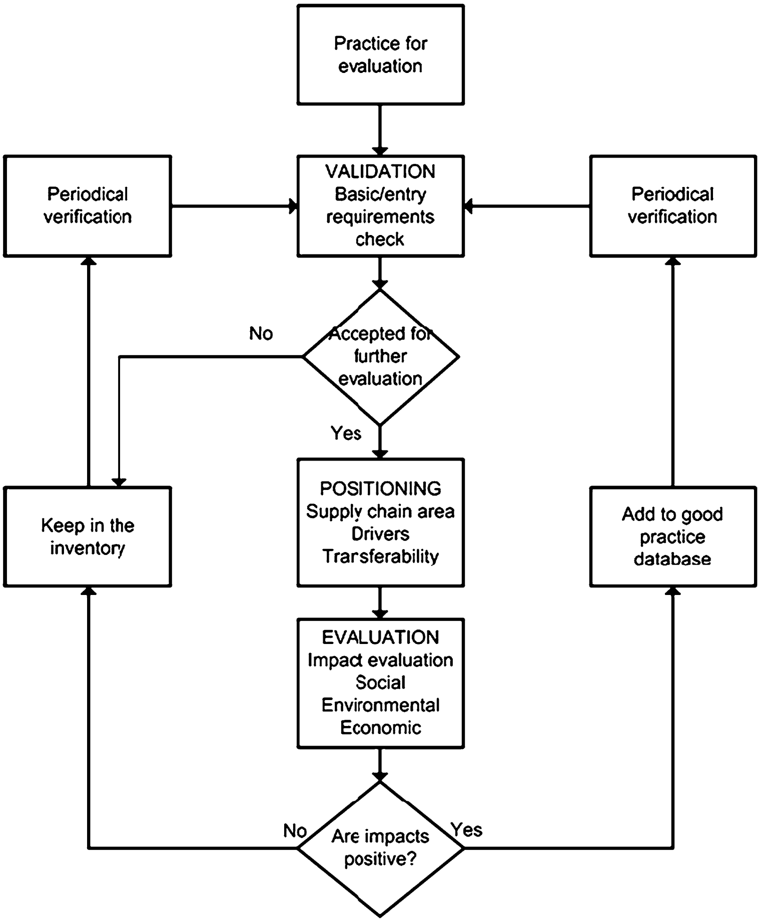

Fig. 2 Assessment of the supply chain practices—main steps

4.1 Validation

The first stage, validation, focuses on checking whether a best practice or case study can be included for further and more detailed analysis. This stage looks at the very basic entry requirements. The criteria that are taken into consideration are as follows:

- When was the practice implemented?
- Is the practice still in use?
- Is the implementation fully completed?
- Is there any relevance to a supply chain?

The questions aim to restrict the selection of cases to those that are up-to-date, actively in use, fully implemented (not planned, or pilot studies) and relevant to a supply chain, to eliminate cases that do not fill basic requirements. This considers changes in relevance over time, which is a weak point of benchmarking (Laugen et al. 2005).

At the validation stage, there is no need for detailed analysis and data collection. Rejection at this stage saves time and effort in data collection, as such cases are not analysed further, allowing concentration on more promising ideas. However, the case could be reconsidered at a later date, for example if a planned initiative becomes fully operational; this could be reviewed periodically. At the validation stage, basic information about the company in cases where the practice was successfully implemented is also collected: company name, sector, core business, country, number of employees and annual turnover. Based on the information collected, the decision to assess the case further or to reject it is made. However, evaluators should be careful with the rejection of practices that are at conceptual or pilot stages, as well as of historical practices that are not in use—it is still possible to learn from such cases, even though the application of such practices might involve additional risks. Rejected practices can be archived so it is possible to return to them later. The fulfilment of the basic requirements results in acceptance for the second stage: positioning.

4.2 Positioning

The positioning stage places the case within the wider context. At this stage, the following are identified:

- The area within the supply chain where the practice is employed;
- The areas within the supply chain affected by the practice;
- The drivers of the practice;
- Limitations to the transferability of the practice.

A definition of the supply chain areas provides the opportunity to compare cases relating to similar supply chain points and tiers. The positioning eliminates the comparison of ‘apples with oranges’, as it provides the possibility of determining and comparing cases that are within the same supply chain function or area, regardless of other factors such as country or sector (which are analysed at a later stage). Positioning also helps to identify where the effects occurred, so there is a possibility of considering the ‘knock-on’ effects from implementing various practices.

This approach, which includes transferability limitations, helps to avoid a major criticism of the benchmarking and best practice approaches, which is that they often ignore contextual issues.

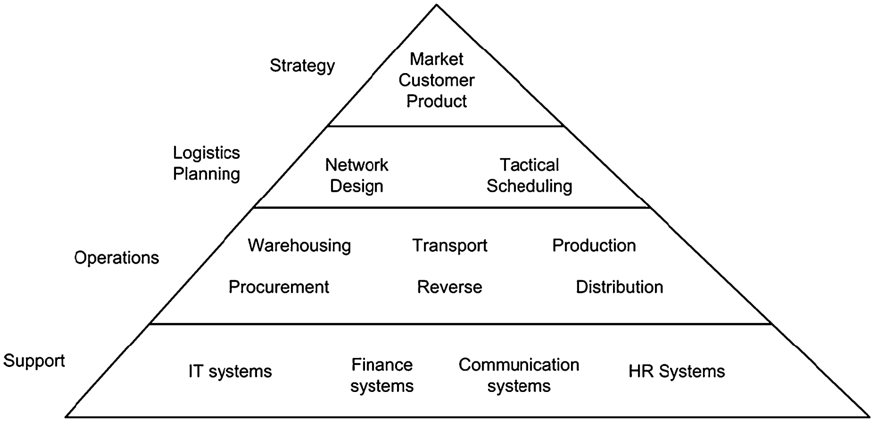

Fig. 3 Supply chain management areas

To define the supply chain area on which the practice is focused, and to determine the parts of the supply chain influenced by the practice, the model developed during a previous European Commission-funded SULOGTRA project (Sulogtra 2002) is used (Fig. 3). However, other supply chain models or frameworks (such as SCOR model) could alternatively be used to visualise areas of the practice, and areas that were influenced by the practice.

Another goal of the positioning stage is to identify and explain the key drivers of the practice and any critical limitations to transferability, according to the structure from the SULOGTRA project (Sulogtra 2002). In the output of the SULOGTRA project, supply chain drivers are defined by the STEEP framework—examples of these drivers are here listed:

- Social—society, consumers, employees, other individuals and impact groups;
- Technology—technologies, infrastructure, systems, tools, IT applications;
- Environmental—natural resources, environment, geographical location;
- Economic—costs, interest rates, growth, competition;
- Political—regulation, deregulation, legislation, directives.

Such an approach creates the opportunity to identify and compare the main drivers and motivations, as well as the constraints on implementing the practice in other organisations. Case drivers and transferability limitations could be internal (within a company), specific to supply chain characteristics and design, or could depend on external factors, such as economic situation, geography or policy. Such data provides the basis for the transferability analysis, as similar constraints and motivations could occur in other companies from different regions or sectors, so the practice could be implemented in new, but similar settings. On the other hand, some transferability limitations may determine that the case cannot be used. For example, certain supply chain practices can be motivated (or restricted) by national regulations. The transferability analysis highlights the factors that support and constrain the case implementation at company and supply chain levels, and in relation to the external environment in which the company operates. Transferability limitations were again grouped according to STEEP criteria (Table 1). Both the BestLog project fieldwork and the input from the focus groups indicated that among STEEP categories, two of them strongly influence transferability: namely, social and economic factors. Social aspects such as cultural differences, communication problems, differences in education and training levels, together with the economic situation—such as high cost levels, long return on investment (ROI), or access to capital—are listed as major problems for implementing practices in new settings. Other groups, such as technology, and political and environmental aspects were also listed; however, contrary to our initial expectations, these were perceived to be easier to identify and overcome. Technology was not perceived as a major transferability barrier, as information technology (IT) could be acquired on the market and implemented; however, financial and human resources were critical for employing technological developments (social and economic factors influenced technology implementation), while a lack of infrastructure could be relatively easily identified.

4.3 Transferability Limitations (STEEP) in the Bestlog Case Studies

In this section, the most common transferability limitations are listed in relation to every STEEP (Social, Technological, Economic, Environmental, Political) dimension (see: Cuthbertson and Piotrowicz 2009 for an earlier version of the analysis).

The limitations identified in 25 case studies, applying the STEEP criteria, are as follows:

4.3.1 Social

The social aspects that were listed as important transferability limitations (identified in 22 cases) included:

- A lack of/need for cooperation between partners (9 cases);
- Cultural differences between countries and organisations (4 cases);
- Employees' attitudes (4 cases);
- Education and training (4 cases).

Table 1 Transferability limitations that influence best practice implementation

Social	Technological	Economic	Environmental	Political
Culture	Lack of IT infrastructure	Financial resources	Lack of infrastructure	Lack of transparency (access to information)
Cultural barriers and differences	Lack of IT supporting systems	Access to capital	Access to sea and inland waterways	Legislation
Lack of understanding	Speed of change in technology	High cost	Access to railway lines	Degree of regulation
Conflict of beliefs	Lack of common standards	Development and implementation costs	Distance	Competition
Different values and values hierarchy		Cost/profit pressure	Geographical location	National policy
Labour relations		Cash flow problems	Scope of operations	
Ethics		Long ROI	Raw materials availability	
Employees' attitudes		Changes in currency exchange rates	Energy availability	
Demography		Subsidies		
Awareness		Resources and scale		
Communication		Lack of resources		
Lack of common terminology		Company size		
Language differences		Cargo and manufacturing volumes		
Resistance		Competition		
Resistance to change		Competition between companies		
Resistance to cooperate Power		Business/company before industry and society		
Danger of losing control				
Education and training				
Lack of knowledge				

4.3.2 Technological

Technology was not listed as a serious barrier for implementing new practice. Any limitations that were identified were linked to service provider availability, the usage of common standards (EDI) and the existence of approved technologies. This type of limitation was mentioned in four cases only.

4.3.3 Economic

In the economic dimension, the most commonly listed transferability limitation was the need for investment, and relating to it the company size and the cargo and manufacturing volumes. Altogether, 42 limitations in this category were identified, including:

- Lack of financial resources (15 cases);
- Company size (11 cases);
- Cargo volume/economy of scale (7 cases).

The need for investment and the lack of financial resources to initiate a practice was identified in over half the cases (15 of 25 cases). In 10 cases it was defined as the need for investment (company resources), while in four additional cases the need for government or EU financial support was mentioned. Long ROI, unexpected changes in infrastructure costs, and high investment at an early stage of the project were identified as obstacles to implementing new practices.

Linked to investment was the company size, as interviewees perceived that to be able to afford the necessary investment for implementing a practice, the company had to be a certain size. Small companies could not usually afford high levels of investment.

Related factors that were mentioned once each are:

- Number of customers;
- Manufacturing volume;
- International scope of the operations.

4.3.4 Environmental (geographical)

In 12 of the completed cases, geography and company location were perceived as transferability limitations. This included the proximity of sea, inland waterways, land availability and natural resources, as well as the distance between supply chain partners.

The most common limitation listed was access to railway infrastructure (8 cases). These environmental factors were considered to be impossible or hard to overcome by the companies concerned.

4.3.5 Political

Political issues were related mainly to existing legislation at EU and national levels (seven cases). Among legislation, the Waste Electrical and Electronic Equipment (WEEE) directive was listed as influential in two cases.

The domination of state-owned companies (one case) and the existence of the Marco Polo initiative (two cases) were both mentioned once as limitations to implement practices in new settings.

4.3.6 Process and Product Differences

Apart from the transferability limitations from the STEEP categories, there were a group of limitations at the company level: these were related to processes and individual product characteristics.

It was necessary to add this separate category to the STEEP criteria, as STEEP concentrates on the macro-level, not the operational level. These types of limitations were listed in nine cases, and mainly related to the particular product or process, with two more specific issues identified: cargo flow balance and service provider availability.

5 Evaluation

While the previous stages (positioning and validation) concentrate on placing the case in context, and providing additional information to fully understand the limitations and difficulties of implementing the case under investigation, the evaluation stage aims to:

- Determine the impacts of the practice, both positive and negative;
- Assign the practice impacts into social, economic and environmental dimensions, and further into its sub-dimensions;
- Confirm that the benefits were achieved (where possible), searching for quantitative and qualitative metrics—identifying impacts on the company and business partners, as well as the external impact of the supply chain.

The fieldwork confirmed that it is often difficult to quantify precisely the impact of a practice. This is especially true of initiatives that have an impact at the whole supply chain and strategic levels. The analysis of existing case studies indicated

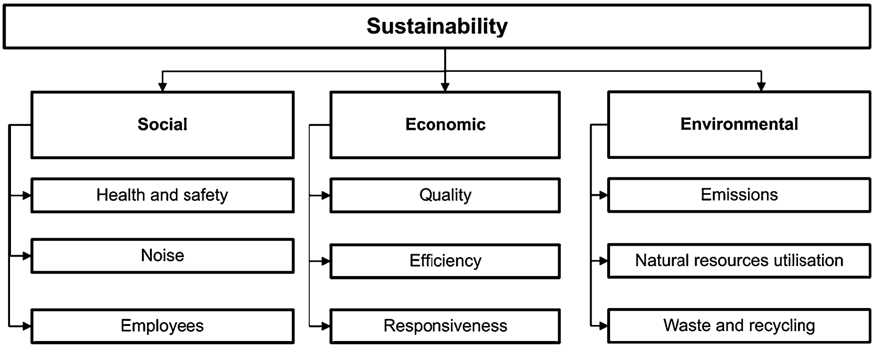

Fig. 4 Metrics-dimensions and sub-dimensions

a lack of metrics at the strategic level, with a concentration on organisational metrics. In such situations, a less structured approach is proposed to reduce the problems of data availability. Data should be collected and verified to confirm the achievement of the claimed benefits, which could be represented by various measures already in use in the organisations in question.

The metrics that reflect the various impacts of the practice could be both quantitative and qualitative. When analysing the practice, impacts, both positive and negative, should be determined during the data collection and assigned into the three key dimensions—social, economic and environmental—and into further sub-dimensions (Fig. 4). To be classified as a 'best practice', the case under investigation should have a net positive impact in each of the required dimensions. A net negative impact, even in a single dimension only, results in a decision that the case cannot be named as a sustainable 'best practice'.

Each dimension, social, economic and environmental, was further divided into three sub-dimensions (Fig. 4). Within every sub-dimension, the impacts of the case (benefits and improvements, as well as negative impacts) were considered. Such a design allowed a flexible approach. While dimensions and sub-dimensions remained unchanged, the claimed benefits and their related metrics could vary to some extent between organisations and supply chains. Detailed supply chain metrics that are, or could be used to reflect performance are listed in: (Gunasekaran 2001; Cuthbertson and Piotrowicz 2008; Shepherd and Gunter 2006). Table 2 presents examples of metrics only, and allows a flexible approach to metrics definition: when new standards and norms are introduced, they can easily be added into the relevant sub-dimension—this is especially important in relation to Co_2 emissions, as there is currently a lack of a universally agreed method that assesses Co_2 emissions within the supply chain.

There is also a need to look at the place where impacts occur. The easiest impacts to identify are those within an organisation; the second level of impact is on supply chain partners (customers and suppliers); and finally, there is the impact on the external environment. Thus, when the impacts are analysed, the influence beyond company boundaries should be considered (for more about measurement, see: Cetinkaya et al. 2011).

Table 2 Examples of impact measures by sub-dimension

Social dimension		
Sub-dimension (category)	Benefits and improvements achieved (examples)	Measures (examples)
Health and safety	Toxic, hazardous emissions Accidents Working conditions	No. of employees, subcontractors or suppliers trained in health and safety procedures; no. of accidents (within a company); no. of accidents that involve third parties; no. of near misses; no. of serious/fatal accidents; better working conditions; reduction of spillages and leakages (chemical substances); reduced accident probability.
Employees	Employment Training Job security	Production in EU (%); no. of jobs created; no. of workers trained to use new system; no. of jobs reduced; no. of people on long-term contracts; staff trained (%); no. of drivers trained; staff retention; absenteeism.
Noise	Volume Timing and location	Noise reduction (time of truck delivery); noise reduction from warehousing operation; activities switched/created at industrial zones.

Environmental dimension		
Sub-dimension (category)	Benefits and improvements achieved (examples)	Measures (examples)
Emissions	CO_2 emissions Other pollutants emissions	CO_2 produced per litre delivered (grams); total CO_2 emissions in tons; reduction of CO_2 emissions (% or in tons).
Natural resources utilisation	Fuel consumption Water consumption Land use Energy consumption	Reduction of fuel utilisation; reduction of water utilisation; land utilisation; energy utilisation per warehouse; reduction of need for road transport.
Waste and recycling	Waste reduction Materials/products recycled (%) Biodegradable materials used	Recyclable packaging (%); reused packaging (%); reduction of equipment losses; reduction of cargo damage; reduction of spillages and leakages; reduction of obsolete, out-of-date items in warehouses.

Economic dimension		
Sub-dimension (category)	Benefits and improvements achieved (examples)	Measures (examples)
Quality	Quality of products and services Customer service level Availability	No. of stock-outs; customer response time; product lateness; on-time delivery (%); delivery reliability; customer satisfaction; customer complaints; product availability.

(continued)

Table 2 (continued)

Economic dimension		
Efficiency	Utilisation Productivity Cost reduction	Cash-to-cash cycle; ROI; inventory level; total logistics cost; value-added productivity; asset returns; inventory utilisation; truck fill rate; warehouse utilisation; delivery cost.
Responsiveness	Response to customer needs Response to market changes Flexibility	Time to market; production flexibility; response time; order cycle time; track and trace performance; order flexibility; order fulfilment lead time.

6 Generic Best Practices: Learning from the Bestlog Case Studies

The BestLog case collection identified practices that are commonly used by logistics companies, but also confirmed that the generic 'best practice' does not exist. Practices should be matched with the company's characteristics and the context in which the company operates. However, it is possible to cluster solutions that have a common topic or area, to determine 'generic practice'. During the fieldwork, we found commonly used solutions such as:

- Cargo shift from road to rail;
- Cargo pooling, consolidation;
- Process redesign;
- Product and packaging redesign;
- Information Technology implementation.

While these solutions are well known, the main issue was not about the novelty of the idea, but the way that it was implemented and under what circumstances. To capture the differences between cases, all practices were analysed and common learning was extracted. Then, for each group of 'generic practices' we listed:

1. The drivers of the practice group, according to STEEP criteria (Social, Technological, Economic, Environmental and Political);
2. The transferability limitations and challenges for implementing the case (again, applying STEEP);
3. The impacts (benefits) achieved.

6.1 Generic Practice: Shifting Cargo from Road to Rail

Among the collected case studies, there were seven practices relating to rail transport utilisation. In such practices, cargo flows were moved from the road to rail, and as a result, the number of trucks on the road was reduced (as were the associated Co_2 and other emissions, and probably also the number of road accidents), while at the same time, transportation costs were reduced and service levels increased. However, it is clear that this intermodal road–rail option is not available to all companies, products and cargo. This solution can be considered for sufficiently large cargo flows and for longer distances between supply chain partners. It is more suitable for large companies that posses enough transport capacity, intermodal planning skills and power for negotiating with railways. As an alternative, rail transport connections can be established with support from logistics providers, which consolidate shipments and offer all the assistance required. The products should be suitable for rail transport from both a technical and an economic point of view; however, developments in train carriage design could reduce this issue over time.

This practice is more likely to be considered in situations where there is a customer demand for 'green' and 'sustainable' solutions, although customers are not willing to compromise on the final cost of the product (price increases are not accepted). The decision to apply a sustainable solution was easier to make in companies that included 'green' and 'sustainable' agendas in their formally written organisational strategy. Increased competition can drive rail usage as the way to reduce costs, while in certain markets, a shortage of truck drivers played an important role in implementation of this practice. While some companies wanted to be the first in the market to deliver their products with rail service, this solution can be easily replicated, and so is unable to provide any long-term advantage over competitors. Deregulation and the liberalisation of railways is also an important factor for companies wanting to use this transport mode.

Programmes such as Marco Polo can initiate rail transport connections, as well as regulatory solutions (such as the truck ban in Switzerland). To establish a rail connection, access to rail infrastructure is obviously needed; however, it is not always possible, and requires cooperation between companies and railways (which is not always successful). Similarly, in some cases there is a need for a new terminal, and substantial financial investments are required, often too high for a single company. However, problems with infrastructure are not the only issue; another is the willingness (or more specifically, the lack of it) to cooperate with supply chain partners—and this is a problem that is hard to overcome. A shortage of competences relevant to intermodal transport can create problems for initiating and executing this practice; however, training for employees related to new planning and operational skills can reduce it in a relatively short period. In the following section, the drivers, limitations and impacts of the practice are listed (Tables 3 and 4).

Table 3 From road to rail—drivers and limitations

STEEP criteria	Drivers	Limitations and challenges
Social	Demand from customers for environmentally friendly solutions, but without trade-off in the cost increase. Lack of truck drivers available in the job market.	High level of competence among supply chain partners is needed, along with new skills among employees. Problems with willingness to cooperate among different partners.
Technological	New design of train wagons and trailers. IT played supportive, but not driving role.	Product should be suitable for rail transport from a technical and economic point of view.
Environmental	Inclusion of sustainability and green agenda in the organisational strategy included analysis of the alternative to road transport modes. Consideration of the external social costs in the decision-making process at strategic level.	Distance between supply chain partners plays important role. Access to rail infrastructure is required, as well as efficient rail network that links business partners. In some cases, additional storage capacity should be available.
Economic	Willingness to achieve competitive advantage, being the first to offer such a transport solution and meet customer demand, while reducing transportation costs.	High cargo or manufacturing volume is required, as well as financial resources to invest in new solution—both aspects are linked with company size. Cost of railway usage can also influence the decision to implement this solution.
Political	Regulations, such as the ban on trucks travelling at night in Switzerland, linked with railways' de-nationalisation and deregulation, motivated companies to use rail. Co-funding from the Marco Polo programme also helped to establish the rail connection.	Some legislation at the national level, such as the truck ban in Switzerland, can motivate an establishment of the rail connection.

6.2 Generic Practice: Pooling, Consolidation

There were three practices that demonstrated how cooperation between cargo owners and logistics companies could help to reduce road transport. Consolidation was used in single mode transportation (road), as well as in the multimodal combination: road–rail. Cargo from various sources was collected in the central warehouse, and delivered to the customer location (or locations), eliminating multiple deliveries from every supplier directly to the final customer.

Economic drivers, such as the opportunity to reduce costs, played a key role in implementing this solution. While pooling can be used both for large and middle-sized companies, in the case of larger companies and their related high volumes of cargo, there is the possibility of employing rail transportation. In situations where

Table 4 From road to rail—impacts of the practice

Economic	Social	Environmental
Higher service level; reduction of lead time; increased reliability; elimination of goods damage; more efficient supply chain; increased utilisation and cost reduction; increased company profitability (although in one case interviewees indicated that rail and road costs are similar, but benefits were realised in other dimensions); higher flexibility, as there is additional transport capacity available; increased demand for goods can be satisfied at low cost.	Utilisation of rail transport eliminated trucks from the roads, which reduced congestion and the number of accidents. At the same time there was a lower need for truck drivers and long haul trips. The need for workers in intermodal terminals and warehouses increased. Noise emissions from road deliveries in urban areas were reduced. Employees were provided with additional training and had to learn about rail and intermodal operations and supply chain planning.	Reduction of trucks was associated with lower fossil fuels utilisation and related Co_2, NOx, SOx and PM emissions. Electrical energy, used for rail transport, can be supplied from alternative or nuclear power plants, which reduced fuel-associated emissions. In some cases there was increased land usage, as new terminals were necessary.

cargo flows are lower, or railway infrastructure is unavailable, usage of the road mode alone also reduces the number of trucks on the road and increases utilisation. In the pooling practice, at least two companies are involved: the logistics service provider and its customer (or customers), or in the case of a more complicated structure, the customer's suppliers as well—close cooperation between all parties is necessary. This requires trust and willingness to cooperate; all parties should be convinced that the new solution will generate long-term benefits, which will be shared among the supply chain participants.

Consolidation can be implemented in situations where cargo flows are stable, and for economically and technically suitable products. The practice allows the use of the logistics service provider's infrastructure and 'know-how', allowing its customer to concentrate on key competences and reducing transport and warehousing-related costs. As the practice is more complex than traditional transport, it is critical to provide training and skills to employees, who have to acquire knowledge relating to operations planning, negotiations, logistics and supply chain management. Education is necessary for both the logistics provider and its customer. When the practice is implemented it results in economic benefits, such as cost reduction and increased utilisation; the supply chain is designed more efficiently and effectively. Consolidated shipments, especially when the rail mode is employed, reduces the number of trucks on the road in addition to increasing trucks' utilisation—this is linked with reduced fuel consumption and its associated Co_2 emissions. As the consolidation is aiming for long-term cooperation, job security is increased; and the new supply chain design requires employees with higher skills. Tables 5 and 6 present the drivers, limitations and impacts of this practice.

Table 5 Pooling, consolidation practice—drivers and limitations

STEEP criteria	Drivers	Limitations and challenges
Social	Not identified	Know-how—warehousing knowledge was perceived as an important issue. Logistics service provider needs experienced planners and warehouse managers, as well as front desk staff to manage contact with customer. Trust, confidentiality and willingness to cooperate were also listed as important issues. There was also an issue about how to distribute cost savings among the supply chain partners.
Technological	IT played supportive but not driving role.	
Environmental	Some customers were hard to reach due to their location.	
Economic	The main role was played by economic drivers and customer requirements. Customers of logistics service providers wanted to concentrate on their core competences, and outsource logistics activities, with the aim of cost reduction, which was important in the highly competitive market. Inclusion of sustainability and green agenda in the organisational strategy included analysis of alternative transport modes to using the road also stimulated pooling practices.	Customers' demand is critical for pooling practices. In one case pooling was perceived as more suitable for larger organisations from the FMCG sector with frequent deliveries, as small companies do not have sufficient volume. Railway consolidation particularly requires high volumes. However, consolidation was used also for SMEs, as illustrated in one case. Product characteristics (technical and economic) are important, as not all products can be transported this way. Market structure may become an obstacle, pooling has to be suited to certain market conditions. In some situations, where free storage capacity is not available, there is a need to invest in new warehousing infrastructure.

6.3 Generic Practice: Process Redesign

Even though the transfer of cargo from road to rail, as well as consolidation practices, required a process redesign, there were additional case studies where elements of the logistics process—either the whole process or the supply chain—were redesigned. Although each case was different, there were similarities in their drivers and transferability limitations (Table 7). While the process changes were

Table 6 Pooling, consolidation—impacts of the practice

Economic	Social	Environmental
Service level and efficiency were increased. Product availability for final customers was improved in line with better on-shelf products rotation. Loading lead time was reduced. Filling rate (utilisation of trucks) was increased, so transportation cost per pallet was reduced. Increased utilisation of logistic infrastructure was reported. Overall costs of road transport were reduced, and all supply chain processes were organised more effectively. The customer was able to concentrate on core competences, while logistics processes and associated costs, including the investment in warehouses, were outsourced by the logistics provider.	Employees were better motivated and were willing to coordinate planned operations. Overtime work was reduced and employees became aware of new pooling rules as their skills improved. Employees had to learn about operations planning, negotiations, logistics and supply chain management. Skills of customers improved, as they had access to training provided by the company. The logistics provider should learn about customer needs. Long-term cooperation between customer and logistics service provider increased job security for employees. Reduction of trucks on the road can be linked with reduced congestion and reduction of noise from deliveries, especially in urban areas.	Fossil fuel consumption and related Co2 emissions were reduced as a result of higher trucks utilisation and fewer trucks on the road. In France the pooling practice resulted in 50% reduction of fuel consumption. In addition, waste level was reduced, as there were fewer obsolete products in warehouses and retailer premises. Pooling linked with rail transportation particularly delivered environmental benefits. Warehouses were used more efficiently, which reduced the need to build new warehousing infrastructure (lower requirement for land).

driving improvements, they were often associated with changes in the physical infrastructure and/or design, such as the development of new warehouse and storage facilities. Changes varied from process simplification and redesign, to the redesign of the whole supply chain. All cases related to the improvement of existing processes, not to a new process design for a newly established company or emerging cargo flow. These practices were driven by similar issues, as a response to company growth and customer expectations. As the company and its scope of operations increased, processes in their initial format were not able to cope with higher cargo flows and/or the cargo portfolio while at the same time maintaining the service level required by customers, without suffering external negative effects. This group of practices—the search for new solutions in a cargo growth situation—could be most relevant in the future, when companies will recover from the current economic downturn, and cargo volume will increase.

Even though the practices were different, the benefits reported by companies were similar. As initiatives were carried out to remove problems associated with company growth or the fulfilment of customer expectations, the practices achieved these goals. Companies reported benefits such as process time reduction, cost

Table 7 Process redesign—drivers and limitations

STEEP criteria	Drivers	Limitations and challenges
Social	Not identified	Culture fit between logistics service provider and its customer is important, especially in international cooperation. Differences in culture and language should be taken into consideration. There is also important issue of trust, as companies might still refuse to open their books to the logistics providers. Warehousing and handling techniques should be tailored to product lines and assortments.
Environmental	There was a lack of land available to expand loading site.	Geographical closeness between LSP and shipper can be important. Need for additional space can limit the practice.
Economic	Economic drivers in all cases were the main motivation. Increase in scope of operations and related cargo volume/portfolio resulted in situations where companies were looking for new solutions and ways to improve their processes. Increased cargo flow resulted in traffic jams, queues and negative impacts on neighbourhood. Inability to meet customer demand was also driver of the practice, as well as lack of sufficient storage capacity and high level of fixed-costs. Improvements were necessary to keep company competitiveness and respond to short-term customer orders. Negative impacts were against the company environmental strategy. Similarly, changes were required to support company supply chain strategy, which is especially important in cases of high volume, low margin products. Existing processes and associated resources were not able to cope with higher flows, thus the search for alternative process designs was required.	Some solutions are dedicated to high volume cargo flow and are more suitable for larger companies, as high investment is required. There should also be a demand for certain characteristics of the supply chain from the customer side, like importance of cycle time and quality.

reduction, better utilisation, increased efficiency, increased customer service level and response time, and the reduction of trucks waiting in traffic jams.

6.4 Generic Practice: Product and Packaging Redesign

While the previous group of practices approached improvement from a process point of view, with physical changes seen as additional factors, there were also two cases that concentrated on the modification of products and packaging; and as a response to such changes in physical characteristics, associated processes were also modified.

While the two cases that were analysed related to very different products (candles and domestic appliances), their general approach was similar. In both cases the product and its packaging were modified to optimise logistics processes. Changes in the products and packaging resulted in increased efficiency and increased utilisation of trucks and warehouses. The number of trucks on the road was reduced, as fewer trucks were needed to transport the same volume of goods. While the principle in both cases was simple—to reduce product volume and its related storage/transport utilisation—the implementation of such an approach was not always straightforward, as it required major changes at several points of the supply chain: product design, manufacturing, packaging, and logistics operations, with processes also needing to be modified. In both case studies the initiatives for change started at the strategic level, driven by senior management in search of improvement. To initiate and implement such changes, a high cargo volume is required, as well as access to a relevant infrastructure and cooperation with transport operators.

6.5 Generic Practice: Information Technology Implementation

Information Technology was perceived in most cases as an enabler: a tool that supported new practices in the company, allowing communication with partners, advanced planning and control. However, there were also cases where IT was used as a new way to improve and automate logistic processes: it was used to monitor driving and trucks' locations; to improve procurement and supplier monitoring; or to integrate seaport partners. There were differences between the goals of this IT implementation: cost reduction and the reduction of natural resources (fuel) usage, linked with the introduction of the LSVA (a toll for trucks per kilometre on all roads) in Switzerland, which obligated the optimisation of routes; in addition, customers wanted more information and required digital interfaces. In the Spanish seaport of Valencia, the different agents used different systems, so there was also a lack of process standardisation. The lack of automation and integration of processes involved a high number of errors, with their consequent associated cost.

Despite the fact that IT tools are widely available, IT-based practices are perceived as not highly transferable, as they are dedicated to a certain company and its requirements. The cost of implementation was also perceived as a potential barrier, as some systems are suitable for larger companies only. Similarly, issues of data exchange in a standardised format should be considered, as they influence implementation.

7 Conclusions

The process proposed to analyse sustainable practices in supply chains was developed during a four-stage research process (literature review, review of existing cases, pilot analysis and fieldwork). The fieldwork confirmed that a three-stage approach (validation, positioning and evaluation) could be successfully applied to evaluate practices at various points within supply chains. The approach presented in this chapter creates an opportunity to analyse and present the practice under investigation in its context, not only listing the claimed benefits, but also providing the necessary information required to understand the motivations and drivers for the case implementation.

The identification of transferability limitations indicates the opportunities for using similar solutions in other companies, while their positioning within the supply chain enables the search for relevant improvement solutions, and provides an understanding of how such practices may impact on an organisation. Finally, the three dimensions (social, economic and environmental) divided into further sub-dimensions, reflect the impact of the implemented practice, and highlight the potential benefits and negative influences emanating from it, considering the impact beyond organisational boundaries.

The approach presented in this chapter can be used to assess different practices related to supply chains and logistics to determine their impact on sustainability. The presented framework provides a structured approach for the analysis of the context in which solutions are used. The purpose of such an analysis can be to select a practice to improve current performance; to transfer a practice into a new context; or to review current practices used in an organisation or supply chain. The inclusion of contextual impacts can help to determine the transferability of the practice and to eliminate options that are not suitable for the organisation, saving implementation costs and time. The practices can be analysed against social, economic and environmental dimensions, reflecting the impact of existing or planned solutions. Such an approach can help to eliminate unintended consequences, such as a negative impact on society or the environment that could potentially be damaging to the organisation.

The proposed evaluation process can be further used, and modified, by researchers and people involved in the evaluation of sustainable supply chain practices. Standardised, but at the same time flexible with regard to metrics selection, this approach creates an opportunity to evaluate and compare various sustainable practices from different regions and sectors, allowing the benchmarking of supply chain practices with regard to their impact on sustainability. Further work could test the presented approach in a different supply chain context (tiers, countries, regions, company sizes, industries). There is also a need to work on the further development of metrics and measurement techniques, especially in the environmental dimension. The collection of cases can help to determine different sets of 'generic practices', to be used as starting points to analyse different solutions proposed to improve supply chains and logistics. Case studies prepared according to this structured approach can also be used for educational purposes.

The results of the cases analysis indicated that a single, universal solution—the best practice for all—does not exist. Companies can select from a variety of solutions available and find a practice that answers their (and their customers') needs.

Cases collected during the fieldwork were clustered into several 'generic' groups:

- From road to rail initiatives;
- Pooling, consolidation;
- Process redesign;
- Product and packaging redesign;
- IT implementation.

Based on common themes identified in the case studies, fieldwork and workshops, it is possible to conclude that:

1. Sustainable practices are not only environmentally and socially friendly—they can generate financial benefits;
2. Improvement can often be achieved using relatively simple solutions, such as packaging redesign;
3. Customer demand for sustainability, both from individual customers and business partners, motivates companies to search for solutions that can satisfy their customers. This also includes the demand for suppliers that operate with a consideration of sustainability practices. Demand from customers can trigger changes in the whole supply chain; however, supply chain transparency is required, allowing customers or NGOs to track products along the supply chain;
4. Good companies actively seek ways of improving their operations, beyond just economic issues;
5. Companies that include sustainability or a green agenda in their formal strategy are searching for such solutions, as there is formal support from the top management that encourages actions at the operational and middle management levels;

6. Public procurement should include sustainability criteria: companies should be able to demonstrate their sustainability policies and actions, which should also consider the company's suppliers;
7. Cargo volume is a key issue for implementing certain practices: cargo consolidation and cooperation between smaller companies, coordinated by logistics providers, can help them to use more sustainable solutions;
8. Sustainable solutions are more advanced than just simple transportation; these require new skills from employees, such as customer-orientation, planning, scheduling and supply chain management;
9. Third-party logistics providers can play a key role, as they are able to provide knowledge, coordination and economy of scale to improve overall supply chain performance;
10. Managers from all levels and areas (not only from operations and logistics departments) should be aware that logistics systems can be improved, and should understand the tools available for their improvement; this requires changes in management education, at both academic and vocational levels;
11. A change of 'mindset' is especially important in the case of SMEs, as they often lack the resources and skills to implement advanced solutions; nevertheless, they can implement a sustainability approach into their everyday operations—but an increase of awareness and education is needed;
12. Logistics issues should be considered from the earliest product design stage. Transport utilisation, handling techniques and similar parameters should be determined at the design stage;
13. Cultural and national differences are considered as important barriers and are hard to reduce in a short space of time. Over longer time spans, programmes such as international education, student exchanges and job placements can be helpful;
14. Performance measurement and benchmarking play important roles as vehicles for demonstrating and comparing the benefits achieved.

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Competitiveness of EU Region and Sustainable Development Policies Measures in Logistics: Experiences of Emilia Romagna

Piotr Nowak

Abstract Competitiveness of European regions depends on many factors which differ according to specific characteristic of each region. There is several attempts to structures these factors in the hierarchy. One of them is competitiveness pyramid presented in this chapter. On the top of this pyramid is placed quality and standard of life as the result of performance of the region. This chapter focuses on one specific aspect of the improvement of the quality of life of all inhabitants of the region—sustainable development through implementation of logistic an spatial policy. Emilia Romagna Region as the case of successful implementation of such policy is presented. Special attention has been paid on one of the tools of logistic and spatial policy of this region—Ecologically Equipped Industrial Areas.

Keywords Regional competitiveness · Sustainable development · Industrial districts · Logistic policies

1 Competitive Region

Starting from the assumption that was accepted for instance by Michel E. Porter that the existing competitive position affects the set of factors determining competitive ability and further assuming that competitiveness of an economy is based on effective use of available resources, a conclusion may be drawn that economic development occurs by ongoing consolidation of the competitive

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position by improving competitive advantages (based on increasingly advanced competitiveness factors) of the existing industries and by creating of new highly efficient segments of the economy (Porter 1990). Consistent with this approach, economies of countries and regions in their economic development pass three development stages characterised by a dynamic development of their specific industries and segments of the economy. The stages include competitiveness based on production factors followed by competitiveness based on investments and finally competitiveness based on innovation. This is consistent with a split of regions into those that are ideal for production, into regions that benefit from the growing effects of scale (regions as places of growing income) and regions with knowledge-based economy (Martin 2003).

The regions where competitiveness is based on production factors are least developed. The predominant economic sectors in such regions are based on primary resources covering natural raw materials or work force with low or medium-level qualifications. Enterprises from such regions compete usually only with prices. The applied manufacturing technologies are not advanced and are commonly available although usually they are imported from other countries. Technologies are acquired by copying foreign solutions and by foreign direct investments or by foreign companies operating in the country. The competitive advantage is not lasting since it is based on factors that are relatively common and easy to acquire. Basically all developing countries are at this stage of development.

Competitiveness based on investments is typical for medium-developed regions and consists in investments in modern and effective technologies and equipment based on most advanced technological solutions and on extending the potential to manufacture modern and advanced goods by purchasing technological solutions conducive to better competition in more complex segments of industry. The effect of scale is important for regions at this development stage (Martin and Sunley 1996). Groups of highly qualified workforce are developed that are able to internalise the adapted technologies and to modify them in a creative manner. The number of sectors of the economy in which the economy of the region may compete is much broader than in production regions based on resources. Achieving competitive advantage in an economy based on growing income and investments is usually possible only in those industries that are characterised with high benefits of scale and high capital requirements as well as a major proportion of labour costs in overall costs (Krugman 1991). The production is based on technologies that are easy to acquire and their offer primarily includes standard goods with relatively little services (Martin 2003).

Knowledge-based economy is the highest level of regional development. At that stage, the number of segments of the economy in which enterprises can successfully compete keeps expending. Domestic demand becomes more sophisticated stimulating development of increasingly complex and advanced goods. The above applies both to individual consumers and industry which—having become the manufacturer of increasingly sophisticated goods—also voices demand for increasingly advanced products. Strong competition in the domestic market keeps stimulating innovation. New competitive enterprises are established in related and collaborating industries. Less and less frequently competitive advantage is based on lower costs and increasingly frequently on non-price related factors. New mechanisms begin to appear to create and improve advanced resources. Enterprises not only incorporate technologies developed abroad but also develop their own solutions (Mansfield 1962). At that stage companies compete in global markets in increasingly differentiated segments. Competitive advantage is being transferred from one industry to another. Competitive advantage of manufacturers of final products stimulates competitiveness of manufacturers of semi-finished products and vice versa. A large number of enterprises functioning in various segments of the economy become a basis to the appearance of new innovation and development opportunities. This level of competitiveness is more resistant to economic cycles and impact of external factors. Competitive advantage of enterprises is based on technologies, innovation and varied offer and not on cots factors.

In 1997 the European Commission proposed a model of regional competitiveness factors, universal for all the above stages of regional development—that was a competitiveness pyramid presented in Fig. 1. In accordance with the model, the factors affecting regional competitiveness may be divided into indirect and direct ones. Of special importance are factors that have direct and immediate impact on economic results, profitability, productivity of work force and employment ratio. Attention should be also paid to factors that affect competitiveness in longer term, mainly: Social, economic, environmental and cultural processes and factors. There are three levels of factors affecting competitiveness:

- key factors measuring competitiveness and including income, productivity of work force, level of employment and openness;
- regional competitiveness development factors that immediately affect the basis factors sued to improve competitiveness of the region in a short-time perspective;
- success factors (social and environmental factors—sources of competitiveness)—factors that have indirect impact on the basic factors and development factors.

At the top of the pyramid there is a life quality factor measured as GDP per capita which splits into employment level and labour efficiency and productivity. The employment is in turn affected by: activity level, ability to create new jobs, flexibility of labour markets, demography and intangible investments (structure of qualifications). Productivity is affected by: market and financial situation, intangible investments (R&D), innovation and investments in fixed capital and public infrastructure, in particular including the tax system. The factors affecting competitiveness in long-term are at the base of the pyramid—those are the sources of competitiveness. At the central level of the pyramid there are development factors also termed as revealed competitiveness.

As already mentioned, the ultimate results of impact of competitiveness factors at the lower levels appear at the top level of the pyramid as welfare, standard and quality of living. Quality of living is the resultant value for all actions aimed at improving the competitiveness of the region. Such model of regional competitiveness remains

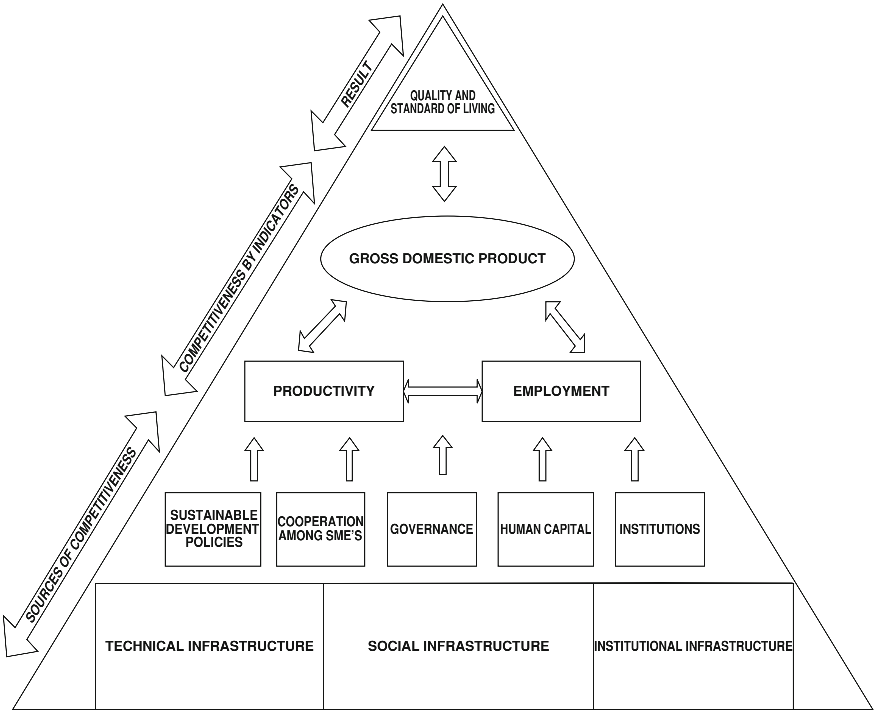

Fig. 1 Model of regional competitiveness pyramid, source: proprietary study based on: (Gardiner et al. 2004, p 26)

unrelated to reality without providing for the idea of sustainable development which provides that the achieved level of welfare and life quality can be maintained only subject to adequate management. Such management is understood as conscious development of relations between economic growth and care for the environment and human health. This is how it is possible to achieve the basis postulate of eco-development expressed by the World Commission on Environment and Development: "At this level of civilisation sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs". World Commission on Environment and Development, also referred to as the Brundtland Commission, was established in 1983 by Gro Harlem Brundtland at the invitation of the UN Secretary. The Commission is best known for development of a broad political concept of sustainable development and for publication in April 1987 of the report "Our Common Future". The activity of the Commission contributed to convening the Earth Summit in 1992 in Rio de Janeiro.

It is of particular importance to create a sustainable policy in the regions that are successful in improving their competitiveness. The purpose of this chapter is to look at an example of such a region—Emilia Romagna in Italy. The analysis will cover development of transportation policy and spatial planning policy in compliance with the sustainable development idea. In the latter case, special attention will be focused on Italian industrial districts and their ecological variety—Ecologically Equipped Areas of Production.

2 Emilia Romagna: Sustainable Development Driven by Policies

The Emilia Romagna region is located in the north-eastern part of Italy and it is divided into nine provinces. This is one of the most developed regions in Italy, historically industrialised very early. The industrialisation process was intensified in the 1950s. As a result, very homogenous business structures emerged that are composed primarily of small and medium-sized enterprises. In the 1970s the region underwent a rapid industrialisation process performed mainly by the SME sector. That was a period during which the region recorded the best GDP growth rates among all the industrialised regions in Italy (in 1971–1980—4.1% while the average for the whole country was 3.8%). During the last decade the regional economy was developing at a rate similar to the whole of Italy of 2%. The 1990s were a period when companies started to grow step by step. Despite the trend, still over 90% of all enterprises employ under 50 persons.

The restructuring process of the production base was carried on as a result of growing penetration by the EU, North American and Asian markets and was based on the developing outsourcing of low value added production to regions with low production costs. Restructuring of the manufacturing sector was related to gradual improvement of the skills of the labour force. Despite successive implementation in the 1980s and 1990s of ICT solutions and other forms of advanced mechanisation and programming, there were no major employment reductions in the region. Organisation of production began be to be based on flexible specialisation within industrial districts characterised by small but very flexible and specialised companies with a strong inclination to consolidate in groups. Specifically dynamic economic development was taking place in an area with the best developed infrastructure along via Emilia running through such urban centres as Bologna, Modena, Reggio Emilia and Parma. Industry specialisation in the region was much varied and covers both the traditional industry sectors (production of ceramics, furniture, clothing and shoes) as well sectors with medium technological level (motor industry, production of machines) and highly technological sectors (biomedical equipment, mechatronics) (Rinaldi 2005).

Freight transport was of major importance for such strongly industrialised region due to its material impact on the economy, environment and social life. The skill to handle transport challenges in regions requires identification of varied, complementary intervention activities. To this end an approach is applied that combines research and planning work used to define actions that directly affect the sphere of[production and transport in the region. This type of philosophy is based on a statement that development of collaboration in logistic activities of enterprises and coordination of such activities may produce better effects that those of individual enterprises.

At present, strategic support methods to competitiveness of enterprises in the region cover implementation of coordinated logistic initiatives and development of related software tools for transportation and support to infrastructural investments. Development of increasingly effective supply and distribution chains through coordinated actions of the regional authorities may have positive impact on industrialised areas of the region. Such actions are not isolated manifestations of the activity of the local authorities but an effect of an overall approach promoting sustainable development through:

- Combination by the regional authorities of infrastructural policies and soft activities (promoting collaboration among enterprises) as a tool to simulate economic development;
- High level of coordination between sectoral strategies in the sphere of economic development, transport and spatial planning.

Describing the specific approach by the authorities of Emilia Romagna to logistic problems of the region, attention should be paid to the elements underlying the efficiency of the approach. Those are:

- Structure and extent of organisation of enterprises—a large share of small and medium-sized enterprises organised in territorial production systems and industrial areas manifesting a high level of readiness to collaborate with other enterprises;
- Organisational base—Department for Planning of Transport and Logistics, created within the structure of the regional authorities to implement logistics and transport policies. The pilot studies referred to earlier are performed by the Department in collaboration with the Regional Development Department;
- Legal basis—activities of the regional authorities affecting logistics development of the region are based on a vast array of legal acts and regulations—on the domestic level (Bassanini Laws) and on the regional level (PRIT98-2010—regional transport development strategy);
- Involvement of entities operating on the regional and local level to developing the logistic policy of the region. The system of government functioning in Emilia Romagna encourages enterprises, their sectoral associations, local authorities and other entities to actively participate in the development of logistics policies in the region (through all kinds of forums, focus groups, etc.);
- Financial basis—a developed financial support system to activities implementing the policy of logistic development of the region.

The legal regulations constituting the base for logistics policies in the region do not include only the nationwide Bassanini Laws but also legal acts regulating the principles of spatial planning and promotion of research work used to transfer innovation and technologies in the region. The main public policies which create unique approach to logistical and environmental issues are:

- PRIT 98-2010;
- Regional Law n. 20/2000—guidelines for territorial safeguard and land use;
- Regional Law n. 7/2002—promotion of industrial research activities, innovation and technological transfers in the Region;
- Institutional Agreements on specific programs between different levels of regional government.

Above mentioned regulations refer to such aspect of regional economy as spatial planning, transport, logistics policies, infrastructure development policies and environmental policies. The system supporting regional activities of the authorities in the area of transport and logistics was set up as a result of transfer of most of the functions and competences related to transport to the level of regional and local authorities. The changes are based on:

- the subsidiary rule providing more power to regional and local administration which is closer to the needs of citizens and enterprises;
- the collaboration principle of all levels of authority from the central government to local authorities in order to guarantee participation in initiatives supported by the European Union.

The regional strategy of transport development is an expression of a unique approach defining the "logistics policies of the region" and identifying it as a problem of collaboration between the manufacturing sphere and transportation systems. The strategies are characterised by:

- Use of the scenario method to make forecasts;
- Description of guidelines for the regional transport policies;
- Breakdown of general objectives into detailed activities with respect to transport development in the region;
- Integration of activities supporting competitiveness of the regional manufacturing system with an integrated transportation system;
- Identification of guidelines for the organisation of the regional transport and logistics system at various levels of public administration.

The strategy further comprises a modified approach and extension of actions related to solving transportation and logistics problems of the region beyond investments in the infrastructure. Such approach provides for promotion of collaboration among companies as a way to improve economic competitiveness of the region without incurring social and environmental costs related to infrastructure development. Such "infrastructural" approach applied most often by public institutions restricts their role to performance of large infrastructural approach. In opposition there is a proposal to identify the role of regional authorities as an active partner to companies operating on the basis of the public–private partnership. Public institutions such be able to listen to and understand the needs and problems of enterprises. They should also promote among them ideas that are compliant with the concept of sustainable development. The structure of such public–private relation may be treated as a key element to success of the approach.

The region of Emilia Romagna has developed a special method of systematic involvement in the decision-making process of a broad array of entities operating in the region. From this viewpoint, such methodology of public–private collaboration may be treated as one of the key competitive advantages of the entire regional economic system.

In reference to the regional strategy of transport development mentioned earlier, a structured collaboration process was activated with all the most important public and private entities. The objective was to plan and approve long-term activities performed by public authorities in the spheres of logistics, transportation and spatial planning that would meet the actual needs of the beneficiaries thereof. Each project involves different bodies including public and governmental bodies, manufacturing companies, logistic providers, consulting companies and universities or research units. Region promotes the implementation of pilot projects especially focused on small and medium enterprises in order to improve the competitiveness of the whole regional industrial and manufacturing context and the environmental sustainability of logistic solutions (CORELOG 2006).

Co-operational projects comprises such activities as sub-supplying centralization, integrated outbound logistics planning, knowledge dissemination among companies and development of sustainable industrial areas called Ecologically Equipped Industrial Areas (EEIA). The chapter further on covers on the one hand theoretical aspects related to formation of industrial districts and on the other hand—practical reference to the current situation in the region of Emilia Romagna with special attention on EEIA.

3 Industrial Districts: Short Overview

The concept of industrial districts is related to specialisation. Specialisation of a territory takes place when a region develops a strong economic structure with one type of industrial production or one product prevailing. Such manufacturing system develops in line with the development logic of the sector and its structure is subject to geographical proximity of its constituent entities and the production, organisational and market relations among them. Activities within manufacturing systems are focused on creating an additional usable value of their manufactured products. Literature refers to that as a "territorial quasi-rent" which becomes an element of competitive advantage (Colletis and Pecqueur 1995). One of the possibilities is development of a network of relations among entities operating in the territory. Concentration of companies with a similar specialisation in a region may be due to the occurrence of specific resources or assets or it may result from the activity of public authorities that want to create a centre of development in their area. The network of relations developed as a result of specialisation gives enterprises with opportunities to collaborate and increase the number of potential combinations of manufacturing activities. Apart from geographical proximity there is also organisational proximity. It is understood as a specific type of organisation and collaboration among companies which becomes a source of faster economic development of the territory.

In literature, the issue of industry specialisation or concept of the region or local area as a source of growing income is related to the discussion on the economy of location and on industrial districts by Alfred Marshall. The theory of location focused on spatial concentration of industry refers to the agglomeration factor by A. Weber identified three types of benefits resulting from grouping of enterprises:

- benefits of scale;
- benefits of location;
- benefits or urbanisation.

The benefits of scale result from decreasing unit production costs due to increased production. The benefits apply primarily to companies providing services to manufacturing companies operating in the area. With concentration of the latter, the service provide benefit from economies of scale. The location benefits apply to specialised companies in the same sector producing in the area. Technical and social infrastructure is being developed in a location providing services to the sector. The benefits of urbanisation in turn refer to access to the infrastructure of the urban areas within which the district is located.

Alfred Marshall attributed the competitive success of key industries to their geographical location. Industrial specialisation was treated by him as a key to success of the region. Key success factors of industrial districts include development of a local base of qualified workforce, sectors supporting development and ancillary and an opportunity to divide work among companies and apply dedicated specialist apparatus. The concept of industrial districts became popular again in the 1970s and 1980s and was related to the economic crisis in industrialised countries. Research has been conducted on new industrial districts with attention focused on northern Italy (co-called Third Italy) and on the local family business that were developing a collaboration network. Those discussions were related to search for new solutions related to placement of economic activities in space and to reference to a model of endogenous development. Those applied to districts that developed in the peripheries of traditional industrial districts. This refers to operations of specialised companies related within local networks, operating outside urban areas, based on strong social capital and successful in global markets. The characteristic feature of Italian industrial districts is the fact that although they operate in traditional industries, they are open to implementation of new technological solutions, including organisational innovations. Due to such openness, their economic results are proportionately higher with reference to the scale of operations in comparison to large companies operating in the same sector. Relations between enterprises and the labour market are informal which contributes to flexibility and efficiency of the district. There is an intensive transfer of competences related to fluctuations in the labour market and technological complementarities among enterprises in the district. The research conducted in the 1990s evidenced that in northern Italy there were about 200 such districts employing totally over 2 million people. It is worth noting that the systems were developed without activating by the authorities of any special support programs and are primarily based on local resources. In fact, that was a bottom up process in which the important role of the districts generated industrial policy instruments further supporting their dynamic development.

The reasons for district development are to be sought in organisational innovations and in disintegration process of vertical relations in favour of horizontal relations among enterprises and groups of enterprises, financial institutions and public authorities. As a result there is a more intensive division of labour and expansion of external benefits of scale, improved labour market flexibility and the process of spatial production concentration becomes accelerated. The advantage of the relations is their flexibility—specialist subcontractors dynamically adapt to the nature of the current production projects. The possibility of fast adaptation and creation of new collaboration configuration gives an opportunity of flexible specialisation to companies functioning within an industrial district. As a result, specialisation is coupled with differentiation of production, organisational flexibility around manufacturing entities that offer access to markets, often global markets, to smaller companies. This is how district became a new form of spatial organisation and a model example of local development (Piore and Sabel 1989).

Emilia Romagna, Tuscany and Veneto are the three Italian regions with the largest concentration of districts and clusters. Industrial specialisation among the clusters of the Emilia Romagna region ranges from manufacturing that does not require advanced technologies such as clothing, food processing, shoes, ceramics and furniture, to high technology industries such as mechatronics or biomedical products. Over a long time, the evolution of the Emilia Romagna was related to increasing economies of scale meaning a growing number and type of activities performed within districts in order to adapt to the changing market requirements. The model of production organisation in the form of a district or cluster made a further step forward with the appearance of networks of small but fast growing enterprises in ICT sectors, multimedia related to motor industry companies such as Ducati, Ferrari, Maserati or Lamborghini.

4 Ecologically Equipped Industrial Areas

An analysis of the active role of the authorities in the Emilia Romagna region in implementing their transport policy and spatial planning policy may not omit the legal regulations that promote the development of new and consolidation of existing industrial zones:

- That are compliant with the environmental and urban premises;

- That group enterprises which can improve their production processes and logistic and economic effectiveness by location in one area and by collaboration practices.

In the legal regulations concerning industrial zones there is a notion of "Ecologically Equipped Industrial Areas" (EEIA) defined as areas provided with infrastructure, services and systems guaranteeing systems that are safe to health and the environment. There are two groups of industrial areas:

- Zones whose social, environmental and territorial impact extends beyond a single industrial district;
- Zones whose impact is limited to a single industrial district.

Support systems organised by regional authorities for enterprises promote creation of new industrial zones meeting EEIA requirements. The authorities establish also special funds as a way to encourage transformation of the existing industrial zones affecting more than one industrial district into EEIA zones. Urban authorities may create new industrial areas and assign the EEIA status to them (even if they affect only one industrial district) and may enter into agreements with interested enterprises identifying stimuli to transform the existing industrial zones to EEIA zones.

In practice, companies are provided with a strong stimulus to organize into EEIA since due to that they can e.g. buy rights to develop certain areas below market price. Additionally, companies organised in this manner have easier and cheaper access to services in which the local authorities are involved (supplies of power, water, waste removal, road repairs). EEIA's promote two basic ways of collaboration:

- Collaboration among companies within the zone. Such collaboration is related to cooperation opportunities in logistic operations and opportunities for joint use of infrastructure by companies located in the same industrial zone, for instance companies jointly purchase electricity or logistic services achieving effects of scale;
- Collaboration between cities consisting in an opportunity to develop inter-urban (inter-municipal) industrial zones. Such zones may be established on the basis of a joint decision of the involved municipalities, irrespective of the geographical boundaries of each city (town) or municipality. Such zones can be managed by public or private entities, operating in the name and on behalf of an organised group of cities or municipalities. Such approach ensures that the involved local authorities will be jointly committed to implementing a spatial planning process with which it will be possible to avoid fragmentation and competition of collaborating zones. Additionally, local authorities will share the costs (e.g. the costs of zone urbanisation) and revenues (from local taxes) related to location of companies and decisions on settling in a zone.

From the logistics viewpoint, location decisions by companies resulting from establishment of industrial zones guarantee optimisation of goods flow which is favourable for the environment and for the companies. Location of companies in the same industrial sector or in the same supply chain within one EEIA ensures closer relations among them and promotion of joint management of internal and external goods flow.

Another important factor is opportunities resulting from organisation of joint procurement or use of common infrastructure by companies located within one EEIA. One of the main benefits is reduction of commodity traffic generated by the companies. At various levels, detailed guidelines are formulated now to implement EEIA subject to such areas of interest as: energy, waste management and logistics. There are three groups of guidelines, related to:

- spatial planning requirements in order to guarantee an adequate inclusion of the zone in its immediate social and economic surrounding;
- a need for the existence of an entity managing the area whose task is to support environment-friendly operation of the zone and create conditions for such activities;
- availability of infrastructure, services specific for the zone and guaranteeing benefits for companies resulting from location within the zone.

Research of the Ecologically Equipped Areas of Production existing in the Emilia Romagna region provides practical guidelines as to what aspects and organisations should be in particular noted. The most important ones are listed below:

- Urban planning-territorial requirements—crucial for the insertion of EEIA in the social, economic and environmental context of the region
- Area Manager—entity responsible for managing EEIA
- Infrastructure, services and integrated environmental management relevant to needs of companies and generating additional value for them.

Industrial zones in northern regions of Italy are at different stage of implementation of the concept of EEIA. According to present studies on the subject the most popular sectors to which belong companies forming EEIA are manufacturing, transport and storage. There are 2 models of ecological cooperation. The first one is sharing of common services and services. The second is creation of the network for exchange of materials and energy. Typical tasks of Area Manager—entity managing EEIA are: energy management, maintenance management, air quality monitoring, waste cycling and purchase of energy. Typical common ecological friendly services and infrastructure includes road sweeping and cleaning, differentiated waste collection, common equipment and spaces, public transport and monitoring of the quality of waste water, single purification system for industrial and drinking water, the water supply network, electricity and methane gas distribution network (Beltramo et al. 2010).

The most complex plan of conversion of industrial area into EEIA is represented by Ponte Rizzoli in Emilia Romagna region. The Ponte Rizzoli project has been promoted by the provincial government of Bologna with the goal to focus on the environment sustainable development. The Ponte Rizzoli is located in the North-Eastern area of Ozzano nell'Emilia, along via Emilia which is main road axis crossing the region and involves 3 municipalities: Castenaso, Ozzano dell'Emilia and San Lazzaro di Savena bordering Bologna. These municipalities signed territorial agreement with the aim to obtain the qualification of EEIA. Three strategic goals were defined: users and operators safety guarantee, decrease of pollution emission and increase of companies efficiency by using technology. Workgroup created in order to develop Ponte Rizzoli project included Bologna Province as the project promoter, Provincial Councillorship as the coordinator of the project, "Valle dell Idice" municipality association and regional development agency ERVET SpA. In addition the working group of technicians and planners worked on definition of urban and environmental prerequisites required by EEIA. Among actions necessary for transformation into EEIA are:

- co-generation power plant and district heating network;
- actions for regulation of flows of surface waters (lamination tank and buffer strip with dense vegetation;
- landscaped areas for insertion in the environmental contact with EEIA;
- common logistic areas developed by private stakeholders (with aim of reducing traffic inside the area design and application of industrial ecological actions.

For further development of EEIA initiatives crucial is flexibility in answering needs of companies settled in area according to the level of its development and management which will pay special attention to environmental monitoring based on definition of specific parameters to be verified during development of the area.

5 Logistics Policies as a Factor of Regional Competitiveness and Sustainable Development

Regional logistics must be oriented on the development of regional economy through the development of logistic infrastructure and services. There is point of view presented in literature that in order to obtain sustainable development of the region it is necessary to improve and harmonize the infrastructure because of it's great influence on production costs and living quality of citizens. Italian example of Emilia Romagna region shows that this standard "infrastructural approach" can be enriched by co-operational policy measures. So on the one hand policy measures introduce coordinated logistic initiatives and support development of related IT instruments for logistic functions optimization. On the other hand infrastructural approach is still developed towards more sustainable solutions like for example Ecologically Equipped Industrial Areas.

Investments into logistic infrastructure influence capacity and accessibility of the region and thus increase efficiency of companies by decrease of logistic costs, shorter delivery time and overall business expansion. As the results we can observe improvement of productivity and competitiveness of the whole regional economic system. Similar results but in smaller scale can be obtained in case of cooperation among companies. Policy-mix presented in this chapter as well as specific policy tools used in Emilia Romagna region may serve as the reference for regional authorities which would like to implement regional strategy of sustainable development.

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Part II
Collaboration Models for Sustainable Transport

Coordination Model of Transport Processes Based on Sustainable Development Concept

Marcin Hajdul

Abstract Sustainable development means that it is possible to organize current needs in the way, which does not eliminate the possibility of organizing the same needs in future. It is the ability to maintain a balance of a certain process or state in any system. In business activities, it is the ability to maintain a balance between three areas: economical, ecological and social one. Author presents the possibility of exploiting concept of sustainable development in organizing transport processes. Furthermore, author presents new business model for vertical and horizontal cooperation between logistics services clients (consignees, consignors) and logistics services providers (SMEs), with the aim of increasing the load factor, reducing transport costs and exploiting co-modality concept (use of different modes on their own and in combination in the aim to obtain an optimal and sustainable utilization of resources).

Keywords Efficiency · Transport process · Co-modality · Sustainability · Cooperation · Economy of scale effect

1 Introduction

Most companies have already noticed that efficient and effective transport process organisation has a great influence on their current performance, which determines total company costs. Therefore a number of methods were established for presenting ways of implementation and reconstruction of processes in business.

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Among others, the following methods were analysed: Distribution Resource Planning (DRP), Just in Time (JIT), Total Quality Management (TQM), Efficient Consumer Response (ECR), Collaborative Planning, Forecasting and Replenishment (CPFR), Theory of constraints (TOC), Business Process Reengineering (BRP), Business process management (BMP), Trillium Model, Capability Maturity Model Integration (CMMI), Benchmarking, Process Improvement and Management (PI&M), Rational Unified Process (RUP), Zachman Framework. Analytical studies carried out indicate that the tested methods correspond to current needs of businesses related to rationalization of current costs. Unfortunately, none of the methods discussed indicates in detail what key logistical processes should be improved and by what specific tools these improvements should be implemented for production or service companies representing links in the supply chain.

In addition, most diagnosed methods recommend focusing on the processes implemented within a single company and only strictly within a given area (such as purchases, transport and warehousing). The leitmotif of all actions taken is solely the customer's needs and economic balance, analyzed in the short term.

The author's research, carried out within selected international projects,[1] also indicates that carrying out changes only within a company is associated with organizational, technical or physical constraints. These limitations can be eliminated through cooperation of companies associated in clusters, or operating in a given area, with common organization of the selected processes and their proper coordination. Coordination in this case is understood as a mechanism consisting of procedures and indications enabling establishing and harmonized implementation of concrete actions of entities involved on the basis of cooperation (agreement between independent companies).

Moreover, these methods also do not include the relationship between efficiency and effectiveness of organization of processes in business and the surroundings in which a company is active. Examined methods do not try to take into account the dependencies between economic, environmental and social aspects. It represents a fundamental flaw of these solutions, since according to one of the fundamental assumptions of systems theory, a company is not self-sufficient and is not isolated from the environment. Companies pursuing their current operations obtain or use selected resources from the environment and as a consequence they

[1] CORELOG–COordinated REgional LOGistics funded under the Community Initiative INTERREG IIIB CADSES in 2005–2007, DIFFERENT–User Reaction and Efficient Differentiation of Charges and Tolls funded by the 6th Framework Programme for Research of the European Union in 2006–2008, Freightwise–Management Framework for Intelligent Intermodal Transport funded by the 6th Framework Programme for Research of the European Union in 2006–2010, KASSETS–Knowledge-enabled Access of Central Europe SMEs to Efficient Transnational Transport Solutions implemented under the programme CENTRAL EUROPE, co-financed by the European Regional Development Fund (ERDF) in the years 2008–2011, DiSCwise–Digital Supply Chains for European SMEs based on the Freightwise Framework implemented for the European Commission DG Enterprise in the years 2010–2011,

communicate the results of their business (direct and indirect) to the environment. Environment contains elements of direct and indirect impact on the company.

The above analysis confirms the observations made by the author: companies—focused mostly on the financial aspects—are trying to rapidly response to market needs while maintaining operating costs of logistics processes at a reasonable level. However, this situation where companies are improving the processes and thereby increasing the level of customer satisfaction in the short term period, may lead to deterioration in their performance in the long term period. An example of this situation is management of transport processes. Frequent and fast delivery requires the involvement of more means of transport, and lack of cooperation between companies and coordination of processes results in the involvement of multiple service providers (carriers) which are not always able to fully exploit the cargo space in the available means of transportation. These actions result in an increase in traffic, deteriorating road safety and increase in emissions. As a result of growing congestion, average technical speed of vehicles is decreasing. This result in longer delivery times, might affect customer satisfaction, and in the worst case, can cause loss of contracts. Thus, in the long term period companies inadvertently lead to the deterioration of their financial performance and decline their competitiveness. Therefore, the tendency to maximize profits in the short term causes pushing long term goals related to development of the company into the background. Meanwhile, studies suggest that the failure to undertake projects taking into account environmental, social and innovation-oriented aspects may in future prevent companies from achieving any goals.

It is also worth remembering that the price of the finished product offered by manufacturing or distribution companies also depends on the level of incurred fixed and variable costs. It is even more important to rationalize the cost of logistics, with special emphasis on the cost of flow of goods, since this will allow offering end customers a lower price for the final product, and thus contributing to the competitiveness of enterprise. The Fig. 1 presents selected components of costs associated with flow of goods between supply chain links, which have an impact on the product price for end customer.

Based on the analysis of Fig. 1, it is clear that this is the element to which more and more companies started to pay attention and try to optimize it to increase their competitiveness.

Competitiveness is defined as the ability to compete, thus taking concrete actions to survive in a competitive environment, and ultimately achieve sustainable competitive advantage (Skawinska 2002, p. 13). In fact, competitiveness in terms of process (functional) is associated inextricably with competitiveness in attribute (result) sense. Process competitiveness leads to achieving competitiveness in attribute terms. Thus understood competitiveness may be related to different levels of economic entity (Golinska and Hajdul 2011, pp. 48–56). Competitiveness is the mechanism which brings together producers and consumers and ensures rational elimination of the weaker entities, and prefers the more efficient ones.

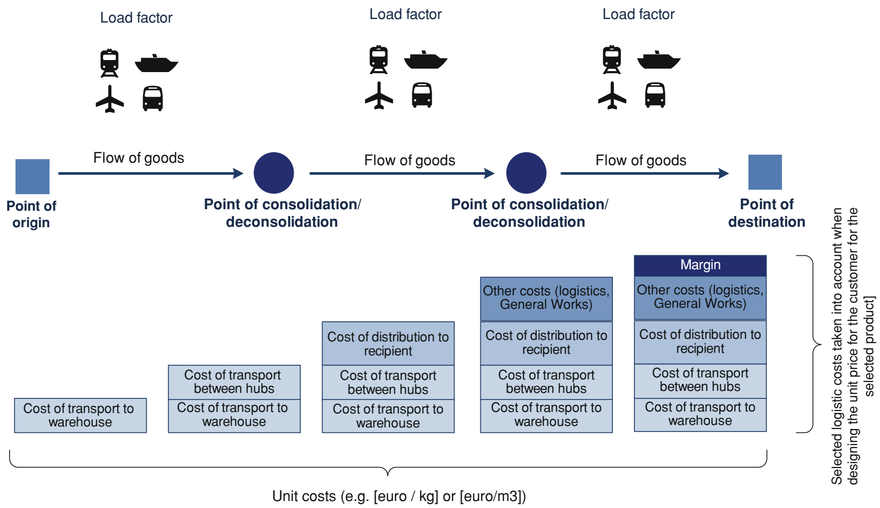


Fig. 1 Impact of selected logistics costs on the price for selected product

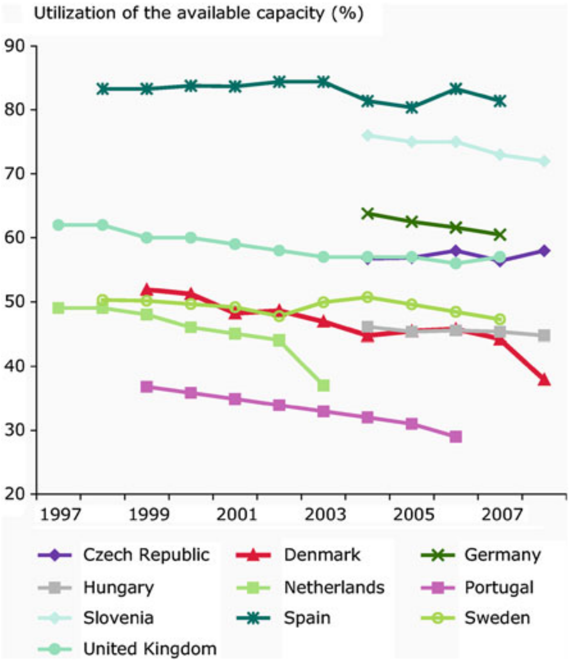
The author refers competitiveness to market economy, in which participants of economic life compete with each other on various levels (Golinska and Hajdul 2011, pp. 48–56):

- Manufacturers seek favours of consumers, trying to get the most benefit;
- Customers seek to acquire goods and services needed to meet the needs on best possible conditions;
- Suppliers compete with other suppliers for customers;
- Customers compete with other consumers for the best conditions at suppliers.

From the standpoint of cost rationalization of logistic processes in order to increase competitiveness, the processes associated with the movement of goods between the hubs of the logistics system are particularly important. Currently, researchers and entrepreneurs note that is not a problem to produce the product, but to sell it. However, with sale, logistic processes play a very important role. Particularly important are processes of movement of goods, whose effect is to offer ever higher levels of customer service. (Pacholski and Trzcielinski 2005, p. 23). It should be noted, however, that the unit costs of flow of goods depend directly on a single moved volume of goods. From the perspective of transport processes, the cost of transport decreases with increasing volume of supplies. Thus, the ideal solution would be maximum utilization of available cargo space of means of transport operated during flow of goods.

Unfortunately, research conducted by the European Environment Agency indicates that in most countries of the European Union use of available capacity of operated means of transport is low. For the most commonly used branch of transport, namely road transport, the average use of available capacity of vehicles during the

Fig. 2 Road freight load factors (during the laden trips). Source: European Environment Agency



supply or distribution is at 54%. For rail transport, this value is 48%. This situation obviously varies depending on individual countries, as illustrated in detail in Fig. 2.

Analysis of Fig. 2 clearly shows the trend among companies, continuing for many years, to under-use available resources enabling the movement of goods. We are therefore dealing with cost-ineffective transportation resources safekeeping, or waste (Wyrwicka 2009, p. 5). These actions include not only the misuse of available resources, but also failure to see or intentional ignoring the possibility of performing an action with less effort (Wyrwicka 2009, p. 5).

Regarding the above, in author's opinion, it is necessary to include, during rationalization of processes in an enterprise, a strong correlation between organization of logistics processes in enterprises, and the surroundings in which they operate. Companies should conduct coordinated actions, which can continue for many years, taking into account environmental and social aspects, to ensure continuity of the company.

Making changes in the implementation of logistics processes should be done using the concept of sustainable development, thus enabling fulfilment of current needs, in such a way that does not eliminate the possibility of fulfilment of the same or other needs by an entity in the future. For business activity, this development implies balancing three areas: economic, ecological and social.

On the basis of observation and research, the author recognizes that there is multidimensional research problem involving the lack of a coherent model of coordination of business processes implemented in the economic activity of a group of independent companies, according to the concept of sustainable development, that is, taking into account economic, environmental and social aspects. This model should result in improved efficiency and effectiveness of current processes in companies, but at the same time it should not prevent the effective operation of companies in the future. In addition, it should minimize adverse impact of companies on environment in which they operate.

On the basis of analysis of the literature in terms of the research work, it was found that the research gap exists and it is reasonable to try to develop:

- Organizational solution to enable increased efficiency and effectiveness of logistics processes of a company;
- A model enabling organization of logistics processes using the concept of sustainable development;
- Proposition of a solution to eliminate drawbacks of existing methods and tools for organization of logistics processes;
- Solution supporting a particular policy of the European Union, promoting the effective organization of logistics processes, taking into account the economic, social and environmental aspects.

The main objective of this chapter is to present a model for achieving synergy effect through coordination of selected logistics processes, in the economic activity of groups of independent enterprises. This model uses the objectives of sustainable development concept. The proposed model reduces generation of adverse effect on company activities in the long term period, as well as on region where the company is active. In addition, a set of indicators for evaluation of the effects of the implementation of the model is presented.

The model of coordination of logistics processes of enterprises using the concept of sustainable development has been prepared on the basis of analysis of literature and empirical studies carried out in a group of independent companies involved in the implementation of selected logistics processes.

Implementation of the main objective has been achieved through the following intermediate objectives:

- Developing a solution which will enable companies to increase efficiency and improve effectiveness of logistics processes through synergy, leading to a reduction in unit costs of these processes and thus positively affecting increased competitiveness of companies;
- Creating a reference model for business cooperation for the common organization of selected logistics processes using the concept of sustainable development;
- Developing an organisational solution which will enable use of synergy effect and thereby contribute to the fulfilment of selected assumptions of the concept of sustainable development;
- Creating a model of coordination of logistics processes, which will not generate additional costs of sustainable development for companies using it;

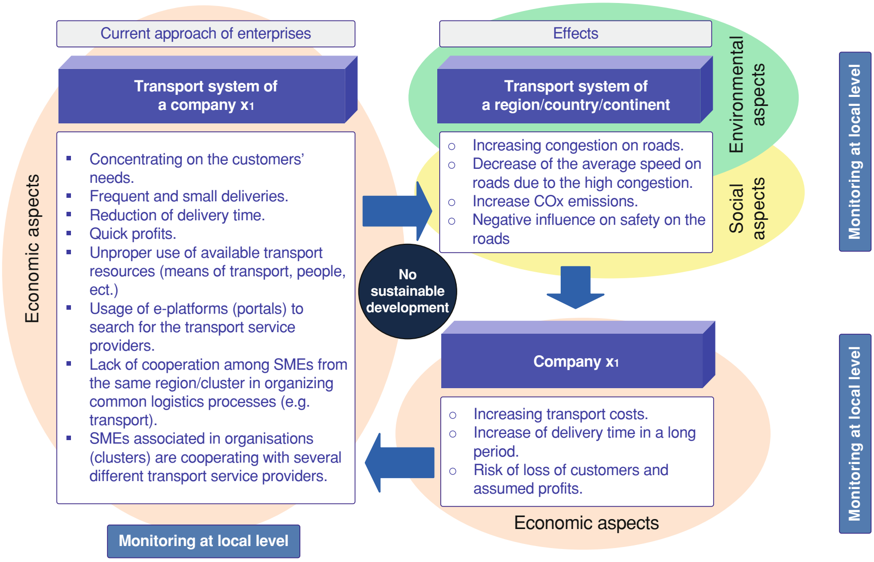


Fig. 3 The current approach of companies to implementation of selected logistic processes

- Developing a method of indicator-based assessment of the model. This method should allow designation of benefits for companies and the region.

2 Organizational Assumptions of the Model

The main assumption of the model is to change the current method of organization of logistics processes by the production companies shown in Fig. 3 through joint and coordinated organization of these processes by groups of manufacturing companies.

This model is designed to enable companies to achieve synergy effect leading to increased efficiency and effectiveness of logistics processes through collaboration of independent operators. It also assumes application of innovative methods of organizing logistics processes using the concept of virtual supply chains. Application of this concept arises from the need to create significant synergy potential and the flexibility and ability to adjust to changing situations.

The model of coordination of logistics processes is also designed to eliminate the negative consequences for the region and companies, generated by the current approach of companies. In addition, this model is designed to enable business activity by companies in the long term with increase in their competitiveness. The main assumptions of the model are presented in Fig. 4. They have been developed

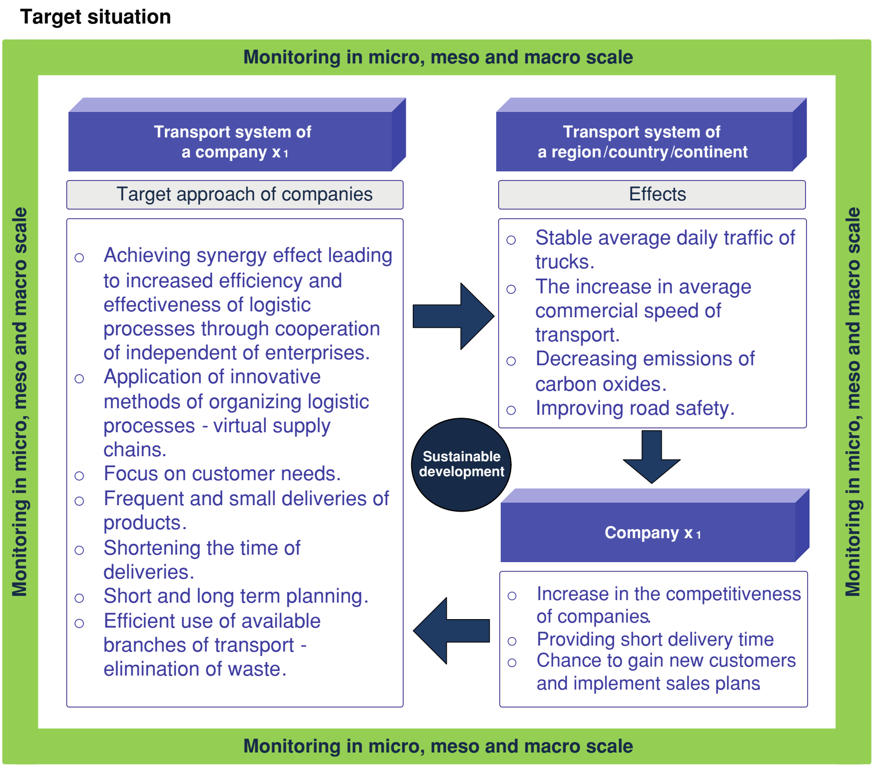


Fig. 4 Assumptions of the coordination model of logistics processes using the concept of sustainable development

based on the analysis of literature and empirical studies carried out on a group of companies affiliated under ECR Poland.

The model relates to the concept of virtual supply chains, and multi-agent systems, providing for coordinated action to solve a specific problem using cooperating agents (holons) (Kawa et al. 2010; Hajdul 2009). Agents, in case of the created model, are manufacturing companies, suppliers of transport services and transport process coordinators. The developed reference model of coordination of logistics processes of enterprises also defines the roles performed by the participants (agents), the relationship between them (inside the virtual supply chain), and between cooperating companies, and the region in which they are active.

The model of coordination of logistics processes of enterprises, as in case of alliances, partnerships in clusters, or virtual organizations is characterized by the legal autonomy of participants (Wyrwicka 2009, p. 45). Participants of the model operate on the assumptions which are based on loyalty of partners, trust, voluntary cooperation, communication with the environment, sharing resources, learning, involvement in distribution of added value and sharing any possible risk. This type of relationship is called cooperence, however, ultimately companies involved in joint organization of selected logistics processes should operate on the basis of cooperation, which is characterized by a higher than cooperence level of trust. Table 1 presents the types of relationships between companies before, during initial implementation and in case of full acceptance of the model.

One of the main assumptions of the model of coordination of logistics processes of enterprises using the concept of sustainable development is to achieve synergy effect leading to increased efficiency and effectiveness of logistics processes through collaboration of independent operators. This cooperation takes place on the basis of proper configuration of independent organizational units (users and providers) working together to achieve the occasional goals. Thus, these entities begin to operate according to the principle which specifies functioning of virtual organizations (Skawinska 2002; Sikorski 2006).

The model, like virtual organizations, has the following characteristics (Skawinska 2002; Sikorski 2006):

- Cooperating businesses have a common vision, mission and purpose;
- Participants focus their activities around their core competencies (e.g. production companies focus on manufacturing products);
- Cooperating companies have a developed knowledge base and IT system for fast and secure exchange of information as well as Internet connection;
- Enables collaboration in competence teams in order to carry out the defined activities in a holistic approach to organization of logistics processes;
- Generates and communicates information in real time throughout the entire network, which allows for quick decision making and coordination;
- Delegates authority to an independent coordinating entity wherever the economies of scale can be achieved or when specific skills are required in order to meet the needs of the group.

In the literature, a virtual organisation is also called a temporary relationship that can last several weeks, but also a few years (Skawinska 2002; Sikorski 2006; Pacholski and Trzcieliński 2005). In addition, virtual organizations, often in relation to networks of institutional enterprises, are primarily determined by physical and social distance. This entails a significant time distance. Moreover, the dispersion of partners is characteristic of a virtual organization (Skawinska 2002; Sikorski 2006; Pacholski and Trzcieliński 2005).

The above described features associated with the dispersion cannot apply in case of co-operation of independent economic entities in organization of logistics processes. A large distance between the cooperating companies, as well as temporary relationship precludes achieving synergy in the implementation of logistics processes.

The very process of implementation of the model and its learning takes time, therefore by definition it cannot be a momentary action. However, after its full implementation commencement of activity according to the principles of cooperation, flexibility in cooperation is possible in terms of organization of selected logistics processes. Specifically, companies can decide individually whether each time a process should be carried out with partners in the group or in the traditional manner.

Table 1 Types of relationships between businesses in the implementation of the model of coordination of logistics processes

Implementation status of the model of coordination of logistics processes of enterprises	Type of relation between competitors	Frequency of relations	Strength of relations	Form of relations	Level of trust	Available resources for effective and efficient process organization	Market position
Lack of implemented model	Competition	High	Low	Informal	Low	Sufficient for effective organization	Strong
Initial stage—learning	Cooperence	High	Remarkable	Formal or informal	Medium	Insufficient	Strong
Fully implemented model	Cooperation	High	Remarkable	Formal or informal	High	Insufficient	Weak individually, strong in group

The area of activity of cooperating entities is also very important. A particularly good illustration is the process of movement of goods, which provides economies of scale through virtual collaboration of independent companies, located not only in the distant, but also in close proximity. Then, for example, it will be possible to eliminate the waste associated with failure to utilise available cargo space in vehicles. This will result in lowering unit costs of logistics, as well as positive impact on the environment by reducing vehicles carrying supplies, reducing harmful emissions or reducing the risk of accidents.

Figure 5 presents the developed reference model of coordination of transport processes based on the concept of sustainable development.

Cooperating entities exchange information electronically, using dedicated electronic platforms.

Three groups of participants that perform dedicated roles are defined in the reference model (Fig. 5):

- **Users of logistics processes (service recipients)**: companies producing and/or distributing and selling products. Logistics is not their main source of activity and has only a supporting role to achieve the main objectives. These companies may have their own resources to implement selected logistics processes or collaborate with service providers (e.g. logistics operators). As users of selected transport processes they generate specific needs in the form of orders (e.g. for transport). Contracts for carrying out specific services are concluded between users and providers of logistics services.
- **Logistics service providers (service providers)**: companies whose main activity is the provision of logistics services. In the model, their task is to fulfil common logistic needs of cooperating companies—users. If one of the cooperating production companies has its own resources to implement selected logistics processes and is able to provide services for other users, then it performs the role of logistics service provider (e.g. transport services, storage, etc.)
- **Coordinator**: this is an independent entity delegated by the other two groups, whose task is to obtain economies of scale. They also have powers to enable meeting the needs of a group of cooperating companies, related to organization of logistics processes.

  For example, with the process of movement of goods, they coordinate transport processes (e.g. analysis of possible to combine transport orders of various users, price negotiations, selection of branches of transport), cooperation with providers of transport services, monitoring the implementation of joint transport processes, conducting analyses at micro and macro level.

The coordinator may also act locally and focus on handling a selected process or group of companies in the region. They can also operate globally, collaborating with local coordinators, in order to achieve even greater economies of scale.

The role of coordinator can be realized in several ways. It may be the position funded by the cooperating companies. Coordinator may be an independent economic entity supporting coordination of logistics processes, which invoices users

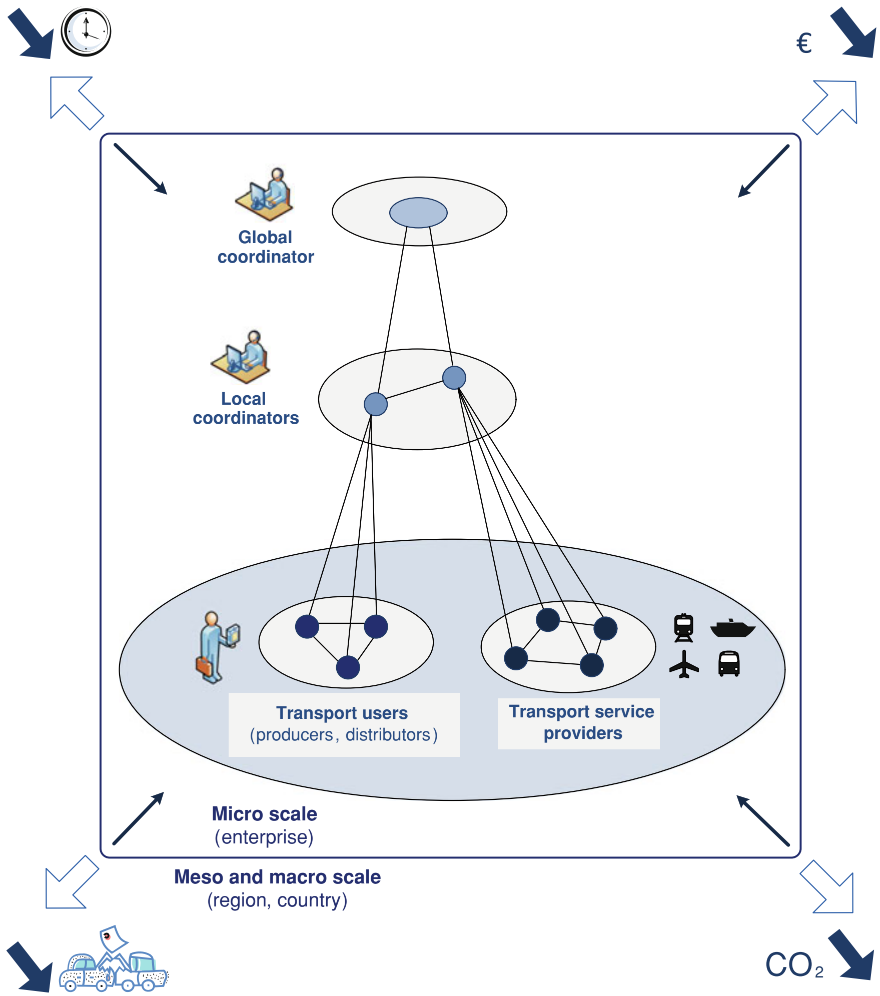


Fig. 5 Reference model of coordination of logistics processes based on sustainable development concept

based on the number of orders executed. Finally, it may be a forwarding company, operating exclusively for handling the companies which have decided to cooperate in organizing transport processes. All this depends on the arrangements between independent entities which decide to undertake cooperation.

The actions of each of these roles have a direct impact on the region's logistics system, in which they operate. In addition, each of the defined entities is also exposed to the effects of environment (e.g. decisions of public administration), in this case - the region's logistics system. These relationships are schematically presented in Fig. 6.

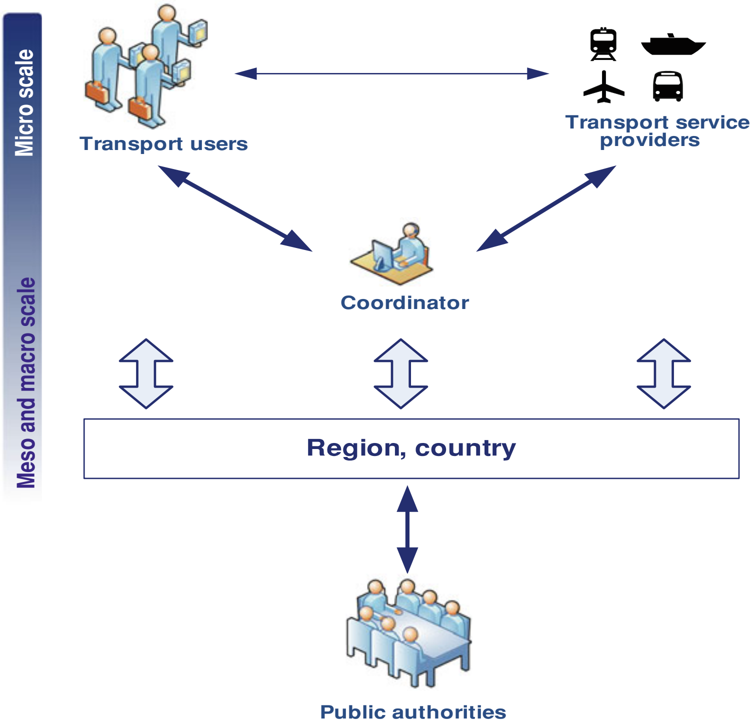


Fig. 6 Roles in the developed model

Figure 7 presents examples of application of the model of coordination of logistic processes of enterprises for the movement of goods from producers to customers, in order to achieve economies of scale. In this example, there are representatives of three groups, namely users, service providers and coordinator. Information exchange is implemented using the electronic platform for supporting communication. It is also a tool that allows the coordinator the aggregation of orders from individual users to use as few transport vehicles as possible, while complying with the imposed constraints (e.g. delivery time). Upon planning a combined shipment, coordinator generates a transport order for the selected transport providers who perform the transport after acceptance.

3 Implementation and Operational Functioning of the Model

In order to verify the usefulness of the reference model, a conduct algorithm for solution implementation has been developed. This algorithm assumes that the verification and implementation process will be executed in three stages:

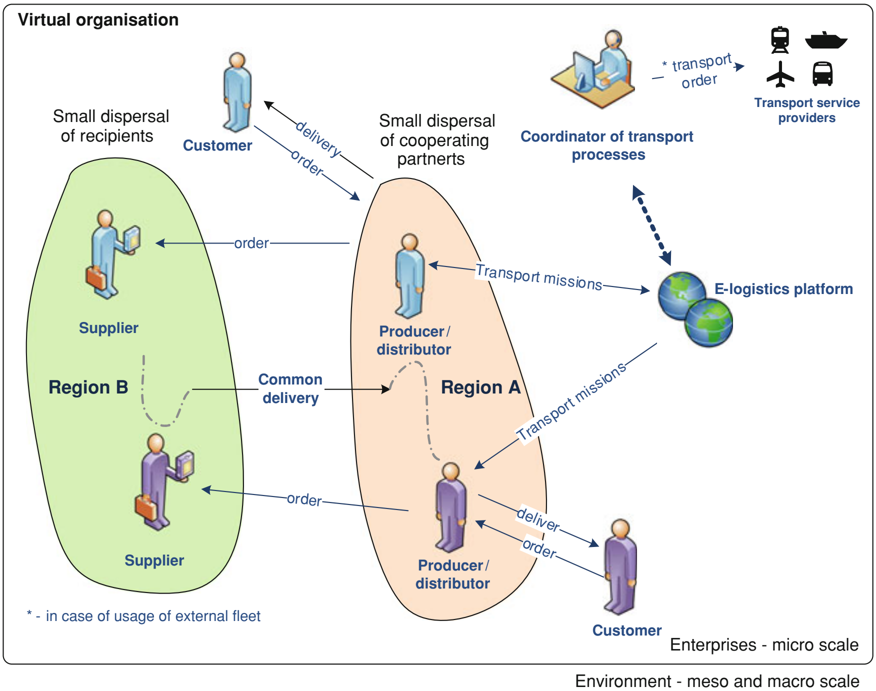


Fig. 7 Cooperation of companies in organizing transport processes

- **Stage 1**: identification of synergy potential. At this stage, based on historical data simulations are performed aiming at estimation of potential benefits for the companies and region, taking into account the sustainable development concept;
- **Stage 2**: configuration and implementation of solution. In case of a favourable outcome in stage 1, one can proceed to configure model for the needs of cooperating companies. Then, implementation is performed;
- **Stage 3**: full-scale activity. This stage implies the operational functioning of the solution and continuous monitoring of results at micro, meso and macro level.

At stage 1, the companies still operate on the basis of competition, but consciously reviewing the possibility of cooperation in order to exploit the synergy potential. In stage 2 companies already operate according to the principles of cooperence. In the third stage, the companies should ultimately work according to the principles of cooperation.

Below, defined stages of implementation of the model for this transport process are defined in detail (Fig. 8).

Table 2 presents the scope of data characterizing the transport needs of companies. These data are necessary to plan combined transportation by the

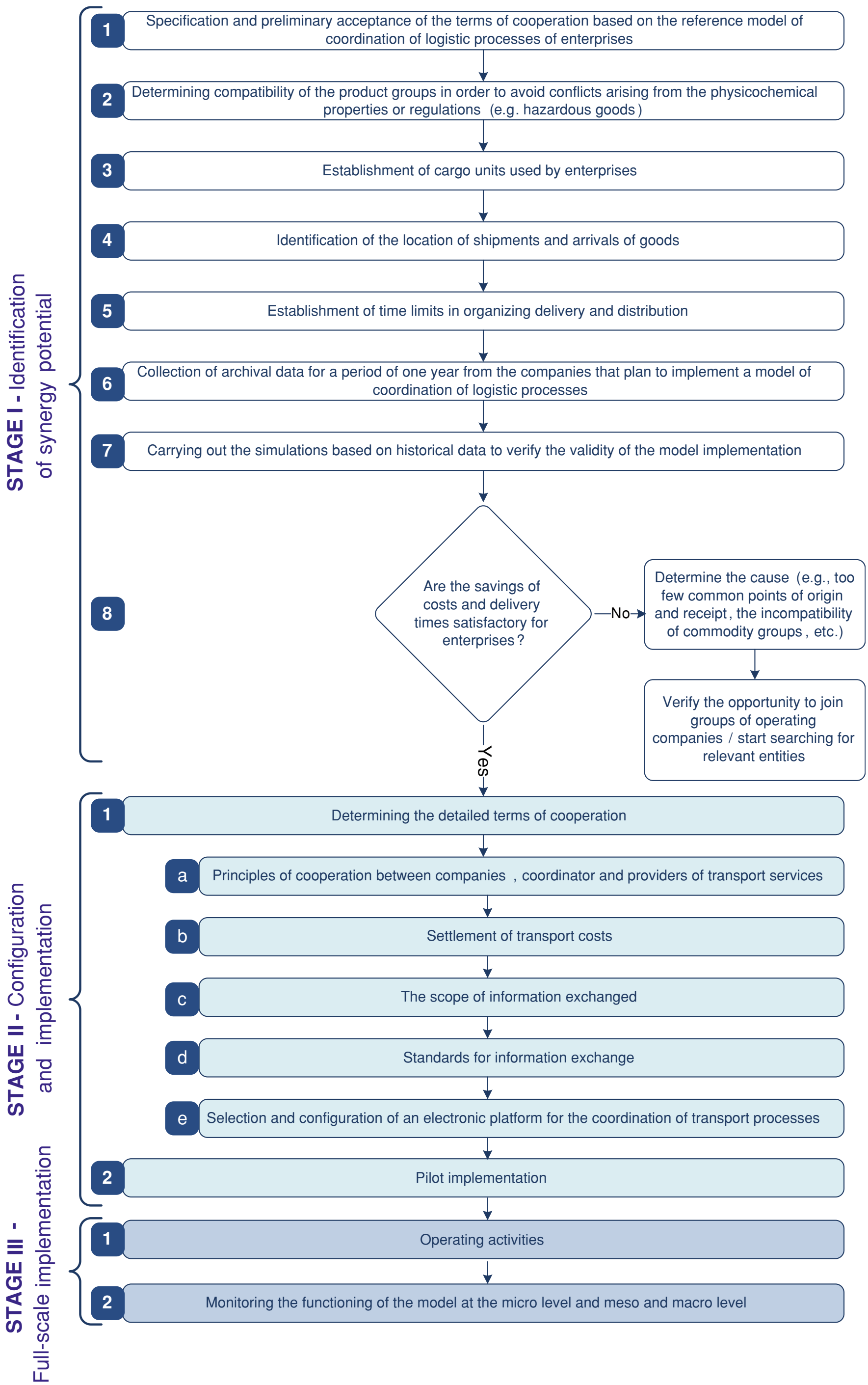


Fig. 8 Stages of model implementation

Table 2 Scope of data necessary for the functioning of the model

No.	Data	Fill-in space
1	Point of origin	
	Name of location (town, village)	
	Postal code	
	Street, no.	
	Country	
2	Delivery point	
	Name of location (town, village)	
	Postal code	
	Street, no.	
	Country	
3	Type of cargo	
4	Type of cargo unit	
5	Number of cargo units	
6	Cargo weight	
7	Volume	
8	Date of cargo delivery/reception	
9	Delivery restrictions	
	Temporary (delivery time windows)	
	Resulting from transport infrastructure	
	Other	
10	Use of own means of transport to carry out transport	
	Type of means of transport	
	Available space (in m^3, tons, number of pallet spaces)	

coordinator. Based on these data coordinator makes an inquiry for providers of transport services.

The data presented in the table above is necessary for the implementation of each of the three stages shown in Fig. 8.

In case of achieving satisfactory results in analysis conducted in Stage 1, one can proceed to clarify the conditions for cooperation and setting up the model for the needs of cooperating companies in accordance with the steps described in Stage 2. Details of implementation of the transportation planning process and the sequence of actions carried out by various entities in the model are shown in Fig. 9.

4 Economic, Social and Environmental Aspects

One of the main assumptions of the model of coordination of logistics processes is to eliminate the adverse impact for the region and companies, generated by the current approach of enterprises to implementation of logistics processes. In addition, this model is designed to enable business activity by companies in the

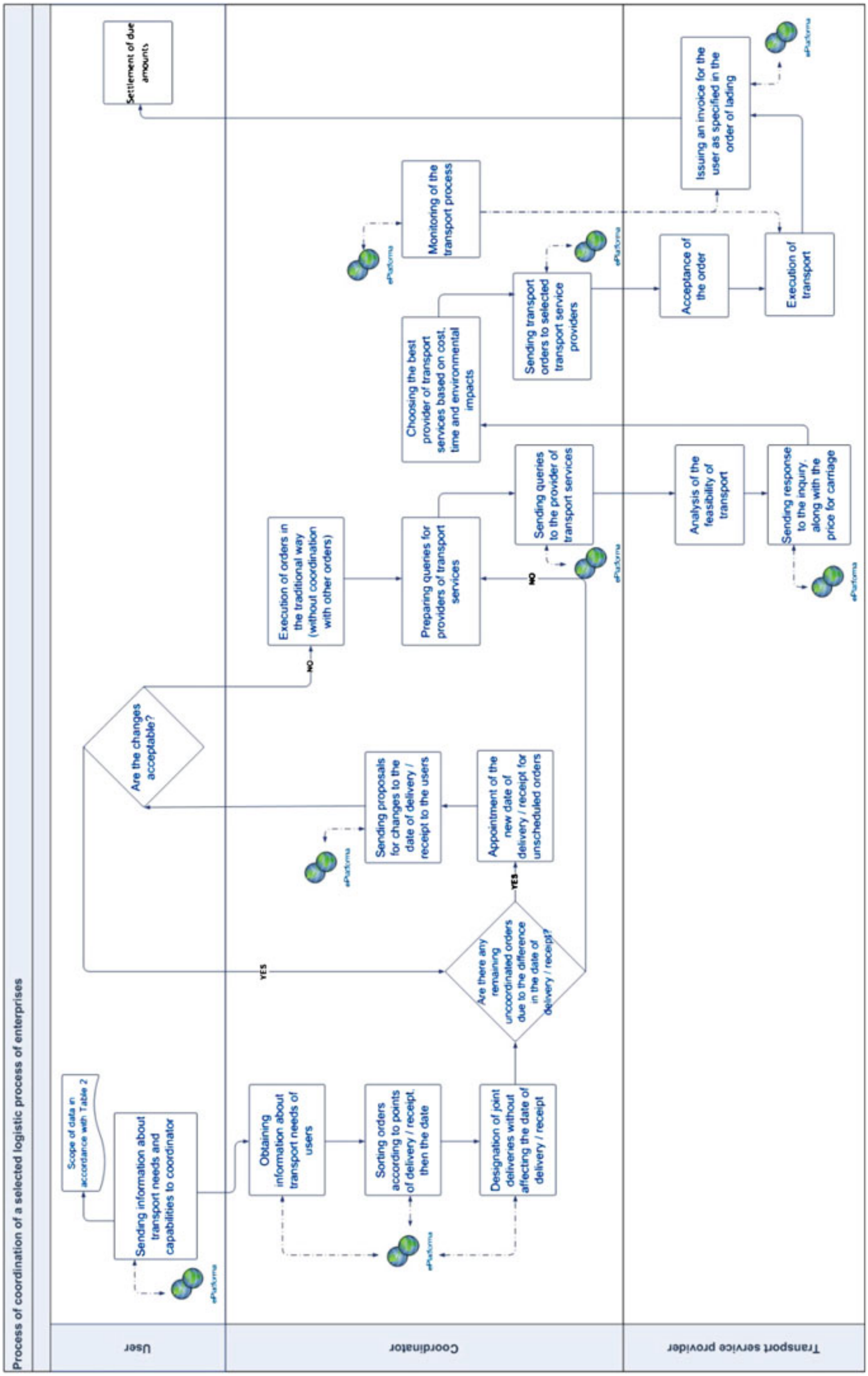


Fig. 9 Transport planning process in the developed model

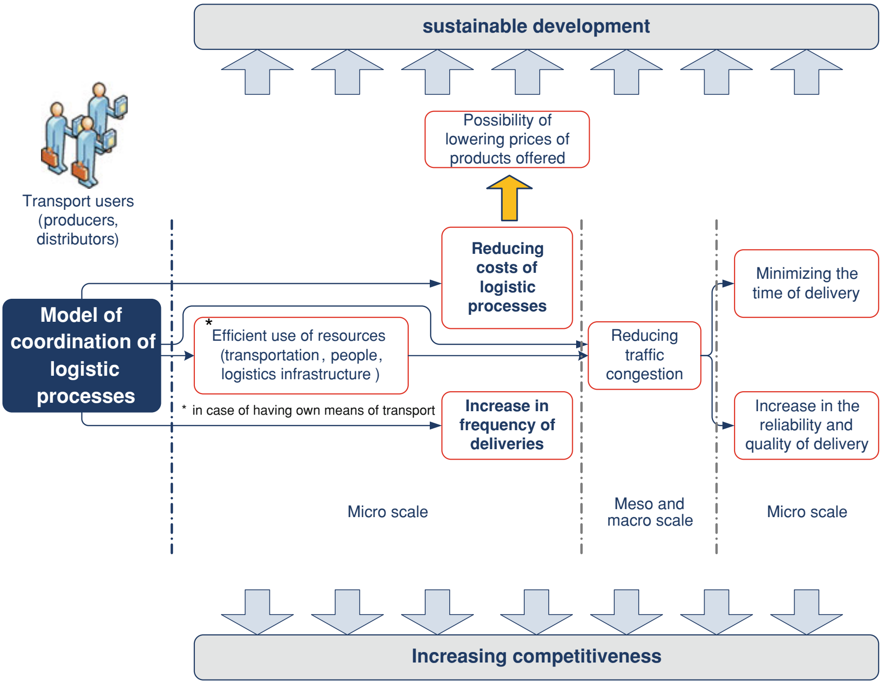


Fig. 10 The economic benefits for users arising from implementation of the model

long term with increase in their competitiveness, by exploiting the synergy potential and elimination of waste. Therefore, the author conducted a detailed analysis of the impact of the model on:

- Conducting business activity by users, e.g. manufacturing, distribution companies;
- Conducting business activity by the logistics service providers;
- Impact on the environment in which businesses are located using the developed solution.

In the first place the impact of the model on users was analyzed. Figure 10 presents the general characteristics.

Analysis of Fig. 10 shows that the companies deciding on cooperation in organizing logistics processes can reduce the costs of organization of selected processes, such as transport, with simultaneous increase in the frequency of deliveries to their customers or supplying products from their suppliers. As a result of lower logistics costs a company is able to offer its customers lower prices for products sold, and thus become more competitive against other companies in the industry. What is more, the increased frequency of deliveries enables the company to reduce total lead time and increase efficiency of execution of orders. This also

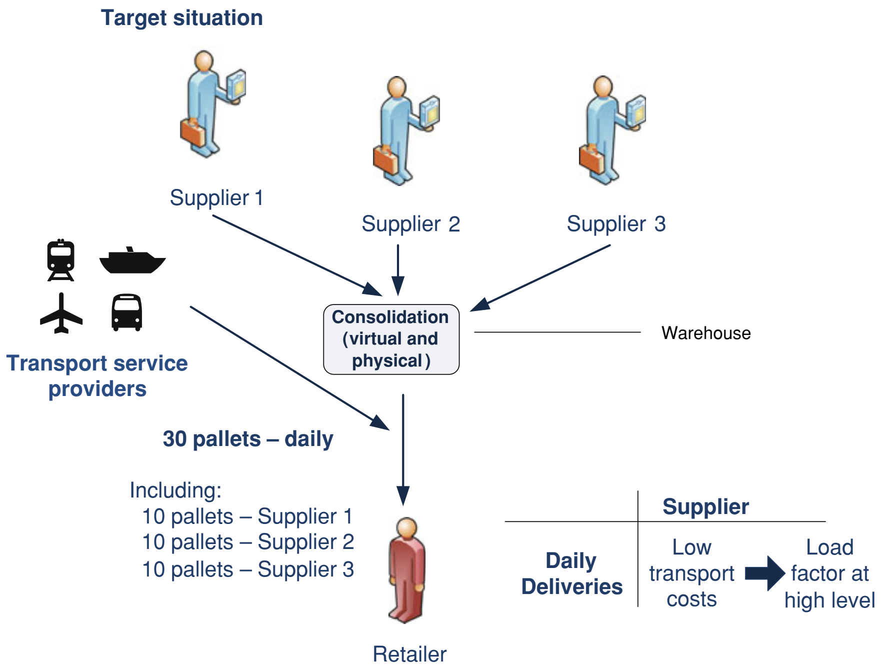


Fig. 11 The benefits from the cooperation of companies in organizing deliveries to a common customer

translates into increased competitiveness. An example of such an action is presented Fig. 11, where due to cooperation, companies are able to perform frequent and small deliveries, while minimizing the cost of carriage.

It is also worth mentioning that companies' activities related to cooperation in organizing logistics processes, and particularly the movement of goods, contribute to reducing traffic congestion and the elimination of waste associated with failure to use available resources (e.g. transportation). Thus, there is a strong correlation between how companies operate, and the condition of logistics system in the region. The reduction of traffic congestion, especially in road transport, will limit reduction of an average speed of vehicles on the roads, as is the case today. Traffic congestion is understood as crowding (heavy traffic) on the routes. As a result of actions taken, truck traffic on the roads will decrease. Thus, this will contribute to minimizing the time of deliveries and increase in their reliability and quality. Thus, the implementation of the model of coordination of logistic processes in the companies allows achieving short and long term economic benefits, increase in their competitiveness and a positive effect on the situation in region's transport system.

According to the concept of sustainable development, the developed model should not only benefit the users (producers, distributors), environment in which they operate, but should take into account needs of logistics service providers and

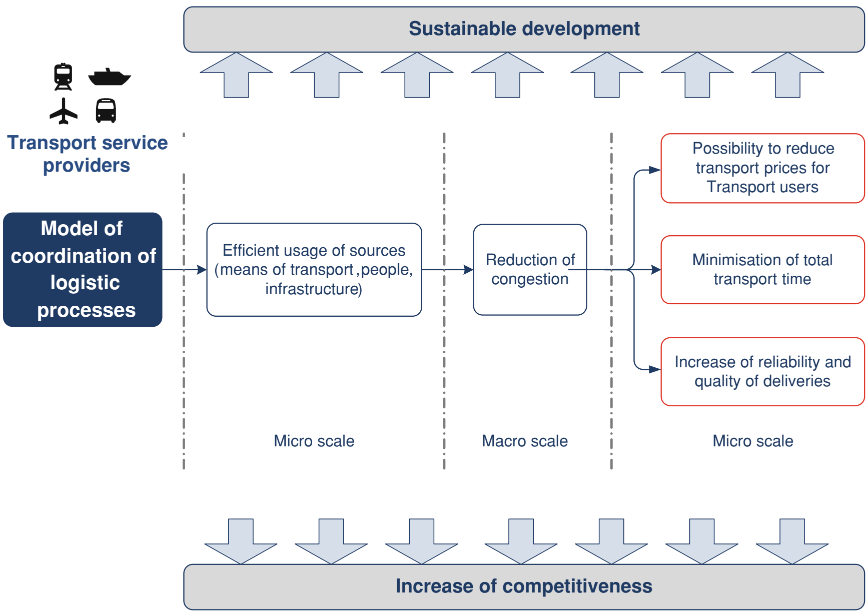


Fig. 12 The economic benefits for transport service providers arising from implementation of the model

have a positive impact on their business. Figure 12 shows the long and short term economic benefits for service providers arising from implementation of the solution developed in the research.

Analysis of Fig. 12 shows that solutions developed within the model may also be beneficial for activity of logistics service providers. Logistics operators will be able to also reduce their costs, e.g. related to drives without cargo or with small cargo. Therefore, they will contribute to progressive elimination of waste associated with failure to fully use the cargo area of vehicles.

Application by the companies of the coordination model of logistics processes using the concept of sustainable development can also be beneficial for the environment in which the co-operating companies operate. The details are presented in Fig. 13.

In the first place, this model allows change in the branch structure in the transport, i.e. use and development of branches of transport alternative to road transport. Particularly important is the impact on the development of intermodal transport, which, as indicated by the research conducted by the author, among other things is limited by too small lots of cargo. And with coordinated shipping orders of several companies, it is possible to obtain the volume of cargo whose intermodal transport is cost-effective.

Also, impact of the model on reduction of the number of means of transport on the roads, resulting in economic, social and environmental benefits is essential for the practical implementation of the concept of sustainable development.

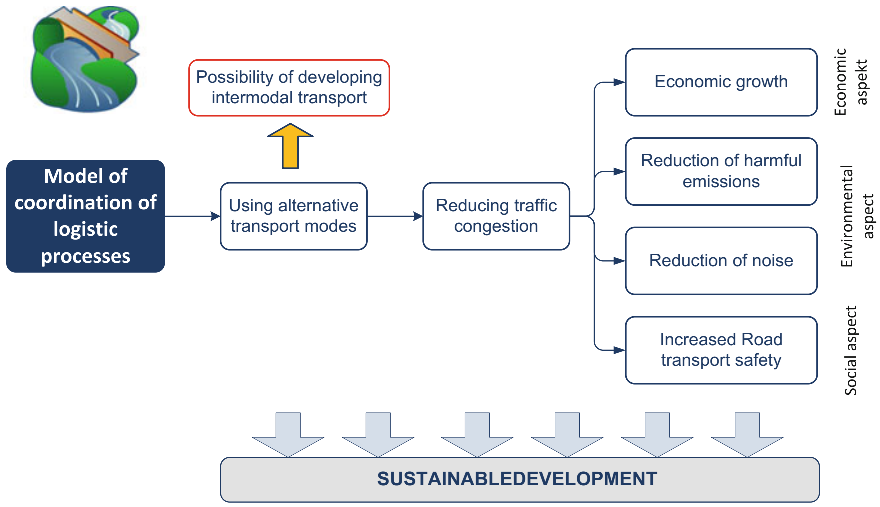


Fig. 13 Economic, social and environmental benefits for the region arising from the implementation of the model in enterprises

In conclusion, the application of the model in economic activity can bring benefits at the micro, meso and macro level, while taking into account economic, social and environmental needs, as defined in the concept of sustainable development. In detail, dependencies between the activities of enterprises and the environment, and potential benefits are presented in Fig. 14.

5 Calculation of the Costs of Joint Operations

One of the main objectives of the common organization of selected logistic processes by a group of companies is to reduce costs through economies of scale effect. For the analyzed selected logistics process, i.e. movement of goods, it is possible to achieve by generating larger volumes of freight, which translates into lower unit transportation costs.

Due to the fact that the developed model will be verified based on cooperation of companies in organizing transport processes, the author also created a methodology for the distribution of savings in transport costs to individual companies, whose transport orders were combined by the coordinator. The developed methodology for cost allocation includes:

- Type of cargo units;
- Number of cargo units;
- Cargo weight;
- Volume of cargo;
- Number of stops/handling cargo if charged extra.

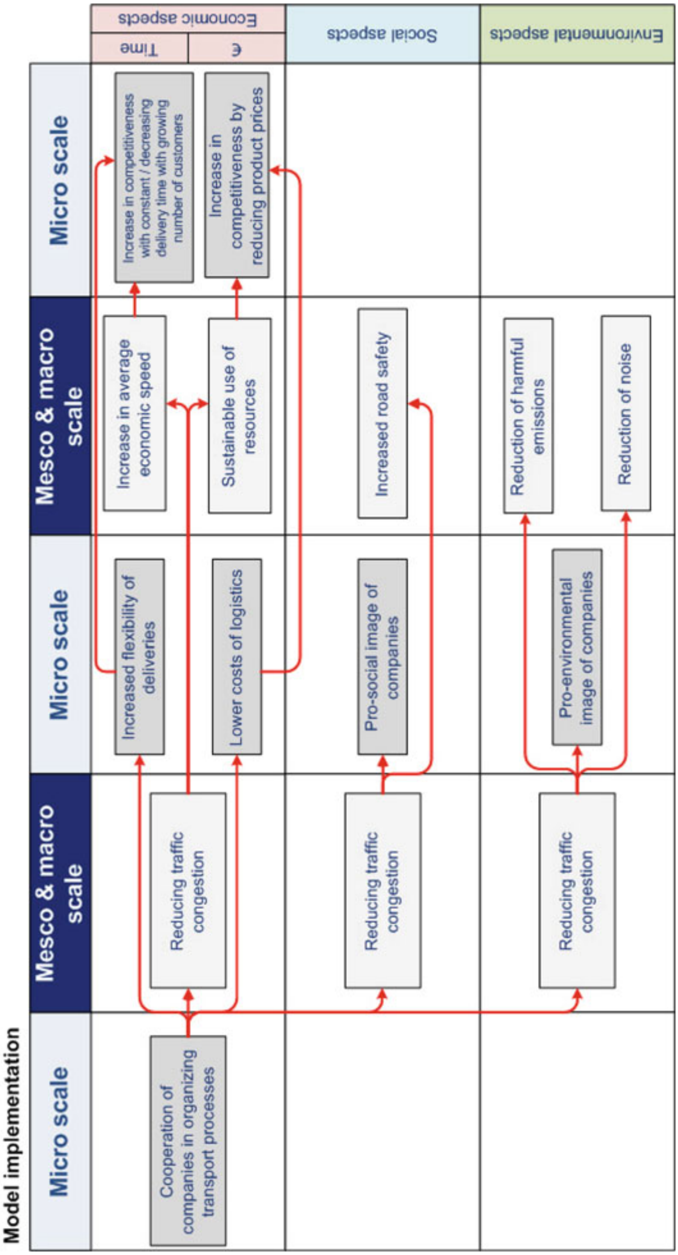


Fig. 14 Economic, social and environmental aspects in the coordination model of logistics processes of enterprises

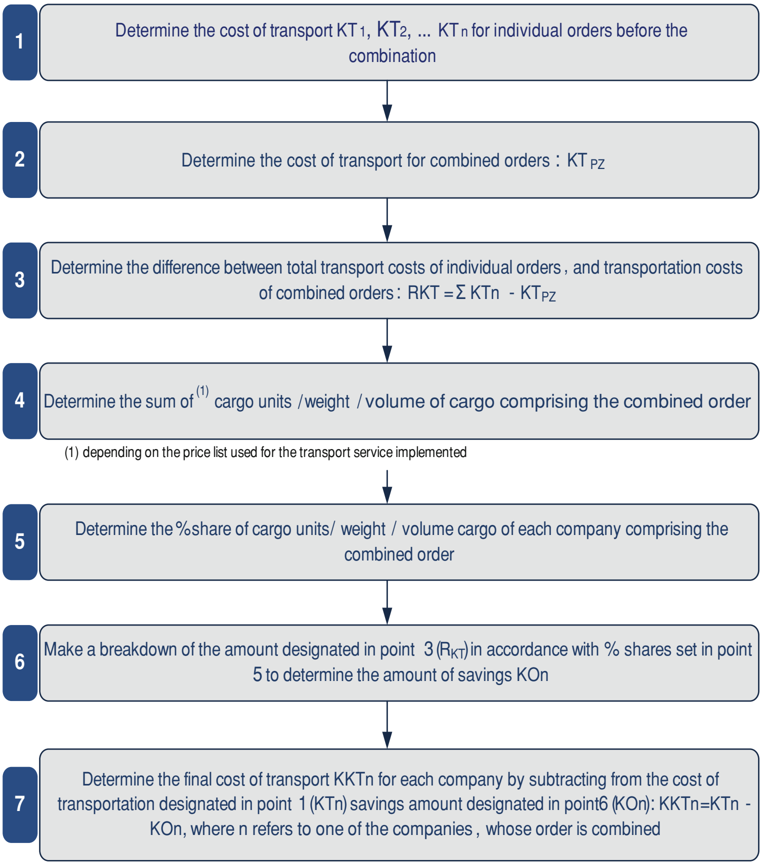


Fig. 15 Methodology of division of transport costs in the Co-m-Tra model

Figure 15 presents the algorithm of transport cost allocation for joint transport. This algorithm is universal, independent of the used transport branches.

6 The Role of Authorities in Coordination of Logistic Processes

In the age of rapid economic changes, companies are forced to continuously search for ways of cost rationalization through implementation of new logistics business models. However, enterprises are part of the wider system.

For over decade the European Commission has placed the emphasis on the stimulation of networking activities among small and medium enterprises (SME). The formal and informal networks allow triggering the potential of SME.

Cooperation helps to aggregate both supply and demand side and overcome the weak negotiation position which very often has SME.

Proposed coordination model of logistic processes of companies supports of production companies and logistic service providers and allow them to achieve better economic effect. Moreover it has also positive impact on the environment where the companies operate. Therefore it is essential that the authorities of the region are engaged in work related to its implementation in groups of companies. Participation of all actors is particularly important. According to the renewed Transport Policy one of the region's priorities should be the development of alternatives to road transport, increase in competitiveness and improving road safety, reduction of noise and traffic.

For effective actions of regional authorities associated with the formation of logistics and transport policy of the region, it is necessary to provide adequate conditions for enterprises and implementation of such solutions as the discussed model (Lissowski 2011, p. 8). These actions, also defined by the European Commission, include:

- Organizational basics: functioning, in the structure of regional authorities, of a specialized unit in charge of logistic problems in the region;
- Legal basis: the activities of regional authorities shaping logistic development of the region, supported by the acts and regulations at national level;
- Involving various entities in the process of forming the logistic policy of the region, acting both at regional and local level. The system of government that encourages companies and their trade associations, universities, local authorities and other entities to actively participate in the process of forming the logistic policy of the region (through various forums, focus groups, etc.);
- Financial basics: developing a system of financial support for actions towards the region's logistics development policy, e.g. implementation of the coordination model of transport processes in the enterprises, based on sustainable development policy.

The proposed model shows the different stakeholders viewpoints on sustainability. It points out how the transport operations organized and conducted in the companies and regions might be consistent with the concept of sustainable development.

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Integration of the Demand for Transport Processes According to the Concept of Sustainable Development—Case Study

Marcin Hajdul and Paulina Golinska

Abstract The idea of sustainable development emphasizes the rationalization of the demand for transport services. The key element in rationalization of freight transport is increased use of vehicle capacity. In the case of small and medium size enterprises, initiatives aiming at aggregation of the demand for transport services are promoted. The chapter presents an information tool called KASSETS, which facilitated integration of small and medium size enterprises to fulfil the goals of sustainable development policy. The analyses have been conducted based on a case study in the pharmaceutical branch representing measurable benefits of implementation of such an information tool.

Keywords Transport · Sustainable development · Coordination of transport processes · IT tools

1 Introduction

The EU Sustainable Development Policy brings out the necessity to limit the negative effects of transport processes on the environment. Actions taken in this area involves both freight and passenger transport. Many projects financed the European Commission focus on optimization of transport amount by actions

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aiming at the integration of transport needs and increased load factor. Road transport share in total freight transport (tkm) in the European countries makes up 76.9%. An increased freight exchange leads to more and more roads reaching their maximum capacity. Transport congestion growth makes transport managing processes more and more difficult. At the same time, road safety is declining.

This is why it is possible to notice an increased interest in the dedicated information solutions supporting the organization of freight and passenger transport. Those solutions include several groups of information tools, such as:

- Experimental Internet platforms to integrate planning and controlling freight transport processes, especially intermodal ones;
- Internet transport markets;
- Intelligent transport systems.

The key element in the rationalization of transport operations for a group of companies is a selection of an information tool that facilitates efficient and reliable exchange of information connected with real-time transport planning. For small land medium-size enterprises where investments are limited, solutions using the Internet for fast and safe communication turn out to be most useful. This chapter deals with an Internet platform for small and medium size enterprises that integrates transport needs of various entities to rationalize the amount of ongoing transport in a given area. The tool will be described and the results of its implementation in a pharmaceutical group of companies will be presented. Evaluation of the results was carried out based on the developed methodology which allows to measure economic, social and environmental impact of the solution in micro, meso and macro scale.

2 Monitoring Logistic Processes

Logistics processes implemented by the manufacturing and distribution companies are designed to support the core business of these companies. Moreover, their implementation should proceed in a way that enables achievement of the maximum profit (Stajniak et al. 2007, p. 108). Therefore, the efficiency and effectiveness of organization of logistical processes in companies should be constantly monitored (Coyle et al. 2002, p. 671).

The effectiveness is defined as a trait that belongs to every action, indicating the level of attainment of adopted performance results, which in general satisfy the needs and enable achievement of a goal and fulfilment of the requirements (Mantura 2010, p. 86). Efficiency is also a non-economic concept, reserved to characterise the action designed to achieve the desired effect (Dziaduch and Konkol 2009).

On the other hand, efficiency requires a comparison of the effects with the costs incurred for its implementation. It means that efficiency of economic action is defined by the relationship between the effects obtained and the inputs factors used to achieve them (there is a causal relationship between inputs and effects) (Fertsch et al. 2009, p. 121).

Efficiency allows, from an economic point of view, to assess whether the measure adopted for achieving the requirements, is best possible. Effective action requires that the net benefit from its adoption is positive and the largest possible.

Monitoring logistical processes based on a defined model will enable identification of any inaccuracies and taking rationalising actions. Companies can use several different ways to measure performance within the organization. Overall, these measures enable comparison of achieved performance results with adopted objectives of the company. These objectives may be diverse, but mostly they are related to cost, performance and service levels (Coyle et al. 2002, p. 671). In the literature on the subject, many ways can be found to measure logistics processes of companies. Each of them takes into account three main parameters: cost, time and quality of service. Indicators and measures assessing selected logistics processes are defined, among others, by Pfohl (1998), Twaróg (2005) and Kisperska-Moroń (2009).

For example, for processes of movement of goods most frequently analysed factors are: the freight rates in case of cooperation with external carriers, the transport costs with own means of transport, the transport speed, delivery time, reliability, flexibility, etc. are most frequently analysed (Stajniak et al. 2007, p. 108).

In fact there are so many indicators and methods for monitoring logistical processes in literature that the companies do not know which of them are most suitable for their business profile and how to use them.

First, the indicators and measures that are presented in the literature only evaluate the efficiency of logistical processes from a cost, quantitative and qualitative point of view (Ghani et al. 2004). However, there is no solution which verifies organization of logistical processes for compliance with the concept of sustainable development, as well as trade-off relationship between the logistics system at the micro and meso and macro scale (Kowalska 1998, p. 57; Kisperska-Moroń and Krzyżaniak (2009) p. 89; Twarog 2002, p. 32).

Assumptions of methodology to assess the model of logistics processes coordination using the concept of sustainable development (compare Atkinson et al. 2007) is presented in Fig. 1. The developed solution is a hybrid of indicators given by the literature and used by practitioners. It also identifies the interfaces between activities of enterprises and the surroundings shown in Fig. 1, taking into account the economic, social and environmental impacts.

3 Methodology of Assessment of Coordination Model of Logistics Processes Based on Sustainable Development Concept

The main idea of the created methodology is to compare a situation before the implementation of the model and after the implementation of the model. In accordance with the objectives of the work, the impact a model on the enterprises

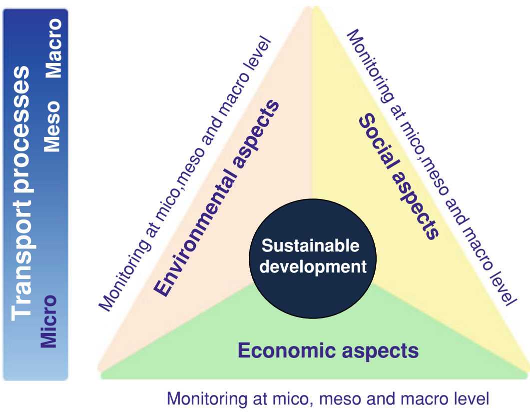

Fig. 1 Assumptions of methodology of assessment of the coordination model of logistics processes of enterprises using the concept of sustainable development

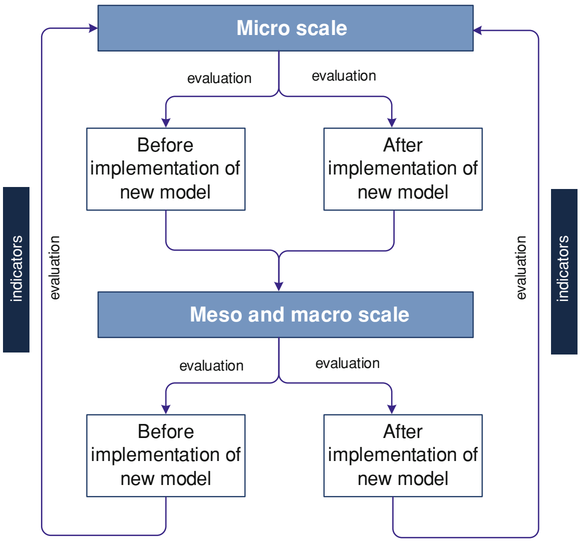

Fig. 2 Methodology of assessment of the coordination model of logistics processes of enterprises using the concept of sustainable development

(micro scale) and the region where the analyzed companies do business (meso and macro scale) will be examined. General diagram of the methodology is presented in Fig. 2.

An important element of the developed methodology is to build a matrix of correlations between the indicators evaluating micro scale and meso and macro scale. For implementation purposes, dependencies between the individual indicators are shown in Table 1 below. Analysis of the indicators in accordance with the presented relationship matrix will enable assessment of the impact of changes on the functioning of businesses, increase in their competitiveness and logistics system.

The assessment may use all or only some of the indicators, depending on current needs. The details are presented in Table 2 below.

Table 1 Relationship matrix between the indicators evaluating micro and macro scale

Macro scale / Micro scale		Region							
		Traffic intensity on roads (vehicles/h)	Average journey length by destination (km) for various branches of transport	Number of tons of cargo for the various branches of transport	Congestion level for the various branches of transport	Shipping work divided into branches (tkm)	Quality of the environment (noise and pollution from transport, the degree of traffic attenuation)	Number of accidents	Number of cooperating companies
Transport user	Transport costs per tkm								X
	Share of transport costs in the value of exported goods								X
	Maximum value of discount on the price of a product resulting from the new organization of transport processes								X
	Structure of shipments	X	X		X	X	X		X
	Average delivery time		X		X				X
	Perfect order								X
	Utilization rate of means of transport				X	X	X		X
	Utilization rate of the working time of means of transport				X	X	X		X
	Share of individual branches of transport in the transport of goods	X	X	X	X	X	X	X	X

(continued)

Table 1 (continued)

Macro scale	Micro scale	Region							
		Traffic intensity on roads (vehicles/h)	Average journey length by destination (km) for various branches of transport	Number of tons of cargo for the various branches of transport	Congestion level for the various branches of transport	Shipping work divided into branches (tkm)	Quality of the environment (noise and pollution from transport, the degree of traffic attenuation)	Number of accidents	Number of cooperating companies
Coordinator	Percentage of co-ordination of orders of cooperating companies	X	X	X	X	X	X	X	X
	Transport costs per tkm								X
	Average delivery time	X							X
	Perfect order								X
Supplier of transport services	Transport costs per tkm								X
	Maximum value of discount on the price of transport service resulting from the new organization of transport processes								X
	Average delivery time		X		X				X
	Perfect order								X
	Utilization rate of means of transport				X	X	X		X
	Utilization rate of the working time of means of transport				X	X	X		X
	Share of individual branches of transport in the transport of goods	X	X	X	X	X	X	X	X

Table 2 A sample sheet for model evaluation in examined entity: model user

Indicator	Situation without implemented model	Situation after model implementation
Transport costs per tkm		
Share of transport costs in the value of exported goods		
Maximum value of discount on the price of a product resulting from the new organization of transport processes		
Structure of shipments:		
Bulk		
Full load		
UTI (intermodal loading units)		
Average delivery time		
Perfect order		
Utilization rate of means of transport		
Utilization rate of the working time of means of transport		
Share of individual branches of transport in the transport of goods		
Share of road transport in total freight volume		
Share of rail transport in total freight volume		
Share of intermodal transport in total freight volume		
Share of sea transport in total freight volume		
Share of inland water bone transport in total freight volume		

4 Indicators Relevant to Model Assessment at the Micro Level

The developed model is dedicated to companies using transport services. However, its assumptions include coordination of transport processes with regard to relationships with suppliers of transport services. A role of coordinator is also an important element.

4.1 *Indicators Relevant to Users*

The following is a set of indicators assessing the organization of transport processes in manufacturing and distribution companies, which may have their own means of transport or use the services of external providers (Fig. 3). These indicators will be used to assess the processes carried out independently and carried out jointly with other companies (for more details see Golinska and Hajdul 2011).

These indicators are designed to assess the benefits of implementing the model in selected enterprises. The following groups of indicators allow assessing the

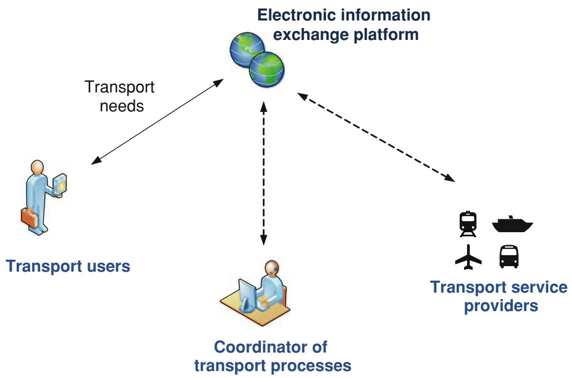

Fig. 3 Role of transport user in the model of coordination of logistics processes

economic, social and environmental issues. Some of them allow an assessment of several aspects simultaneously. These relations are presented in detail in Table 3.

The selected indicators are (Kowalska 1998, p. 57; Twarog 2005, p. 53–66; Twarog 2002, p. 32):

- **Transport cost per 1 tkm**: will allow to control transport costs and to assess the benefits of implementing the model. Decrease of this indicator will have an impact on increasing the competitiveness of businesses, because incurring lower costs it will be possible to reduce prices or make new investments.
- **The cost of transport per 1 load unit/1 ton**: this indicator is very similar to the one evaluating the costs of transport per 1 tkm, however, it is more often used by businesses and can be easily interpreted. This indicator is also currently used by pharmaceutical companies, which practically verify the developed.
- **Share of transport costs in the value of exported goods**: this indicator allows controlling profitability of individual directions and cooperation with selected recipients. It also has a strong influence on the degree of competitiveness of the company.
- **Maximum value of discount on the price of a product resulting from new organization of transport processes**: this indicator shows by how much a company can reduce the maximum price for products after receiving benefits from implementation of the model.
- **Structure of shipments**: this indicator is to determine the structure of the LCL shipments, full truck loads and Intermodal Load Units. The more full truck load shipments and Intermodal Load Units, the more favourable impact on the environment and traffic reduction.
- **Average delivery time**: will allow assessing effects of the model implementation on company activity in the long run, and more specifically on ensuring the feasibility of fast deliveries. This indicator also allows the company to assess the degree of competitiveness relative to other operators the lower the duration of delivery, the more competitive the company.
- **Correct order**: this indicator will verify how the implementation of the model of coordination of transport processes will affect execution of complete, error-

Table 3 Summary of indicators assessing organization of transport processes among transport users

No.	Name of indicator	Formula	Assessment of aspects		
			Economic	Environmental	Social
1	Transport costs per tkm	$\frac{Transport\ \text{costs}}{Number of ton-kilometers}[\frac{PLN}{tkm}]$	Yes		
2	Transport cost per unit of cargo/1 ton	$\frac{Transport\ \text{costs}}{Number\ of\ \text{cargo}\ units/tons}[\frac{PLN}{tu/t}]$	Yes		
3	Share of transport costs in the value of exported goods	$\frac{Transport\ \text{costs}}{Value\ of\ goods\ in\ delivery}[\frac{PLN}{time\ unit}]$	Yes		
4	Maximum value of discount on the price of a product resulting from the new organization of transport processes	ΔR_{max}=*KTn-KKTn* [*PLN*], where KTn—cost of transport organised in the traditional way, KKTn—final cost of transport for coordinated shipments	Yes		
5	*Structure of shipments*:				
	Bulk	$\frac{Number\ of\ general\ \text{cargo}\ shipments}{time\ unit}[\frac{items}{time\ unit}]$	Yes	Indirectly	Indirectly
	Full load	$\frac{Number\ of\ full\ truck\ shipments}{time\ unit}[\frac{items}{time\ unit}]$	Yes	Indirectly	Indirectly
	UTI (intermodal loading units)	$\frac{Number\ of\ UTI\ shipments}{time\ unit}[\frac{items}{time\ unit}]$	Yes	Yes	Indirectly
6	Average delivery time	$\frac{Total\ delivery\ time}{Number\ of\ deliveries}[h]$	Yes	Indirectly	Indirectly
7	Correct order	$\frac{Tot.\ num.\ of\ deliveries\ in\ desired\ time, completely, flawlessly}{Total\ number\ of\ product\ deliveries} \times 100\%$	Yes		
8	Utilization rate of means of transport	$\frac{Actual\ \text{cargo}\ [t]\ or\ [m^3]}{Potential\ \text{cargo}\ [t]\ or\ [m^3]} \times 100\%$	Yes	Yes	

(continued)

Table 3 (continued)

No.	Name of indicator	Formula	Assessment of aspects		
			Economic	Environmental	Social
9	Utilization rate of the working time of means of transport	$\frac{Actual\ operation\ time}{Available\ operating\ time} \times 100\%$	Yes	Yes	
10	Share of individual branches of transport in the transport of goods				
	Share of road transport in total freight volume	$\frac{Number\ of\ tkm\ for\ road\ transport}{Total\ number\ of\ tkm} \times 100\%$	Yes	Yes	Yes
	Share of rail transport in total freight volume	$\frac{Number\ of\ tkm\ for\ rail\ transport}{Total\ number\ of\ tkm} \times 100\%$	Yes	Yes	Yes
	Share of intermodal transport in total freight volume	$\frac{Number\ of\ tkm\ for\ \text{intermodel}\ transport}{Total\ number\ of\ tkm} \times 100\%$	Yes	Yes	Yes
	Share of sea transport in total freight volume	$\frac{Number\ of\ tkm\ for\ sea\ transport}{Total\ number\ of\ tkm} \times 100\%$	Yes	Yes	Yes
	Share of inland water transport in total freight volume	$\frac{Number\ of\ tkm\ for\ inland\ water\ transport}{Total\ number\ of\ tkm} \times 100\%$	Yes	Yes	Yes

free and timely deliveries. This indicator also allows assessing competitiveness of companies.

- **Utilization rate of means of transport**: this indicator allows assessing how loading space is used in the means of transport before and after implementation of the model. It has a direct impact on reducing transport costs in the company, but also a positive impact on the region, helping to reduce traffic congestion.
- **Utilization rate of operation time of means of transport**: this indicator allows assessing how operation time of means of transport is used before and after implementation of the model. This indicator allows assessing economic and environmental aspects.
- **Share of individual branches of transport in the transport of goods**: this indicator helps identify the modes of transport mostly used by the company: whether it focuses exclusively on road transport or, maybe, in selected directions it uses better-priced solution. This indicator allows assessing economic, social and environmental aspects.

4.2 Indicators Relevant to the Coordination of Selected Logistics Processes

Coordinator plays a key role in the developed model. His goal is to best coordinate the processes from the perspective of meeting the expectations of cooperating companies through economies of scale and use of the concept of sustainable development objectives. He is also an intermediary between service users and service providers. Coordinator also monitors the implementation of tasks by providers of transport services based on qualitative indicators. In addition, some of his actions directly affect the functioning of the region's logistics system, in which companies are active. Therefore, below is presented a set of indicators to evaluate the tasks performed by the coordinator Fig. 4.

These indicators are designed to assess the benefits of coordination of selected logistics processes—the benefits in micro, meso and macro scale. The groups of indicators allow assessing the economic, social and environmental issues. Some of them allow an assessment of several aspects simultaneously. These relations are presented in detail in Table 4.

The selected indicators are (Kowalska 1998, p. 57; Twarog 2005, p. 53–66, Twarog 2002, p. 32):

- **Percentage of coordination of orders from cooperating companies**: allows evaluating how many orders were coordinated in relation to all transportation needs of cooperating companies. This indicator allows the assessment of the economic, social and environmental aspects. It is also extremely important from the perspective of transport users, transport providers and the region.

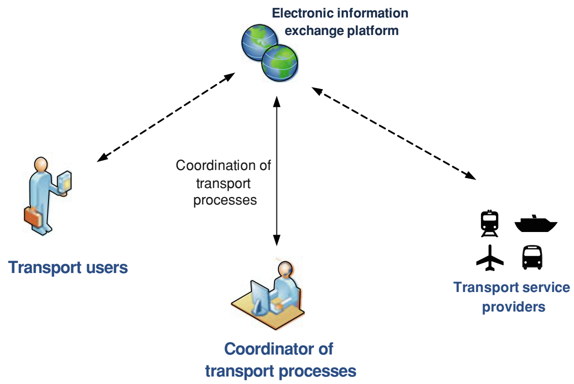

Fig. 4 Role of coordinator in the developed model

- **Transport cost per 1 tkm**: will allow to control transport costs and to assess the benefits of implementing the model. Decrease of this indicator will have an impact on increasing the competitiveness of businesses, because incurring lower costs it will be possible to reduce prices of products/services or make new investments.
- **Average delivery time**: will allow assessing effects of the model implementation on company activity in the long run, and more specifically on ensuring the feasibility of fast deliveries. This indicator also allows the company to assess the degree of competitiveness relative to other operators. The lower the duration of delivery, the more competitive the company. This indicator is also important for the region, because the lower the duration of delivery, the less traffic congestion in the area.
- **Perfect order**: this indicator will verify how the implementation of the model of coordination of transport processes will affect execution of complete, error-free and timely deliveries. This indicator also allows assessing competitiveness of companies.

4.3 Indicators relevant to logistics service providers

The task of logistics providers in the developed model is to execute orders coordinated by an independent entity acting on behalf of companies with specific needs in terms of logistics. In addition, some of his actions directly affect the functioning of the region's logistics system, in which companies are active. Therefore, below is presented a set of indicators to evaluate the tasks performed by provider of selected logistics services Fig. 5.

These indicators are designed to assess the effects of using the model by transport users on providers of transport services. The following groups of indicators allow assessing the economic, social and environmental issues. Some of them allow an assessment of several aspects simultaneously. These relations are presented in detail in Table 5. The selected indicators are (Kowalska 1998, p. 57; Twarog 2005, p. 53–66; Twarog 2002, p. 32):

Table 4 Summary of indicators assessing the coordination of transport processes

No.	Name of indicator	Formula	Assessment of aspects		
			Economic	Environmental	Social
1	Percentage of co-ordination of orders of cooperating companies	$\frac{Number\ of\ combined\ orders}{Total\ number\ of\ orders} \times 100\%$	Yes	Yes	Indirectly
2	Transport costs per tkm (or per ton)	$\frac{Transport\ \text{costs}}{number\ of\ tons - kilometers} \times 100\%$	Yes		
3	Average delivery time	$\frac{Total\ \ time\ of\ deliveries}{Number\ of\ deliveries}[h]$	Yes	Indirectly	Indirectly
4	Perfect order	$\frac{Tot.\ num.\ of\ deliveries\ in\ desired\ time, completely, flawlessly}{Total\ number\ of\ product\ deliveries}$	Yes		

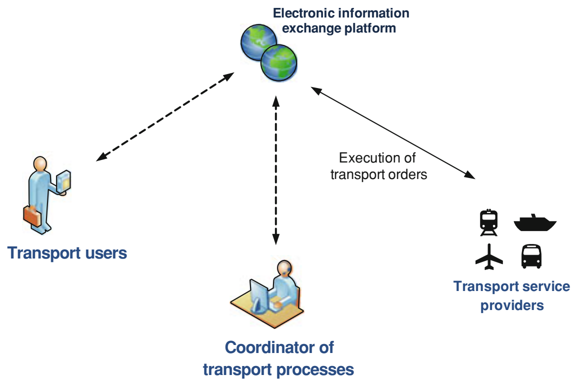

Fig. 5 Role of provider of transport services in the model

- **Transport cost per 1 tkm**: will allow to control transport costs and to assess the benefits of implementing the model. Decrease of this indicator will have an impact on increasing the competitiveness of businesses, because incurring lower costs it will be possible to reduce prices of transport services or make new investments.
- **Maximum value of discount on the price of a product resulting from new organization of transport processes**: this indicator shows by how much a company can reduce the maximum price for transport service after receiving benefits from implementation of the model.
- **Average delivery time**: will allow assessing effects of the model implementation on company activity in the long run, and more specifically on ensuring the feasibility of fast deliveries. This indicator also allows the company to assess the degree of competitiveness relative to other operators. The lower the duration of delivery, the more competitive the company.
- **Perfect order**: this indicator will verify how the implementation of the model of coordination of transport processes will affect execution of complete, error-free and timely deliveries. This indicator also allows assessing competitiveness of companies.
- **Utilization rate of means of transport**: this indicator allows assessing how loading space is used in the means of transport before and after implementation of the model. It has a direct impact on reducing transport costs in the company, but also a positive impact on the region, helping to reduce traffic congestion.
- **Utilization rate of operation time of means of transport**: this indicator allows assessing how operation time of means of transport is used before and after implementation of the model. This indicator allows assessing economic and environmental aspects.
- **Share of individual branches of transport in the transport of goods**: this indicator helps identify the modes of transport mostly used by the company: whether it focuses exclusively on road transport or, maybe, in selected directions it uses better-priced solution. This indicator allows assessing economic, social and environmental aspects.

Table 5 Summary of indicators assessing the implementation of transport services among carriers

No.	Name of indicator	Formula	Assessment of aspects		
			Economic	Environmental	Social
1	Transport costs per tkm	$\frac{Transport\ \text{costs}}{number\ of\ tons-kilometers}[\frac{PLN}{tkm}]$	Yes		
2	Maximum value of discount on the price of transport service resulting from the new organization of transport processes	*ΔRmax=KTn-KKTn* [PLN], where KTn—cost of transport organised in the traditional way, KKTn—final cost of transport for coordinated shipments	Yes		
3	Average delivery time	$\frac{Total\ \ time\ of\ deliveries}{Number\ of\ deliveries}[h]$	Yes	Indirectly	Indirectly
4	Perfect order	$\frac{Tot.\ num.\ of\ deliveries\ in\ desired\ time, completely, flawlessly}{Total\ number\ of\ product\ deliveries} \times 100\%$	Yes		
5	Utilization rate of means of transport	$\frac{Actual\ \text{cargo}\ [t]\ or\ [m^3]}{Potential\ \text{cargo}\ [t]\ or\ [m^3]} \times 100\%$	Yes	Yes	
6	Utilization rate of the working time of means of transport	$\frac{Actual\ operation\ time}{Available\ operating\ time} \times 100\%$	Yes	Yes	
7	Share of individual branches of transport in the transport of goods				
	Share of road transport in total freight volume	$\frac{Number\ of\ tkm\ for\ road\ transport}{Total\ number\ of\ tkm} \times 100\%$ Yes	Yes	Yes	
	Share of rail transport in total freight volume	$\frac{Number\ of\ tkm\ for\ rail\ transport}{Total\ number\ of\ tkm} \times 100\%$ Yes	Yes	Yes	
	Share of intermodal transport in total freight volume	$\frac{Number\ of\ tkm\ for\ \text{intermodel}\ transport}{Total\ number\ of\ tkm} \times 100\%$ Yes	Yes	Yes	
	Share of sea transport in total freight volume	$\frac{Number\ of\ tkm\ for\ sea\ transport}{Total\ number\ of\ tkm} \times 100\%$ Yes	Yes	Yes	
	Share of inland water transport in total freight volume	$\frac{Number\ of\ tkm\ for\ inland\ water\ transport}{Total\ number\ of\ tkm} \times 100\%$ Yes	Yes	Yes	

Table 6 Summary of indicators assessing the logistics system in meso and macro scale

No.	Name of indicator	Source of data on indicator value	Assessment of aspects		
			Economic	Environmental	Social
1	Traffic intensity on roads (vehicles/h)	Linear transport infrastructure managers	Yes	Yes	Yes
2	Average journey length by destination (km) for various branches of transport	Statistical office	Indirectly	Yes	Yes
3	Number of tons of cargo for the various branches of transport	Statistical office	Indirectly	Yes	Yes
4	Congestion level (average speed on a given distance) for the various branches of transport	Linear transport infrastructure managers	Yes	Yes	Yes
5	Shipping work divided into branches (tkm)	Statistical office	Yes	Yes	Yes
6	Quality of the environment (noise and pollution from transport, the degree of traffic attenuation)	Statistical office	–	Yes	Yes
7	Number of accidents	National police headquarters	Yes	Yes	Yes
8	Number of cooperating companies	Coordinators in a given region	Yes	Yes	Yes

5 Relevance of the model for the meso and macro level

From the perspective of assessment of the model impact on environment (macro scale), it is necessary to select indicators to conduct an appropriate analysis. It is also essential to identify the relationship between the indicators at macro, meso and micro levels. Table 6 below presents set of indicators used to develop methodology to assess the model of coordination of logistics processes of enterprises using the concept of sustainable development.

Based on the set of indicators it is possible to evaluate impact of implementation of new business transport models on enterprise. Moreover, presented solution allows identifying influence of new solution on the environment and society in region where companies are carrying out their processes.

6 Kassetts—IT tool for integration of transport processes

Kassetts project (Knowledge-enabled Access of Central Europe SMEs to Efficient Transnational Transport Solutions) is financed by the European Commission (programme for Central Europe). It is implemented by partners from seven countries and its leader is the Institute of Transport and Logistics in Bologna. KASSETTS aims to support the rationalization of selected transport processes and logistic procedures leading to better competitiveness and protection of the environment via the European net of logistic coordinators using the dedicated information tool. The main effect of the project is an electronic platform facilitating real-time exchange of information between entities involved in transport and, more importantly, coordination of transport processes. Following is a general description of the platform, works connected with its configuration and sample tests on selected data.

6.1 Description of Kassetts Platform

Kassetts platform enables the coordinator to send information between the production companies and companies providing selected logistic services. Additionally, this solution supports efficient planning of transport by the coordinator. Current functions include:

- Ordering: placing daily transport orders and monitoring the degree of their fulfillment.
- Planning: optimization of transport tasks, rationalization of route planning process and efficient use of the potential of logistic operators.
- Reporting: sending detailed information on the vehicle used, costs and mileage to the ordering production company.

When planning transport tasks, the tool factors in restrictions of logistic infrastructure in the point of origin and destination. Additionally, the available in-house vehicles as well as external ones are factored in. The prepared algorithms factor in the specificity of cargo units. The optimization criterion is the minimization of transport costs by increased use of freight space of vehicles and onetime transport of large batches of cargo. Figure 6 shows the view from the user's perspective.

6.2 Configuration of Kassetts Platform

For the purpose of integration of transport processes for a group of companies, it is necessary to customize the configuration of for individual users and service providers. Steps in configuring the platform are show on Fig. 7.

Configuration at the Coordinator's Level:

- Providing log-in rights to the platform to companies;
- Configuration of service regions (Table 7);
- Determination of cargo groups transported by companies,

Fig. 6 User window on Kassetts platform; Source: http://nic.ing.unimo.it/broker-pl/

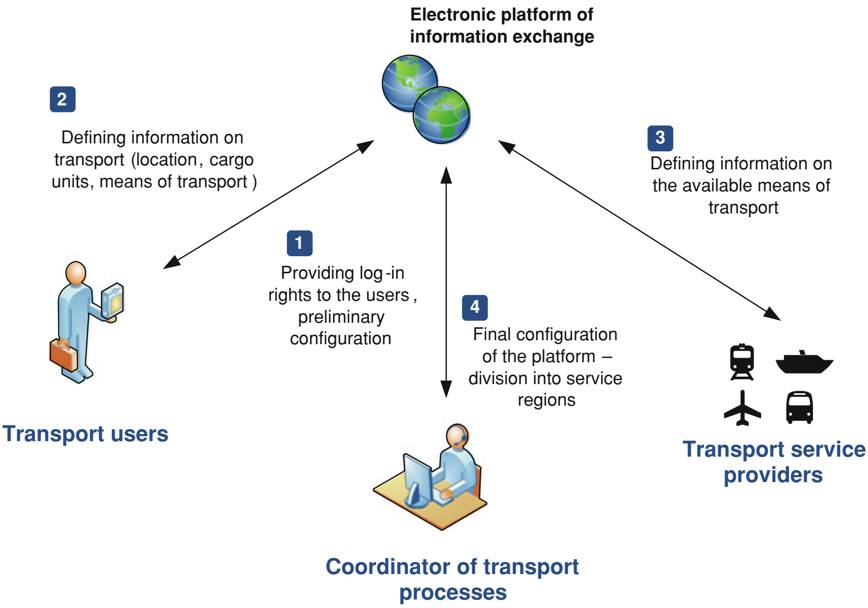

Fig. 7 Steps in configuration of Kassetts platform

- Determination of groups of vehicles: type of vehicle, name, acceptable capacity, length of loading space, maximum width, speed coefficient;

Table 7 Data used for configuration of service regions

Name (locality)*	Province or district*	Zip code*	Country*	Clustering code
SWADZIM	POZ	62081	Polska	POZ

- Determination of suitability of the vehicle for the transport of cargo previously defined.

6.2.1 Configuration at the Company's Level

- Defining specific means of transport (if the company has its own fleet)—selection based on groups defined by the coordinator. Determination was necessary for: license plate, vehicle (from the selection list), transport base (from the selection list)—previously defined locations, number of drivers;
- Determination of information on: price list and work schedule of the means of transport;
- Configuration of used cargo unit with name and dimensions;
- Determination of location (point of origins and destinations). Obligatory determinations for each location include: ID number, city (town, village), postal code, opening and closing times;
- Additional (optional) definitions include:
  – Maximum width of the vehicle which can perform transport in a given location;
  – Maximum height of the vehicle which can perform transport in a given location;
  – Maximum weight of the vehicle which can perform transport in a given location.

Configuration at the level of transport service provider: defining specific means of transport and price list.

7 Pilot implementation—a case study for pharmaceutical sector

The tool has been tested on a group of companies which own a chain of drugstores, warehouses and production factories in Poland. Data for analysis were obtained from carriers regularly cooperating with those companies. First, the cooperation principles between the users, service providers and coordinators have been specified. Users do not have their own vehicles and the transport will be performed by external carriers. Combined transport orders to selected service providers will be

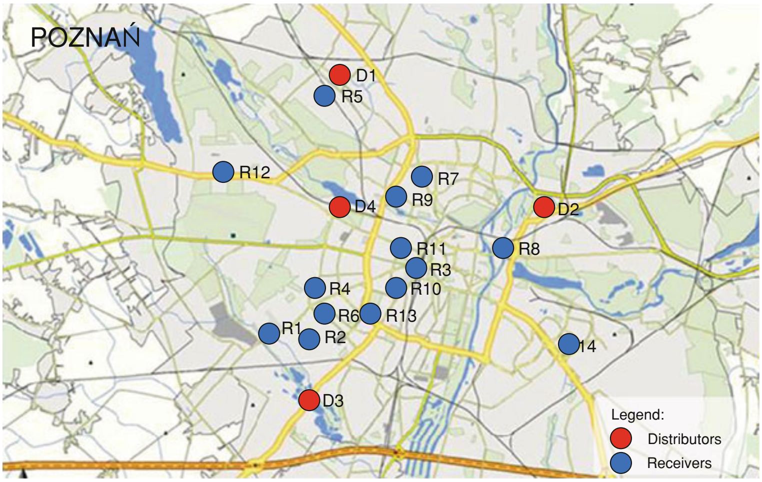

Fig. 8 Locations of warehouses analyzed in this case study

given by the coordinator. Transport billing and the scope of the information were approved based on the scheme proposed in the model. Transport users which have not participated in the transport organization. Those companies have their reloading points (warehouses) in Poland. They are marked as PP1, PP2, PP3 and PP4. Each of the warehouses deals with freight transport to individual points - drugstores: O1, O2, O3,…, O14. Details are presented in Fig. 8.

Pilot implementation was conducted based on averaging data. The cargo is delivered to drugstores in special containers of 30 L capacity. Average value of the cargo per container is PLN460. In the analyzed case study each drugstore ordered one container with medicine. Details are presented in Table 8.

In reality, the drugstores receives 1–3 deliveries per day. The deliveries are serviced with 6-palette vehicles which facilitates onetime transport of 24 containers of 30 L capacity. In the analyzed case, the transport cost is calculated based on tkm at PLN 1.08/tkm.

Below are two variants of the solution:

- Variant 1: each user plans the transport separately,
- Variant 2: cargo transport to the destinations is planned by all users.

The planning in both processes used Kassetts platform. Using the functionality of Kassetts platform, the best route for the assigned restrictions was planned. Kassetts platform facilitates the visualization of the order which is presented in Fig. 9.

In Variant 1 each company organized the transport separately using road transport. As an alternative, a model of joint planning was used. For this purpose each of the distributors introduced the following inquiries on the platform:

Table 8 Deliveries of containers to drugstore from four reloading points

Delivery point Point of origin	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12	O13	O14
PP1	1			1	1									
PP2	1	1	1		1	1								
PP3					1	1	1	1					1	
PP4				1					1	1	1	1		1

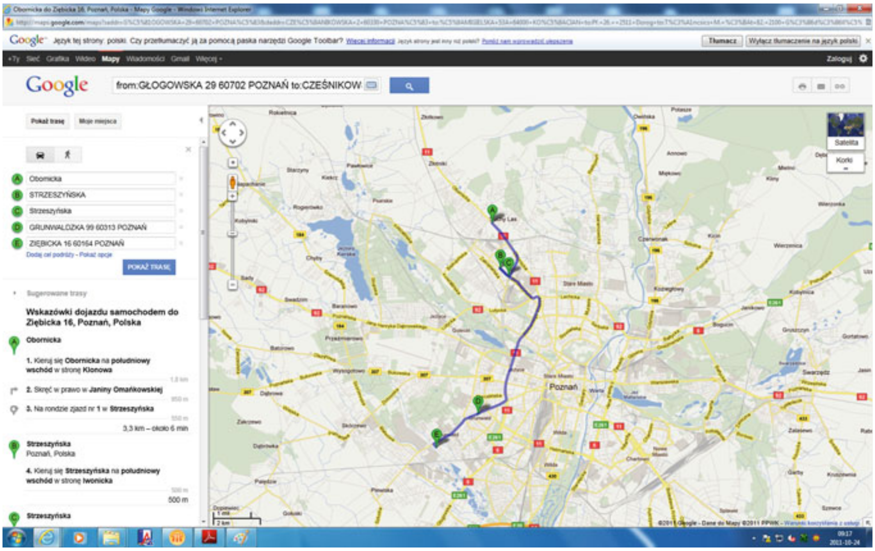

Fig. 9 Visualization on the map of order; Source: http://nic.ing.unimo.it/broker-pl

- Distributor P1 introduced transport inquires about the following points: O1, O4, O5;
- Distributor P2 introduced transport inquires about the following points: O5, O6, O1, O2, O3;
- Distributor P3 introduced transport inquires about the following points: O7, O8, O5, O6, O13;
- Distributor P4 introduced transport inquires about the following points: O9, O10, O11, O12, O4, O14.

The conducted planning process showed that for the assigned restriction it is possible to transport the cargo with one vehicle. Results for both variants are presented below. Table 9 shows values obtained by individual companies without using the model.

Table 9 Values obtained for individual planning of transport

Transport users planning the transport separately	Tkm	Transport cost KT_n (at 1 tkm = PLN 1.08)	Number of vehicles used	Number of transported packages [items]	Average transport cost per 1 package [PLN]
PP 1	15.9	19.7	1	3	6.57
PP 2	27.7	34.3	1	5	6.87
PP 3	21.2	26.3	1	5	5.26
PP 4	40.1	49.7	1	6	8.29
Total	*104.9*	*130.1*	*4*	*19*	*6.85*

Table 10 Values obtained in joint planning

Joint planning	Tkm	Transport cost KT_n (at 1 tkm = PLN 1.08)	Number of vehicles used	Number of transported packages [items]
Total	81.1	100.6	1	19

Table 10 shows values obtained when using the model of logistic process coordination.

To determine the final cost of transport for each company, a method of cost breakdown was used. Table 11 shows the results of calculation.

Collective comparison of both variants in terms of transport costs is shown in Table 12.

Based on the analyses above, it is clear that the implementation and practical use of the model, in this case study, brought many benefits to the cooperating companies. Deliveries to drugstore were executed using 1 vehicle instead of 4. This affected both the micro (companies) and macro (region) scales. Transport cost dropped by about 23%. One consignor reduced its costs even by 30%. Additionally, the number of vehicles used in the delivery also decreased with greater degree of use of loading space of one vehicle. The mileage also dropped by 22.6%.

8 Verification of Implementation of KASSETS Tool

An attempt has been made to evaluate the application of the tool in functioning of the company. Tests have been conducted based on simulation of selected orders of one day as well as yearly aggregated orders. Table 13 shows results for one day.

As showed in Table 13 the cooperation between companies in organizing transport processes brings not only economic but also social and environmental benefits. The synergy effect obtained here enabled increased use of capacity from about 20–80%, i.e. there is clear elimination of prodigality.

Also the value of possible discounts is of great importance to the growth of competitiveness of companies. Discount value against the value of picked up cargo

Table 11 Cost calculation of coordinated transport for 4 users

Transport users	Transport cost before coordination KTn [PLN]	Cost of jointly planned transport KTpz [PLN]	Difference between the total cost of separately planned transport and cost of jointly planned transport Rkt [PLN]	% share of packages comprising the whole order	Savings in joint planning [PLN]	Final transport cost for each company KKTn [PLN]	Average transport cost per 1 package [PLN]
PP1	19.7	–	–	15.79%	4.66	*15.1*	*5.02*
PP2	34.3	–	–	26.32%	7.77	*26.6*	*5.32*
PP3	26.3	–	–	26.32%	7.77	*18.5*	*3.70*
PP4	49.7	–	–	31.58%	9.32	*40.4*	*6.73*
Total	130.1	100.6	29.5	1	29.5	*100.6*	*5.29*

Table 12 Collective comparison of transport costs for both variants

Transport users	No cooperation		Using Co-m-Tra model		
	Transport cost KT_n (at 1 tkm = PLN 1.08)	Average transport cost per 1 package [PLN]	Transport cost KKT_n (at 1 tkm = PLN 1.08)	Average transport cost per 1 package [PLN]	Reductionof transport costs [%]
PP 1	19.7	6.57	15.1	5.02	23.6
PP 2	34.3	6.87	26.6	5.32	22.6
PP 3	26.3	5.26	18.5	3.70	29.5
PP 4	49.7	8.29	40.4	6.73	18.7
Total	130.1	6.85	100.6	5.29	22.7

Table 13 Evaluation of implementation effect in four companies on the example of one day

Indictor evaluating transport processes from the perspective of transport users	Before	After using coordination model
Transport costs per 1 kg km [PLN/kg km]	0.009	0.002
Transport costs per 1 package [PLN/container]	6.85	5.29
Share of transport costs in the value of picked up cargo [%]	1.44	1.10
Maximum discount on the product price resulting from new organization of transport processes [PLN]	–	7.38
Structure of groupage packages [%]	100	0
Structure of full carload freight [%]	0	100
UTI (of intermodal transport units)	0	0
Average use of means of transport [%]	19.79	79.17

does not generate considerable price reductions of all products, but it does facilitate, with a proper scale of transport, introduction of promotional prices for selected goods.

Another important fact is that the number of vehicles decreases from 4 to 1. These values have a direct effect on the transport situation in economic, social and environmental terms. Below is an analysis of possible benefits to be obtained by a company in the Wielkopolska province. The analysis indicates that the biggest company, out of the four cooperating companies, executes, on average, 114 deliveries to drugstores per day. The rest of the companies execute 44, 38 and 29 daily deliveries respectively. On average, each shipping transport delivers goods to 10 drugstores. Details of the current situation for an average day are presented in table 14.

Assuming that the transport costs can be reduced through cooperation by 20% per day, by joint serving of all drugstores, the companies can save about PLN 4,900[1]which translates into PLN 1,125,000 a year. Details of real benefits for four cooperating companies are shown in Table 15.

[1] 1 euro = approx. 4.00 PLN

Table 14 Real data on delivery costs to drugstores of four companies from Wielkopolska

User	Daily number of deliveries	Daily turnover [PLN]	Transport cost [PLN/day]	Share of transport costs in the value of picked up cargo [%]
Company 1	114	53,580	9,670	18.05
Company 2	44	20,680	5,720	27.66
Company 3	38	17,860	4,345	24.33
Company 4	29	13,630	3,703	27.17
Total	225	105,750	23,438	22.16

Table 15 Costs of transport for an average day of four companies from wielkopolska

Transport users	Transport cost before coordination KTn [PLN]	Share of transport costs for in the value of picked up cargo [%]	Final transport cost for each company KKTn [PLN]	Savings made when using joint planning [PLN]	Share of transport costs for joint deliveries in the value of picked up cargo [%]
Company 1	9,670	18.05	7,736	1,934	14.44
Company 2	5,720	27.66	4,576	1,144	22.13
Company 3	4,345	24.33	3,476	869	19.46
Company 4	3,703	27.17	2,962	741	21.73
Total	23,438	22.16	18,750	4,688	17.73

It follows from the table that the implementation of the model in all deliveries in Wielkopolska can generate considerable savings which lead to lower prices of selected products, which in turn translates into growing competitiveness of companies.

Another important fact is that the total number of vehicles executing deliveries decreases from 225 to 112. This helps, in accordance with the model, to keep and even improve the assumed time of delivery to clients in the future. Thanks to this the companies consciously, in accordance with the concept of sustainable development, implement their processes following the model which enables ongoing organization and coordination of transport processes and at the same time does not generate a long-term negative effect on the company and the region where the companies operate.

In the macro scale the reduction of daily number of vehicles also reduces traffic congestion in the region. Traffic reduction positively affects road safety, limits hazardous emissions and noise. Summing up, the model is fully compatible with the concept of sustainable development.

9 Conclusions

Using the IT tool for coordination of logistic processes in a group of companies from the pharmaceutical branch helped obtain desired results of the synergy effect. The efficiency has been confirmed both the micro scale for the users and the service providers and on the macro scale where it contributed to reduction of traffic congestion on selected road sections. Cooperation between companies in organizing transport process can greatly reduce transport costs incurred by the companies. The analyses conducted here indicate that the reduction can reach from 20% to 30%. This is confirmed by the research conducted simultaneously, within the Kassetts project, at the University of Modena. Research carried out in Italy showed that it is possible to generate savings—in transport costs (about 20%), mileage (almost 30%), or reduce the number of individual transport by 37%, and reduce time of tasks execution. Implementation attempts in companies confirm that there must be an independent body—the coordinator-which will try to synchronize transport users in terms of joint organization of transport processes. This will eliminate suspicion of bias displayed by one of the users or service providers.

Using modern information technology in real-time applications (e.g. Kassetts platform) facilitates fast and safe data exchange for the purpose of planning joint transport by the coordinator, and also makes the process of information exchange between transport users, coordinator and service providers more efficient. When using the model one must remember about using coherent standard of information exchange between the links of virtual supply chain to ensure best-quality communication and full identification of essential information. If companies use different standards of information exchange, proper interfaces must be created.

The developed model enables companies to increase efficiency and improve selected logistic processes via the synergy effect which will translate into reduction of unit costs of execution of these processes and thus positively affect competitiveness of companies. The more companies cooperate in the organization of selected processes, the greater the synergy effect will be achieved.

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Sustainable Transport Models by Simulation

Flavio Bonfatti, Luca Martinelli and Paola Daniela Monari

Abstract Imagine a network of manufacturing SMEs in an industrial district willing to aggregate their transport demand for sharing trucks and routes; or a municipality willing to smooth down the rush-hour traffic generated by people reaching or living their work places. In these and possibly many other cases the introduction of the new transport model implies investments and a deep revision of organizational processes. Therefore the decision should be taken being sure to choose the most sustainable solution among the possible alternatives. This calls for quantitative estimations of the transport model impact that only simulation can actually produce. This chapter introduces first the simulation approach in logistics as an effective work method. Then it describes the functionality of a running simulation tool, the variables it considers, the logic of the simulation algorithm, the quantitative indicators it produces. Finally, it presents three real-life scenarios where the simulation approach was successfully employed in the last years.

Keywords Simulations · Sustainable transport system · Simulation scenarios

1 Simulation in Transports

According to the Cambridge online English Dictionary (CAMB 2011) the term simulation, intended as computer simulation, is defined as "a model of a set of problems or events that can be used to teach someone how to do something, or the

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process of making such model". Simulation is then a scientific discipline, and a technical support, to understand and represent a real-life system with the aim of analysing its behaviour by executing its model.

In the transports sector there are (besides traffic flow simulation games) at least two main concepts of professional simulation, depending on whether it is addressed to provide real-time hints to operations or off-line support to strategic decisions:

- In the former case the simulation compares the system model with continuous inputs from disparate sources in order to produce dynamic forecasts of forthcoming problems and propose a concrete set of actions that might be applied to improve the situation.
- In the latter case the simulation is intended to evaluate in quantitative terms the impact of investments and transport model changes. Quantitative indicators are in fact necessary to assure that the strategic decision is taken by choosing the most suitable solution among alternative hypotheses.

This chapter is specifically addressed to examine the latter idea of simulation in transports. More precisely, it focuses on transport of goods on the short-medium distance, meaning a distance covered by a daytime route or corresponding to a maximum of, say, 500 km. The ultimate aim is showing how that kind of simulation can help defining sustainable transport models in different operational conditions.

Transport model is here intended as the way transportations are organised to meet the requirements of a given logistic problem. It deals with definition of transport demand and offer management policy, territory partition into service zones, best fleet configuration, as well as computation of best routes, optimal picking and delivery sequence, task assignment to proper vehicle types, and the like.

The adopted approach is inspired to the Rational Decision Making Model, which is defined in the Business Dictionary (BIZD 2011) as a "systematic, step by step method in which 'hard' (quantitative) data obtained through observation or mathematical (statistical) analysis or modelling are used for making long-term decisions". The emphasis put on quantitative aspects is really crucial to provide unambiguous indications (Bonfatti et al. 2005).

In fact, the strategic simulation process is organised into a number of steps, some of which are normally iterated to achieve increasingly better results. With reference to the Rational Planning Model (Robbins and Judge 2007) there are four main steps to consider in all cases:

- Define the problem. Although problem identification is often considered an obvious task, it happens that a wrong or partial problem definition risks orienting the analysis towards an ineffective direction. Then it is the basic condition to build up the transport model to be simulated.
- Identify possible solutions. Once the problem is clearly defined it is quite natural to start thinking of its possible solutions. Having alternative solutions, or at least

alternative options, on hand makes the search for an optimal choice much richer and confirmed by sound comparisons.

- Establish assessment criteria. Evaluative criteria are measurements to determine success and failure of alternatives. They must provide quantitative indicators for each of the alternatives under evaluation, which should normally be weighted to combine them into a unique picture.
- Perform simulations. Finally, simulation is performed on the transport model and iterated to test the alternative solutions and options. Depending on the simulation outcomes the iterations can be extended to revise the assessment criteria and, sometimes, to introduce further alternatives.

At the end of the strategic simulation process the most suitable solution is chosen. It is worth observing that, in the analogy with the previous steps, even this decision must be made by human experts that are in condition to evaluate the deep implications of the generated quantitative indicators. As it will be shown later, there are always informal system variables that only the human expert can globally take into account.

Concerning the selection of the simulation tool there is a basic question to answer: "how can it help choosing the most suited transport model being sure that, once adopted, the operational behaviour will confirm the indications coming from simulation". The answer is very simple: "the simulation must use the same software tool that will be employed, at run time, to plan day by day the operational transport routes".

Thus the attention moves to the features of the planning software to be used for simulation purposes. There are very interesting packages on the market covering these needs, the well-known Transport Planning System by PTV (PTVS 2011) holds for all. However, for the experiences described in this chapter it was decided to develop a new software tool specifically conceived to act as both planner and simulator.

This decision was taken in the frame of four successive INTERREG European projects, namely ILOG (ILOG 2011), CORELOG (CORE 2011), MATAARI (MATA 2011), KASSETTS (KASS 2011; Bonfatti et al. 2009) to fully satisfy four strong requirements, coming from the studied cases, which are here briefly recalled:

- Not all variables can be formalised. In addition to the main transport model variables, as detailed in the next section, it is often necessary to deal with aspects of the problem under study that, although impacting on the final decision, are hardly formalised. They normally correspond to qualitative criteria that only the human expert can actually consider, such as the perceived overall quality of a computed route besides its duration, distance on number of stops.
- The computation time must be short. Rather than an optimal solution requiring long time to be computed the human expert definitely prefers a sub-optimal solution achievable in a short time. The reason is quite simple: the result quality depends in both cases on the parameters that are set before every computation,

and the human expert can be sure of their correctness and suitability only after examining and validating the computation outcome.

- The results must be understandable. Clearly understanding how the computation results have been generated is another important requirement. Most of the so-called “exact” operational research techniques (Hillier and Lieberman 2004) imply the construction of proper mathematical models able to produce good but often opaque outcomes. Much better are considered those techniques adopting stepwise computation procedures and showing the impact of each parameter on the results.
- It must be easy to iterate the computation. As a natural consequence of the previous requirements there is the need to repeat the computation, having modified the problem parameters, to verify whether the last hypotheses is better or worse with respect to the others already considered. Thus the simulation (as well as the planning) process becomes iterative and enables the human expert to apply his/her qualitative evaluation criteria in choosing the most convenient solution.

In synthesis, the human experts participating in the pilot cases of the mentioned projects expressed a clear orientation in favour of a manual implementation of the Ruin & Recreate technique (Schrimpf et al. 2000), which instead is normally included as final, result-improving part in the optimisation process. As a matter of fact, only in this way they are put in the condition to exploit their own experience and justify the decisions they make.

2 Input and Context Data

In principle, simulation is carried out by executing the software tool on a data pack representing the hypothetical transport condition to study, while planning is carried out by executing the same tool on real-life data pack representing the actual transport problem to solve. At the first sight that tool presents the functionality, uses the data, and produces the outcome depicted in Fig. 1.

Although very simple, this representation is sufficient to show that there are important differences between the two applications of the Planner/Simulator tool. In case of simulation they concern both the nature of the input data, and the use of the resulting outputs:

- Some or even all the input data might be imaginary. The transport requests could represent a hypothetical work load possibly derived from historical information; the locations could correspond to warehouses and plants of potential customers; the fleet could include existing as well as candidate vehicles.
- The resulting outputs express in turn “what” could happen “if” the operational conditions will become those represented by the input data. They are then a sound basis to derive quantitative indicators whose values change according to changes in the input data and regulation parameters.

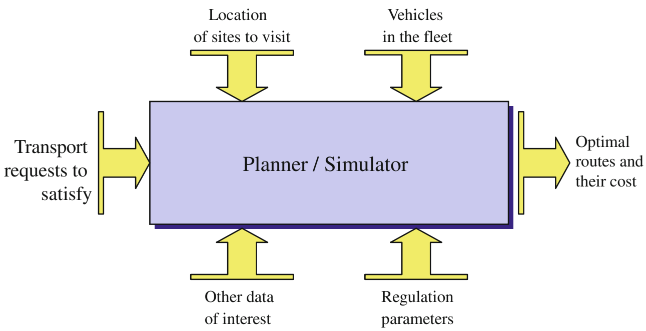

Fig. 1 Overview of the planner/simulator functionality

It is now worth considering in more detail the different data, included those mentioned above, that are needed to represent the operational conditions to simulate. To this purpose it is useful to distinguish input data, namely the transport requests, from the context data. The successive sections will go through the planning/simulation algorithm and its parameters, and present a possible set of simulation outcomes.

2.1 Input Data

2.1.1 Transport Requests

This is the main part of the input data providing the demand for which satisfaction optimal routes shall be computed and impact measures derived. The single transport request is the atomic element of the service demand and basically includes the following values (besides a unique identifier):

- Issuing company. This information is needed whenever the case to simulate refers to transport requests issued by two or more companies. In fact this includes the possibility to aggregate their demand so as to host loads from different companies on the same truck.
- Origin site, destination site. These are the identifiers of the sites (plants, warehouses) where the loads to transport have, respectively, to be picked up and delivered. Details about every site are typically given as context information (see later).
- Picking time, delivery time. These are the time windows (start and end date-and-time) concerning the moment when the payloads to transport are available to be picked up at the origin site and must definitely be delivered at the destination site.
- Aggregability. It is a flag stating whether that payload can be carried together with payloads from other transport requests (demand aggregation) or, vice versa, it must be carried by a different truck. The aggregability condition extends to all the parcels composing that load.

- Vehicle type, required equipment. These indications are used in those particular cases when the transport of that payload needs trucks with special features. It is convenient to take such indications from lists of items defined at the system initialisation stage.

2.1.2 Parcels

A transport request is completed by the list of parcels (one or more) constituting its payload. The dimensional properties of the whole payload result from summing up the relative quantities of the component parcels. Each parcel is described by the following values (besides a unique identifier):

- Package type. It indicates the nature of the package used for that parcel, e.g. box, pallet, or crate. It is convenient to take such information from a list of items defined at the system initialisation stage.
- Transported material. This information helps to code the possible (in)compatibility of that parcel with certain vehicle types and even with other materials so as they are not carried by the same truck. It is convenient to take such information from a list of items defined at the system initialisation stage.
- Number of units. If there are two or more units to transport of that particular parcel type then this variable provides their number.
- Weight, volume. They indicate the quantities concerning that parcel (or set of homogeneous parcels) the computation algorithm will take into account to measure the saturation level of the truck under planning. The third quantity, namely the occupied surface, is normally a feature of the package type.
- Superimposability. It is a flag stating whether that parcel can support one or more parcels of the same type placed upon it. The default value is NO.

2.2 Context Data

2.2.1 Sites

Sites are the picking and/or delivery places (plants, warehouses) to visit. For daily planning use it is necessary to know their names, contact persons, phone numbers and so on, while for simulation purposes it is sufficient to provide the following values (besides a unique identifier):

- Address. The site geographic location is generally represented by street, street number, zip code, town, province, and region. This information is used to find out the geographic zone where that site lies and to compute the distances from the other sites (see later).

- Opening time, closing time. These times are needed to assure that the picking and delivery activities are planned in accordance with the site working hours. In case of multiple, narrower time windows this information shall be refined accordingly.
- Waiting time. It expresses the average waiting times at the site gates, before the picking or delivery operations can start. It normally depends on the operational organisation of that site, differently from the handling time that somehow depends on the payload size. We suggest using a 4–5 values classification, for instance ranging from very fast (e.g. 0 min) to very slow (e.g. 90 min).

2.2.2 Geographic Covering

Experience teaches that most routes move in an area around the starting location or along geographic directions determined by the main roads or connecting the major industrial settlements. In order to adopt this model it is necessary to initialise the simulator with the definition of (partially overlapping) geographic areas which union assures the complete covering of the territory to serve.

The pilot cases that have been studied in the frame of the mentioned projects provide important hints on the criteria to adopt in defining the geographic covering. The following criteria are particularly suited for transport organisation on the medium-short distance (see Fig. 2):

- The areas forming the geographic covering are normally designed in daisy-like shape centred on the (main) truck stating location. The daisy head represents the "surrounding" area where routes move all around, while petals correspond to the main road directions.
- It is convenient that the covering areas are partially overlapping with each other. A site contained in both the daisy head and a petal could be served by a surrounding route or by a longer route passing through that location. A site contained in two adjacent petals could be served by a long route organised in either of them.
- The overlapping degree between two covering areas impacts on system flexibility. In case of wide overlapping degree most sites have the possibility to be considered in at least two alternative routes. Vice versa, in case of limited overlapping degree few sites can benefit of that condition.
- Finally, we warmly suggest providing the simulator with two or more geographic coverings, differing for number and extension of the component areas. Geographic coverings with many narrow areas are very suited in presence of large numbers of transport requests since they generate efficient routes, while coverings made of few large areas are useful to obtain distant sites in the same route.

Each of the geographic coverings defined for the territory to serve is denoted univocally by its name and described by the set of its component areas. Each component area is coded, in turn, by the following values (besides a unique identifier):

Fig. 2 Geographic covering of the territory to serve

- List of zip codes, or list of provinces, or even list of regions. Depending on the chosen granularity each of the covering areas is constituted by the union of more or less refined administrative partitions. It is important that such a list is given in terms of data that are available in the site addresses, so that the presence of a given site in a given area can be computed automatically.

2.2.3 Distance and Time Matrices

Once defined the sites that will appear in the transport requests the simulator initialisation must proceed with computing their respective distances. More precisely for each pair of sites it is necessary to know the number of kilometres that separate them on the shortest or most common way, and the conventional time spent by a truck, typically the fastest van, to cover them.

This computation is conveniently provided by one of the many geo-location and distance computation services available on the web, for instance the well-known Google Maps (MAPS 2011) service. In order to minimise the number of distance and time computations it can be convenient to realise sparse matrices with non-zero values corresponding to the only site pairs that belong together to the adopted covering areas.

2.2.4 Fleet

Fleet composition is another fundamental element to represent the reference context for simulation. In order to support both finite and infinite capacity simulation algorithms it is useful to split this knowledge into two distinct parts. They are the list of vehicle (truck) types, with their respective load capacities and performances, and the list of available vehicle (truck) instances, with their respective work calendars.

The list of vehicle types is the necessary and sufficient information to support infinite capacity simulations, that is, simulations based on a hypothetical fleet of unlimited size. Each vehicle type is represented by the following values (besides a unique identifier):

- Load capacity. It is normally expressed in tons to indicate the maximum payload weight that vehicle type can carry. It is used to keep under control the saturation level of a truck with respect to the weight quantity.
- Length, width, height. They are the neat measures of that cargo hosting the parcels of the served transport requests. They could feed proper packaging problem algorithms (Martello and Toth 1990) to calculate the best possible payload placing. However, it is often enough to assure that the parcel bases are consistent with the cargo length and width, and that total parcel volume is consistent with its three dimensions.
- Incompatible materials. It is the possible list of material types that vehicle type is not enabled to carry.
- Equipment. It is the possible list of equipment types that are available for that vehicle type to satisfy special requirements included in the transport request.
- Speed factor. It is the coefficient, a real value normally smaller that 1.0, expressing the ratio between the average speed of that vehicle type with respect to the reference vehicle (the fastest van) used to derive the time matrix. The time spent by the vehicle type in discourse to move between two sites is obtained by dividing the reference time by its speed factor.

In case of finite capacity simulation, that is, with reference to a hypothetical or real fleet which composition is known and limited, it is necessary to add the list of vehicle instances. Each vehicle instance is represented by the following values (besides the plate as unique identifier):

- Vehicle type. It is a reference to the proper item in the previous list for inheriting the already defined properties of that kind of truck.
- Vehicle base. It is the site where that vehicle instance is located during its idle time, e.g. during the night, and from which it leaves at the service start and to which it returns at the service end. This site is included in all the areas belonging to the defined geographic coverings.
- Service start time, service end time. They are the working hours for that vehicle instance, expressing respectively the time to start the service and the time to end the service at the latest.

2.2.5 Price Lists

Finally, it is normally asked to close the simulation session with an estimate of the costs for executing the routes that satisfy the input transport requests. To this purpose it is necessary to code one or more price lists as a further important aspect of the simulation context. If the price lists are more than one, they can be compared at every simulation to derive hints for negotiating them with the carriers.

There is indeed a wide variety of price list models, as well as many specialisations depending on the contractual relationship with the single customer of transport services. In general every price list is constituted by the following components (besides a unique identifier):

- Basic model. It relates prices to the main route variables or their combinations, for instance total distance, time spent, transported payload, occupied volume, and the like.
- Additional parameters. These are further quantities acting as correctors or qualifiers on the values produced by the basic model. For instance they may include an extra cost for each stop, for stops in uncomfortable places, for long waiting times, and so on.

3 Simulator Functionality

The benefits of adopting an iterative approach have already been explained. This enables the human expert to organise simulation sessions where some problem variables are modified time by time with the aim of exploring different alternatives to the solution under study, as shown in Fig. 3.

After the simulator is initialised in terms of geographic coverings, sites, distance matrix and time matrix, the transport requests to simulate are uploaded. In the already mentioned projects the transport requests were packed per week and simulations were normally performed on 4–6 weeks selected among those most representative of the problem under study.

Then the (infinite capacity or finite capacity) fleet configuration to be considered for satisfying that set of transport requests is selected together with the price list according to which estimating the route costs. Moreover, the geographic covering is chosen for grouping the transport requests with respect to the defined geographic areas, and finally the computation algorithm is launched.

The simulation outcome is the quasi-best set of routes that can satisfy the input transport requests under the given conditions, each with indication of the assigned vehicle (type or instance). In infinite capacity simulation the algorithm chooses the vehicle type assuring the overall best performances, while in finite capacity simulation the algorithm tries to exploit at best the available vehicle instances.

Once examined the computation outcome the human expert decides what changes are worth introducing for the next simulations, until a satisfactory result is achieved. For instance, if some routes present questionable features it must be allowed to cancel them (while keeping the others) and launch a new simulation by modifying the fleet configuration or choosing another geographic covering.

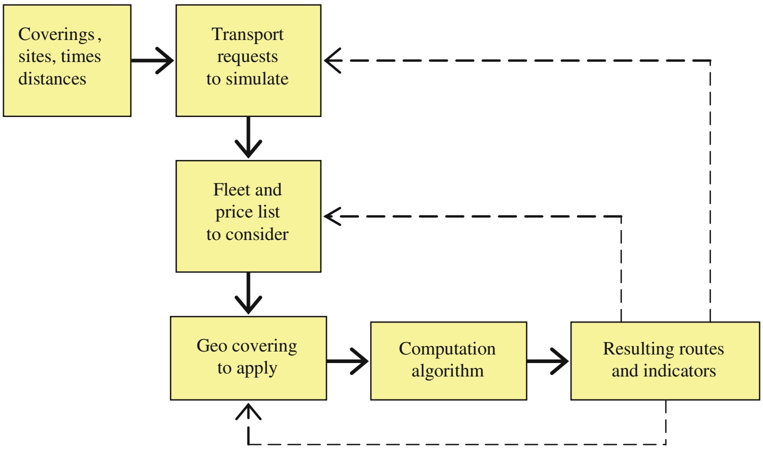

Fig. 3 The iterative simulation process

3.1 Planning/Simulation Algorithm

There are a large numbers of computation algorithms, often based on different models, and each of them presents strong and weak points with respect to the variety of situations to face. In other words, the complexity of the planning/ simulation problem under study is such that no computational approach is actually prevailing with respect to the others.

For the purposes of this Chapter it is important to understand the complexity level of the problem. Compared with the typical classification given by operational researchers we are facing a complex combination of the *Travelling Salesman Problem* (TSP) and the *Bin Packing Problem* (BPP):

- A first complication to the TSP is given by the simultaneous execution of picking and delivery activities (TSP-PD), implying precedence constraints, as well as by the presence of load and unload time windows to respect (TSP-TW) at the visited sites.
- A further complication to the BPP is given by the need to manage payloads differing by weight, volume, surface and superimposability, whose composition must meet at the same time load capacity and dimensional constraints of the fleet vehicles, thus introducing a knapsack problem.
- The third level of complication arises from the need to face the routing problem for a fleet of many vehicles at a time, not only for a single vehicle, where such vehicles present different features. This introduces in turn a so-called m-TSP problem.
- The combination of the m-TSP and knapsack problems is known in the literature as a *Capacitated Vehicle Routing Problem* (CVRP or simply VRP). Of course there will be a VRP-TW because of the time windows, a VRP-PD for the picking and delivery operations, a VRP-HF because of the heterogeneous fleet.

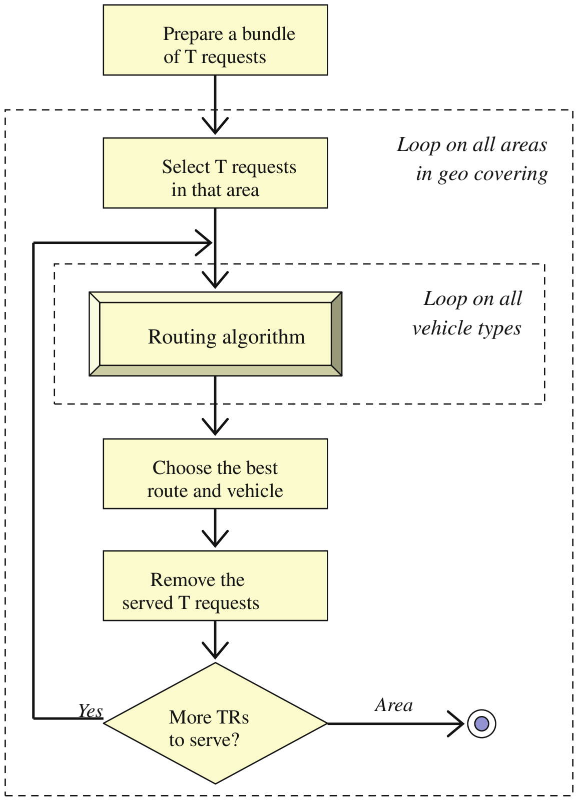

Fig. 4 General schema of the simulation function

The problems belonging to this class are those typically coming from the study of real-life situations, and have a relevant number of constraints to comply with. They are normally denoted as *Rich Vehicle Routing Problem* (RVRP) and since their complexity is NP-hard many interesting heuristics have been developed to fasten the search for approximate solutions (Vazirani 2003).

According to this line the KASSETTS (Bonfatti et al. 2011a) project developed a simulation function pursuing an approximate solution that can be progressively refined through iterations carried out under the control of the human expert. Its general schema for the infinite capacity case is sketched in Fig. 4.

The first operation is preparing the bundle of transport (T) requests to simulate by grouping those that shall be processed together. Grouping criteria are therefore date, compatible materials, same equipment requirements, and so on. In other words the simulation function is applied separately to all the bundles that result by this first operation performed on the entire set of transport requests.

Then the simulation function loops on the areas of the chosen geographic covering, normally starting from the daisy head. For each area the function selects

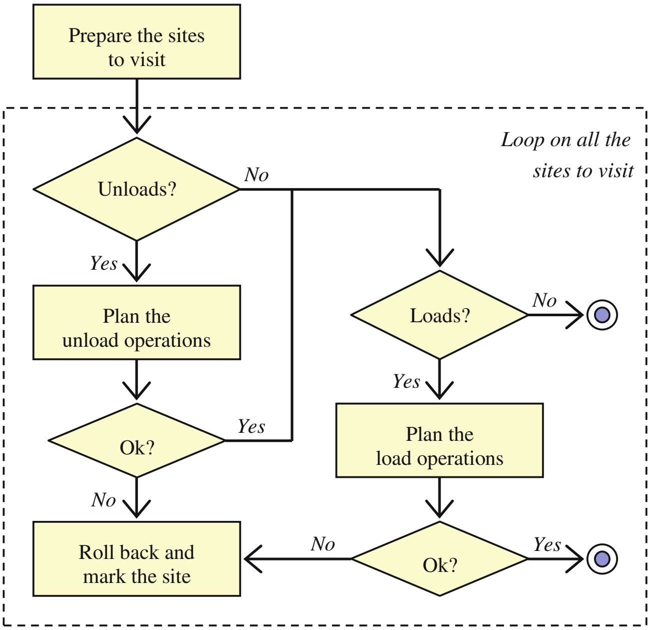

Fig. 5 General schema of the routing algorithm

from the bundle those transport requests whose origin and/or destination sites are there. The next step is determining the best routes that can completely satisfy the selected subset of transport requests, before moving to the next covering area.

This is done trying to serve the subset of transport requests by using each of the available vehicle types. At the end of this loop the simulation function has computed as many routes as the number of vehicle types. One of them is chosen as the best depending on a number of parameters (saturation index, number of stops, longest distance, etc.) the human expert can tune time by time.

Once chosen, this route is stored as element of the solution and the served transport requests are removed from the bundle. If the bundle contains other transport requests to serve the computation is iterated, if it is empty or the remaining transport requests pertain also to other areas the inner loop ends and the simulation function moves to another area in the geographic covering.

The hearth of the simulation function is the routing algorithm, namely the algorithm computing the best route that a given vehicle can execute in the given covering area. In the KASSETTS case it is based on a variant of the nearest neighbour method (Gutin et al. 2002) as depicted in Fig. 5.

Preparing the sites to visit means extracting them from the transport requests to serve, together with the indication of the loading or unloading operations to carry out in each of them. It happens that some sites present just one operation to perform while others present a list of operations among which, obviously, the unloading operations shall be performed first.

An important feature of the routing algorithm is the criterion for choosing the first site of the route. After that, the next site in the loop is chosen according to a "modified" nearest neighbour method, constrained by the stated time windows. Whenever the unloading or loading operations violate some constraints, the route is rolled back to the first suited site and the defaulting site is marked as "unreachable" from the current site.

3.2 Simulation Outcomes

In conclusion of this section it is worth recalling the data generated by the simulation function, on which basis deriving proper quantitative indicators to compare alternatives and options. As a rule, every generated route is characterised by the following values (besides a unique identifier):

- Assigned vehicle, covering area. It indicates the vehicle type (infinite capacity) or the vehicle instance (finite capacity) chosen to perform that route, and the covering area containing it.
- Start time, end time, moving rate. This informs about the route positioning on the time axis (date-and-time) and its duration computed by difference. It also informs on the percentage of that duration spent moving on the roads and the remaining time spent at the visited sites.
- Stops. For each of the stops planned for that route it indicates the reached site, the distance covered so far, the arrival time, the estimated waiting and handling times, the list of unloading and loading operations each referencing the relative transport requests, the payload size (total weight, volume, surface on the truck) when leaving the site.
- Saturation indexes. These are three values representing the ratio between the maximum payload size during the entire route and the homologous truck features in terms of load capacity and dimensional properties. At least one of the saturation indexes should approach the unit.
- Estimated costs. Finally, these are the cost estimates for that route computed with respect to one or more available price lists. They are integrated with estimates on fuel consumption and CO_2 emission.

This is indeed a rich amount of data for deriving quantitative indicators.

In the mentioned projects it was found very useful to compute synthesis indicators on a weekly basis, the same basis adopted for organising the transport requests. Examples of indicators are:

- Number of transport requests, number of resulting routes, total length of routes (kilometres), total duration of routes (hours), total fuel consumed, total CO_2 emitted.

- Percentage of aggregated routes, average route length, average route duration, average number of stops per route, average moving rate, average saturation indexes, average cost per kilometre.

4 Successful Simulation Cases

4.1 The Demand Aggregation Case

The Emilia-Romagna region, in Italy, presents a high concentration of industries. The central Institute for Statistics (ISTA 2011) identifies over 9,000 companies with more than 10 employees in the only D segment (manufacturing). Most of these companies participate in production networks made of distributed partners located in the same region and in the near regions.

This widely-adopted distributed manufacturing model generates an intense short-range freight traffic whose impact is dramatically worsened by a couple of negative factors affecting in particular the small and medium sized companies, namely:

- Massive use of own trucks instead of transport services provided by professional carriers. This is normally justified by the need to face "urgencies" arising from the high flexibility guaranteed to the customer. The immediate consequence is a large number of almost empty trucks running on the regional roads.
- Weak contractual power with respect to carriers and logistic operators because of the small volumes moved by the single company. This results in high costs or in delegating transports to suppliers and customers in such a way to miss any practical perception of the transport cost incidence on products.

Under initiative of the Emilia-Romagna regional administration, through the Foundation Institute for Transports and Logistics (ITL), a specific study was carried out on this theme with the participation of 11 companies located in the same industrial settlement, near Modena, and belonging to different sectors including mechanics, machinery, electro-mechanics, chemistry and paper printing.

The size of the participating companies was actually variable, ranging from 20 to 800 employees. Only the three larger companies had a dispatch clerk and all of them organised transports by means of phone calls in a quite naïve way. Very important, no of them had a clear idea of the global transport costs paid yearly and simply considered logistics and transports an unavoidable and hardly controllable problem.

The ultimate objective of the study was (1) measuring the actual total amount of the (hidden and explicit) transport costs spent by each company, then (2) understanding to which extent their transport demand could be aggregated so as to exploit better the load capacity of the involved trucks, and finally (3) which could be the savings in terms of cost and environmental impact (Kawa et al. 2010).

Thus it was decided to consider all the transport activities generated by the 11 companies, including for each of them consignment of final products to customers, acquisition of raw materials and components from suppliers, as well as dispatching and return of worked parts to/from subcontractors. And this independently of whether the companies manage these transport directly or leave them to the partners.

4.1.1 Simulation Setting

The simulation was aimed at combining inbound and outbound freight flows into a unique transport model. It was carried out on a sample of four full weeks of transport operations of the past, provided by every company and transformed into transport requests, and by setting the following quantities:

- Sites. The sites to serve for the 11 companies were 815, with a minimum of 6 for the smallest and a maximum of 225 for the largest. They are all located in the Centre-North of Italy and many of them belong to the territory of the Emilia-Romagna region.
- Geo covering. This was an interesting challenge since a mere daisy shape was not suited in this case for the large number of sites in the range of 150 km. It was decided to adopt a geographic covering based on 14 partially overlapping areas that, according to the daisy metaphor, can be described as a flower with two tears of petals. The inner petals are seven and correspond to couples or terns of Emilia-Romagna provinces, e.g. Parma + Reggio, Reggio + Modena, Modena + Bologna + Ferrara. The external petals are seven in turn and correspond to the main transport directions, e.g. West, North-west, North, and so on.
- Vehicle types. The simulation had to be performed at infinite capacity to discover, among other aspects, which could be the best fleet configuration for the set of the participating companies. Six vehicle types were considered with load capacity ranging between 1.5 (van) to 28 tons (semi-trailer or articulated truck) and speed coefficients ranging in turn between 0.95 and 0.65. These vehicle types included those of the internal fleets available at some companies so as to show them an improved use of their vehicles.
- Price list. It was decided to define a price list representing a sort of synthesis among the price lists in use at the participating companies. In detail, this price list applied a hourly rate for routes shorter that 70 km, while it applied a stepwise kilometric rate over that distance. The adoption of just one price list was justified by the need to obtain comparable results over the entire set of companies.
- Transport requests. The transport flows at the different companies ranged between 5 and 615 transport requests per week, and their sum resulted in an average of 2,450 transport requests per week to serve. 80% of transports presented strong regularities while the remaining 20% corresponded to occasional or urgent transport requests.

Table 1 Individual vs. aggregated performances in industrial districts

	Individual simulation (€)	Demand aggregation (€)
Company #1	1,587,205	1,297,223
Company #2	1,356,808	1,024,797
Company #3	213,673	125,533
Company #4	116,960	57,591
Company #5	64,264	43,847
Company #6	254,256	132,518
Company #7	138,076	67,561
Company #8	1,895,926	1,634,857
Company #9	1,187,435	1,051,474
Company #10	434,163	337,518
Company #11	231,178	137,713
Totals	*7,479,944*	*5,910,632*

4.1.2 Results and Comments

The study was carried out in two simulation stages corresponding to the cases of null and full demand aggregation among the participating companies. More precisely, the two simulation stages were bases on the following principles:

- Individual simulation. The simulation was performed on the transport requests of the single companies with the aim of optimising each of them separately. The resulting routes were taken as "best individual solution" for each company, likely equivalent to or more efficient than its current practice.
- Demand aggregation. The simulation was then performed on the whole set of transport requests, taken all together, in such a way that the participating companies are put in condition to share at best routes and trucks and therefore benefit of a potentially strong economy of scale.

Both simulations were performed on the four sample weeks and their results were reported to the entire year so as to become more understandable to the participating companies. Table 1 summarises those results it terms of estimated yearly transport costs.

The first outstanding consequence of this work was showing the participating companies their own (possibly optimistic) present yearly transport costs. Those figures were not believed at the beginning, and only after a discussion on the simulation method the companies became aware of the fact that their transport costs are normally much higher than perceived and call for more careful analyses.

The second important indication is that a simple demand aggregation among few companies has the potential to dramatically reduce the transport costs. The difference measured between the two approaches is 1,569,312 € corresponding to a rate of about 21%. It is obvious that this will increase with the number of companies especially on longer-range routes where convenient aggregation conditions are less frequent.

Going deeper into the analysis it is possible to discover that the cost reduction rate is much higher (in the order of 50%) for small companies because of their inefficient current practice, while it is lower (in the order of 15%) for large companies but with yearly savings of several hundreds Euro. The conclusion, published on the national specialised press (Alteri 2008), is that all kinds of companies can actually benefit.

A problem that arose when simulating the aggregated demand was the choice of the criterion to subdivide the transport costs among the served companies for those routes that carried payloads of two or more of them. The adopted criterion is a balanced mix, for each route, of number of transport requests, number of stops, distances between stops, weight and volume of parcels.

The outcome of this study was so encouraging that four of the eleven companies decided to operate a joint logistic office where a young engineer played the role of logistic broker (Finelli 2008). His task is collecting twice a day the transport requests, and planning them by the same software tool by saturating first the internal fleets and assigning the remaining routes to qualified carriers.

4.2 The Rush-Hour Traffic Case

Castelnuovo Rangone is a small town of about 15,000 inhabitants in the province of Modena, Italy. It is characterised and well-known by the presence of several meat industries, especially pork processing and packing industries. Those enterprises employ more than 2,000 people coming from the surrounding territory, most of whom from a distance of less than 50 km.

Their transfer between home and work is concentrated in the opening hours (around 08.00 h) and closing hours (around 17.00 h) of those industries. This generates strong picks of traffic with heavy consequences on resident mobility and air pollution. For this reason the municipality of Castelnuovo Rangone proposed to enterprises and labour unions the study of a sustainable transport model.

The main hypothesis was evaluating the potential benefits of incentives that could push many workers to leave their cars at home and get on those of colleagues. The alternative hypothesis to create a shuttle-bus service collecting workers in their villages and moving them to the respective enterprises was also considered and simulated, but it resulted too expensive and non efficient enough.

In the study preparation phase it was decided to conduct a survey among the involved workers. It obtained about 500 answers that were considered widely sufficient to support the investigation. The resulting picture was quite interesting and suited to feed the simulation phase:

- 70% of workers move by car while the remaining 30%, living in town or nearby, move by foot or bicycle hence they are not pertinent to the study.

- The enterprise opining hours are actually two, 08.00 and 08.30 h. of the 350 workers using the car about 210 (60%) start at 08.00 h and the remaining 140 (40%) start at 08.30 h.
- The about 350 cars resulting from the survey cover daily a total distance of 9,800 km (2,156,000 km/year), meaning 4,900 km one way.

The study was intended to find a sustainable car-pooling solution that could reduce at the same time both the number of cars and the number of kilometres.

4.2.1 Simulation Setting

First of all it was decided to study the only transport phase from home to work, being the reverse phase completely determined by the former. The preparation of the simulation sessions required some adaptations of the basic model, namely:

- Sites. The locations of all enterprises and worker residences were coded as sites to visit. It was possible to simplify the coding of worker residences by grouping into a single location those adjacent or belonging to the same village. The result was about 250 sites for which the distance and time matrices were computed.
- Geographic overlapping. Only one covering was defined with five partially covered petals corresponding to the main roads reaching Castelnuovo Rangone. The flower head was not introduced because it basically grouped workers moving without car.
- Vehicle types. A finite capacity simulation was required in this case since the available car instances were clearly known. For all the cars the load capacity was set alternatively to 3 or 4 including the driver, and a speed factor of 1,2 was chosen to indicate that cars are 20% faster of the fastest van.
- Fleet configuration. It was decided to carry out different simulations with three alternative fleet configurations. Since drivers move from far away and collect passengers along the way, the cars to consider were, respectively, those leaving from over 30 km, those leaving from over 15 km, and all cars.
- Price list. It was also decided to evaluate the case of cars transporting workers going to possibly different enterprise (multiple destination), as well as the restricted case of cars transporting workers to the same enterprise. In order to cope with both cases the adopted price list computes a route cost that is proportional to the covered distance plus an amount for each load and unload stop.
- Transport requests. Finally, the demand was coded by generating for each worker a daily transport request with origin at home and destination at his/her enterprise, and with a rigid time window corresponding to his/her entrance hour. The transport request presents the worker as a parcel of unitary size.

4.2.2 Results and Comments

The combination of alternative parameters to consider, namely two values for car load capacity, three values for fleet configuration, and two values for destination, produced 12 simulation sessions. The most convenient solution resulted the following:

Load capacity	4 persons	
Fleet configuration	All cars	
Multiple destination	Yes	
Nr. of pooling cars	106	Each transporting 2–4 workers
Nr. of individual cars	61	Each transporting the only driver
Total nr. of cars	167	Vs. the present 350 (−52.3%)
Total nr. of daily km	3,731	Vs. the present 4,900 (−23.9%)
Avg. pooling factor	2.1	More than two persons per car

This confirmed the feasibility of the hypothesised solution and quantifies the potential savings. It is obvious that the saving in number of cars is greater than that in number of kilometres, since the pooling cars must normally cover longer distances to collect their passengers. Moreover, the solution is less sensitive to the load capacity than to the other two parameters since few cars carry four passengers.

Figure 6 shows one of the most effective pooling routes among the 106 generated by the simulation. Worker 211 is the driver of his/her own car, collects as passengers workers 121, 479 and 75, and finally all them reach enterprise Co#3. The distance of this route is 15.2 km and its duration is 27 min. Since the way is quite direct there is no additional distance and just 3 min of additional time for as many intermediate stops.

At the end of this case it is worth emphasising the usefulness of quantitative results in support to the practical organisation of a car-pooling service like that. As a matter of fact this enables quantifying extra costs for drivers and savings for passengers, and therefore the amount and the distribution of incentives to introduce for promoting the new transport model.

4.3 The Pharmacy Warehouse Centralisation Case

In Italy there is at least one so-called Local Health-care Organisation (ASL) in every province. A recent law is pushing ASLs to merge into larger organisations, named Wide Health-care Areas to gain benefits from economies of scale. Among other aspects this implies centralising services like analysis laboratories, blood processing and, very critical, pharmaceutical warehouses.

211	Marano s/ Panaro	7:33
121	Castelvetro	7:44
479	Castelvetro	7:45
75	Cà De' Leonardi	7:53
Co#3	Castelnuovo R.	8:00
Total distance (km)		15.2

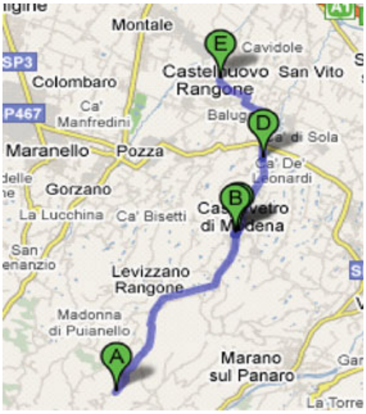

Fig. 6 Example of pooling route

Table 2 Service levels (deliveries per week) considered by the study

	Minimum	Current	Maximum
Hospital department	1	2–3	3
Territorial service	1	1	1
Hospital pharmacy	5	5	5

The centralisation of pharmacy warehouses is critical because it increases transport costs. In fact the present model devises medicine suppliers replenishing the numerous ASL warehouses individually, then each ASL distributes to hospital departments and territory services, while with the new motel it is a task of the centralised Wide Area warehouse to assure the entire distribution.

It was then decided to study the impact of warehouse centralisation in a significantly complex case constituted by the North-Emilia Wide Area (AVEN). It includes all the hospitals and territorial health-care services of the Piacenza, Parma, Reggio Emilia and Modena provinces, with the creation of a centralised warehouse in barycentre position replacing the seven existing local warehouses.

The study was aimed in particular to measure the expected transport costs with reference to different service levels, including the current one (see Table 2). The service level is represented by the number of weekly deliveries per type of destination unit, namely hospital department, territorial service or hospital pharmacy:

4.3.1 Simulation Setting

The simulation was prepared as usual by representing the problem in terms of its relevant context data and coding properly the demand to be satisfied. This was done by setting the following quantities:

Fig. 7 Example of roll container

- Sites. The relevant sites were the centralised warehouse and the destination units. The number of destination units was 1,803 in the entire AVEN, 1,039 of which were hospital departments, 730 were territorial services, and 34 were hospital pharmacies. There were located in 117 distinct sites.
- Geographic covering. A unique geographic covering was defined whose components areas were just three, each constituted of a couple of provinces, namely (1) Piacenza + Parma (2) Parma + Reggio (3) Reggio + Modena.
- Packages. The materials to distribute are packed in cardboard boxes and transported in roll containers (see Fig. 7). A rolling container can bring boxes addressed to several destination units provided they are located in the same geographic site.
- Vehicle types. An infinite capacity simulation was required considering the typical vehicles used for that distribution service, namely medium sized trucks able to reach any destination ranging on the following load capacities: 3.5 tons or 24 rolls, 4.5 tons or 33 rolls, and 6.5 tons or 47 rolls (see Table 3). Special and infrequent transports, like those requiring refrigerated trucks, were ignored.
- Price list. A unique price list was considered split into two parts: the typical structure based on hourly and distance rates, as reported in Table 3, and an additional cost of 15 €/h for the time spent in unload and delivery operations.
- Transport requests. Four sample weeks of transport requests were generated from recent data on performed transport orders provided by all the involved

Table 3 The adopted price list

	Rolls	Cost within 70 km	Cost over 70 km
Truck 3.5 tons	24	31.00 €/h	0.90 €/km
Truck 4.5 tons	33	33.00 €/h	0.96 €/km
Truck 6.5 tons	47	35.00 €/h	1.00 €/km

Table 4 Summary of yearly costs and other indicators to obtain the current service level

	0 min	4 min	6 min
Distance covered (km)	495,352	496,196	506,352
Transport time (hours)	10,428	10,512	10,584
Delivery time (hours)	0	5,634	8,452
Transport cost (€)	486,068	488,664	503,228
Delivery cost (€)	0	84,524	126,764
Total cost (€)	486,068	573,188	629,992
Deliveries after 13.30 h	4%	17%	30%

Table 5 Resulting (suggested) fleet configuration

	Minimum	Current	Maximum
Truck 3.5 tons	6	6	7
Truck 4.5 tons	6	7	7
Truck 6.5 tons	2	3	3
Total nr. of trucks	14	16	17

ASLs. It was found that in the average a box is generated by 2.5 order lines, and that one roll can host a maximum of 20 boxes. In this way the simulated demand was an exact representation of the material flows currently managed by the ASLs, assuming they will be transferred to the centralised warehouse.

- Time constraints. Very important, the transports leave the centralised warehouse at 07.00 h and all deliveries should be concluded before 13.30 h. The transport duration includes one minute per roll unloaded at the planned stops. In addition three different values were assumed for estimating the time spent in delivery to the destination unit, namely 0, 4 and 6 min per roll in the average corresponding, respectively, to the cases of no delivery (the roll is left at the site gates), fast delivery or slow delivery.

4.3.2 Results and Comments

Several simulations were performed to tune the transport model and then derive an analytical picture of the possible solutions. Table 4 summarises the results for confirming the current service level reported in terms of yearly indicators and costs to make them more understandable to AVEN managers:

The optimal fleet configuration is reported in Table 5 in terms of number of truck of each type with respect to the different service levels considered:

The study showed that the examined transport model is very complex and many variables impact on its performances and sustainability. In particular the achieved results were fundamental to decide a neat separation between the transport activities, in charge of the centralised warehouses, and the delivery activities, that were eventually assigned to the local hospitals and services.

Another important effect of this simulation was the possibility to prepare a very accurate and realistic specification for the tender that was successively launched for outsourcing the transport service. The deep knowledge of mutual influences between service level, fleet composition and costs was fundamental to select the most suited offer from the participating organisations.

5 Summary and Final Remarks

This chapter introduces the concept of simulation in logistics and transports and discusses the benefit it can bring to the definition of sustainable transport models. It also demonstrates that simulation should and could be a widespread work method replacing qualitative and mostly ideological approaches with sound quantitative analyses representing the only correct way to support impacting decisions.

The validity of the simulation method was confirmed by the presentation of three real-life problems that were successfully solved in recent years. These examples are just a subset of the many situations that had benefits from simulation in the definition of sustainable solutions. In all cases the simulation setting stage was itself a first important step forward in understanding the problem, and the simulation outcome finally assured the needed deep view into critical elements and their interdependencies.

The first lesson to learn from this experience is that new models, in particular new and more efficient transport models, not always ask for more resources to be successful (Atkinson 2007). On the contrary, in many cases the solution is very close and corresponds to a more effective use of the available resources provided that changes and investments are decided on the basis of clear and verifiable estimations.

The second lesson to learn is that sustainability is the synthesis of three fundamental components, namely economy, ecology and human perspective (Hajdul 2010). Sustainable solutions must be economically viable, reduce the impact on territory, and be fully understandable by decision makers. This implies facilitating cooperation and assuring coordination between the involved actors.

There is in conclusion a third lesson to learn: most of these benefits are achievable only with the support of suited ICT tools. In particular cooperation and collaboration are slowed down by obstacles to communication and data exchange (Bonfatti et al. 2011b), and simulation itself can hardly become a systemic approach if it is not fed by data coming from different interoperable information systems.

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Part III
Information Systems and Information Management Supporting Sustainable Transport

One Common Framework for Information and Communication Systems in Transport and Logistics: Facilitating Interoperability

Jan Tore Pedersen

Abstract Supply chains are becoming more and more global and responsive. The drive for more environment-friendly, decongested and secure logistics has led to the introduction of such concepts as Co-Modality, Motorways of the Sea, Secure Trade Lanes and Green Corridors. Effective logistics and supply chain management re-quires sharing knowledge and information along the supply chain. In this context, efficient cooperation between actors in integrated supply chains becomes more and more important. To achieve this, the information and communication systems used for managing transport and logistics operation need to interact efficiently, share information—they must be interoperable—and the actors must be enabled to share that information according to their own business rules. Similar exchange of information is necessary between private stakeholders and authorities. This chapter presents the Common Framework that supports interoperability between commercial actors and communication to authorities and transportation network responsible—to make the best possible use of the available transportation infrastructure, provide appropriate supply chain security, and support compliance requirements.

Keywords Co-modality · Sustainable development · ICT · Communication standards · Common framework · Sustainable transport system

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1 Introduction

Supply chains are becoming more and more global and responsive. The drive for more environment-friendly, decongested and secure logistics has led to the introduction of such concepts as Co-Modality, Motorways of the Sea, Secure Trade Lanes and Green Corridors. Effective logistics and supply chain management requires sharing knowledge and information along the supply chain. In this context, efficient cooperation between actors in integrated supply chains becomes more and more important. To achieve this, the information and communication systems used for managing transport and logistics operation need to interact efficiently, share information—they must be interoperable—and the actors must be enabled to share that information according to their own business rules.

Despite the fact that standards exist, industry representatives have realised that a paradigm shift in interoperability is needed if logistics efficiency is to be improved and political goals of reducing the environmental impact of transport are to be met. One example of an industrial initiative in this direction is the development of a new Logistics Interoperability Model (LIM) by GS1. Behind the LIM proposal are large manufacturers and logistics service providers.

A number of EU funded research and development projects have been addressing the issues of information and communication technologies in transport and logistics. Traditionally, these projects have been quite autonomous and there has been little coordinated contact between the projects. This has, however, now changed. The partners in a number of projects have realised that there are project benefits that may be exploited from better cooperation. This view is also shared by the EU Commission.

As industrial developments and the research community have reached similar conclusions, a joint initiative has been taken to improve interoperability considerably by developing one Common Framework for exchange of information between ICT systems in transport and logistics.

The Common Framework supports interoperability between commercial actors and communication to authorities—to make the best possible use of the available transportation infrastructure, provide appropriate supply chain security, and support compliance requirements. To drive the required paradigm shift, the Common Framework addresses interoperability issues at two main levels in a technology-independent way. At the process and information level, the Common Framework is developed to ensure that only necessary and sufficient information is being exchanged, that the number of messages and their complexity is kept to a minimum, and that the messages are unambiguous. At the architectural level, the framework builds on open services platforms and self-configuring logistics networks and devices—to support Intelligent Cargo, Single Windows and other mechanisms for collaboration and monitoring.

The Common Framework approach lowers the cost for companies to electronically connect in transport and logistics, without forcing those who already have invested much in the area to stop using what they have. Close cooperation has been established with standards organisations. In addition to being deployed in industry, the Common Framework will provide a mechanism for current and new research and development project to provide interoperability of relevant results.

2 Rationale

2.1 Industrial and Political Initiatives

The EU projects FREIGHTWISE,[1] e-Freight,[2] INTEGRITY,[3] Smart-CM,[4] SMARTFREIGHT,[5] EURIDICE,[6] RISING,[7] and DiSCwise[8] represent a long line of development projects funded by various DGs[9] in the EU Commission in the area of freight transport management and related security issues. Most of these projects have been loyal to the standardisation schemes offered by organisations like CEN and UN/CEFACT in the important area of information exchange in transport and logistics. In other words, electronic documents standardised by these organisations were implemented in these projects.

Standardisation organisations describe their electronic documents through specifications and implementation guidelines. This leads to situations where organisations and groups of industries are interpreting specifications differently and the result is lack of interoperability.

This is not just a conceptual problem discussed in research and development projects, put problems experienced by industry to the extent that GS1[10] established its Logistics Forum with representatives from companies like Unilever, DHL, Schenker, Firmenich, Army & Air Force Exchange Service, GEFCO, Bring Frigoscandia, DSV, ICA, DIA (Carrefour), El Corte Inglés, Mercadona, Eroski, Easytech, Campofrío, and Sotec. This Logistics Forum has the following objective:

> Globalisation has become a key word in today's economy and efficient logistics plays crucial role in it. One of the major challenges to a successful global logistics solution is interoperability—the capability to run business processes seamlessly across organisational boundaries and to ensure on-time progress of goods through the supply chain. End-to-end

1 www.freightwise.info

2 www.efreightproject.eu

3 http://www.integrity-supplychain.eu

4 http://www.smart-cm.eu/

5 http://www.smartfreight.info/

6 http://www.euridice-project.eu

7 http://www.rising.eu

8 http://www.discwise.eu/

9 Directorate-General.

10 http://www.gs1.org/transportlogistics/forum/work_groups/lim/

> traceability, security and safety of shipments are required by buyers and suppliers, mandated by regulatory authorities and made possible by interoperable solutions.

The GS1 Logistics Forum aims to achieve the business benefits and remove unnecessary costs of global supply chains in transport and warehouse management activities by:

- *overcoming barriers of scalability;*
- *moving to truly interoperable systems;*
- *standardising identification and communication solutions.*

In a meeting in the beginning of 2011, the Supply Chain Interoperability manager of a large shipper essentially stated: "If we are using 5 different logistics companies, then we have to communicate with logistics service providers in 5 different ways. We only want to communicate one way only". This is an indication of the fact that even though there have been standards for information exchanges between actors in supply chains for many years, the way that these standards have been developed and deployed has not led to interoperability, except on a one-to-one basis.

Another initiative worth mentioning is the Electronic Freight Management (EFM)[11] initiative from the US Department of Transport that

> applies Web technologies that improve data and message transmissions between supply chain partners. It promotes and evaluates innovative e-business concepts, enabling process coordination and information sharing for supply chain freight partners…

Elements of EFM are:

- Common electronic communication platform;
- Comprehensive shipment information visibility;
- Data standards in a transportation logistics environment.

2.2 Relevant EU Project Results

The EU projects mentioned above may be divided into the following groups:

Group 1 INTEGRITY and Smart_CM focus on security and visibility of supply chains concluded that there is no standard message for reporting information from Container Security Devices (CSDs). Hence, a joint action by these two projects suggested such a standard and is presenting it to CEN in a formalised standardisation process. This message is an element of the proposed Common Framework and will be addressed later. The principle is that a neutral platform is made available to receive information from various CSDs. The neutral platform communicates to stakeholders in the standardised format.

[11] http://www.efm.us.com/

Both projects have also developed applications for supply chain visibility and have experienced that sharing of such information is simple if all stakeholders access the same visibility system, but that it is not as straightforward if this is not the case. Since there is no standard easily available here, one large logistics operator asked for information in a tailor made XML format. In another setting, container status information was provided using e-mail.

Group 2 FREIGHTWISE, RISING, DiSCwise, and e-Freight concentrated on freight transport management and framework for information exchange, with particular focus on involving SMEs. A new framework, called the FREIGHT-WISE Framework (FWF) was developed and validated in a number of business cases. The FWF was developed on the basis of an analysis of what supply chain stakeholders regard as necessary and sufficient information for performing their functions well and form the point of view of keeping implementation cost at the lowest possible level. RISING, DiSCwise and e-Freight continues the development of the FWF in areas where weak points have been identified. This will be addressed later.

Group 3 EURIDICE deals with freight transport management, but with a specific focus on architectures that may support the introduction of emerging technologies that enable cargo that have information about itself and its movements and to process and communicate it to supply chain stakeholders. The experience here is that the use of emerging technologies does not impose specific requirements on the Common Framework as such, but it offers alternative architectures for implementation.

Group 4 SMARTFREIGHT deals with integrating urban traffic management systems with the management of freight and logistics in urban areas and concludes that some of the standards that exist for exchanging information between traffic (cooperative) systems and transport management systems need improvement in order to make the best possible use of resources.

2.3 Creating a Common Framework

As the projects in Group 1 through 4 started to communicate, it was concluded that it would be beneficial to jointly address the idea of a Common Framework Information and Communication Systems in Transport and Logistics. The need for such a Common Framework is also recognised in the logistics industry and in the international community. Such a Common Framework need to offer a level of standardisation that is different from the type of standardisation currently offered (where there are significant possibilities for interpretation) such that it will be possible for small and medium sized enterprises to implement it and connect to and/or be part of efficient multimodal logistics networks. Fragments exist, but there is no single framework dealing with all the areas of:

- Information exchange between stakeholders in efficient supply (and transport) chains;
- Communication of security information to public and private stakeholders and supply chain visibility;
- Reporting to authorities for clearance and compliance;
- Interaction between traffic management systems (also called cooperative systems when including communication between vehicles and the transportation infrastructure) and systems for freight transport management;
- Facilitation of emerging technologies, particularly in the area known as "intelligent cargo".

In addition to describing such a Common Framework conceptually, a practical example on how it will function is presented on the basis of solutions developed in the above-mentioned projects and beyond.

3 Scope

3.1 Transport and Trade

Although some of the projects mentioned in preceding sections have concentrated only on freight transport, transport is responding to a need for transport, caused by trade. In dialogues with industries and with the EU funded project for public purchasing, PEPPOL,[12] it becomes clear that the ability to provide complete traceability must be supported by the Common Framework.

To support traceability, it is important to have a relation between the trade units that are the topic in the ordering and invoicing process between trading partners (eOrdering and eInvoicing in Fig. 1) and the units that are used for transport, called logistics units.

The relationship between trade units and logistics units is established in the eFulfillment process in Fig. 1.

3.2 Roles

What is a role

There are a number of stakeholders involved in transport and logistics. A stakeholder may be a person, a team, or an organisation and will have one or more responsibilities. In order to be able to discuss the framework in a way that is independent upon different organisational structures etc., the concept of roles is introduced.

[12] http://www.peppol.eu/

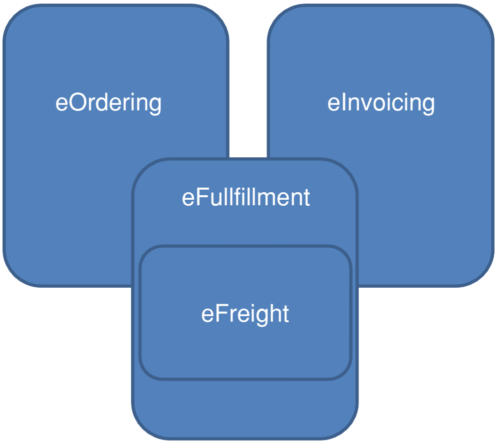


Fig. 1 Linking trade and transport

A role:

- Represents a unique set of responsibilities;
- Is independent of organisational issues
  - It will to a large extent persist through organisational changes;
  - Even though the responsibility is unique, the way it may be performed will support local differences;
  - A role may not necessarily be performed by human beings, but may be performed by systems or by a combination of people and systems. Hence, the concept of role supports changing levels of automation;
- Is independent of managerial and legal concepts and, as such, facilitate change when required.

Roles may be performed by commercial companies or by public authorities. For the process of intermodal freight to be efficient, all roles need to interact and cooperate efficiently.

Those who are performing roles may be applying various tools and systems, including information and communication systems.

View from Industry

When the scope of the Common Framework is extended to include a relationship to trade, the following two roles should be included:

- *Consignor*—in a contract of carriage, the sender of an order to be delivered whether by land, sea or air;
- *Consignee*—in a contract of carriage, the receiver of the order.

In its development of the Logistics Interoperability Model (LIM),[13] the GS1 Logistics Forum defines what they call *parties* (physical or legal entity):

[13] Logistics Interoperability Model, Version 1, Issue 1.0, June 2007.

- Retailer;
- Manufacturer;
- Material supplier;
- Logistics Service Provider (warehousing and/or transport).

These parties can play one or more of the following roles (a role represents a unique set of functions or responsibilities):

- *Logistics Services Provider* (LSP), representing those that provides one or a combination of logistics services;
- *Logistics Services Client* (LSC), representing those that purchases one or a combination of many different services.

A carrier is one form of Logistics Services Provider.

Roles from the FREIGHTWISE Framework

In an effort to simplify information exchange in the transport sector, the FREIGHTWISE project also concentrating on defining roles in the same meaning as roles in the preceding Section.

FREIGHTWISE analysed the issues or roles carefully, and four superior roles have been identified to be essential to freight transport:

- The *Transport User* is the role representing anyone that searches for transport services; books transport services and follows up the execution of transport services. The Transport User also provides the Transport Service Provider with instructions and detailed information about the transport items to be included in the transport services.
- The *Transport Service Provider* is the role that plans, markets and executes transport services. The requirements for the services are collected from the Transport User. Information from the Transportation Network Manager and the Transport Regulator is collected and used both during planning and execution of the services. The Transport Service Provider has the responsibility of providing the Transport User with status information during the execution of the transport services.
- The *Transportation Network Manager* is the role that extracts all information available regarding the infrastructure (static or dynamic) related to planning and executing transport and makes this information available to the Transport User and the Transport Service Provider.
- The *Transport Regulator* is the role that receives all mandatory reporting (and checks if reporting has been carried out) in order to ensure that all transport services are completed according to existing rules and regulations. The Transport Regulator has the responsibility to do the necessary clearance (security, compliance) of the goods.

In relation to the previously defined domains, The *Transport User* and *Transport Service Provider* reside in the e-Freight domain. It should be noted, however, that the term e-Freight domain in this report differs slightly from the e-Freight framework description that has currently been presented in the e-Freight project.

In the e-Freight project, the scope has covered links to cooperative systems and Transport Regulator functions that goes beyond just security.

As can be seen from the two preceding Sections there are similarities and differences. The most interesting observation, however, is that both approaches have two commercial roles related to the transport and logistics operations (Logistics Services Client/Transport User and Logistics Services Provider/Transport Service Provider).

The other observation is that neither FREIGHTWISE, nor any of the other projects have considered the need to include relationship to trade units in the framework. In order to "close the ordering, invoicing and transport loop, however, it is necessary to include the roles Consignor and Consignee in the Common Framework".

The two roles Transportation Network Manager and Transport Regulator were not considered in the industrial case. However, in order to ensure interaction between traffic (cooperative) systems and transport management systems, the Transportation Network Manager role need to be included, as has been concluded in the projects MarNIS, SMARTFREIGHT and FREIGHTWISE. Similarly, in order to link to functions and systems for clearance and compliance verification, the role Transport Regulator will be included.

Hence, the roles to be included are (see Fig. 2):

- Consignor;
- Consignee;
- Logistics Services Client (LSC);
- Logistics Services Provider (LSP);
- Transportation Network Manager (TNM);
- Transport Regulator (TR).

All reporting to authorities is now concentrated on communicating to the role of Transport regulator.

3.3 Business Processes

In the FREIGHTWISE project (and the preceding ARKTRANS[14] activities), the main focus is operational planning and execution, dividing the process into 3 essential parts:

- Planning—selecting the transport chain (if necessary), ensuring space and agreeing to terms and conditions
- Execution—issuing instructions, monitoring progress documenting delivery and initiating planning if necessary
- Completion—dealing with claims if any and finalising financial settlements etc.

[14] www.arktrans.no

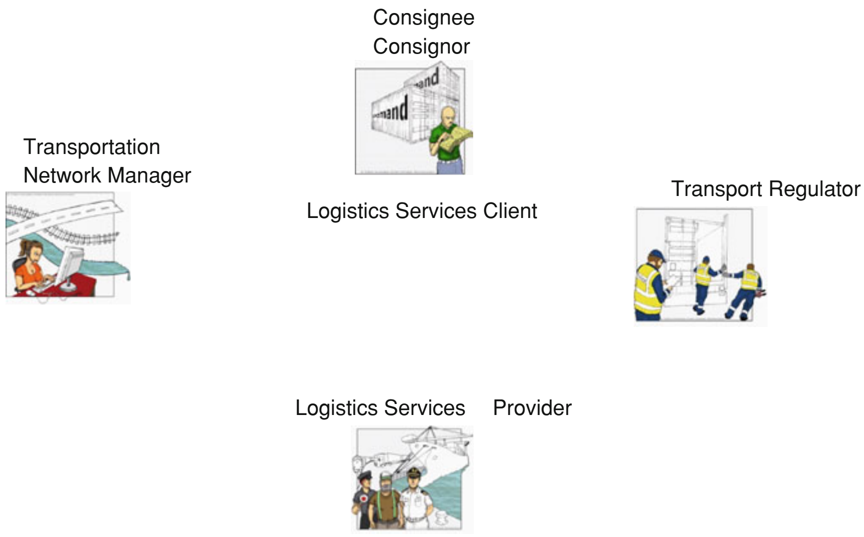


Fig. 2 Relevant roles

This all well, but when communicating results from framework developments in these projects to industrial audiences, the response has typically been that what is presented is representative for single, or spot, transport contracts, while the industry use long term agreements.

In order to avoid such misunderstandings in the future, the Common Framework should also include the business processes that set up the long term agreements between LSC and LSP.

Again inspired by GS1, the set of business processes that will be supported by the Common Framework is illustrated in Fig. 3.

- *Interoperation Agreement* is the process that results in an overall agreement between Logistic Services Provider (LSP) and Client (LSC). It is a process that essentially is performed once, or whenever changes are needed. It defines coverage of services (warehousing, transport, etc.), principles and responsibilities regarding all activities. Important elements are: master data management, capacity management, service delivery, frequency of rate review, payment, claims, systems security, confidentiality/non-disclosure agreement, traceability requirements, service levels (and other performance measures), quality management, requirements and escalation procedures. It also defines the technical and administrative mechanism by which integration between Logistic Services Provider and Client will occur, including standards used, performance expectations, back-up procedures and data privacy.
- *Master Data Alignment* includes definition of the items, locations and other relevant attributes used in the logistics execution to ensure that both parties have the same and unambiguous understanding of this basic supply chain

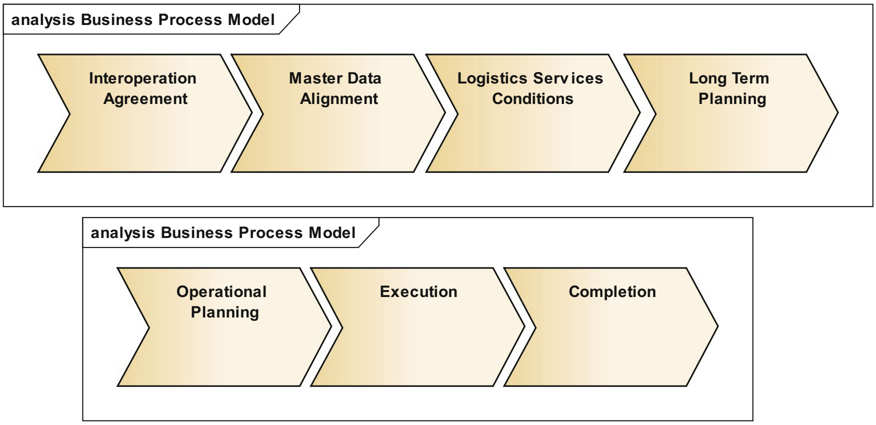


Fig. 3 Business processes

information. This process takes place periodically (once per year, for example, of when changes makes it necessary).

- *Logistics Services Conditions* describes the commitment between the Logistic Service Provider and Client on execution of the agreed services for a given period and at the stated rate/price. The Logistic Services Conditions define the relevant contractual data to be able to invoice the logistic services rendered. It does not intend to cover the totality of the contractual data (ref. the Interoperation Agreement). This process takes place periodically.
- *Long Term Planning* focuses on capacity planning Logistics Services Providers for all types of services based historic information, already agreed contracts (and bookings) and forecasts from Logistics Services Clients. This process takes place periodically.
- *Operational Planning* leading to the final agreement on logistics services to be used (one or several in combination) and the associated terms and conditions. If Interoperation Agreement, Master Data Alignment and Logistics Services Conditions have been agreed between Logistics Services Provider (LSP) and Logistics Services Client (LSC), terms and conditions from these are being used as a basis for operational planning. If no such agreements exist, more in-depth negotiation between LSC and LSP may be required.

Interaction between Logistics Service Provider and Transportation Network Manager may take place during Operational Planning, such that the condition and capacity of the transportation infrastructure may be taken into account in the planning process. Initial reporting to the Transport regulator may also take place. Operational planning is performed continuously.

- *Execution* is about performing the services that have been agreed between LSC and LSP, monitoring their performance, quality and security and providing

information about status when agreed (on request, regularly or if there are deviations). During Execution there will be interaction with Transport Regulators and possibly Transportation Network managers.
- *Completion* includes the activities necessary to complete the logistics assignment and includes all forms of reporting, agreeing claims if any and financial settlements.

4 Interoperability

The term interoperability means different things to different people and organisations.

The GS1 initiative uses the term "business interoperability":

> Business interoperability is the capability to run business processes seamlessly across organisational boundaries. Interoperability is achieved by understanding how business processes of different organisations can interconnect, developing the standards to support these business processes efficiently and by specifying the semantics of messages exchanged between the organizations to support these business processes in a scalable way.

In line with the definition of roles in Sect. 3.3, this definition leads to harmonisation of the interaction between the Logistics Services Client and the Logistics Services provider. Details about the supply (transport) chain employed by the Logistics Service provider are not part of this interaction.

Another definition of interoperability, particularly related to the use of ICT system is: the ability of two or more systems or components to exchange information and to use the information that has been exchanged. The focus on the *use* of information demands that both the syntax and the semantics of the information that is exchanged need to be perceived in the same way by all those exchanging the information.

The term used for interoperability in this Common Framework is leaning to the latter. If costs for connecting to a Common Framework are to be kept as low as possible, business process harmonisation should be kept to an absolute minimum, leaving stakeholders as much freedom as possible to structure their own activities.

5 ICT Systems Involved

5.1 Overview

ICT systems in freight transport management may be divided into the following three groups:

- Systems used by individual transport companies (or terminal operators) to manage their own (or in-sourced) resources and carry out transportation tasks for their clients. Such systems are typically sufficient if transportation is carried out from origin to destination using a single mode (or better, a single transport vehicle).

- Systems used by companies that organises transport operations involving more than one mode and/or involving the participation of more than one transport company. Such systems may be called supply chain management systems or transport chain management systems—depending upon the scope of functionality. In this paper this type of system will be referred to as transport chain management system TCM system.
- Systems essentially used by authorities to receive information about future and ongoing transport operations. This group also includes systems that are used for traffic management (also providing information about infrastructure capacity used by Logistics Services Providers). Such systems are used on a local level—Port Community Systems (PCS) being one example (these systems are also used for communication between authorities and commercial stakeholders in and around the port), national level—is where National Single Window (NSW) systems are being applied, and regional or European level—Safe Sea net being one example.

These groups are illustrated in Fig. 4. In the example in Fig. 4, the individual providers of single transport services have their own legacy systems for bookings etc. and fleet management. The initial rail, terminal, and maritime transport services are managed as one composite service by an organisation (freight forwarder, freight integrator) using a Transport Chain Management (TCM) system. The terminal at port of discharge, the second rail, the logistics terminal (with a warehouse) and the truck transport is organised by another company using a second TCM system or a Supply Chain Management (SCM) system dependent on the situation. The complete door-to-door transport operation (connecting the two smaller chains) is organised by a third company using its own TCM or SCM system.

When dealing with interoperability, there is little need to describe or discuss the inner workings of the transport legacy systems or the individual TCM systems. However, how these systems interact (interoperate) is of crucial interest. In state-of-the art implementations, these systems interact as indicated in Fig. 4, when proper governance is adhered to. With emerging technologies, for examples those that are applied in the EU project Euridice- dealing with cargo that is self-aware, context-aware and connected, communication paths may change, but the governance structure must still be obeyed.

The Logit D2D system[15] developed in the D2D and FREIGHTWISE projects and used in RISING and DiSCwise is one example of a TCM/SCM system. The application developed in the PORTMOS[16] TEN-T project has similar capabilities.

TCM systems need updated information about status of progress, cargo, load unit, etc. These systems may obtain such information directly, or they may obtain

[15] www.logit-systems.com

[16] Portuguese Motorways of the Sea project conducted by the association of Portuguese ports.

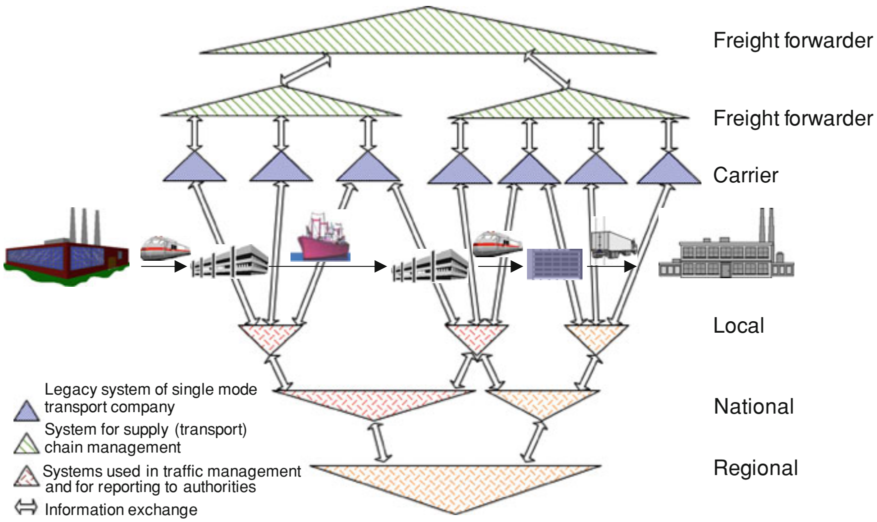


Fig. 4 ICT systems in supply (transport) chain management

it from systems that are specialising in "supply chain visibility". Such applications have been developed in projects like INTEGRITY and Smart_CM.

Systems used for reporting to authorities exist also on different levels. On the local levels we find a variety of systems at points of transhipment, Port Community Systems (PCS) being one example. They are used for receiving all forms on information about vehicles and their cargo and are being used partly to collect and convey information to authorities and partly for adapting and sending information to various other stakeholders in and around the transhipment point (terminal, port, etc.).

A number of authorities are in need for information about vehicle movements and cargo, and national Single Window systems have been developed for this purpose; this is the national level in Fig. 4. In some situations, the local level (PCS is again an example) systems may provide the single window interface.

On a regional (European) level, we find systems like the SafeSeaNet, which collects information about ship movements all around Europe, based on reports from individual Member States.

5.2 Governance

Governance is about accountability for consistent, cohesive policies, processes and decision rights.[17] In relation to the Common Framework, it is important to be

[17] http://en.wiktionary.org/wiki/governance

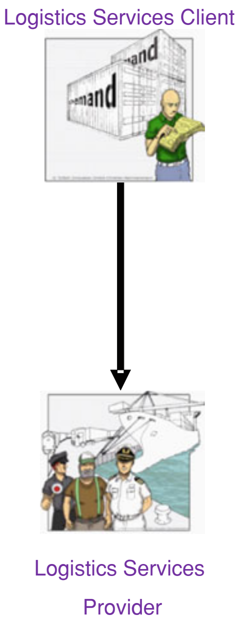


Fig. 5 Line of responsibility

aware of the “lines of responsibility” between the parties that are involved in the management of transport and supply chains; see Fig. 5.

It should be recognised that, regardless of circumstance, a Logistics Service Provider is undertaking a transport or logistics services under contract with (on behalf of) the Client. In situations where there is the need for more than one service to satisfy the need of the Client, there may be more than one “level” in this “line of responsibility”, as illustrated in Fig. 5.

5.3 Interactions

One must not be led to believe that, even though governance and “line of responsibility” are important, that all exchange of information take place only along the “line of responsibility”. It is easy to spot areas where information exchange does not seem to follow the “line of responsibility”.

Example 1: A Freight Forwarder (in the role of Logistics Services Client) is subcontracting a trucking company (in the role of Logistics Services Provider) to bring cargo from a manufacturer to a port. In order to make the port operation smooth, information about the identity of the truck, driver, the arrival time etc. need to be sent to the port from the trucking company and information about parking space and other relevant information need to be sent from the port to the trucking company. The practical exchange of information here is directly between the trucking company and the port. This may seem to breach of obeying "line of responsibility", but when the Freight Forwarder has accepted that such exchange is acceptable then it is OK. Otherwise, all communication need to take place via the Freight Forwarder.

This is typically a situation where a Port Community System is being used for information exchange to commercial stakeholders around the port.

Example 2: The Smart_CM and INTEGRITY project deal with security and visibility of intercontinental container transport. In these projects the shipper (Logistics Services Client) is acquiring the container seals and ensures that they are being mounted, initiated and set up for communication. In principle, the information from the container seals should go directly to the proper authorities (at each end of the intercontinental transport service). However, the information provided by such seals has also valuable logistics information and may be set up to communicate such information to other stakeholders. Such direct communication is efficient and practical, but agreements need to be set up in order to ensure that communication between stakeholders is properly performed.

6 The Framework

6.1 Requirements

On the basis of the projects already mentioned, a list of requirements for a Common Framework has been identified:

- Support multimodality (co-modality);
- Be stable and easy to refine and expand;
- Be future-oriented (independent of current solutions);
- Provide a total picture (supporting transparency, management, and security);
- Facilitate hiding of complexity (abstraction, simplification);
- Focus on interoperability (not on inner parts of systems);
- Independent of technology;
- Facilitating interaction with existing standards (to help protect investments already made in legacy and other systems).

Further requirements that have been extracted in the process leading up to the development of this document. Different stakeholders have their own strategies and objectives and will have to be given the possibilities to continuously develop these. As a consequence, the Framework needs to:

- Assist in making the European transport and logistics system more efficient and environmentally friendly;
- Provide interoperability without constraining business process development and improvements;

- Lower barriers to improve business processes and develop new business models. The document "CO^3: Collaboration Concepts for Co-modality"[18] expresses a situation where the transport and logistics industry needs to develop business processes over time until the goal of ensuring the best possible use of all transportation resources has been reached;
- Simplify interaction with authorities and compliance. For the time being there are different requirements for compliance and reporting for different modes and different geographies;
- Unlock access to services that would not be available without it;
- Enable market leaders and SMEs to interact at a low cost, and this should emerge as a standard endorsed and adopted by major freight ICT systems providers and logistics operators. Stakeholders that already have invested significant in existing ICT systems and associated technologies should be able to further exploit these investments and not replace them.

6.2 Scope

One of the challenges relating to developing a Common Framework is to define its scope in reaction to the requirements identified previously, where it is possible to efficiently map, harmonize and integrate different solutions for ICT in transport logistics.

The Reference Model developed is shown in Fig. 6 and explained in the succeeding sections.

6.3 Domains

Cooperative Systems

Cooperative systems, by some called traffic management systems, deal with the interaction between vehicles and the infrastructure, and there are different systems for different modes. By having all the interactions being inside the cooperative systems domain is a simplification. The vehicles are operated by Logistics Services Providers. Hence, the cooperative systems domain should cover both Transportation Network Manager and Logistics Services Provider. For the purposes of the Common Framework, this simplification does not have any significance, since the Common Framework deals with logistics and not traffic management.

All the mode-orientated initiatives from the EU Commission fall into this category:

[18] Dirk t'Hooft, Sergio Barbarino, FransCruijssen, Sven Verstrepen, AntonellaFumuso: "CO3: Collaboration Concepts for Co-modality", Transport Research Arena Europe 2010, Brussels.

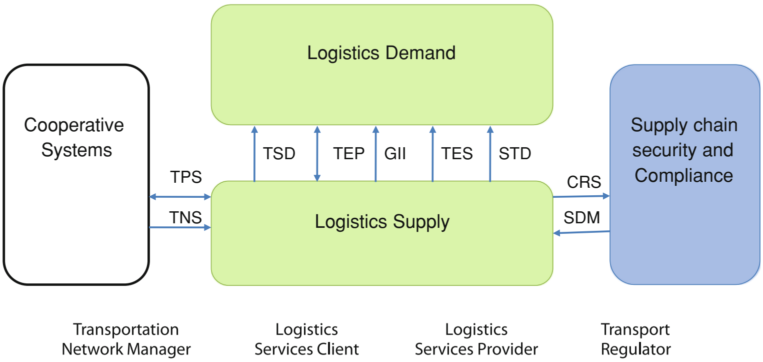


Fig. 6 The reference model

- River Information Services (RIS)[19] dealing with inland waterway transport;
- Intelligent Transport Systems (ITS)[20] dealing with road transport and interfaces to other modes (which refers to e-Freight);
- TAF TSI (Telematic Applications for Freight—Technical Specification for Interoperability) Regulation[21] focused on rail;
- e-Maritime[22] dealing with business in the maritime sector with the support of advanced electronic capabilities.

The maturity in these areas is different. However, standardisation has been developing for quite some time in some of them, and within these domains, there is no reason for a Common Framework as suggested here to "intervene".

What is of interest, however, is the information within the Cooperative Systems domain that is of interest in the area of e-Freight. This will be described later in the chapter.

Transport Demand

Transport Demand is the domain of the following roles:

- Consignor;
- Consignee;
- Logistics Services Client (LSC).

[19] Directive 2005/44/EC of the European Parliament and of the Council of 7 September 2005.

[20] Communication from the Commission COM(2008) 886 final.

[21] Commission Regulation (EC) No 62/2006.

[22] SKEMA —PROPS Stakeholder workshop "Accelerated Implementation of EU Maritime Transport policy" Riga, 11th June 2009: Christos Pipitsoulis, Maritime Transport Policy, DG Energy and Transport.

The domain deals with all activities defining the need for transport and identifying the appropriate services (in industrial transport mostly based on pre-existing agreements).

Where there exists an order between Consignor and Consignee, information about the need for transport may be extracted from the order.

Transport Supply

Transport Supply is the domain of Logistics Service Providers (LSP) and may be divided into the following three sub-domains:

- **Commercial Operations Management** deals with handling all interactions with Logistics Services Clients. In performing these activities there is close interaction with;
- **Transport Operations Management** makes sure that all transport and logistics operations agreed with Logistics Services Clients are being performed as agreed, with the best possible use of resources;
- **Vehicle, equipment and cargo operations** deals with all operations related to movement of vehicles, operating cargo handling equipment (cranes etc.) and cargo (including load units).

Transport Chain Security and Compliance

Transport Chain Security and Compliance is the domain of the Transport Regulator. All activities that are directed to setting up and monitoring adherence to rules and regulations in freight transport belong to this domain. One example is monitoring movement of dangerous goods. Another is customs clearance. A third task is related to security along the supply chain.

6.4 Interactions Between Domains

As stated previously, the Common Framework should leave companies as much freedom as possible to organise activities and designing business processes. Hence, the focus is on interaction between the different domains (or roles belonging to the domains).

6.4.1 Interaction Between Transport Demand and Transport Supply

In the standards offered by the standardisation organisations listed in Section, the principle has been that each of the transport and logistics documents that were used in the past (on paper) have been converted into electronic documents. The result is large number of electronic documents with much redundancy.

During the FREIGHTWISE and e-Freight projects there have been continuous discussions within the projects and between project participants and representatives from the logistics industry. The latter states that “all” needs identified in the processes Operational Planning, Execution, and Completion can be met by a

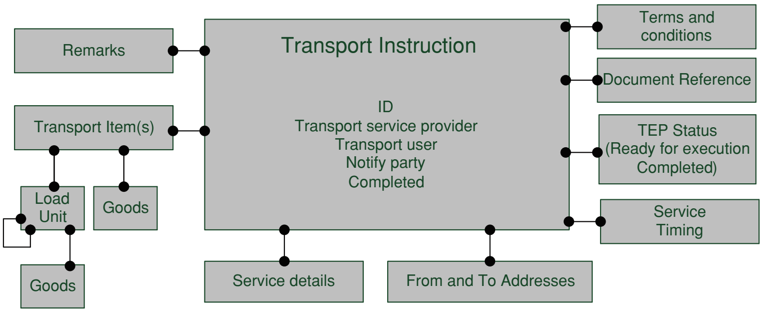


Fig. 7 Structure of the transport instruction

well-defined "Transport Instruction" package and an associated status message. This, however requires that LSC and LSP have entered into a long term agreement where all terms and conditions have been defined and agreed.

Such long term agreements may not cover all eventualities. In the case where no long term agreement exist, interaction between LSC and LSP need to support negotiation of terms and conditions between the parties. This is needed when spot transport operations are required. It may also be needed in situations where transport initiated between LSCs and LSPs that have long term agreements between themselves, but where deviations during transport requires complete replanning under conditions where the long term agreement are not valid. The "Transport Execution Plan" was developed to handle all forms of exchanges between Logistics Services Providers and their Clients related to individual transport services covering situations with or without long term agreement between LSCs and LSPs. Hence, the Common Framework will be based on this principle.

Hence, two of the information packages, or messages, which are exchanged between the roles illustrated in Fig. 5 are:

- **Transport Execution Plan (TEP)**—This contains all the information needed for a Logistics Service Client and a Logistics Services Provider related to the execution of a transport service. A Transport Instruction can be developed through several steps, or it can be created in one step only. This depends on the agreements already in place between the Logistics Services Client and the Logistics Services Provider, and the complexity of the service to be executed. The execution of a service can start when the Transport Instruction is marked "Ready for Execution". A Transport Instruction is identified by a unique identifier, valid for the relationship between a given Logistics Services Client and a given Logistics Services Provider. The structure of the Transport Instruction is illustrated in Fig. 7.
- **Transport Execution Status (TES)**—The Transport Execution Status information package gives the status for a Transport Instruction. The identifier of the

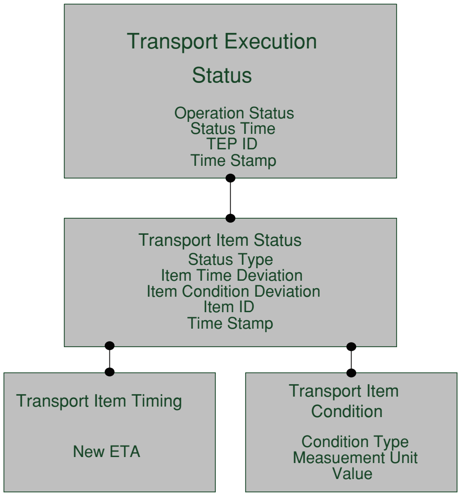


Fig. 8 Transport execution status

Transport Instruction is needed. The status is marked as Boolean, either there is a deviation, or not. If there is a deviation, the identifier(s) of the transport item(s) causing the deviation is given. If there is deviation on a Transport Execution, this information package gives the status of the involved transport item(s). The type of deviation is given. The structure of the Transport Execution Status is illustrated in Fig. 8.

When the Framework is developed, it is important that the information that is exchanged enables all stakeholders to perform well. Hence, information needs to be necessary and sufficient. The two messages described above are necessary, but three more are needed in order to make the communication between Transport Demand and Transport Supply Complete:

- **Transport Service Description (TSD)**—This is the information that any Logistics Services Provider needs to communicate to Logistics Services Clients (potential clients) such that they may use the information about the service provided when the need for transport has been established. This is an attempt to define a standard way of describing transport services such that they will be "searchable" and such that individual services may be automatically connected into transport (supply) chains. The structure of the Transport Service Description is illustrated in Fig. 9.
- **Goods Item Itinerary (GII)**—All door-to-door transport operations using more than one mode of transport, and many of those that use only one mode, are not direct services being provided without transhipment. Hence, it is necessary to be able to describe the complete itinerary for a given goods item. The Goods Item Itinerary provides this capability and the planned, estimated, and actual times for departure and arrival for each service, or segment is included. This means that information in the GII may later be used to trace the

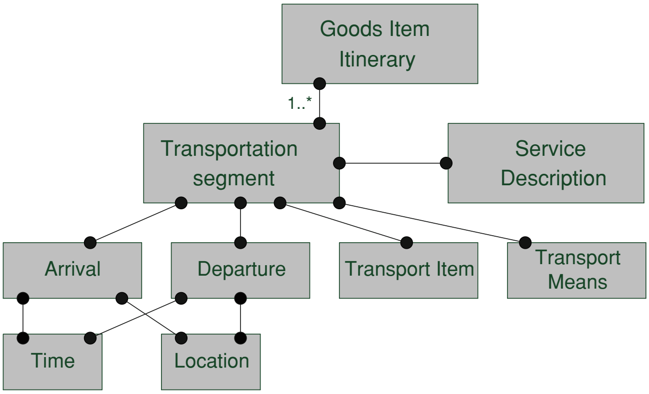
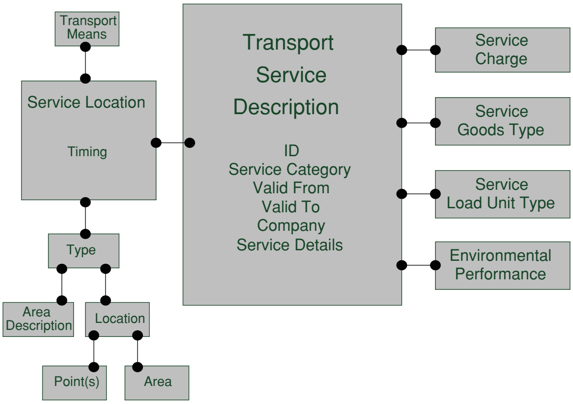


Fig. 9 Transport service description

Fig. 10 Goods item itinerary



exact movement of goods through a supply chain. It is communicated from the Logistics Services Provider to Logistics Services Client when the Transport Instruction is marked "Ready for Execution". The structure of the GII is illustrated in Fig. 10.

- **The Single Transport Document (STD)**—This document may also be called the multimodal **eWaybill**. A Waybill is issued by the Logistics Services Provider to the Logistics Services Client. It states the details of the transportation, charges, and terms and conditions under which the transportation service is provided. A Waybill is not negotiable and cannot be assigned to a third party, it essentially a confirmation that the transport will be performed. The content of the eWaybill is illustrated in Fig. 11.

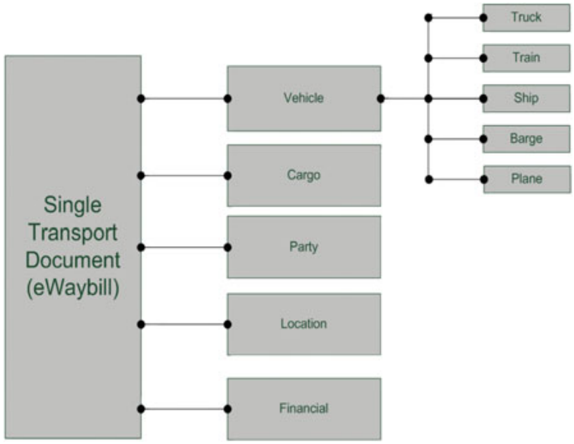


Fig. 11 Single transport document (eWaybill)

6.4.2 Communication Between Logistics Services Provider and Transport Regulator

It is not the purpose of the Common Framework to provide any form of standard within the Transport regulator's domain, previously termed "Supply Chain Security and Compliance". However, communication between the Transport Supply and the Supply Chain Security and Compliance domains are important and will be addressed here.

The projects INTEGRITY and Smart_CM both deal with the issue of Supply Chain Security. However, in addition, to make this issue useful for actors, elements of supply chain visualisation and logistics status reporting have been included in the respective ICT systems developed in the two projects.

From INTEGRITY and Smart_CM, there are strong indications that the messages developed in FREIGHTWISE and presented in Sect. 6.4.1 can be used when it comes to reporting the status of the logistics operations, even though neither project has attempted to use the appropriate FREIGHTWISE messages for this. The systems for value-added services in both projects are configurable and adaptation to Common Framework is straightforward.

However, FREIGHTWISE has not been engaged in the security aspect, and this needs to be covered by the Common Framework.

Supply Chain Security

The focus here is the provisioning of information that enables customs authorities to release the container from the terminal in the port of discharge within the EU. Note that Smart_CM and INTEGRITY have focussed on releasing the container from a security perspective—but also the release by customs from a fiscal perspective and the commercial release is to be taken into account in an integrated manner.

The information required for a security release is based on three pillars:

1. Authorized economic operator status of the involved economic operators. If alternative certification regimes are used, the customs authorities involved need mutual recognition of each other's control mechanisms.
2. Provision of summarized cargo information (describing the content of a container). This can be based on the Entry Summary Declaration (ENS) provided as part of the Import Control System (ICS). If possible, this can be complemented with purchase order and/or invoice information. This information supports Customs Authorities in performing risk management.
3. The use of security devices on containers and other relevant load units, in this document termed Container Security Device (CSD).

The CSD holds the following information (capabilities dependent):

- Event—representing the last status of the CSD;
- Unit—unique load unit ID;
- EventSensor—measurement of temperature, humidity, etc.;
- Location—informing about location and speed of movement;
- Device—device ID;
- Reader—ID of device reader if the device is not capable of sending by itself;
- User—ID of partner that attached the device;
- Technology—reference to provider of the device;
- References—the secure trade lane used.

The reference to the secure trade lane determines the itinerary: The services to the used and corresponding schedules.

The event can be used to determine the container integrity status, with the following states:

- Secure (GREEN): The container has not been reported breached and cannot be intruded;
- Endangered (YELLOW): The container has not been reported breached but is vulnerable for intrusion;
- Intruded (RED): The container has been reported breached.

All relevant information regarding itinerary is available in the Common Framework messages described in Sect. 6.4.1. However, there is a need to communicate the CSD status, and for that purpose the Smart_CM project has developed a Security Data Message (SDM).

The format of the SDM (SDMF) defines a standard format for data provided by CSDs, enriched with a reference to a MRN (movement reference nr) assigned by customs authorities as part of the so-called import control system (ICS) procedure.

The Smart_CM project has established a CEN workshop[23] for the SDM in the process of making this a standard. As soon as Transport Execution starts (more specifically after activation of the CSD), the CSD starts transmitting.

Compliance

Compliance is about reporting information about transport to customs and other authorities. Such reporting is typically performed per country. In the EU there are also examples of information that are being reported (via systems in each Member State) to common EU authorities. An example of such an EU authority is the European Maritime Safety Agency (EMSA). The system that is being used for ship reporting is called SafeSeaNet.

The situation regarding reporting formalities for ships (administered by the Master or Ship's Agent) has arisen from a combination of Port State Control inspections, IMO FAL forms, the International Ship and Port Security (ISPS) code, the VTM Directive (SSN Notifications) and customs (import/export) declarations. Although the content of the forms is standardised there are several issues that need to be addressed:

- The interpretation of "timing rules"—i.e. the requirements for the information which needs to be submitted at 72, 24 and 2 h before arrival may differ from state to state (in practice, combinations of forms are often used);
- There may be additional national or local port specific requirements that should be communicated efficiently and accurately to the reporting party;
- In many countries, ship formalities are still discharged manually and on paper. In other cases, information is submitted electronically through various channels;
- Authorities responsible for processing various forms and the associated "clearances" differ from country to country and therefore the necessary flexibility must be built into interoperable solutions.

An overview of ship formalities and corresponding information flows is given in Fig. 12.

In attempt to simplify reporting to authorities regardless of mode and geography, the Common Framework introduces the *Common Regulatory Schema (CRS)*, which can be thought of as a "standardised configurable form" which contains fields for all the information required for reporting by trade and transport for customs and across all modes. Furthermore, it can be generated automatically from systems already using the standard e-Freight Framework messages (TEP, GII etc.) and the Single Transport Document. The content of the CRS is illustrated in Fig. 13.

Through the INTEGRITY and Smart_CM projects it is clear that the World Customs Organisation (WCO) data model will have to be taken into account when the Single Transport Document is being finalised. Furthermore, the SDM presented in the previous section may need some adaptations.

[23] A CEN workshop acts as an intermediate standard for a limited period in time.

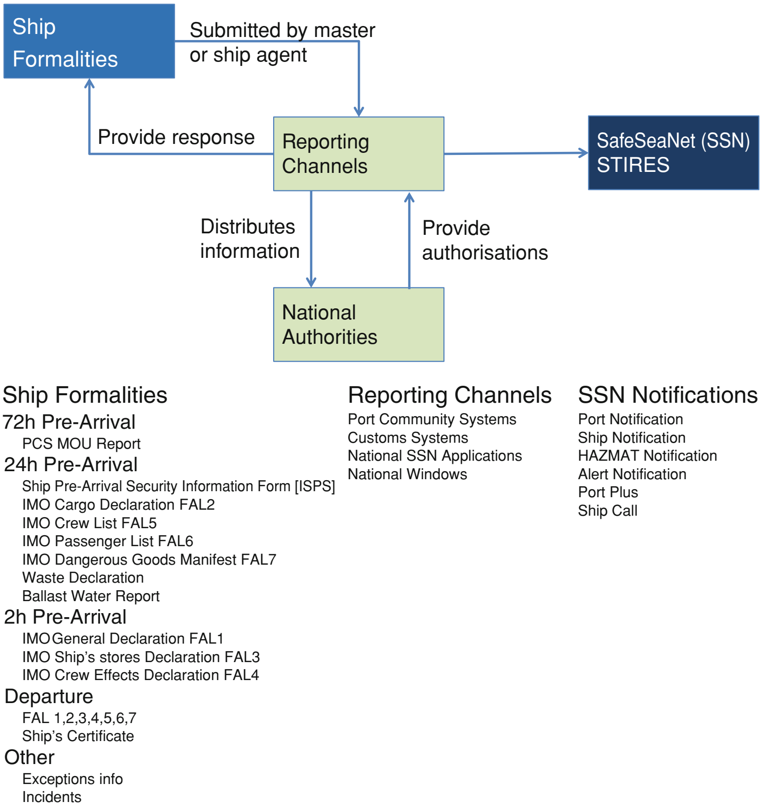


Fig. 12 Ship formalities and information flow channels

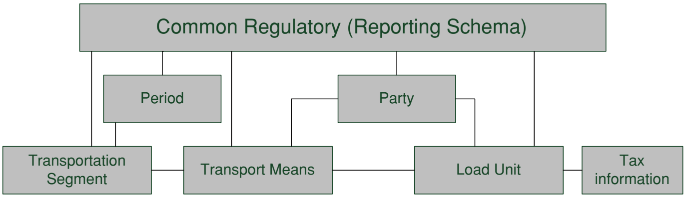


Fig. 13 Common regulatory schema

6.4.3 Communication Between Logistics Services Provider and Transportation Network Manager

Transportation Network Status

In the FREIGHTWISE project, a message called Transportation Network Status (TNS) was defined with the purpose of have one standard information package that might be used by Logistics Services Providers when planning transport operations, such as the real capacity of transport infrastructure, weather, etc.

In FREIGHTWISE, business cases led the project to direct its attention to road transport for the TNS, and the first version was strongly influenced by DATEX.

As the FREIGHTWISE TNS message was attempted used in the RISING project, it soon became clear that other messages containing similar information had progressed in standardisation as a part of the RIS developments.

After careful consideration, it has been concluded that even if the concept of Transportation Network Status is an important one, to try to make one, common mode independent message for providing Transportation Network Status at this stage will be counterproductive.

The Common Framework should at this point have the TNS point to the mode specific messages for providing such information. Examples are: road—DATEX and on inland waterways—Notices to Skippers—as being used in RISING. Similar information is available in the TAF/TSI community and will be properly developed in the e-Maritime initiative.

Transport Progress Status

Reliable information about Estimated Time of Arrival (ETA) is crucial for proper logistics management. Normally such information is exchanged between Transport Operation Management and Vehicle, Equipment and Cargo Operations. In other words, the one responsible for operating a vehicle is the one responsible for providing reliable ETA. However, there may be situations where updated information about infrastructure capacity is needed for calculating ETA properly. Such information is normally not available onboard a vehicle. The Transportation Network Manager, however, holds such information.

To facilitate cooperation between Logistics Services Provider and Transportation Network Manager in establishing the best possible ETA, the Transport Progress Status Message was defined.

The Transport Progress Status message contains information about an identified transport means, and provides information about its current location and arrival and departure details at this location, as well as details related to subsequent arrivals and departures along the route (locations and times) for this transport means; see Fig. 14.

7 Deployment

When developing a new Framework for information exchange with the ambition of obtaining global acceptance, it is important to have the Framework accepted by the various standardisation organisations. At the time of writing, the TSD, TEP, GII, TES, and TPS are in the final stages of being part of OASIS/UBL version 2.1. OASIS/UBL[24] is one of the global standardisation organisations in the area.

24 http://ubl.xml.org/

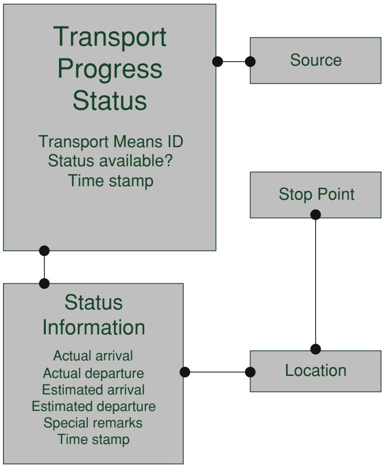


Fig. 14 Transport progress status

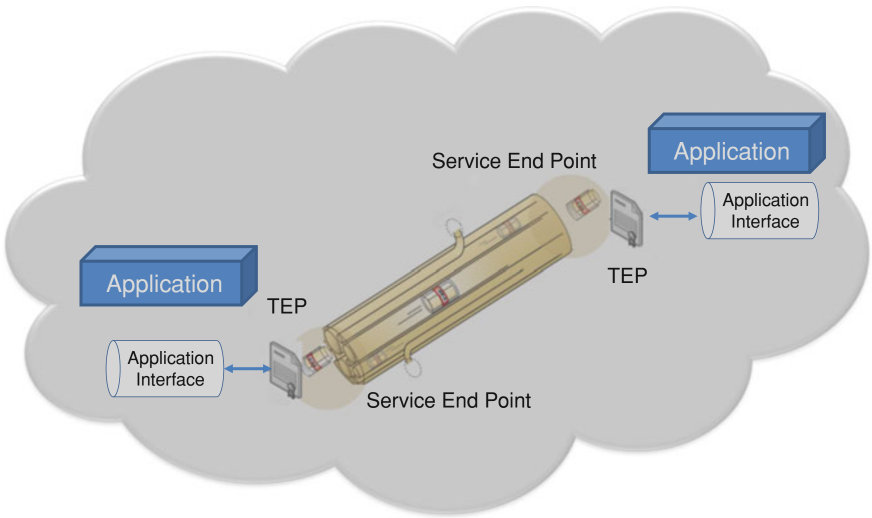


Fig. 15 Using applets to exchange information (example TEP)

In addition to providing the specification guidelines used by standardisation organisations, the Common Framework will be distributed as small applications (applets) that are able to transmit the Framework "messages" between those who want to use the Framework in their operations. This is lustrated in Fig. 15.

Here the internal databases of the applications need to be mapped to the database of the applet. When such a mapping has been performed once, the application may interact with all other applications that have adopted the use of the Framework (either through applets or any other form of implementation). For small and

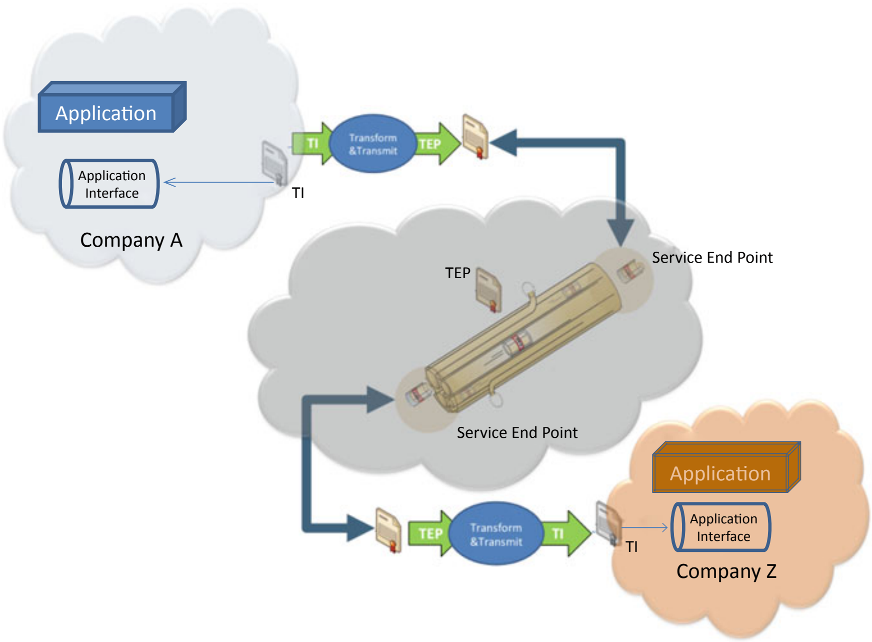


Fig. 16 Interoperability across communities

medium sized enterprises without any ICT systems available, applets exists to provide manual input and output using forms on devices that can be connected to the Internet.

Electronic information exchange in transport has a long history, and many companies have made significant investments in solutions and systems for exchanging information. The GS1 initiative has previously been mentioned. The PapiNet, RosettaNet and Odette in the forestry, the electronics, and automotive industries respectively are examples of communities that have well established internal electronic information exchange.

In order to make it possible for new companies to communicate with these communities, the concept of applets is taken one step further. In addition to working with OASIS/UBL, the developers of the Framework have cooperated with other standardisation organisations and initiatives. The cooperation between EU activities and similar activities in the USA has been documented in a presentation given at the ICT world congress in 2011.[25] Cooperation with CS1 and UN/CE-FACT has resulted in harmonisation of internal message structures. Hence, real-time conversion to and from Framework formats are feasible and a number of

[25] JT Pedersen and MP Onder: Electronic Freight Management: US vs EU, ITS World Congress, Orlando, October 2011.

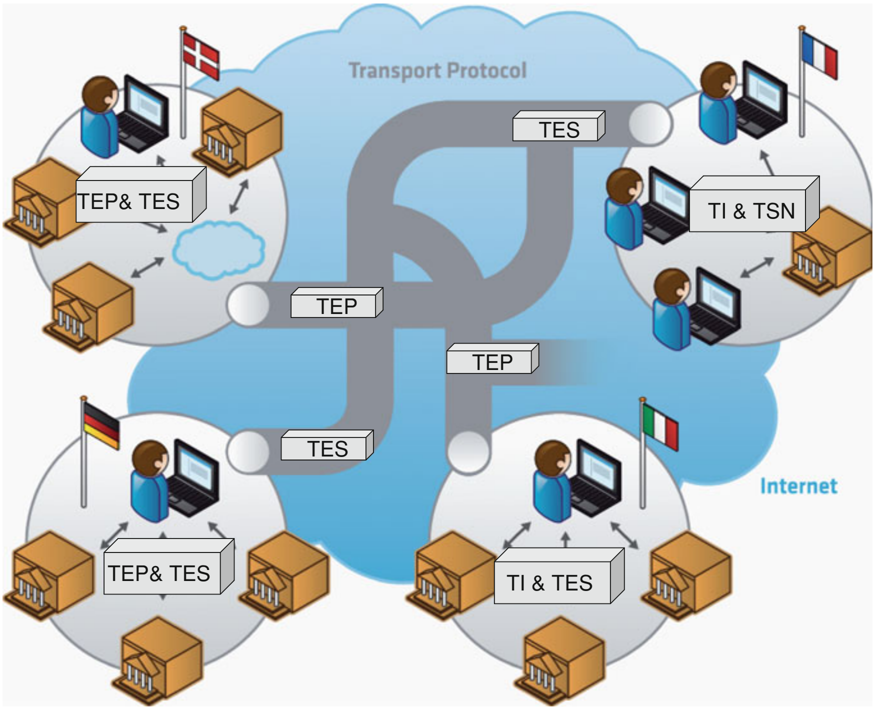


Fig. 17 e-Freight provides interoperability between communities

applets exists for making such transformations and transmissions. An example is shown in Fig. 16.

Here Company A in one community (using Transport Instruction—TI) needs to communicate with Company Z in another community also using TI. The applets available provide the following function: The IT from Company A is transformed into a TEP and the TEP is communicated to Company Z over the network. When received by Company Z, the TEP is transformed into the TI format of the community to which Company Z belongs and can be directly used by Company Z.

Similar transform and transmit exist for all of the Framework messages, with the exception of the TSD and GII, for which there are no equivalents in any other electronic message exchange community for freight transport.

Again using the TEP messages as an example, the principle in Fig. 16 will result in a global interoperation regime as shown in Fig. 17.

Members of Community Z have also downloaded a web service form the e-Freight Platform, this time transforming real-time form TEP to the Community Z version of the TI. "in the middle", there is a web service that transmits TEPs within the e-Freight community. Stakeholders being a member of the e-Freight Community do not have to use any web services performing transformations.

As mentioned above, the EFM and e-Freight messages are being harmonized. Hence, the transformation needed between EFM and e-Freight will be minimal.

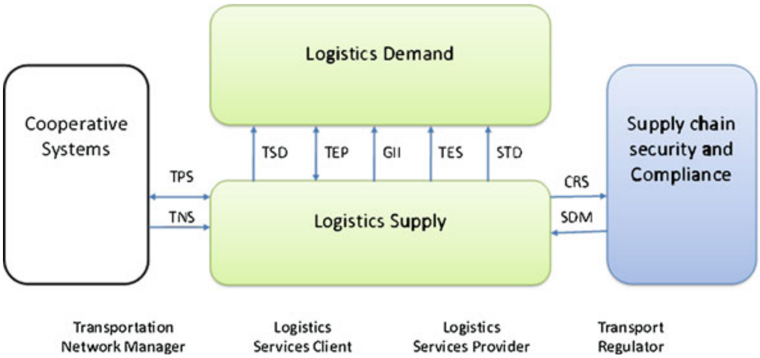


Fig. 18 Common framework summary

The US DOT and EU are working to establish a joint pilot for transport between Europe and the USA to verify that the common approach to interoperability really works.

8 Common Framework Summary

The ambition of the Common Framework is that it shall be able to communicate necessary and sufficient information between the stakeholders involved in freight transport management. Figure 18 shows the elements of the Common Framework:

TSD Transport Service Description—a standard description of transport services suitable for automatic detection;

TEP Transport Execution Plan— describing all the information needed related to the execution of a transport service;

GII Goods Item Itinerary—providing information about the movement of the goods (possibly through a chain of services);

TES Transport Execution Status—providing information about the progress of the transport and of the cargo condition;

STD Standard Transport Document—providing a multimodal eWaybill signifying that an agreement to transport cargo has been reached;

CRS Common Regulatory Schema—providing a unified way of informing authorities about transport such that compliance may be verified;

SDM Security Data Message—providing information about the security of a sealed load unit;

TPS Transport Progress Status—assisting in establishing the best possible arrival time estimates;

TNS Transportation Network Status—not suggested as a new standard, but a pointer to messages providing such information for the different transport modes.

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ICT Support for Intermodal Transport Chain Development

Christine Behnke and Bertram Meimbresse

Abstract The growth of freight transport in Europe seems to be connected to the increase of the GDP. The uppermost of the freight growth is covered by road transport. Therefore the European Commission started some initiatives to promote intermodal or co-modal freight transport and related supporting mechanisms to either optimize or to shift road freight to other modes. A focal point is the implementation of Intelligent Transport Systems. But the market actors have heterogeneous requirements regarding the exchange and provisions of information. The chapter describes first approaches of intermodal transport chain development tools and gives an outlook about the necessary next steps.

Keywords Intermodal transport · Information systems · Sustainability · Freight

1 Introduction

The transport industry holds an important role in the economy of the European Union and accounts for about 7% of the GDP and for about 5% of employment (European Commission 2006). The growth rate of freight transport performance in ton-kilometres within the EU in the period 1996–2008, at a rate of 2.6% per year (without the crisis years 2008 and 2009; with this years it would have a rate of only 1.3%), was broadly in line with the economic growth, which was 2.5% on average (European Commission 2011a and Eurostat). For the next decade, forecasts

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establish the average annual GDP growth rate at 2.1% with roughly similar rates for freight transport (European Commission 2006).

Comparing the modal split shares of the different freight transport modes (road traffic, rail traffic, inland navigation, maritime transport, air traffic) a dominance of road freight transport regarding share and growth can be identified. Road freight covers more than 46.6% of the complete EU transport market and 74% of the inland transports without sea. Road freight is also the only partial market with significant growth rates from 1996 to 2008: plus 4.5% inside the complete market and 6.4% for the inland market (European Commission 2011a).

The European transport policy observes this development with concerns. One the one hand a strong freight transport sector is an inevitable precondition for the export economy and the supply of industry as well as population. On the other hand the freight transport should be carried out in a more sustainable and environmentally friendly way. The Commission identified some driving forces behind the ongoing changes: "acceleration of the globalisation of production, insecurity of energy supplies, the increase in global warming and the continental dimension of the EU after enlargement to Central and Eastern Europe" (European Commission 2007). In the new Road Map to the White Paper (European Commission 2011a) the Commission said about passenger and freight transport together: "It is the only sector where greenhouse gas (GHG) emissions have almost continuously grown over the last 20 years and are now about one third above their 1990 levels". Also the high dependence of the transport sector on oil was identified as a serious risk.

Following this argumentation, goals for the freight transport were focused on:

- 30% of road freight over 300 km should be shifted to other modes by 2,030, and more than 50% by 2,050.
- Land and waterborne transport management systems should be deployed as prepared for air.

It is obvious that both goals have to do with intermodality or co-modality. Shifting such large amounts of freight from one mode to another requires capacities and information. Consequently, the Commission adopted the action plan "Intelligent Transport Systems in action" from 2008 to a working programme in 2011 (European Commission 2011b). A key sentence in this document is: "ITS (Intelligent Transport Systems) can also make it easier to link the various transport modes, for example by means of integrated multimodal trip planners or tracking services for co-modal freight transport." This leads to two essentials to be solved before shift more road transport to other modes: (1) where one have the chance to use another mode and who is able to provide the service, and (2) what happens with my freight during a chain of co-modal or intermodal transport processes? The first question addresses the possibility of intermodal transport and the second the reliability. It is the challenge now to provide the very heterogeneous actors in the intermodal freight market applications which can answer the essential questions. A prerequisite for the desired "intelligent" ITS are broad available ICT (Information & Communication Technologies) applications.

2 Requirements on ICT From Market Actors

To make intermodal transport more competitive to road haulage it is important to provide a one-stop-shop to simplify the access to intermodal transport and to provide tracking and tracing information along the entire transport chain for the customers out of one hand. But today a key problem is that information is often isolated in the different groups of market actors. Carriers, railway operators, terminal operators and freight forwarders, all have their own IT system and standardised interfaces between them are not available (ECO4LOG 2005a). In general applications for planning, management and control/monitoring of whole intermodal transport chains are needed by the transport and logistics service companies. This leads to the need for interconnected complex but also flexible applications. Each market actor has different requirements. In the following requirements of large intermodal transport operators and of small and medium-sized enterprises of the intermodal transport market as well as intermodal terminals will be characterised separately.

2.1 Large Intermodal Transport Operators

Large logistics companies often have ubiquitous well-established ICT systems. But there is also room for future improvement. A survey where key account managers were interviewed identified the following deficits and plans for improvements, which have in common that these are only for in-house purposes or only in cooperation with contractors (ECO4LOG 2005b):

- Collaborative supply and demand planning
- Supply chain risk management
- Supply chain financial management
- Support for combined (intermodal) transport and distribution facilities
- Knowledge management to improve skills and knowledge of employees

2.2 Small and Medium Sized Transport Operators

Small operators often face problems with automatic communication and experience information gaps. They usually have isolated manually information systems that are not connected automatically with partners or other companies (CLISME

2001). SMEs have in general only very limited resources for the improvement of ICT systems. They need efficient information systems to support chain organisers, cooperation partners, terminals and intermodal networks, e. g. to provide a persistent information flow for the whole transport chain to their customers and to get easy access to the whole intermodal market to carry out and develop their own business. Within a survey the following priority areas were identified for future improvements (CLISME 2001):

- Transport planning and scheduling as well as online booking process;
- Transport control/monitoring;
- Management reporting.

2.3 Intermodal Terminals

Intermodal terminals are connecting the different transport modes of an intermodal transport chain as they are the place where the freight is transhipped from one transport carrier to another. In general terminals have ICT systems oriented on processes inside the terminal, like management of storage capacities and handling equipment. But they can contribute significantly to the information flow of the whole intermodal transport chain with benefits for all market actors of the transport chain:

- Information about other market actors, transport networks and demands supports the establishment of business contacts and intermodal networks (especially important for SME);
- Information about technical equipment, organisational procedures and real time capacities supports the efficient planning and integration of the terminals in intermodal transport chains;
- Status information about cargo and loading units supports the monitoring of the intermodal transport chain.

The major IT needs for future improvement and resulting priorities at intermodal terminals are shown in Fig. 1.

The TOP priority need for web-based intermodal planning tools means the connection of the planning of transport and transhipment processes by integrating both in one ICT application with the aim to shift transport from road to alternative transport modes. Resource management tools at terminals concerns especially activities and equipment of the handling process (loading and unloading). Safety and security of transport chains includes applications for tracking and tracing of cargo and risks as well as physical security at terminals. More interconnection with

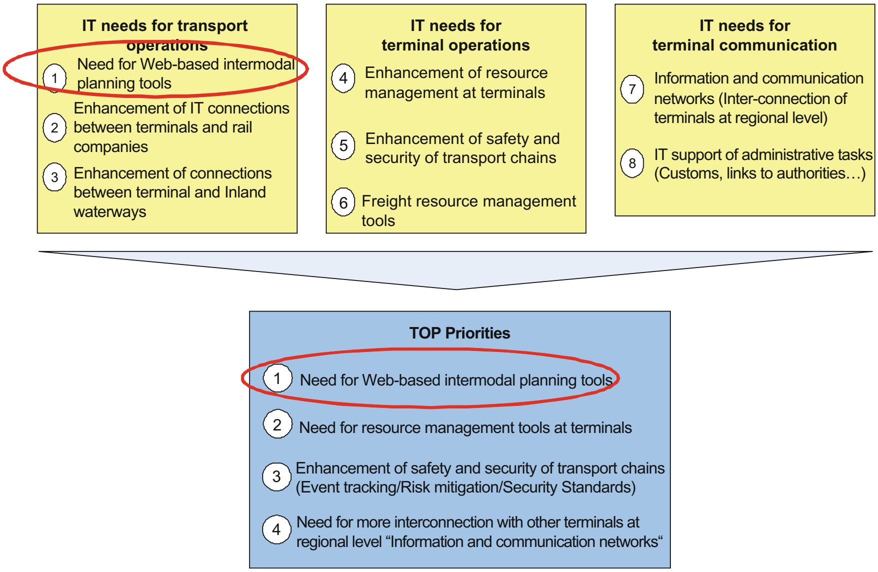


Fig. 1 Identified IT gaps and resulting TOP priorities in intermodal terminals (ECO4LOG 2006)

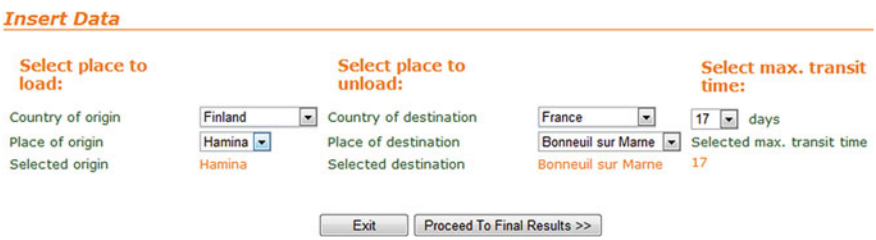
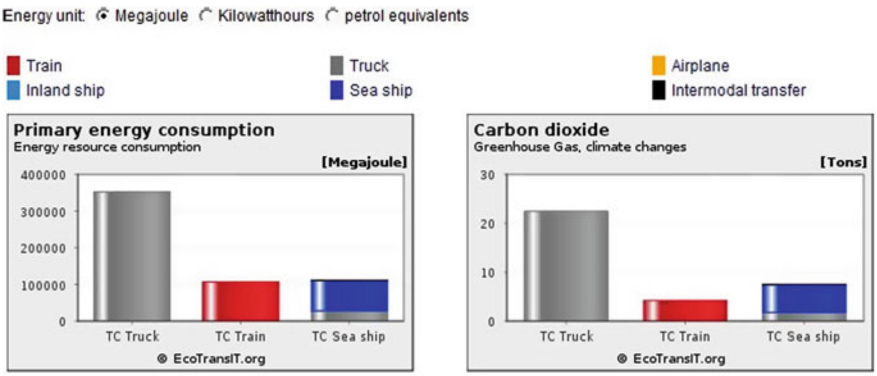


Fig. 2 BeLogic European intermodal route finder—data input mask

other terminals means enhanced cooperation and networking of terminals to improve productivity and promote intermodality.

3 Applications for Intermodal Transport Planning

Considering the before described different needs of the market actors and the identified priorities focus of this chapter will be applications for intermodal transport information and planning. In the following different existing tools will be shortly described and evaluated by several criteria. Most of them have been developed within research projects.



Primary energy consumption
Energy resource consumption
[Megajoule]

	TC Truck	TC Train	TC Sea ship
Truck	351.945	0	27.907
Train	0	106.648	0
Sea ship	0	0	82.836
Intermodal transfer	0	0	712
Sum:	**351.945**	**106.648**	**111.455**

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Carbon dioxide
Greenhouse Gas, climate changes
[Tonnes]

	TC Truck	TC Train	TC Sea ship
Truck	22,423	0	1,763
Train	0	4,216	0
Sea ship	0	0	5,671
Intermodal transfer	0	0	0,042
Sum:	**22,423**	**4,216**	**7,476**

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Fig. 3 EcoTransIT result presentation

3.1 BeLogic European Intermodal Route Finder

BeLogic is a collaborative project co-funded by the European Commission in the scope of the 7th Framework Programme for Research and Development (September 2008–February 2011). Aim of the project is to improve the quality and efficiency within and across different modes of transport, by means of benchmarking in logistics and co-modality.

Within the scope of the project a European intermodal route finder was developed which is available at www.be-logic.info. The user has to select origin and destination of the route (each with country and place out of a given list) and optionally a maximum transit time. As result the tool gives a list of possible connections with total transit time, mode per transport segment and transhipment terminal (if applicable) (Fig. 2).

3.2 DISMOD

DISMOD is a planning tool developed by the Fraunhofer IML for planning, optimising and restructuring supply chains. It includes optimisation of locations, optimisation of capacity utilisation and planning of distribution districts.

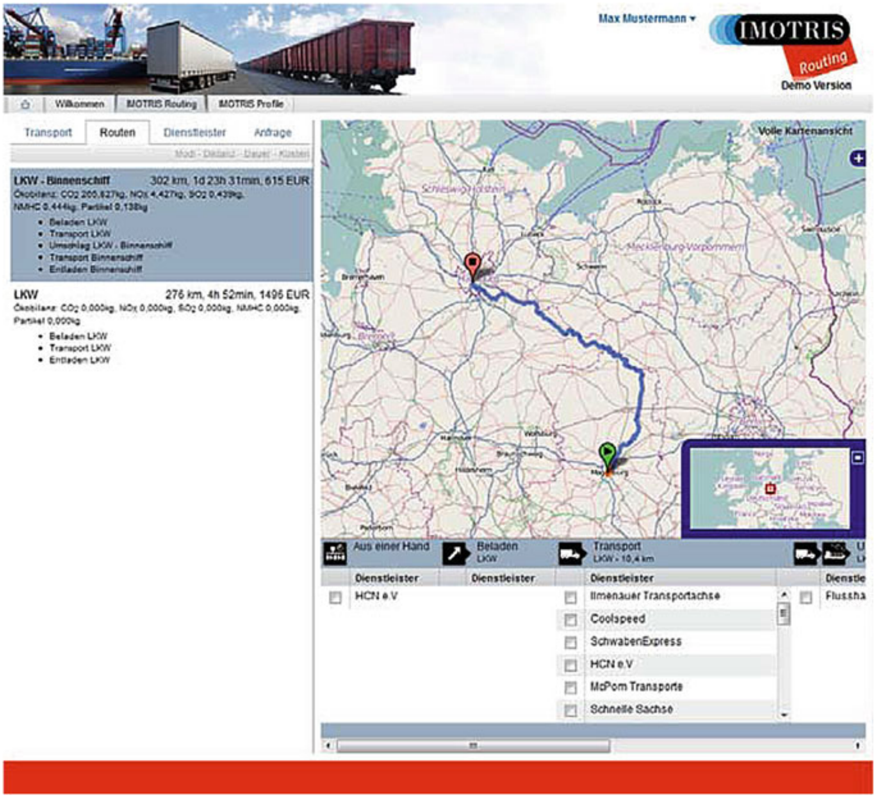

Fig. 4 IMOTRIS result presentation (SoNorA 2011, update by scheller systemtechnik)

3.3 *EcoTransIT*

EcoTransIT is an ecological transport information tool available at www.ecotransit.org. It calculates environmental impacts of any freight transport by rail, road, ship and aircraft in any combination. It is developed by the Institute for Energy and Environmental Research Heidelberg and the Rail Management Consultants GmbH initiated by a number of European railway companies in the year 2000. Aim of the tool is to determine the energy consumption, CO_2 and exhaust emission for the transport covering also the indirect energy consumption and emissions related to production, transportation and distribution of energy required for operating the respective vehicles and takes also into account the different technical standards of vehicles. A simple GIS-system details the route segment for each transport mode. The result of each calculation is presented in diagrams showing the energy consumption and emissions of different environmental pollutants and comparing different transport modes (Fig. 3).

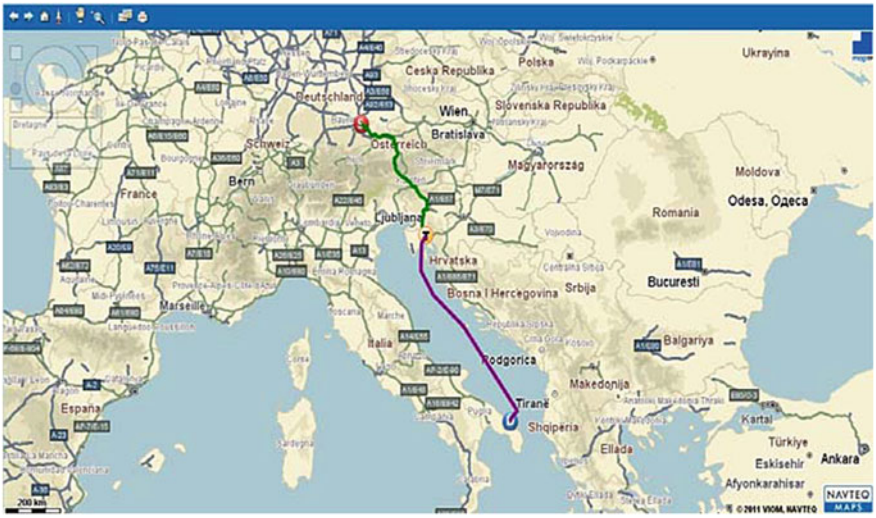

Fig. 5 SoNorA-Tool map presentation of routing result

3.4 IMOTRIS Intermodal Transport Routing Information System

IMOTRIS is a German R&D project supported by the Federal Ministry of Economics and Technology developed by Scheller Systemtechnik GmbH, Fraunhofer Institute for Factory Operation and Automation, University Hamburg-Harburg and Fraunhofer Institute for Computer Graphics Research.

Aim is the optimisation and development of new international transport chains within Europe via the Baltic Sea ports by using an automated intermodal transport routing information system. The system calculates optimal transport routes for freight in terms of service provider availability and capacity, transit times and ecological factors.

On the one hand it acts as sales and marketing platform for service providers and on the other hand it offers automated routings and listing of service providers meeting the requirements of shippers. The system compiles and optimises transport chains consisting of different service providers (Fig. 4).

3.5 SoNorA-Tool: Intermodal Routing

Within the scope of the European Unions project SoNorA (implemented through the CENTRAL EUROPE Programme co-financed by the ERDF) a web-based IT-tool for the evaluation of intermodal freight nodes and networks was developed, based on the existing ECO4LOG/interim IT-tool. This includes as one of the basic functions intermodal routing. The tool includes inland navigation-, railway-, street-, short sea shipping- and ferry-network of all European countries. The user

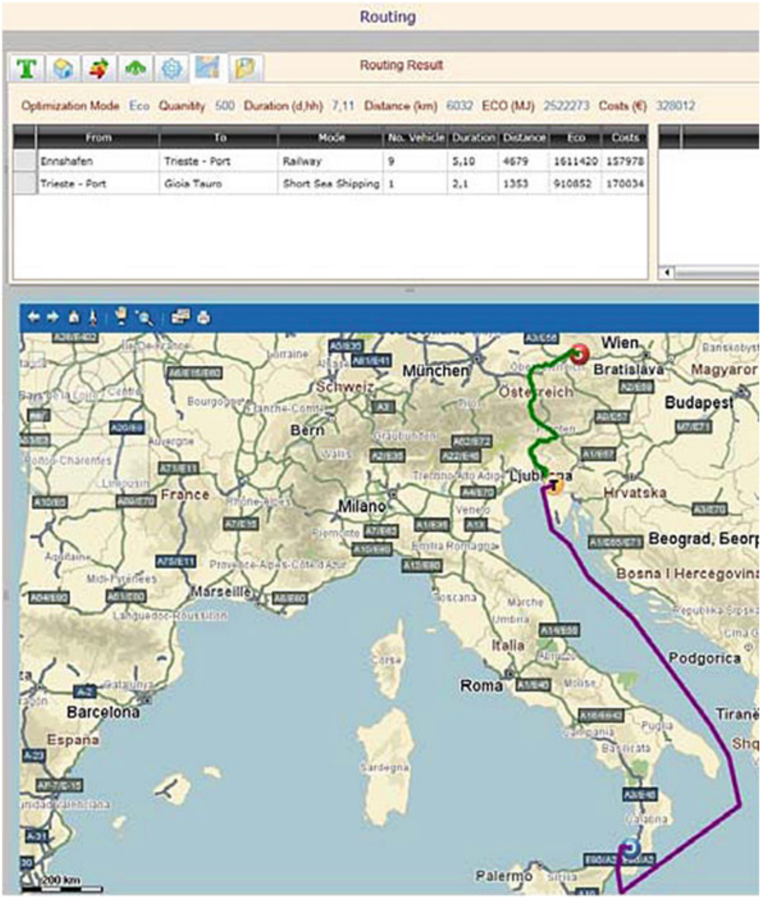

Fig. 6 Intermodal routing result (*top* part table, *bottom* part routing)

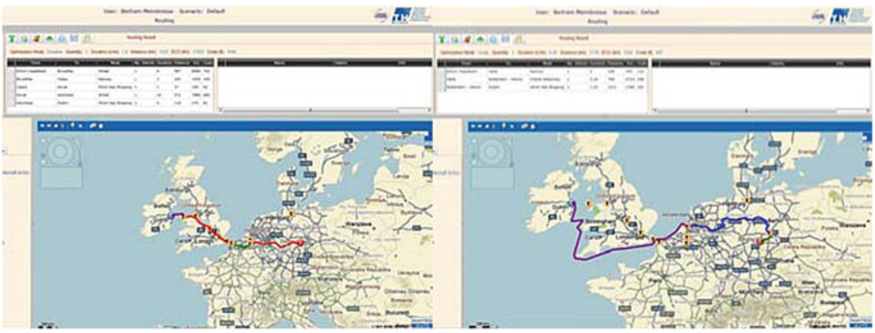

Fig. 7 Routing results for optimisation in terms of duration (*left* side) and optimisation in terms of costs (*right* side)

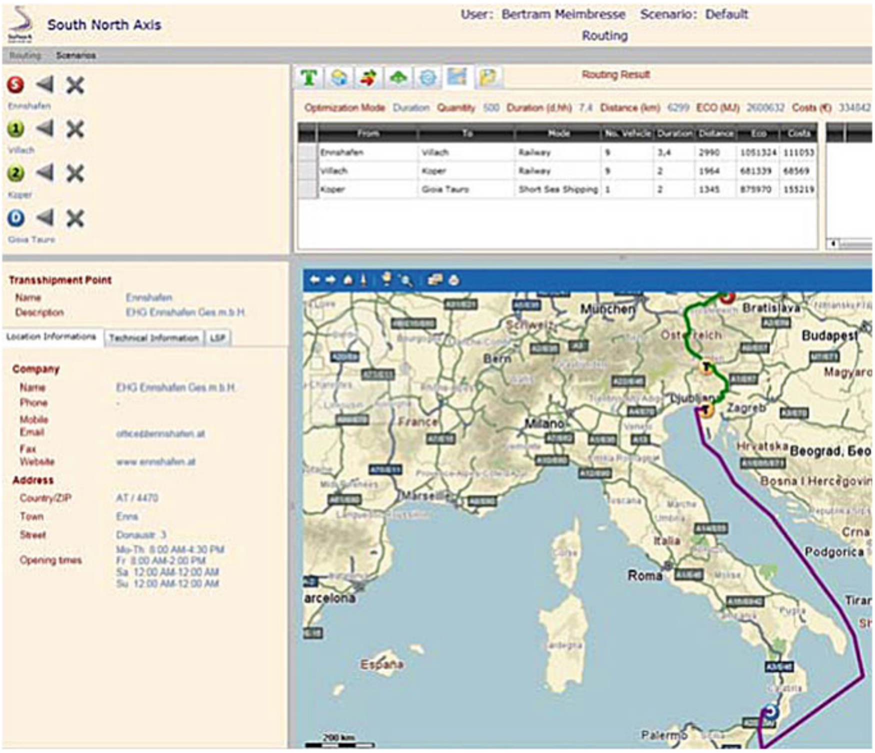

Fig. 8 Routing result with 2 stopover terminals

can choose between the routing between intermodal terminals or free addresses, with up to two defined stopover terminals. It is possible to calculate various routings of alternative intermodal logistics chains in terms of minimised time, distance, costs and energy consumption.

The tool offers the possibility to include fixed relations in the routing process (already existing intermodal service offers operated by a transport operator). Result of the routing is a map and a list showing the used sections per transport mode and values of the routing result are given (duration, distance, energy consumption, costs). Furthermore the tool provides comprehensive terminal information, e. g. number of gantry cranes or reach-stackers, opening hours, special goods, container storage, etc (Fig. 5).

3.6 Evaluation of the Applications for Intermodal Transport Planning

In the following the before described applications will be evaluated and compared to each other (Table 1).

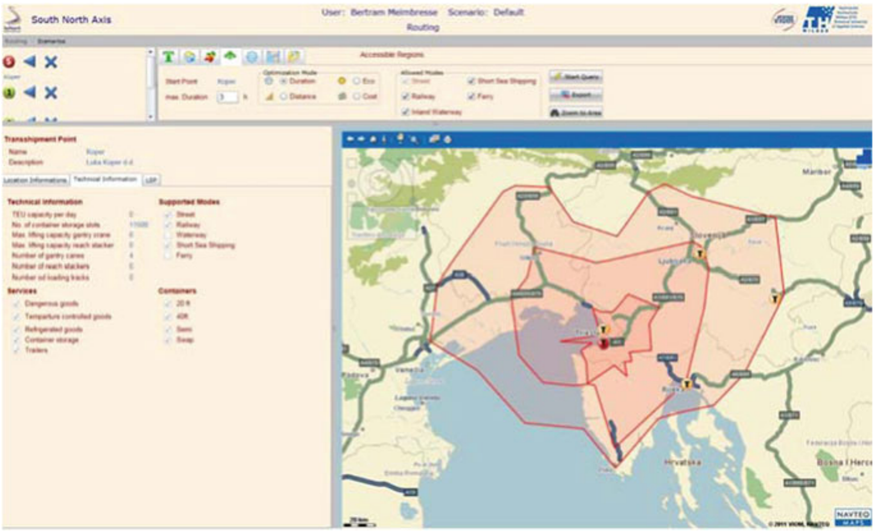

Fig. 9 Result of accessibility analysis (iso-chrones of 1, 2 and 3 h travel time)

In the following functions, examples, user benefits and further developments will be described using the example of the SoNorA-tool.

4 In Depth Analysis of Functions

Applications for information and intermodal transport planning in general consist of a database (normally infrastructure network database) and an algorithm for the calculation of routes. For intermodal applications the infrastructure network database includes several networks of millions of network segments: ferry network, inland waterway network, rail network, road network and short sea shipping network. To each network segment several attributes are attached, e. g. costs, distance, energy consumption, velocity, delay times, direction (Sonntag et al. 2009). To connect these single networks with each other nodes are needed: the intermodal terminals serve as transhipment points from one network (transport mode) to another.

For the calculation of transport routes a shortest path routing algorithm is implemented, using the respective attributes for the different optimisation criteria (e. g. for optimisation in terms of costs the attribute costs will be used, for optimisation in terms of time the attributes distance, velocity and delay times will be used) (Sonntag and Meimbresse 2006). In the last century several routing algorithms for the calculation of the shortest path in networks have been developed. The first shortest path algorithm was the algorithm of Dijkstra (Dijkstra 1959):

Fig. 10 Example for changeable attributes in the scenario

This algorithm provides the shortest path from one start node *s* to another destination node *d* if the attributes of the network segments are not negative. The A* algorithm is an enhancement of the algorithm of Dijkstra considering only segments that are likely on the shortest path. This A* algorithm is a fast method but needs a heuristic guess about the distances to the destination node *d*. Other algorithms to calculate shortest paths are the Bellman-Ford algorithm (used for networks with negative attributes, slower than Dijkstra algorithm) and the Floyd-Warshall algorithm (finding shortest paths between all pairs of nodes) (Cormen et. al. 2001). Another algorithm is the Ant colony optimisation algorithm, but it cannot assure that the shortest path will be provided (Dorigo 2004). Therefore the algorithm of Dijkstra was selected for implementation in the intermodal routing of the SoNorA tool as in general in transport networks no

Table 1 Evaluation of applications for intermodal transport planning

	BeLogic	DISMOD	EcoTransIT	IMOTRIS	SoNorA
Transport modes	Inland waterway, rail, sea,	Inland waterway, rail, road (only routing per mode)	Airplane, inland waterway, rail, road, sea	Inland waterway, rail, road, sea	Ferry, inland waterway, rail, road, short sea shipping
Geographical coverage	Europe	Europe (road)	World	Europe (but with constrictions)	Europe
GIS based	No	Yes	No	Yes	Yes
Target group	Shippers	Shippers	Shippers, logistics service providers	Shippers, logistics service providers	Transport planners, logistics service providers
Optimisation criteria	Ordered by time	Costs	Environmental impacts	Costs, distance, energy consumption, time	Costs, distance, energy consumption, time
Available via internet	Yes	Commercially	Yes	Yes (registration necessary)	Yes (registration necessary)
Operational/ strategic	Operational	Strategic	Strategic	Operational	Strategic
Main advantage	Very easy and fast handling	Comprehensive cost functions	Comprehensive evaluation of environmental impacts	All presented results are existing offers of logistics service providers	Presented results are possible (optimised) transport routes based on the available transport network
Main		disadvantage	Only search in defined routes	Not really intermodal	Presents not transport route
Very strong		dependency on cooperation of logistics service providers	No offer for resulting transport route may be available		

negative attributes have to be expected and only the one shortest path between start node *s* to destination node *d* has to be found.

In the calculation of the shortest paths between start node *s* and destination node *d* with the algorithm of Dijkstra the “distance” (distance is used as synonym for all different optimisation criteria) towards start node *s* and the predecessor node of each already considered node is stored. The distance towards start node *s* is the addition of the distance of the predecessor node to the start node *s* and the edge length between the actual node and the predecessor node. Only shortest distances to a node will be stored, longer distances will be rejected. Always the node with the shortest distance to the start node *s* will be considered next. The algorithm has found the shortest path between start node *s* to destination node *d* if distances from all other nodes to start node *s* are longer than the distance between destination node *d* and start node *s*. To consider also costs, distances, energy consumption and times for the transhipment in intermodal terminals, which is essential for the calculation and comparison of different transport alternatives or paths in the network, (virtual) segments representing the connections to the infrastructure networks, weighted with attributes for distances to cover, transhipment times, costs and energy consumption for handling operations inside the terminal, were integrated (Meimbresse and Lipinski 2007). Based on the infrastructure networks and the routing algorithm the SoNorA tool consists on the following functions.

4.1 Basic Intermodal Routing

Intermodal transport routes between terminals as well as between free addresses in whole Europe on the basis of infrastructure networks and terminals can be generated and are displayed in two ways: GIS based and list based. In general the calculation of the intermodal transport routes follows the algorithm described above (Fig. 6).

4.2 Alternative Routes

With the tool different route alternatives can be calculated by optimising in terms of costs, distance, energy consumption and time. To compute the different values the routing algorithm addresses the relevant attributes of the network segments in a database. This means that all network segments should be equipped with the attribute regarding transport costs, average velocity (with the length of the segment transport times can be computed easily) and energy consumption for a normal traction. The length of the segments is normally provided by the Geographic Information System with which the networks were created. To address the different types of the segments of a specific network (e. g. road) attribute categories can be used for segments with higher capacity, velocity, etc. and segments with minor relevance. It is recommendable to insert attributes with exact figures from traffic counts in the database, but if a network consists of millions of segments the usage of average values per segment category is the only reasonable way to fill the database and to give the routing algorithm all necessary data (Fig. 7).

4.3 Routing With Stopover Terminals

Up to two terminals as stopover for the start—destination relation can be defined in order to make payload possible or to prefer specific transport corridors or transhipment terminals. The technique to provide the user with the possibility to define stopover points and compute the routing with these points is simple: instead of one routing from the start node/terminal *s* to the destination node/terminal *d* two or more routings will carried out by the tool, dividing the complete route in part routes. After the calculation of all part routes the results will be added and displayed together. It should be mentioned that such a splitting in two or more routings needs also more computing capacities (Fig. 8).

4.4 Routing with Fixed Relations

In the application are already included existing intermodal service offers executed by a transport operator, these can be selected and will be considered in the routing result, only pre- and post-transport will be calculated individually. The existing intermodal service offers are inserted in the database as temporary segments of a separate network. Those segments are called "fixed relations" and are connected with the start and destination terminal of the service provided. Since usually no information of the exact train path is available (depends on the capacity planning of the infrastructure owner and are subject of change) such segments are implemented as direct lines between start and destination terminal. To give the user additional information those segments are attributed with the name of the transport operator and an internet hyperlink to the homepage of the operator. The missing data about the "fixed relations" hampers the comparability with other routings without "fixed relations". A useful approach to solve the problem partly can be to integrate the time schedules of the operators in the database or to provide interfaces to the relevant internet resources.

4.5 Information

Information of intermodal terminals, logistics service providers of fixed relations as well as values of the routing results per routing segment (costs, distance, duration, and energy consumption) are presented in the application. The tool provides this information in the context of the routing. Links to other parts of the database give the users the opportunity to inform themselves about technical capacities, like number of cranes, reach stackers, container storage, etc. in any selected terminal.

5 Current Developments of the SoNorA-Tool

Besides the intermodal transport routing the SoNorA-tool has additional functions which are described in the following section.

5.1 Accessibility Analysis

Now the tool can compute accessibility measures of intermodal terminals or free addresses regarding the different optimisation criteria (costs, distance, duration, energy consumption). The question that will be answered is: How far can one transport unit be transported from the start point in each direction within the given value (e. g. 3 h) using all possibilities of intermodal transport. Result of the accessibility analysis is a map showing the reachable area within 33, 67 and 100% of the given value and indicating the reachable intermodal terminals on the map and in a list. After the selection of a start point by a user the tool defines automatically a set of virtual destination points around the start point and with a distance which cannot be reached with the given value anymore. Then the tool starts a set of intermodal routings from the start point to all destination points. During the computing process the tool stores in a temporary database how far the specific routing can go without exceeding the given value. Finally the founded maximum points in all direction are connected by lines and visualised as iso-curves. Such accessibility analyses can provide insight in spatial interdependencies and enable decision makers to analyse the reasons of a bad accessibility measure in general or for a specific direction. The computed iso-curves are helpful as an information as it is, but in combination with the possibility to change the network attributes or to add/delete network segments this feature is able to provide results of pre-/post analyses, case studies and scenario comparisons (Fig. 9).

5.2 Creation of Network Scenarios and Change of Global Attributes

The latest development of the application is the possibility to create scenarios by changing the infrastructure networks and attributes/parameters of the nodes (intermodal terminals) of the default (reality). It is possible to:

- edit parameters/attributes of terminals (e. g. access to infrastructure networks);
- add new terminals;
- delete terminals;
- edit parameters/attributes of infrastructure network segments (e. g. velocity);
- add new network segments;
- delete/disable infrastructure network segments.

With these modifications in a scenario changes in the situation of the intermodal network can be simulated, e. g. changes in infrastructure of a terminal, extension of a terminal, building of a new terminal, alternative locations of a terminal, change of terminal access public/private, improvement of a transport link, building of a new transport link and obstacles on a transport link. As the complete networks and databases must be duplicated to open a scenario and shall run in parallel to the “mother” scenario (default networks and databases) the operation of scenarios is extremely resource consuming in terms of server storage capacity and calculation velocity. Therefore, the tool can only manage up to 5 scenarios in parallel. Created scenarios can be published to other users and files can be uploaded, which e. g. describe the scenario, the idea and the changes made. Furthermore the scenario with its changes can be evaluated and automatically compared with the default (unchangeable)”mother” scenario. Previously by the user defined routes as well as accessibility analyses will be calculated both, on the scenario and the default. Results are shown as map and list. Another feature implemented in the scenario framework is the possibility to change global attributes of the networks and nodes/terminals. With this changes developments on a macro-level can be evaluated, e. g. the reduction of the energy consumption of a certain transport mode. Such scenarios can reveal the effects on the transport chain development by technical improvements of motors and new regulations (Fig. 10).

6 User Benefits and Case Examples

Users of intermodal transportation services as well as logistics service providers shall be supported by the tool in their strategic planning of transportation by reliable information about intermodal transport facilities and infrastructure networks.

With the different optimisation criteria the users of the application shall be enabled to choose between a number of alternative transport routes and modes.

In Table 2 problems, the dedicated user groups and benefits of the tool are shown.

In the following some case examples will be presented to show benefits and possible usage of the tool with practical examples. The first example (see Fig. 11) shows the different routing results for the relation Erfurt-Vieselbach (DE)—Dublin (IE). With the optimisation criterion energy consumption the used transport modes are railway and short sea shipping. In the optimisation in terms of distance road, railway and short sea shipping are used.

Table 2 User groups, problems and benefits

Problem	User group	Benefit
Missing knowledge about infrastructure (especially in foreign countries)	Logistics service providers Transport chain planners	Fast access to actual information
Deficient knowledge of intermodal transport and intermodal infrastructure	Development agencies	Access to information and widened knowledge regarding intermodal transport and spatial planning
	Planning authorities International, national, regional and local public organised agencies Private organised agencies	Get a general but also possible detailed overview of the involved infrastructure with its parameters
Deficient knowledge about intermodal market and offers	Customers	Fast overview of the intermodal transport market out of one hand Contact information of logistics service providers
Insufficient consideration of transport alternatives	Logistics service providers Transport chain planners	Routing results based on different optimisation criteria (costs, distance, duration, energy consumption)
Low publicity of technical and economical performance	Terminal operators	Widespread information
Contacts to transport chain planners	Logistics service providers	Platform to present their offers (fixed relations)
Deficient knowledge about possible partners in the intermodal sector	Logistics chain organisers	Information about offers and contact to the logistics service providers
Deficient knowledge about impacts of possible future changes and investment in the intermodal terminal and infrastructure network	Spatial planners Administrations Logistics service providers	Evaluation of impacts and influences to intermodal transport chains Increased understanding of impacts of investments in terminals and network facilitates effective investments

The next example (see Fig. 12) shows an accessibility analysis: how far one transport unit can be transport from the start point Genoa-Voltri (IT) with 110 € transport costs. Five intermodal terminals (symbol: T in a yellow circle) can be reached within the given value.

For the last example a scenario was created were a new railway network segment due to the construction of the new Gottbard Base railway tunnel was inserted. Figure 13 shows the result of a comparative intermodal routing from Luzern (CH)

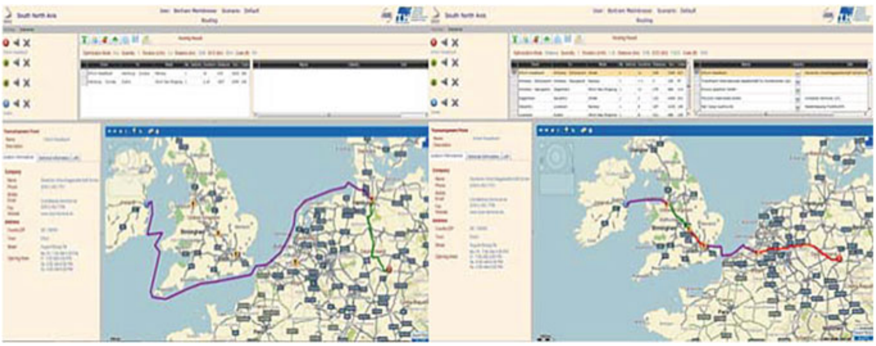

Fig. 11 Routing results Erfurt-Vieselbach—Dublin, optimisation criterion: energy consumption (*left* side) and distance (*right* side)

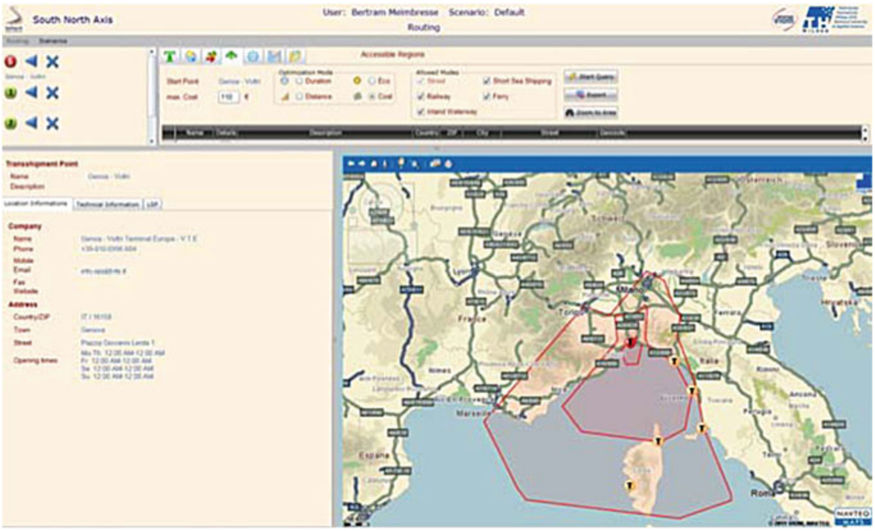

Fig. 12 Accessibility analysis from Genoa-Voltri with 110 €

to Bioggio (CH). The route on the scenario (with Gottbard Base) is faster, less energy consuming, cheaper and shorter.

7 Outlook

The European transport industry has over a long time demonstrated that it was able to cover market dynamics and implement innovations. New ICT technologies—like the Internet, cellular phones and the GPS—have been used by the transport

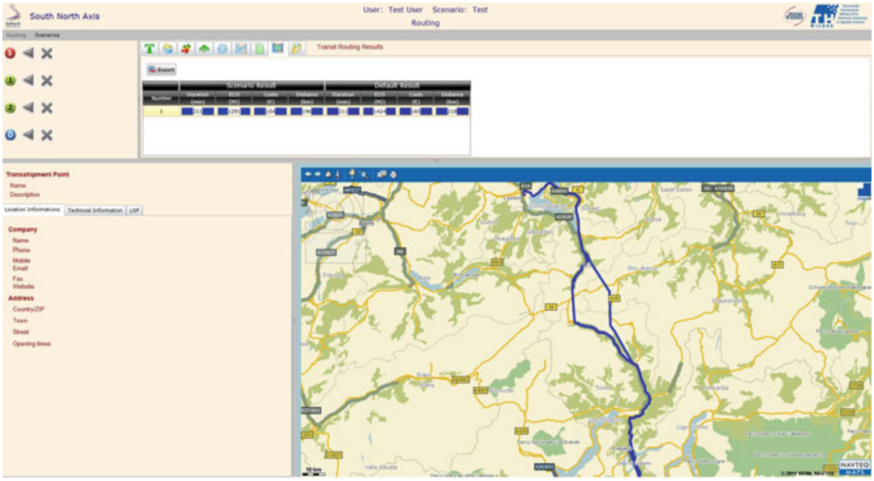

Fig. 13 Comparative routing Luzern—Bioggio, *light blue* (route on the *right* side) is the route used in the scenario, *dark blue* (route on the *left* side) is the route used in the default

industry short after availability at low costs. On the basis of such common available basic technologies specific ICT-based logistics services (e.g. tracking & tracing, transport resource planning) have been designed, developed and implemented. Nowadays and in the near future, the major challenge will be to provide and share information to and in the different systems. To rise the attractiveness and efficiency of intermodal transport all market actors of the intermodal transport chains must provide clear and precise information about transport units, transport and transhipment capacities, possible risks on transport routes and information about the status of the transport process of the whole intermodal transport chain preferably out of one hand. Interconnection of ICT applications with automatic information flow between all concerned market actors is very important for this and can be a first step for Intelligent Transport Systems (ITS) in the freight sector. The share and provision of planning, tacking & tracing and capacity information is a must for the optimal usage of all available transport modes, will be one of the key topics to be tackled by the transport industry. Door-to-door freight transport planning and monitoring is a principal problem in today's intermodal transport. Due to competition reasons, there is no adequate commercial approach on the European transport market available capable of either easing intermodal transport planning or tracking and tracing intermodal flows en route. Although the SoNorA-tool has already many different useful functions included, there is still room for further developments. What will be really needed for the next enhancement step of intermodal transport planning applications are the consideration of train and barge schedules and the integration of tracking & tracing data to justify the underlying planning data on a continuous basis. Within the scope of the European Unions project FLAVIA (implemented through the CENTRAL EUROPE Programme co-financed by the ERDF) the inclusion of schedules and tracking and tracing for intermodal trains will be realised in the SoNorA tool until 2012. This will be a step forward to a more operational tool.

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Eurostat, online statistics: GDP and main components

Design Methodology and an Integrated Decisions Support System for Sustainable Transportation Plans

Jesús Racero, Marta Hernández, Fernando Guerrero and Gregorio Racero

Abstract The transport is one of a major source (15%) of greenhouse gases contributors' and the road transport accounts for 80% of emissions divided equally between urban and interurban. The Sustainable Urban Mobility Plans arise as a shock measure, with the aim of increasing energy efficiency, environmental quality and externalities reduction from the road transport. This chapter proposes a standardized methodology to develop Sustainable Transportation Plan that includes an information system and decision support system (based on indicators) that helps to manages sustainable mobility plans and aid in the evaluation and strategies selections. The system is based on free tools, as geographic information system libraries (GEOEXT), Java programming environment and MySQL database manager in an open distributed system, which are used to support data collection and mobility analysis.

Keywords Decision support system · Sustainable transportation plan · Mobility plans · Standardized methodology

1 Introduction

1.1 Climate Change and Transportation

Climate change may be the most significant issue facing transportation today. Scientific consensus on climate change has grown rapidly in recent years as advances in analysis have been achieved. As evidenced by the most recent draft

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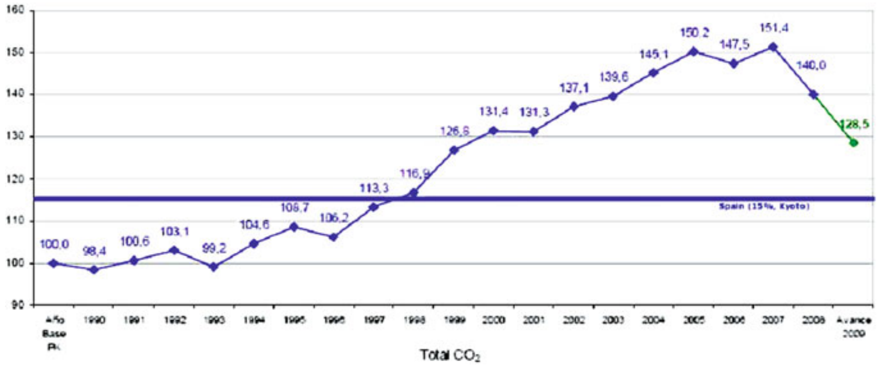


Fig. 1 Greenhouse gases emissions evolution (source Ministerio de Medio Ambiente, 2009)

report of the Intergovernmental Panel on Climate Change (IPCC), the reality of climate change—and the anthropogenic influences on that change—is now broadly accepted by both national and internationally-recognized scientific organizations and governments. The Kyoto Protocol agreement, that came into effect in 2004 (Fig. 1), established an excess of emissions for Spain of 15% in relation to the emissions of 1990 while in the European Union it was established in an 8%. Nowadays, Spain is placed in a 28.5% in relation to the reference year being the transport sector with the 15% one of the main sources (Ministerio de medio ambiente y marino 2009; IPCC 2007). Analysing the sectors in detail, the studies indicate the road transport as the biggest contributor to the warming from the end of nineteenth century, followed by the aviation. Other means of transport, like the train, have reduced their influence during the last years. The other means of transport (like the rail), have reduced their influence during the last years. The transport is responsible of the 26% of the carbon dioxide emissions (CO_2), the main greenhouse gas, and the road transport is responsible of the third part of this percentage. It is caused by the increasing road and air traffic (which are the most inefficient means) together with the increasing loss of the transport efficiency etc.

Contamination becomes worse for weather situations, thermal inversions and traffic congestion in rush hours. In Madrid, Barcelona and in other Spanish cities year by year during November, December and January the contamination reaches excessive limits that generate irritation of the respiratory tracts and negative effects for health in the long term.

1.2 Transport Situation in Spain

Apart from the consequences derived from the gas emission to the environment, transport generates several adverse effects for people's daily live (externalities). The externalities (pollution, accident rate and congestion) assume nowadays an

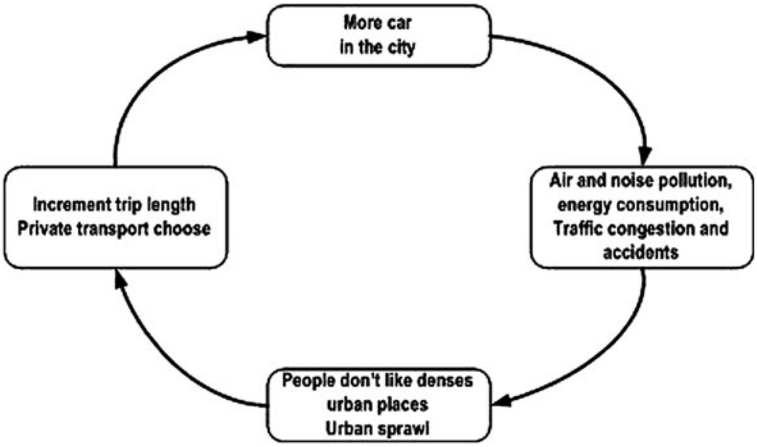


Fig. 2 Mobility effect (source, IDAEa 2006; IDAEb 2006)

8% of the Gross Domestic Product and it is foreseen that it rises until 2012 up to the 12%. The traffic in cities generates the 80% of the noise, as well as it generates insecurity situations to the walking users, being these ones the most vulnerable collective of the road users. A high traffic generates a larger rate of accidents of vehicles and pedestrians, generating a considerable number of dead victims and material damages. This amount of vehicles absorbs a big quantity of urban space too, which is addressed to the vehicles to be able to circulate comfortably, and to be able to park. During the last years, surveys have been developed with the aim of knowing and analysing in depth the characteristics of the transportation in Spain. The results of these surveys can be found in MOVILIA and are published by the MINISTRY OF PUBLIC WORKS/ECONOMIC DEVELOPMENT in relation to "How Spaniards move" (Ministerio de fomento 2007). The main conclusions of MOVILIA show that the number of daily travels is 3 regardless of the town size. The 40% of the travels are for work reason and the main way of travel is the private vehicle (60%). The urban dispersion is one of the main responsible of the increase of the private transportation demand. The congestion and damage of the environmental quality in an area promotes the socio-economic factors as a base towards urban expansion patterns. The urban expansion with low density of population encourages the private transportation caused by the inefficiency of the public transportation that at the same it leads to a massive use of the private vehicle. In Spain, this pattern has been shown in the level of motorization (vehicles per every 1,000 inhabitants) where in the last 15 years the level of motorization has increased from 350 vehicles every one thousand inhabitants until 550 vehicles. Likewise, the level of average occupation of the vehicles is of 1.2 people (Fig. 2).

Given the possibility of reducing the negative impact of the transportation emerge the concept of sustainable mobility which is the base for the development of the plans of the sustainable urban mobility (PMUS) and transportation plans for workers (PTT).

1.3 Sustainable Transport

The term transport refers to the way of travel, that is, the different possibilities of travels that may exist. We have to differentiate then the term "transport" from the term "transportation". "Transport" refers to the collective transfer of people and mobile objects, meanwhile the "transportation" only considers transfers of mechanical type, leaving apart the most important and plentiful social sector: pedestrians. Therefore, a definition of mobility is summarized as the group of transfers that people and goods make for work, formative, health, social, cultural, leisure time or for any other reason. On the other hand, sustainability refers to the needed resources for the development of an activity. The sustainability entails satisfying the needs of the current generation without compromising the possibilities of the ones of the future in order to assist their own needs. Sustainable transport is defined as the transport that satisfies within a reasonable time and at appropriate cost, and minimizes the negative effects on the environment and people quality of life. In the last decade the studies and the interventions have been directed to the increase of energetic efficiency and the environmental quality in many towns. The development of transport plans has not been normalized and some differences among them have appeared which prevent from comparing one plan to the other. In effect the ability was limited to establish common policies of present and future performance in relation to the characteristics of each town. The following work aims to describe the processes of the development of plans of sustainable transport which can be used as reference (rules and norms of performance) in order to increase the energetic efficiency in the urban transport field.

2 Plans of Sustainable Urban Transport

2.1 Plans of Sustainable Urban Transport and Plans of Transportation for Workers

The plans of sustainable transport (PMUS) are defined as a group of stages which have the aim to diagnose the sustainable urban transport in order to propose the establishment of the ways of most sustainable transfers (walking, bikes, public transportation, optimization of the private transportation) in a town. It should be done in a way that is compatible with the economic growth, social cohesion, and defence of the environment (IDAEa 2006; IDAEb 2006). In Europe, this task has been developed in the last two decades by means of the plan of déplacements urbains (PDU, ADEME/CERTÚ 2001) initiated in France in 1982, "the Local Transport Plans (LTP, Department for Transport 2008), the English ones or the Piani Urbani de Mobilitá (PUM, Ministero dei Trasporti 2001) the Italian ones. The Italians ones aim to diagnose, design and to establish the means which increase the energetic efficiency in the transfer and improve the transport.

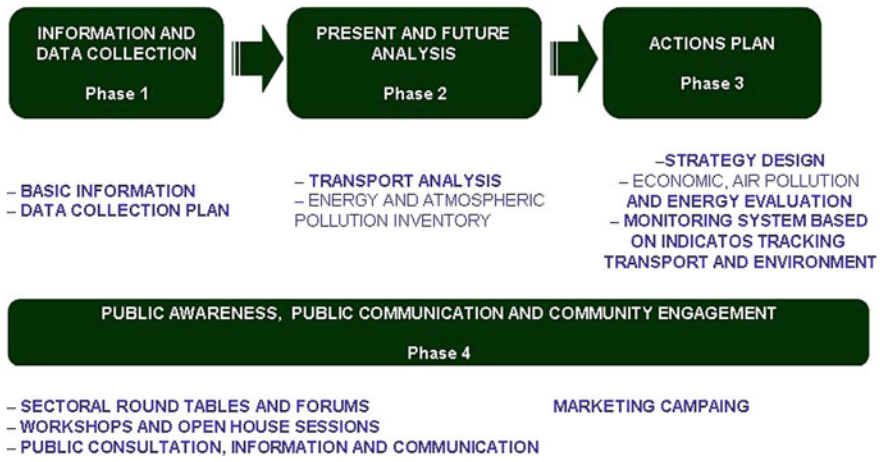


Fig. 3 Stages of transport plans production

Nowadays in Spain two guides are available. In these guides, the stages for the development and establishment of the plans of sustainable urban transport and the plans of transportation for workers are defined.

2.2 Design of a Plan of Sustainable Urban Transport (PMUS plan de movilidad urbana sostenible)

A PMUS can be structured in five big phases (Fig. 3). Although the first four phases usually are developed in a sequential way it is possible that part of the tasks associated to different phases can be executed in parallel. The possibility of executing partial tasks is the result of the subdivision of the phases in work sections, where initially it is executed an individualized analysis by sections (diagnosis) in order to execute subsequently a partial altogether analysis, grouping sections, and total one. The sections to take into consideration are:

- **Social-economic aspects and road uses**. The social-economic structure of the town is crucial for the analysis of the transport demand to identify the places that attract and generate trips (uses of the road), the localization of the educational, health care, economic, commercial and industrial activities and even the collectives and associations existing in the town. It is important for the subsequent analysis of the influence in the transport.
- **Private vehicle transport**. The private transport includes parking place, transport demand, accessibility to towns and centres (educative, administrative, and health care) or areas and of course the road network (offer).

- **Public transportation transport**. The collecting data, diagnosis and performances in relation to public transport lines which include information associated to the routes, stops, accessibility, coverage, information level. To sum up, the aspects that affects the competitive of the public transport system.
- **Pedestrian and cycling transport mode**. The collecting data, the diagnosis and performances in relation to the cycling transport, pedestrian and transportation of goods are interrelated. Although the diagnosis can be developed in an independent way, with some common parts, it is recommended to apply a joint treatment so that the performances, in any of these fields, pay special attention into themselves being necessary the complementation of correction performances and reducers of the negative effects.
- **Cycling transport**. The collecting data, diagnosis and performances are associated to know the used routes, the typology of the transfers, parking and timetables. Analysing the opportunities, weaknesses, threatens, and strengths that the town provides for a cycling transfer.
- **Pedestrian transport**. One of the priorities is the promotion of the pedestrian mode for which is necessary to gain space for the pedestrian, detect, and solve insecurity vial problems so in a way it becomes a securer and more comfortable mean of transport in short distances.
- **Transportation of goods (urban logistics)**. The transport of merchandise accounts until the 25% of the transfers in the towns (city logistics). An organization, procedure and regulation of the transportation of goods help to improve the mobility, the environmental quality and the energetic efficiency of the group not only from the general point of view but also from the particular point of view of the truck drivers.

Each phase of the PMUS is composed by work stages where the processes and the activities to develop are defined stages. The results of each phase are reflected in two types of information. The first one describes the tasks fulfilled and the obtained results and a final document which contains the fulfilled results in the phase. The phases are composed by activities which describe the processes that have to develop in the production of the PMUS. Finally, the processes have techniques and gadgets associated which are employed in each stage for the collecting data, analysis and diagnosis and assistance to the making decisions in relation to the performances.

Finally, a transport plan is linked to an intense process of participation, public awareness and civic information. The process of participation and information is developed in parallel to the collecting data tasks, diagnosis and performances but at the end of each phase is necessary some acts where the results are presented and inform about the possible performances. This phase includes several activities, such as group procedure techniques, gadgets and face to face/on line sessions of information and participation.

3 Systems of Transport Analysis

3.1 The System of the Geographical Information

Nowadays the geographical information can be transferred, edited, visualized, superimposed, processed using many IT applications (information technology), some of them are commercial application and some of them can be used free of charge. In the industry of the companies dedicated to the commercialization of SIG as ESRI, Intergraph, Mapinfo, Autodesk or Smallworld offer complete applications.

The SIG were at their peak some years ago. In the 90s, the data of the SIG were located in big computers and they were used to keep internal registers, it was independent of the software. However, with the advent of internet to the present society more and more it is being chosen the distribution of data through the net. The current SIG which are in the market are a mixing of interoperable applications and API. The applications SIG can be grouped in seven sections depending on the type of IT applications:

- **GIS of desk**. It is used to edit, create, analyse and manage the geographical information. It is very often to find SIG of desks of different types, the most usual ones are: Viewfinder SIG: They usually are easy applications that allow visualizing the geographical information in the viewfinder, besides being able to choose different layers to visualize.
- **Editor SIG**. They are applications whose main function is analysing and processing the geographical information. Usually, the inherited data or taken from other systems and transfer them to a format the software can understand. SIG of analysis: They are applications that provide with the function of spatial analysis and cartographic modelling of the processes.
- **Spatial or geographical Database Management System (DBMS)**. Basically, they are employed to keep the geographical information, although they often manipulate and analyse too the data which is stored. A spatial or geographical database is a data base with extensions which give support to geographical objects allowing the storage, indexation, consulting and manipulation of geographical information spatial data, if these have implemented functions of geoprocessing, this implies that it can storage the georeferenced data.
- **Cartographic Servers**. They are used to distribute maps through Internet. The most useful ones are Open Geospatial Consortium WFS (Web Feature Server) and WMS (Web Map Server).
- **GIS Servers**. They provide basically the same functionality the GIS desk has but they allow to access to these utilities of geoprocessing through a technological net. GIS web customers: Its main function is to access to the data of a SIG server. There is a distinction between two types of customers, the light ones which are the browser and have the functionality of visualizing and making consults about the information of the server or the heavy customers which are the desktop applications. These one allow edit, analyse and process the data.

- **Libraries and spatial extensions**. These are functionalities which are added to tool and are not necessary for the daily use of the application. These expansions can be functionalities like the change from an external format to another that use the application, units of specific functionalities of analysis, etc.
- **GIS mobile**. These GIS have the main advantage of being able to take data from the field through mobile devices (PDA, Smartphone, Tablet PC, etc.). The introduction of data on these devices which have integrated a GPS tracking system that allows collected data to be already georeferenced. Finally, note that there are many disciplines that have benefited from the development of GIS and its implementation on the Internet. The active market for Geographic Information Systems has resulted in lower costs and constant improvements in hardware and software systems. This has led to universities, governments, businesses and institutions to use this technology in sectors such as real estate, public health, criminology, national defence, sustainable development, natural resources, archaeology, town and country planning, urban planning, transport and logistics among others.

3.2 GIS Tools and Models Applied to Sustainable Mobility

GIS applications on the current market haven been cited on previous section. Following section will focus on the description of tools which use GIS applied to sustainable mobility. It has to be said that they are associated with environment, and the display of pollution levels. TRAEMS (Transport planning Add-on Environmental Modelling System): a development of road transport plans tool which has been developed using MapInfo GIS. Its main features are (Brown et al 2002):

- Prediction of roads transport impact;
- Traffic noise calculation models;
- Air pollution calculation models;
- Energy consumption calculation models;
- Water pollution on clouds from that area calculation models.

Other applications with similar features are ESTEEM (Hall et al. 1999), SPARTACUS (Lautso et al. 1998), IMPEACT (Taylor et al. 1994), PROPOLIS (2001) and ADMS-Urban (Owen et al. 1999).

There are tools that offer features more focused on pollution and pollutant gasses emissions such as: (Berkowicz et al. 2008). Likewise, there are extensions (ArcView) Operational Street Pollution Model (OSPM, Berkowicz et al. 2006), which have functions for calculating emissions in the streets (Tang 2007, Berkowicz et al. 2006). Other independent works of geographical information systems are Emission Inventory System from Transport (EIST, Samaali et al. 2007) which calculate the emissions caused by traffic. Finally note that there are models based on neural networks. Specifically the Perceteptron Multilayer type (Multilayer Perceptrons, MLP), which are the most widely used artificial neural networks for predicting air pollution (Salazar-Ruiz et al. 2008).

4 System Design

The diagnosis of mobility plans help system is a distributed system that manages the entire process of data collection and of mobility. The system consists of 5 blocks that interact between each other to monitor the work of data collection and obtain the results of the diagnosis (Fig. 4).

4.1 Information Subsystem

The main components are: database and a Geographic Information System (GIS) which store all information (graphic and non-graphic) related to the study area. The information system is responsible for managing and generating dialogues for data collection and processing of information which is adapted to the needs of the system. The basis of the information system is a GIS environment where road are shaped and digitized; the centre, aim of study, is localized and adjacent centres which influence in the mobility and it is the support of automation and monitoring of data collection. The information system manages not only data entry but also serves as support to field work by the generation of data collection cards based on the digitization of the road. The data collection cards are generated based on the digitization of the road by a directed graph G (V, A), where the vertices are intersections and arcs sense of journey. The basis of the digitization of the road is the orthophotos (aerial photography standardized and imported from the GIS) (Fig. 5).

4.2 Diagnosis Subsystem

Diagnosis of mobility is not a simple task that can be established based on the value of an indicator. Actions based on a diagnosis depend on several factors. In many cases there is an expert or group of experts who decide on the diagnosis and mode of action on these issues. The main characteristic of this system is the development and automation of processes that commonly have been developed in the area of mobility and have served as a basis for establishing a diagnosis of the situation and proposing actions to improve mobility. The diagnostic phase of mobility can be structured in 2 points:

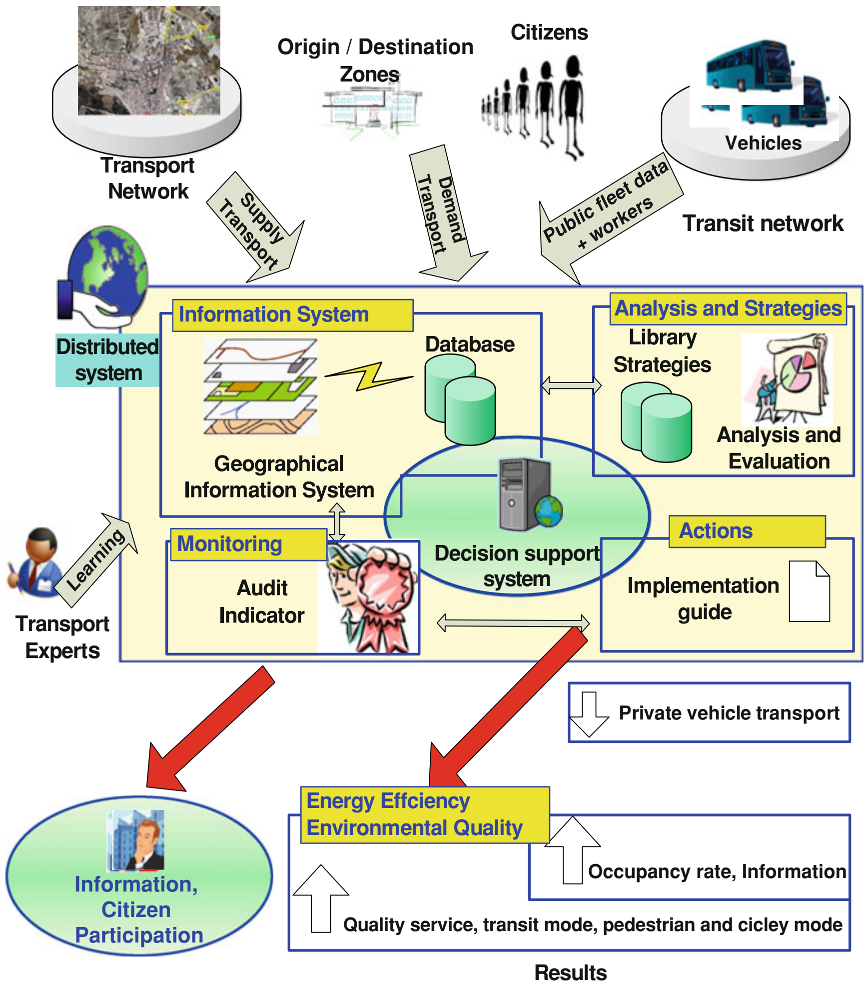


Fig. 4 System's conceptual design

Mobility diagnosis—analysis process of information associated with the movements taking place in relation to the supply of available transport and mobility needs expressed in the demand. The supply analyzes the different modes of transport, availability and available means of transport. The demand focuses on meeting the needs of displacement in the area studied.

Energy and environmental inventories—the final goal of a sustainable urban mobility plan is an energy and environmental inventory which can be the base of evolution analysis or municipality trend. The energy inventory is the first indicator which expresses the goodness of the actions proposed in the next phase. As the data collection phase, the diagnostic process is also subject to monitoring and

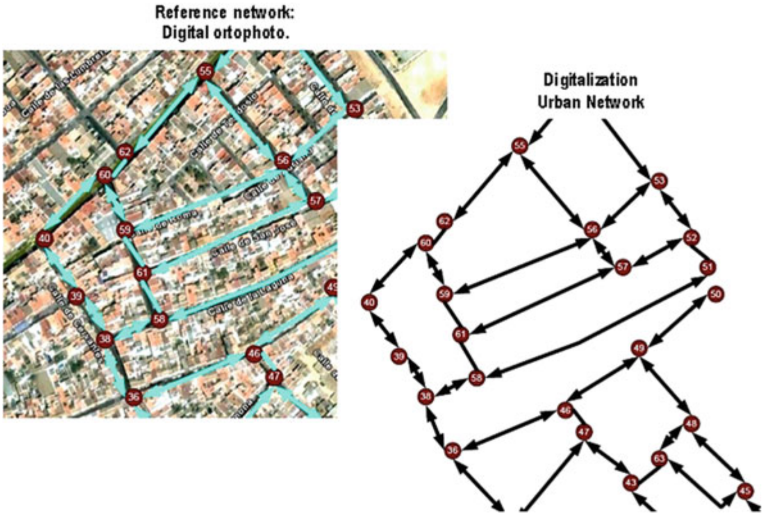


Fig. 5 Digitalization of the road by a graph for data collection

tracking tasks of work. Although in many cases the diagnosis is done once the process of data collection is completed, need not be so, because some may be developed in parallel with data collection. The diagnosis process can be divided into several stages. The first is the most critical stage because until this one will not be completed, the remaining stages will be blocked. The stage can be developed in parallel with data collection and is where the database is design physically, ordering each one of them adequately for the calculations required at the different stages of diagnosis. Stage 2 allows the statistical data evaluation obtained from surveys, analyzing in detail the information. Stage 3 is more complex and wide than previous one, as it goes more deeply into the data analysis related to the existing road network in the locality. This stage analyse the "pedestrian network", in which existing roads and characterization of pedestrian's space in the locality, as well as its main deficiencies are detailed. The "access road network" characterizes each of the entrances to the town and analyzes the traffic intensities in different directions of movement. The "internal road network" examines the characteristics and possibilities of the internal road as well as its use. This stage is divided into the analysis of the traffic intensity, the calculation of road capacity and service level. The geographical information system is the base for obtaining graphical and representative maps and graphics from the municipality. Stage 2 also analyses aspects from "road safety" which evaluates the points concerning the signposting adaptation and road interference layout in order to define and manage the potential problems in this field. Once it is completed, existing infrastructure are analysed in terms of "cyclist mobility", as well as if these infrastructures are properly, analyzing its use according to existing capacity. At this point, it is important to highlight all difficulties in this transport type. Of course, a key point in the mobility analysis is the study of "public means of transport", determining how they work according to existing needs, as well as the facilities suitability. It is important to verify the range of citizens covered by this service and identify deficiencies in certain areas regarding the possibility of access to this means of transport. Another point to study is the "parking", in which a thorough analysis of its use in the locality is done as well as the location and management of the spaces reserved for that purpose. Finally, there is the analysis of the "loading and unloading of goods". This section focuses on the analysis of the spaces reserved for goods loading and unloading in the locality, and the management and operation of the use made for that purpose. Similarly, an analysis of the use for loading and unloading areas not reserved for that purpose is done. Stage 3 studies from existing data which is the trend on the number of cars in the town, as well as which is the evolution on the different locality's access, anticipating future possible incidents in these places and globally in the locality. Stage 4, "analysis of the origin–destination matrix", examines population groups' mobility in the locality thanks to statistical samples and zonal division. This allows identifying a kilometre route average and a number of trips between the areas previously identified for the study. Like that you can get an estimate of how population moves and the total route kilometres that are made daily. Finally and linked to the previous stage we can find the "energy and environmental inventory" stage, which allows to estimate the pollutants generated in everyday journeys, as well as the total consumption of fossil fuels, by two different methods: aggregate method and disaggregate method. Once the energy inventory is completed, diagnosis phase focused on the generation of an emission model to predict from noise data generated on city roads from wheeled traffic taking into account the structural characteristics and around the tracks, would be completed. Energetic and environmental inventory is a strategic tool that allows knowing the energy consumption and pollutant emissions due to mobility and establishing reduction aims and commitments on how to quantify the expected results of implementing energy efficiency actions. The inventory is made from the municipality's mobility demand and emission factors (Table 1) representing a map of streets consumption and emissions.

4.3 Decision Support System (tools)

Proposals or actions on the mobility field are based on diagnostic results and aim to improve the current situation. As same as on previous modules, actions subsystem has a database manager, decision model and the user interface. The database manager stores actions, giving them an economic cost, indicators values involved in its selection and indicators for performance monitoring. The decision model is in charge of selecting different implementation alternatives based on the diagnosis and decision rules based set of indicators. The user interface not only

Table 1 Emissions factors according to vehicle′s typology

Emision factor	Private vehicle (gr./passenger·km)	Bus	Train (diesel)	Train (electric)
CO_2	240	70	80	16
CO	21	1	0.01	0.001
HC	2.9	0.5	0.004	0.0004
NOx	1.5	0.9	0.3	0.05

shows alternatives but should be an interactive support where solutions implementation plan is described, allow the updating or addition of new decision rules and new actions. The strategy of selection based on the diagnosis is supported by a semiautomatic process, where decision making propose different measure suitable to the indicators value. The sub-indicator is used in several areas, diagnosis, decision making and finally monitoring the results and proposed corrective action. To get the indicators set is essential to pre-calculate a set of variables (data) to obtain these indicators. The variables are always quantified by systems of simple or complex units as km, population, meters, passenger/km, etc., and referrals to selected areas, economic or social information, a network infrastructure, a geography of a specific population, and so on. Its value is generally quantitative, that is, descriptive, and occasionally acquire qualitative value when compared with other variables as long as they are calculated under similar criteria. Therefore, the variable rarely gets the character of indicator. The indicators are derived from the interplay of variables. Its formula is more complicated and designed with the aim of achieving a quantitative fundamental valuation, calculated on a time and a certain level, and to monitor developments. The purpose is to seek more synthetic information and homogenized to facilitate comparison between them. Therefore, many indicators are standardized, It′s making indices or values without units, thus allowing a comparison and independent assessment of the scope or size. For example, the number of accidents per km of road a particular stretch is comparable to any other and that have downplayed the specific conditions of each. However, it should not fall into the temptation to compare, for example, widely differing sizes and populations because rates do not reflect differences in behaviour resulting from the nature of their size. It is always advisable to compare items with similar orders of magnitude.

The indicators also acquire an additional function as the benchmark to achieve or avoid. It may set this dimension through statistical or theoretical extrapolation, sometimes associated with a given time horizon, so that successive derived indicators always have a benchmark to define the degree of success or failure. Other times, without defining an explicit dimension, the degree is assessed on the variation of indicators across time. This index is generally a percentage. Proper treatment of evaluation and assessment will consider the absolute and relative indicators and variables for their later measurement. By studying the indicators are recognized variables required to obtain, so it is tremendously important to analyze the degree of simplicity, realism and completeness of the information to be obtained for the desired level. Indicators are important factors to ensure their actual availability in different periods and of sufficient quality (reliability calculation and continuous monitoring). Much of this information is collected by government bodies or working groups whose frequency is not guaranteed, and is obtained from some population groups predisposed to respond to complex information.

The indicators described below are structured into five groups:

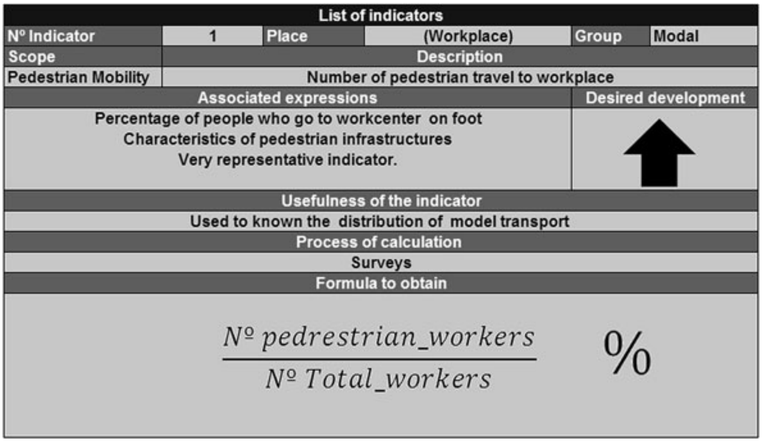
- **Modals Indicators**—these indicators are associated with mobility, specifically with the use of each mode of transport. (Pedestrian mobility, use of public transport);
- **Energy indicators**—energy consumption related to daily mobility;
- **Environmental indicators**—the associated emissions result from the mobility of each municipality, marking the level of mobility in environmental terms;
- **Social indicators**—it's associated with urban and social impact of the transport system, marking the affection degree of mobility in society as well as trends and patterns future;
- **Economic indicators**—it's associated with the economic impact that will represent the plan in the region.

For each indicator described above is intended to give meaning and usefulness, the description of the expression to obtain the source of information and finally the trend of the indicator and the necessary observations. The indicators are described and classified (Fig. 6) as a card. In the card are assigned number, scope (Pedestrian, Cyclist, Transit, private mode, Environmental and Energy), description of some characteristics of indicator, additional information related to other indicators and the source for calculate the indicator.

Some examples of indicators of these groups are showed in the following tables. The tables resume some indicators classified by groups. The tables have five columns, the first one is the group, next the indicator name, formulation or expression to calculate, the units and desired trend.

Environmental indicators show the pollution inventories and their evolution. These indicators are associated with pollutants by vehicles (Table 2). Related to environmental indicators, the energy indicators measure the energy consumption depending on the mode of transport (Table 3). The modal indicators (Table 4) is oriented to know the demand for transport, as information associated to parking, travel distance and time, public transport use and other modes use (cyclist and pedestrian) (Table 5). Finally, the economic and social indicators (Tables 6, 7) describe the scenarios or city characteristic as investment, cost and infrastructures. These indicators are used to analyze the chances of successful implementation of actions.

A decision support system (DSS) is a computer-based information system that supports business or organizational decision-making activities. DSSs serve the management, operations, and planning levels of an organization and help to make



List of indicators					
Nº Indicator	1	Place	(Workplace)	Group	Modal
Scope	Description				
Pedestrian Mobility	Number of pedestrian travel to workplace				
Associated expressions				Desired development	
Percentage of people who go to workcenter on foot Characteristics of pedestrian infrastructures Very representative indicator.				↑	
Usefulness of the indicator					
Used to known the distribution of model transport					
Process of calculation					
Surveys					
Formula to obtain					
$\frac{N^{\underline{o}}\ pedrestrian\_workers}{N^{\underline{o}}\ Total\_workers}$ %					

Fig. 6 Sheet Summary indicators

Table 2 Table of environmental indicators

GROUP OF INDICATOR	IDICATORS	FORMULATION	UNIT	DESIRED DEVELOPMENT
ENVIRONMENTAL	GHG Emissions	$\frac{Total\_GHG\_emissions}{N^{a}\ Workers}$	Tn/worker	↓
	CO Emissions	$\frac{Total\_CO\_emissions}{N^{a}\ Workers}$	Tn/worker	↓
	NO_x Emissions	$\frac{Total\_NOx\_emissions}{N^{a}\ Workers}$	Tn/worker	↓
	VOC Emissions	$\frac{Total\_VOC\_emissions}{N^{a}\ Workers}$	Tn/worker	↓
	PM Emissions	$\frac{Total\_PM\_emissions}{N^{a}\ Workers}$	Tn/worker	↓
	O_3 Emissions	$\frac{Total\_O3\_emissions}{N^{a}\ Workers}$	Tn/worker	↓

decisions, which may be rapidly changing and not easily specified in advance. DSSs include knowledge-based systems. A properly designed DSS is an interactive software-based system intended to help decision makers compile useful information from a combination of raw data, documents, personal knowledge, or business models to identify and solve problems and make decisions. Decision tree learning is a method for approximating discrete-valued target functions, in which the learned function is represented by a decision tree. Learned trees can also be re-represented as sets of if–then rules to improve human readability. These learning

Table 3 Table of energy indicators

GROUP OF INDICATOR	IDICATORS	FORMULATION	UNIT	DESIRED DEVELOPMENT
ENERGY	Energy consumption - Private Vehicle	$\frac{Energy\_consumption\_private\_ve}{N^{\circ}\ Workers}$	Toe/Worker	↓
	Energy consumption – Public Transport	$\frac{Energy\_consumption\_public\_tra}{N^{\circ}\ Workers}$	Toe/Worker	↓
	Energy consumption - Private Vehicle / Total	$\frac{Energy\_consumption\_private\_ve}{Consumption\_total\_energy}$	%	↓

Table 4 Table of modals indicators

GROUP OF INDICATOR	IDICATORS	FORMULATION	UNIT	DESIRED DEVELOPMENT
MODALS	Use of Cyclist mobility	$\frac{N^{\circ}\ cyclist\_workers}{N^{\circ}\ Total\_workers}$	%	↑
	Use of Public transport	$\frac{N^{\circ}\ use\_public\_transport\_workers}{N^{\circ}\ Total\_workers}$	%	↑
	Use of private vehicle	$\frac{N^{\circ}\ use\_private\_\_vehicle\_workers}{N^{\circ}\ Total\_workers}$	%	↓
	Use of car sharing	$\frac{N^{\circ}\ use\_car\_sharing\_workers}{N^{\circ}\ Total\_workers}$	%	↑
	Private Vehicle Occupancy	$\frac{N^{\circ}\ use\_private\_\_vehicle\_workers}{N^{\circ}\ cars\_in\_workplace}$	Workers/veh	↑
	Occupation of parking	$\frac{N^{\circ}\ busy\_parking}{N^{\circ}\ free\_parking}$	%	↓
	Occupation of illegal parking	$\frac{N^{a} legal\ parking\ spaces}{N^{\circ}\ legal\_spaces + N^{\circ}\ ilega\_spaces}$	%	↓
	Waiting time at stops	$\frac{\sum Waiting\ time\ at\ stops}{N^{\circ}\ public\ transport\_workers}$	Min/Workers	↓
	Time of travel	$\frac{\sum Time\ of\ travel\ \_workers}{N^{a}\ workers}$	Min/Workers	↓

methods are among the most popular of inductive inference algorithms and have been successfully applied to a broad range of tasks from learning to diagnose medical cases to learning to assess credit risk of loan applicants. A decision tree is a prediction model used in the field of artificial intelligence. With a default database diagrams is defined these logical constructs, which are very similar to the

Table 5 Table of economic indicators

GROUP OF INDICATOR	IDICATORS	FORMULATION	UNIT	DESIRED DEVELOPMENT
ECONOMIC	Investment in Mobility	$\frac{Investment\_mobility}{Nº\ Workers}$	€/Worker	↑
	Investment in Pedestrian Mobility	$\frac{Investment\_pedestrian\_mobility}{Nº\ Workers}$	€/Worker	↑
	Investment in Cyclist Mobility	$\frac{Investment\_cyclist\_mobility}{Nº\ Workers}$	€/Worker	↑
	Investment in Public Transport	$\frac{Investment\_public\_transport}{Nº\ Workers}$	€/Worker	↑
	Cost of motorized mobility	$\frac{Cost\_of\_motorized\_}{Nº\ Workers}$	€/Worker	↓

Table 6 Table of social indicators

GROUP OF INDICATOR	IDICATORS	FORMULATION	UNIT	DESIRED DEVELOPMENT
SOCIAL	Company policy	$\frac{Nº workers\_with\_company\_policy}{Nª Workers}$	%	↑
	Teleworkers	$\frac{Nº workers\_with\_teleworker}{Nº\_teleworker}$	%	↑
	Workers who lunch in the workplace	$\frac{Nº\ workers\_lunch\_in\_workplace}{Nº\ worker\_full-time}$	%	↑
	Pedestrian infrastructures	$\frac{Km\_pedestrian\_road}{Total\_Km\_road}$	%	↑
	Cyclist infrastructures	$\frac{Km\_bike\_line}{Total\_Km\_road}$	%	↑
	Public transport coverage	$\frac{Nº workers\_with\_PT\_coverage}{Nº\ trabajadores}$	%	↑
	Traffic violation	$\frac{Nª Traffic\_violation}{Nº\ workers}$	%	↓
	Accidents	$\frac{Nª Accidents}{Nº\ Workers}$	%	↓

prediction systems based on rules that serve to represent and categorize a series of conditions that occur on an ongoing basis to solve a problem. A decision tree has entries which can be an object or a situation described by a set of attributes and from this returns a response, which is a decision that is taken from the entries

Table 7 Table of pedestrian mobility indicators to make a tree decision

Indicator	Since (m)	To (m)	Ranges
Amplitude of sidewalk	0	1.49	2
	1.5	8	
Width of road	0	3	2
	3	8	

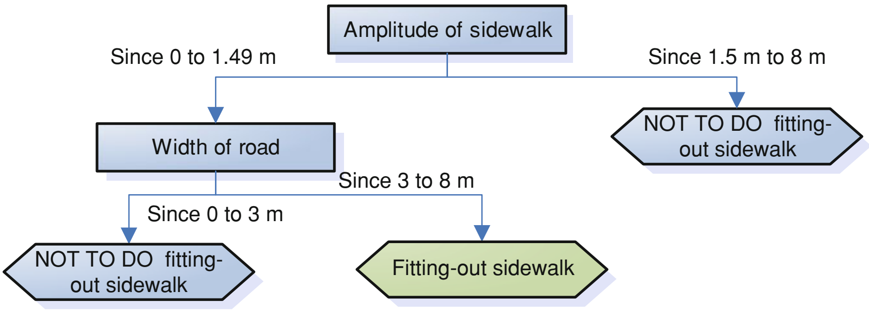


Fig. 7 The decision tree for the proposed fitting-out sidewalk

Table 8 Table of controlled time parking indicators to make a tree decision

Value	Level of occupancy	Level of rotation	Residential density	Commercial density
High	> 0.75	1.2 veh/h	>750 hab/km^2	>250 m^2/km^2
Low	<= 0.75	< 1.2 veh/h	<= 750 hab/km^2	<= 250m^2/km^2

defined previously. The values that can take the inputs and outputs can be discrete or continuous values are the discrete values the most used for their simplicity When using discrete values in the functions of a classification application is called and when using the continuous is called regression. A decision tree performs a test to measure, which goes to the leaves so as to reach a decision. The decision tree typically contains internal nodes, nodes of probability, leaf nodes and arcs. An internal node contains a test for some value of a property, a chance node indicates that a random event should occur according to the nature of the problem, this type of nodes is round, and others are square. A leaf node represents the value that will return the decision tree branches and finally provide the possible paths that are in accordance with the decision. These trees are associated with a proposed de-ended scope, such as the conditioning operation of the sidewalk. Here is a case study.

Decision trees that are designed in this paper are twofold:

- Trees performances—designed to aid decision making regarding the implementation of actions;
- Trees correction/Empowerment—trees that are dependent on the monitor used to decide on the need to implement complementary actions to achieve the energy, environmental and socio-economic expectations.

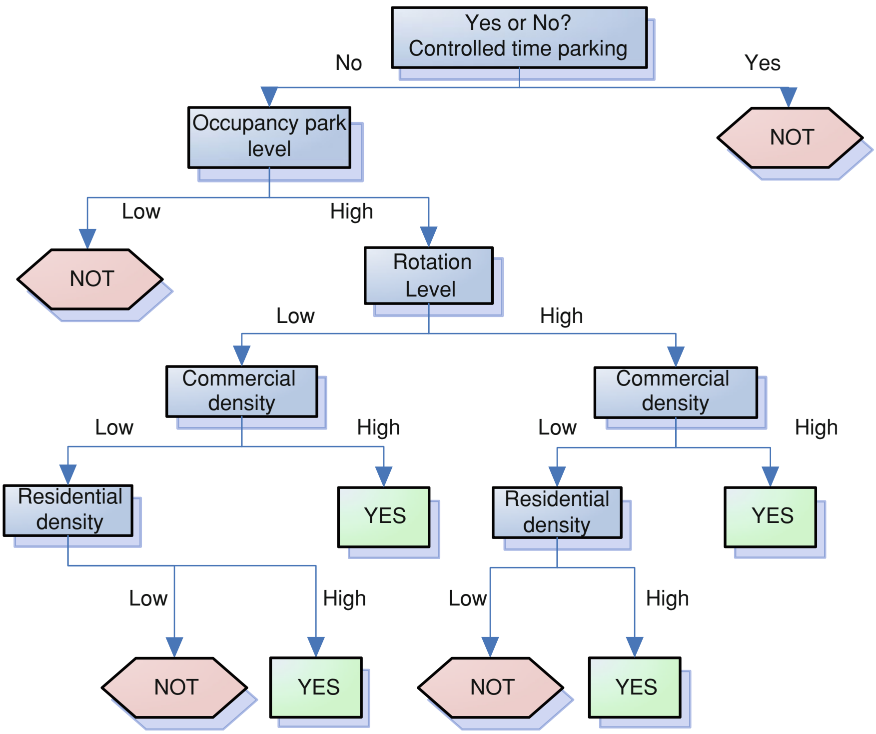


Fig. 8 The decision tree form for the controlled time parking implementation

The experts choose the indicators that will be needed to build such a decision tree, as well as creating appropriate numeric intervals for each indicator (amplitude of the pavement, width of the road) when they have determined these indicators, the tree construction begins.

Suppose the expert wishes to build a decision tree in the field of pedestrian mobility, and want to support the decision to the implementation of the proposed design of the sidewalk. Then, suppose that the expert has chosen two of the indicators in the field of pedestrian mobility, as is the amplitude of the pavement and the roadway giving each of them the following ranges:

Once defined the ranges of the indicators chosen by the expert, will decide which indicator is placed in the root of the tree and then proceed to give body to this decision tree. The guidelines for constructing the tree are as follows:

- You start by choosing the root indicator, which will have as many children as the number of intervals you have decided on expert. In this example two as shown in the table above;
- For each interval the expert will decide what action to take.

(Fig. 7).

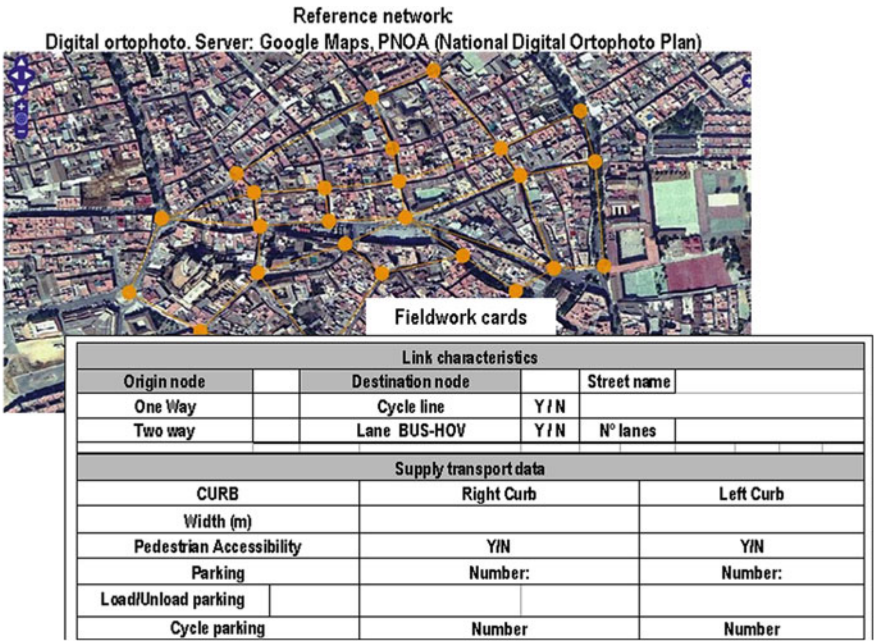


Fig. 9 Digitalization interface and generation of fieldwork cards

Once you get to that it is feasible to implement the new measure is concluded in the decision tree for the proposed fitting-out sidewalk. The following example shows the structure for making decisions in the field of parking management, in particular the establishment of a controlled time parking. In assessing the controlled time parking indicators to consider are 4 (occupancy, level of rotation, residential density and commercial density) The value or ranges of values associated with each indicator to characterize as high or low is in the Table 8.

The learning system is based on the success of the performances measured by indicators in the monitoring system. The proceedings implantation are characterized by the type of municipalities (population, location, level of motorization) and energy performance, environmental, economic, and social obtained. For example, the controlled time parking decision tree show whether it is necessary to implement parking strategies. The tree (Fig. 8) shows the rules, based on indicators, and must be analyzed.

4.4 Monitoring Subsystem

The monitoring subsystem is responsible for ensuring the success of the actions by monitoring indicators. The monitoring process sets, according to associated measures, collected information based on the data collection cards. This system

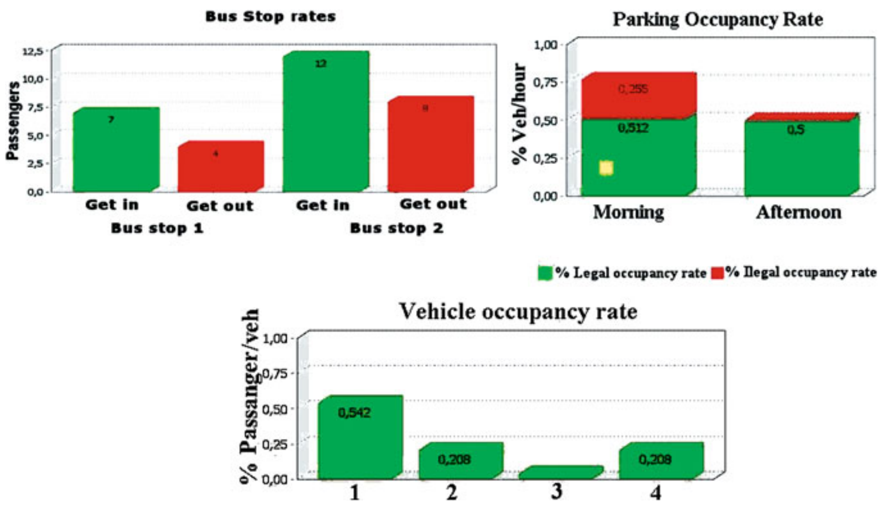


Fig. 10 Mobility diagnosis results sample

sets the level of deviation or problems in the implementation based on the information associated with the indicators. Subsequently it provides recommendations about complementary and/or enhancer actions.

4.5 Management Subsystem and Citizen Participation

Citizens' participation is the key element to the plan success. The participation process is structured in 2 complementary phases: present and virtual phase. The management subsystem organizes each one of the agents involved in the plan, neighbours, associations, hauliers, public administration and through a virtual system provides information on the evolution of each one if the phases also serves as agenda for present sessions, as a information centre and opinion forum through the virtual platform available 24 h a day, 365 days a year.

5 Results

The described system is still under consideration and validation. The results obtained in this phase focus on the development of tests on different municipalities (particularly in a municipality in the metropolitan area of Seville). The first step in developing a mobility plan is the digitalization of the road where a graph is defined and in which intersections and streets are represented. Simultaneously, the system

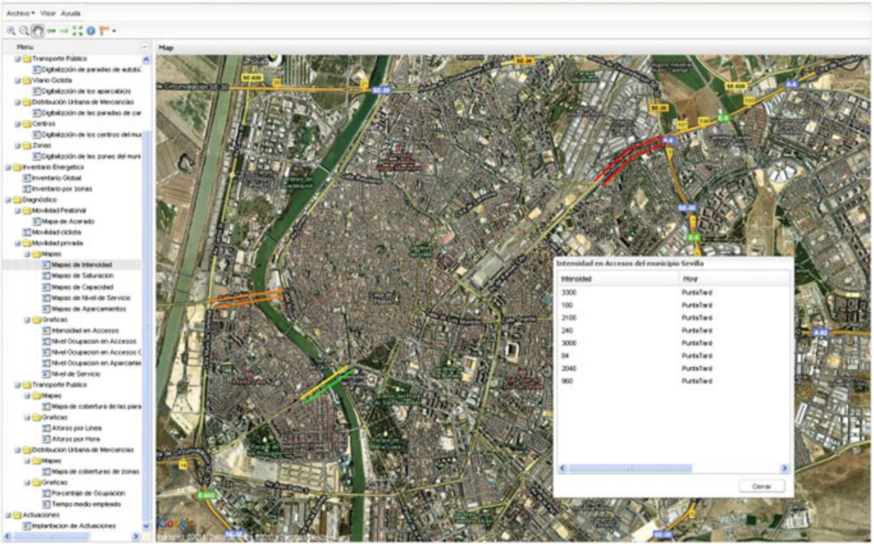


Fig. 11 Traffic flow maps

Table 9 Energy and environmental inventory based on the mobility of areas

Pollutants (Tn/year)					
Areas	Fuel (toe/year)	COV	NOx	CO	CO_2
1	107,412	4,867	2,517	35,245	402,797
2	52,961	2,4	1,241	17,378	198,605
3	28,539	1,293	0,669	9,364	107,021
4	174,228	7,895	4,083	57,169	653,357
5	597,243	27,06	13,99	195,97	2239,661
Total	960,383	43,51	22,50	315,126	3601,441

generates data cards that will be the reference to the fieldwork and in the updating of the database of geographical information system (Fig. 9).

The diagnosis subsystem provides information about mobility in the study area, from the data collected, indicators, graphs and maps are generated. They provide the basis for the diagnosis of the current situation. The graphics are arranged into pedestrian mobility, cyclist mobility, private mobility (parking and displacement, Figs. 10 and 11), public transport mobility, and freights mobility.

The diagnosis ends with the development of the energetic and environmental inventory based on mobility surveys developed after the data collection. Mobility surveys allow estimating the journeys matrix which describes the displacement between each pair of zones defined in the study area (Fig. 11). Finally, energetic and environmental inventories are obtained based on the average distance of displacement, average speed and emission factors table (Table 9). The results are obtained in aggregated and disaggregated form by location.

6 Conclusions

In recent years, a wide variety of sustainable urban mobility plans have been developed. These plans are very similar (general guidelines) but with great disparity in techniques and procedures used. These differences have influenced in the inability of having a common and standard methodology base which would be used as a base of knowledge for a common and coordinated strategy among municipalities. This disparity between the contents of sustainable urban mobility plans appear because local, provincial and regional agencies do not have the enough means for standardization of work that allows transposition measures in municipalities. The following paper focuses not only on the standardization of mobility plans development but provides techniques and tools that in a semi-automated way allow the development and control of mobility plans. This paper has focused on standardization of data collection by developing a tool for digitalization and generation of cards. The elaborated system allows automation of diagnosis process based on the data collection. It provides parameterized library of actions by features of the municipality. Monitoring and management system of PMUs recommends the actions based on indicators.

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Part IV
Intermodal Transport and Models for CO2 Reduction

Supporting Intermodal Transport Solutions in Selected European Countries: Case Studies

Maciej Mindur and Ireneusz Fechner

Abstract Reduction of congestion, through usage of alternative to road modes of transport, is one of the priorities of European transport Policy publish in such documents as: White Paper (2010, 2011), Keep Europe Moving (2006), Logistics: Keep Freight Moving (2007), Greening Transport (2008), Maritime Transport Strategy 2018 (2009) and Future of transport (2009). Authors are presenting selected best practices from EU Member States focusing on intermodal transport development. In addition, the role of public authorities in creation of efficient transport infrastructure for intermodal haulages is presented.

Keywords Intermodal transport · Logistics centres · Best practices · Intermodal haulages

1 Guidelines for Creating the Logistic Policy of the European Union

1.1 Effective Actions in Logistics

An expanded European Union (27 Member States) is fading new challenges in terms of equalling differences in regional development, creation of new EU economic structure, production, trade and transport interrelations within its

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boundaries. Logistics connection with the rest of the world, especially with the geographically closest areas must also be considered. The aim is a socio-economic growth, in particular higher standard of living of the EU citizens. In the global economic competition with countries such as Russia, the USA, India or China, the victory can be achieved only through a systematic increase of competitiveness of EU products. Major part of product costs at the recipient's place is logistic expenses (Liberadzki 2006), direct and derivative, caused by the unreliability of inefficiency of supply chains.

Transport is key element for maintaining and increasing European competitiveness. Today, managing complex transport operations calls for efficient types of transport and their coherent cooperation. Advanced and integrated logistics solutions might facilitate optimization of freight transport, and thus ensure the economic growth in Europe and its greater global competitiveness.

The European Commission brought it up already in 1997 in its document on freight transport (COM/97/0243). The document deals with a systematic approach to transport with special focus on intermodal transport.

The following reasons for creating European logistic policy might be distinguished:

- Influence of logistic on economic competitiveness;
- Integration within the EU;
- End users' growing requirements;
- Liberalization of transport and postal services.

In almost all spheres of social life, logistic constitutes on of the key elements of business activity, production and trade. Time and cost are of great importance as they determine the location of companies. The growing globalization of the economy makes logistics and its cost an increasingly important factor in competition and rationalization as well as in environmental protection. The European Commission clearly states that transport is the key factor in maintaining and boosting Europe's competitiveness (COM/97/0243).

1.2 Influence of Changes in EU Transport on the Logistics Policy

The important reason for creating a modern logistics policy in the EU is system and regulation changes in transport. Changes in quantities in freight transport and GDP dynamics indicate a regularity that transport absorptiveness is growing faster than GDP in EU countries (Fig. 1).

An efficient economic growth calls for rationalization of actions, particularly in logistics and is reflected in a faster economic growth rather than increase in transport size. This relation is referred to as transport absorptiveness of the economy (Mindur 2006), whose decrease can be due to factors such as:

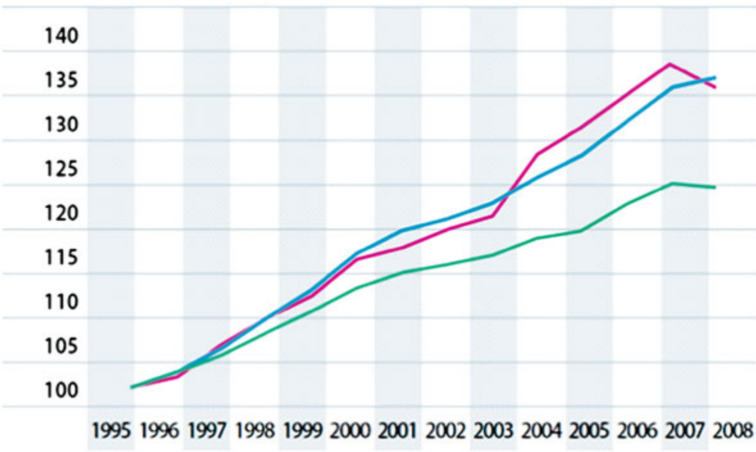

Fig. 1 GDP dynamics and transport performance (freight and passenger) dynamics in 27 EU countries, (1995 = 100%), *Source* EU Energy and Transport in Figures, 2010

rationalization of distribution of production activity, increasing the effectiveness of using the transport system and, perhaps to a large extent, changes of economic structure (COM/2001/370). Even though the decision had taken at the Community level to support decoupling (COM/2001/370), i.e. make the economic growth independent of transport size, the tendency is reverse. Transport performance is growing faster than GDP, especially in 2004–2005. Therefore, the question about the legitimacy of the decoupling policy might be raised. More thought should also be given to the policy guidelines in terms of the possible developments in the economy with the decreasing role of transport.

The economies of the developed countries have an increasing share of the service sector which does not need freight logistics as much as, the industrial sector. However, the developing services sector might have a positive effect on residents' mobility.

The European Transport Policy supports the idea of a balanced share of individual transport branches in the total transport. Following this concept, the current structure of transport seems to be inadequate. Road and sea transport play the key role as they together cover over 80% of transport performance. A disadvantageous disproportion exists in the case of land transport: road (45%) and rail (10%). It is due to new requirements set by the end users (clients) in terms of logistics services. Increasingly, door-to-door shipping is expected as ordered by the client. This, in turn calls for elastic transport in terms of space and time availability.

Table 1 shows that road transport has not only the biggest share in freight transport but also the highest dynamics thus deepening the disproportion against rail transport. Road transport in 1995–2005 recorded an increase in transport performance from 1250 to 1724 mld tkm, i.e. by 38%. Average yearly increase rate in this period for the road transport was 3.5%, and for rail only 0.8%.

Table 1 Transport performance by transport branch (mld of tkm) in EU-27

Year	Rail	Road	Inland water	Pipelines	Sea	Air	Total
1995	386	1,289	122	115	1,150	2.0	3,064
2000	404	1,519	134	127	1,348	2.7	3,534
2001	386	1,556	133	132	1,400	2.7	3,610
2002	384	1,606	132	128	1,415	2.6	3,668
2003	392	1,625	124	130	1,444	2.6	3,718
2004	416	1,747	137	132	1,485	2.8	3,920
2005	414	1,800	139	136	1,520	2.9	4,012
2006	440	1,855	139	135	1,548	3.0	4,120
2007	452	1,927	141	129	1,575	3.1	4,228
2008	443	1,878	145	124	1,498	2.7	4,091
1995–2007	17.1%	49.6%	15.6%	12.1%	37%	55%	38%
2007–2008	–2.3%	–1.9%	–1.2%	–2.2%	–2.2%	–1.8%	–2.1%

Source based on EU Energy and Transport in Figures, 2010

1.3 Aims and Scope of Logistics Policy

The need for a comprehensive look at logistics was also stressed in *White Paper* on transport from 2001 (COM/2001/370). It presented the strategy of the European Commission which involved fighting any problems with excessive traffic in some of the EU transport routes by restoring proportional use of different types of transport. Such an approach seems to be insufficient. In the new *Communication* (COM/2006/314) from 2006, *White Paper* was revised, with the same guidelines but with a new rule of intermodality.

Since *White Paper* was released in 2001, further opening of the market of air, road and partly rail transport services has taken place. Trans-European transport networks contributed to increased territorial coherence and construction of fast railway lines. International links and cooperation have also been strengthened. A lot has been done to increase the ecological aspect of transport, however, the development of a transport system does not respect the rule of sustainable development.

In accordance with the initiative "Europe's effective use of resources" within the strategy "Europe 2020" and new plan for energy effectiveness from 2011, the main goal of the European Transport Policy is to help establish a system supporting economic growth in Europe, strengthening competitiveness and offering high quality services in terms of mobility with efficient use of resources (COM/2011/144). In practice, it means that the transport sector must use less energy in a more ecological way, make better use of the modern infrastructure and limit negative effect on the environment and key natural resources.

A further development of the transport in Europe must be based on several principles:

- Improvement of energetic effectiveness of vehicles in all types of transport;
- Optimization of multimodal logistics chains by more common use of resource-efficient means of transport in situation when other technological innovations might be insufficient (e.g. long-distance transport),
- More efficient use of transport and infrastructure by using better traffic management and information systems and advanced logistics and market means such as full development of integrated European railway market.

Optimization of multimodal logistics chains by more common use of resource-efficient means of transport is one of the three main areas of the perspective development of the European transport where the following aims have been identified:

- Till 2030, 30% of road freight transport on distances longer than 300 km must be transferred to other means of transport such as railway or water transport; till 2050 it should constitute over 50% of this type of transport. This will facilitate the development of ecological transport routes. To achieve this goal, a proper transport logistics infrastructure should be created.
- Till 2030, a fully functional EU-wide multimodal base network TEN-T must be created and till 2050 the network should reach high quality and capacity; proper information services should also be provided.

The European Social and Economic Committee has also contributed its opinion as regards the process of creating, the European logistics policy (2007/C 97/08). The Committee states that the starting point for development should be a strategic plan for logistics as the growth and competitiveness factor. Such a plan should include clear tasks for public authorities and transport sector. The plan should concern all transport branches and be based on the current economic situation, as well as transport policy, social interests as well as environmental and regional aspects.

As regards EU legislation, the most important document directly referring to logistics is *Communication* from 2006, *Freight transport logistics in Europe—the key to sustainable mobility* (COM/2006/336). It says that transport is the key element of logistics supply chain. The Committee's approach is focused on logistics in freight transport and includes all forms of transport.

The development of the freight transport logistics is connected mainly with business activity. However, authorities at the Community level as well as individual Member States play an important role in terms of creating proper conditions for the development of logistics. Such an approach focused on proper innovativeness in logistics and thus on its competitiveness.

Based on social consultation, the European Commission proposes actions in the following areas: modern technologies for data communication, trainings in logistics, optimal use of infrastructure and loading standards (COM/2006/336).

1.4 Data Communication Technologies

The Commission's document indicates that in logistics more attention is put on modern technologies. Data communication technologies are becoming increasingly important as they condition the existence of efficient logistics and facilitate monitoring and tracking freight at all stages of transport. Here, it is forth mentioning such EU actions as the European GALILEO satellite navigation system. It is a long-term research project started in February, 1999 which deals with creating satellite connections, including data transfer, which is to give great results in terms of research and implementation. Apart from military applications, it will also affect the functioning of the European transport and logistics systems. The system will be composed of 30 satellites. It is expected to work with the American GPS and Russian GLONASS, which will cover over 90% of urbanized areas.

Within the GALILEO system, different logistics-supporting technologies are being developed. One example is project *System for Mobile Maintenance Accessible in Real Time* (SMMART), implemented within the current research cycle, i.e. VI European Union Framework Programme (SMMART). The aim is to create a real time satellite, global (initially only European) system supporting maintenance, repair and selection of spare parts for selected means of transport. The project includes air and road transport. The goal is to limit time and costs connected with stops, repairs and services of the mentioned means of transport, which should lead to a general increase of the transport competitiveness.

In the case of rail transport, the application for the integrated railway logistics is the European Rail Traffic Management System (ERTMS) (COM/2005/0298). It is a project of harmonization of railway traffic signalling system. Its implementation will contribute to overcoming technical barriers in the international railway transport, and thus influencing the growth of competitiveness of this transport branch.

1.5 Upgrading the Qualifications of Logistics Personnel

The quality of the logistics services largely depends on the average level of qualification of the logistics personnel. An efficient logistics system cannot exist without highly qualified staff. Operators and their clients pay a great deal of attention to the knowledge and competences of the employees involved in logistics service. This view is shared by the employers as well, which is confirmed by the research in the Polish logistics system (Hat-Garncarz and Janowska-Bucka 2007). They prefer candidates with university degrees for the post of logistician (Fig. 2).

What the European Commission fears is the differentiation of the education in logistics in the Member States. This can cause problem in mutual acknowledging the experienced and competence of logisticians. This is an important problem given that logistics operators are usually international companies which strive for a

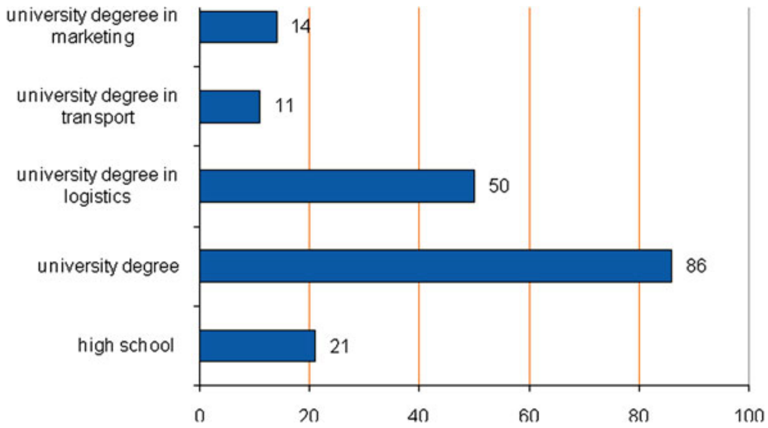

Fig. 2 Educational requirements for candidates for the post of logistician (% of companies which chose a given answer), *Source* (adapted from Hat-Garncarz and Janowska-Bucka 2007, p. 27)

high and unified level of qualification of the staff in all its branches. That is why the European Commission considers supporting a voluntary system of mutual acknowledgment of qualifications of logistician in freight transport. The unification of qualifications and supporting cooperation of training institutions will lead to a unified and high quality education in Europe, which can be compared according to commonly accepted requirements. Companies employing people with such qualifications gain a guarantee of professional knowledge. It will also influence the standard of the customer service.

1.6 Use of Infrastructure and Standardization of Loading

One of the key elements affecting the efficiency of logistics systems is infrastructure. The effective usage greatly influences the functioning and competitiveness of the economy. With limited funds for the extension and modernization of infrastructure to the desired level, it is important to take all possible actions optimally supporting the existing transport network.

The European transport policy sets concrete directions for the development of transport network, including the needs of individual branches as well sources of funding. The most important elements of infrastructure, from the European perspective, are included in the plans of trans-European transport networks TEN-T. In particular, 30 priority projects are distinguished, marked as most urgent (EC, DG TREN 2005). Using structural funds, the Coherence Fund and direct budget line for the TEN-T projects, the EU modernizes and expands transport infrastructure to maintain or increase its capacity. The principles of logistics policy indicate that the expansion of infrastructure is not the only available solution. It is more effective to aim at better use of the existing transport network. One of the factors affecting the use of infrastructure is the transport policy and its principles which guide the users to particular choices. They are implemented by instruments such as fees for using the infrastructure, including all costs generated by a given transport branch, including internal costs.

The Commissions has taken action to develop a European standardization project for freight units in intermodal transport (COM/2004/361). The general aim of this action is improving competitiveness of intermodal transport by setting frameworks and conditions for better use of freight units such as shipping containers and swap bodies in all transport branches.

It is expected to conduct an evaluation of possibilities in adjusting the units as well as maintenance and inspection standards in order to improve transport and reloading safety. Such actions are necessary given the current state, i.e. variety of unit configurations, which causes excessive costs and delays in reloading between individual forms of transport. Rules regarding the size of vehicles and freight units should meet the needs of advanced logistics and balanced mobility.

1.7 The Importance of Intermodal Transport in the European Transport Policy

In the European logistics policy, the intermodal transport is treated as a factor that can greatly improve competitiveness of the European logistics by a more effective use of the existing potential of the transport system. A logistics system based on the non-interpretational transport system, where each change of transport generates costs, loses its competitive aspect in the global perspective. The concept of the intermodal transport enables to avoid unnecessary transport costs. A special role in this process is attributed to logistics centres whose availability and efficient operation condition the effective movement of freight.

The European policy pays a lot of attention to the intermodal transport indicating its pro-environmental aspect. *White Paper* from 2011 (COM/2011/144) cites, as one of the aims of the developmental strategy of the European transport till 2050, the achievement of an inter-branch balance by limiting the share of road transport and increasing the share of railway and water transport within the intermodal transport chains. It is worth mentioning here that the full compliance, as suggested in *White Paper*, with the rule “the user pays” and “the polluter pays” imposing external costs on all transport branches will contribute to the equalization of inter-branch competition on the European transport market. The financial instruments, supporting the development of the logistics services using railway, sea and inland water transport, are very important. Such an approach to the cooperation between individual branches is what the already mentioned co-modality concept, introduced in the mid-year *White Paper* (COM/2006/314), involves. Another aim is efficient use of transport forms operating separately or multimodal integrated within the European transport system for the purpose of efficient and sustainable use of resources. The Community's actions aim at more effective and wider use of the existing capacity within all transport branches and focus on the clients' needs. Increased efficiency not only influences logistics competitiveness but also the competitiveness of the European economy. There exist various obstacles to reaching this aim, they include: lack of interoperability within the branches and between branches, excess and differentiation of regulations, different condition of infrastructure, different service standard in transport branches and also insufficient information about intermodal services. Therefore, it is essential to coordinate actions supporting the development of the intermodal transport at the EU level, especially financial support.

In this matter, the actions of the EU are focused around the following areas:

- Support of intermodality in the TEN-T projects;
- Support of the development and functionality of logistics centres;
- Harmonization of standards;
- Integration of freight transport routes;
- Support of research projects on intermodal transport.

The main instrument for financial support of intermodal transport is a project, initiated by the European Commission—Marco Polo (OJ L196 2003), whose aim is active reduction of road traffic and alleviating the effects on the environment, at the same time supporting efficiency and balance of transport systems.

Given that the first edition of the programme brought a desired effect, its continuation has been suggested under the name Marco Polo II, financed from the EU funds within the EU financial perspective EU 2007–2013 (COM/2004/478). As the road traffic is constantly increasing, more emphasis has been put on intermodality. The programme, renewed and adjusted to the current situation, contains two new areas for actions: sea motorways and actions aiming at avoiding road traffic.

Reliance on intermodal transport will lead to a more even distribution of the transport demand. Actions aiming at avoiding road traffic are a challenge for the EU—one that will have to be faced in order to achieve a balanced transport system without affecting competitiveness and well being. A more active participation of the production sector and logistics systems in the coherent strategy for the purpose of a sustainable development is necessary. In order to raise transport intensity of industrial production, the models of production, supply and ordering must be improved. Changes to these factors affect the general economic demand for transport, i.e. transport absorptiveness (Mindur 2007). That is why the Commission promotes actions aiming at reducing traffic. The industrial sector began to show interest in this matter mainly to improve its supply chains and distribution reduction as well as transport costs in road transport…

2 Presentation of Solutions in Selected Countries

2.1 Introduction

The situation on the European intermodal market as well as the system and structure of relations between its main participants can be described as follows:

- In the EU countries there is no single and centralized organizational structure which would organize and manage intermodal transport, which is obvious given the necessity to comply with the rules of free and fair competition;
- The key role in organizing intermodal transport is given to national associations of intermodal transport which act as intermodal transport operator and are members of UIRR (International Union of intermodal Road–Rail transport companies). Those associations, by buying services from the railway, organize and supervise railway services in terminal–terminal relations;
- Road carries deals with transport acquisition, transporting freight from the loading site to the terminal and organizing its on-carrying from the destination terminal to the recipient using its own vehicles or partner's vehicles.

Proper cooperation between rail and road transport is the basis for the success of intermodal transport operators, in accordance with the basic rule that intermodal transport will develop only when the interests of both road and railway transports are considered.

2.2 Directions in Supporting Intermodal Transport by the European Commission

According to the European Commission (COM/2011/144) structural changed on freight transport market, in compliance with the recommended rule of sustainable transport development, will be possible by implementing a package of the following means promoting the transfer of some freight transport from the road transport to the railway and intermodal transport. The challenges are:

- Improving the efficiency and quality of railway services, including higher reliability and frequency of railway services, especially those provided within intermodal transport;
- Ensuring interoperationality of the railway in the international system by eliminating the existing technical, operational and organization bottlenecks in international freight railway transport and ensuring long-term financing for the infrastructural railway projects;
- Introducing till 2020 management systems for land and water transport (ERTMS, ITS, SSN and LRIT, RIS) and use of Galileo navigation system;
- Establishing till 2020 frameworks of the European information, management and payment systems for intermodal transport;

- Ensuring an effective and non-discriminating access to railway infrastructure, especially by distinguishing between infrastructure management and service provision;
- Actions to introduce the concept “Multimodal freight transport: e-Freight”:
- Creating proper framework that enable tracking freight in real time, ensuring intermodal responsibility and promoting ecological freight transport,
- Introducing the concept of “one-stop service point” and “one-stop administration point” by creating a unified waybill in electronic form and creating proper framework for using the technology of freight tracking and point-of-origin;
- Ensuring that transport systems promote railway, water and intermodal transport,
- Creating—as base network—multimodal structures for transport routes enabling the synchronization of infrastructure project and supporting effective, innovative and multimodal transport services, including railway services on medium and long distances;
- Supporting the multimodal transport system and single-load transport, stimulating integration with inland water transport in intermodal transport chains and promoting ecological innovation in freight transport;
- Introducing, till 2020, full internalization of external transport costs for all transport branches;
- Introducing effective and coherent taxes and fees for freight cars;
- Introducing coherent, at the European level, regulations on freight road transport, especially in terms of taxes and cargo limits, safety, time of driving, work and rest of drivers, etc.

According to the Commission, the above-mentioned actions, introduced within the new EU transport policy will lead to equalization of intern-branch competition conditions on the European transport market. Thus eco-friendly industry branches (railway, water and intermodal transport) will be competitive to road transport, especially on medium and long distances.

2.3 Assistance Provided for Intermodal Transport in Selected Countries in Western Europe

2.3.1 Austria

Austria uses comprehensive instruments supporting intermodal transport[1]—starting from financial support up to 30% of terminal project costs, reloading equipment, special equipment and fleet, through subsidies to operational costs for

[1] Pursuant to § 3 of the Act on Austrian Federal Railways of 1992, pursuant to Regulation of EC Council no. 1191/69 of 26 June 1969, modified by Council Regulation no. 1893/91 of 20 June 1991, transport which for environmental reasons, are in the public interest, can obtain financial aid in accordance with their execution as public services. For those benefits, within intermodal transport (including Ro-La) the compensation is set depending on the number of shipments.

railway and ending with discounts and tax and fee exemptions for road use, as well as restriction in terms of cargo capacity of road vehicles or location of eco-points.

Basic agreements on means promoting intermodal transport in Austria are included in relevant acts and government programmes which stipulate the rules and conditions of granting financial aid by the state for the intermodal road/rail/inland water transport and other means promoting intermodal transport. The initial and final operation conducted via road transport in Ro-La technology in transport route had been liberalized while transits for intermodal transport were excluded from traffic ban on Saturdays, Sundays and holidays if they do not exceed a radius of 65 km from/to terminals.

In order to create Cargo Centre Graz (CCG) in Werndorf near Graz, the government of Styria formed a commercial partnership—SCHIG Company, whose 100% shares belong to the Austrian federal State Treasury. The company bought land to build a logistics centre. Another public sector company—HL-AG Company built infrastructure (utilities, sites, roads and sidings). Upon construction of the infrastructure SCHIG Company leased the land along with its infrastructure to CCG which manages the logistics centre. In 2001, Cargo Centre Graz Betriebsgesellschaft mbH & CoKG was formed with the following shareholder distribution: 51% private companies, 23.9% Styria banks, 25.1% Styria government.

On June 28, 2003, Cargo Centre Graz opened for business. Figure 4 shows that the logistics centre was built according to the idea of public–private partnership. HL-AG is a public sector company which built the infrastructure in Cargo Centre Graz. HL-AG Eisenbahn Hochleistungsstrecken AG (HL-AG) is a company dealing with planning, designing and construction of modern railway lines and railway infrastructure such as tunnels. The company was formed under an act of the Austrian parliament. It impalements the goals of Austrian transport policy. It is a state-owned company.

SCHIG mbH is a public sector company which financed the constriction of the infrastructure of Cargo Centre Graz. SCHIG mbH belongs to SCHIG Holding Company. SCHIG is a company formed within PPP (public–private partnership) in 1996 and it finances railway infrastructural projects in Austria. The shareholders include Österreichische Bundesbahnen (ÖBB)—Austrian Railway, Eisenbahn-Hochleistungsstrecken AG (HL-AG) (company building railways lines) and Brenner Eisenbahn Gesellschaft mbH (BEG). The Austrian Ministry of Infrastructure commission projects to the above-mentioned companies connected with expansion of the railway network financed by SCHIG (Fig. 3).

Thanks to the PPP format, CCG was built considerably cheaper than expected—instead of 140 million euros, the cost of the project was 110 million euros. The loan granted by EBR and ASCHIG Company must be paid by CCG. The purchase of land, utilities and the construction of the remaining infrastructure as well as the entrance building were financed by SCHIG mbH in the amount of 67 million euros. The price of land was 23–25 euros/m2—the land is mostly covered with forests. Immorent Süd company built a hall for 40 million euros and leased it for 20 years to CCG.

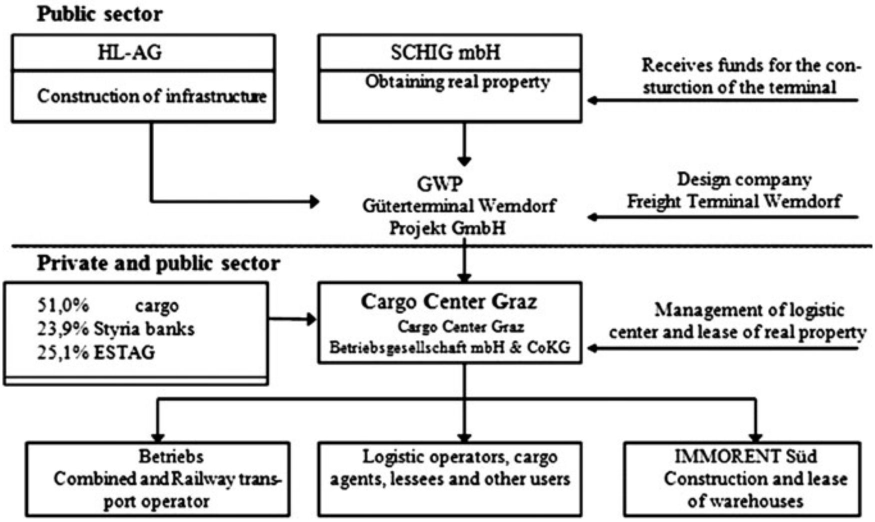

Fig. 3 The structure of the public–private partnership of Cargo Centre Graz in Austria, *Source* based on materials from the board of Cargo Centre Graz, 2004

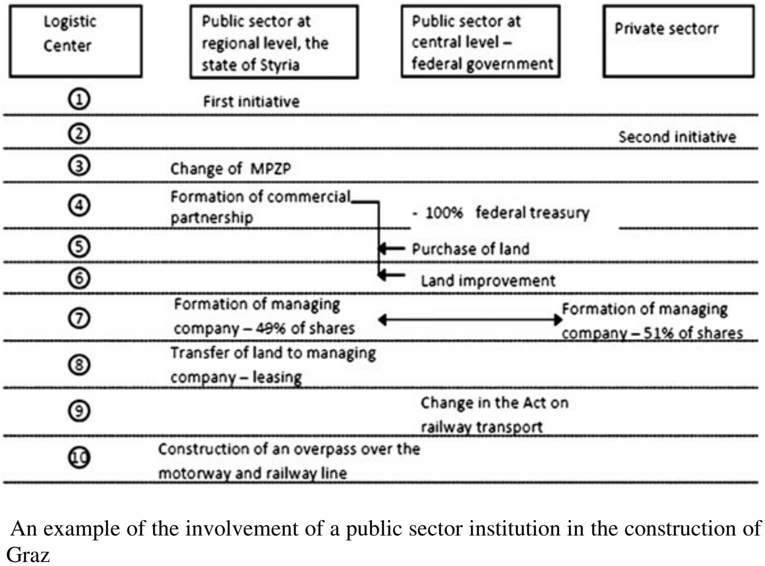

Fig. 4 An example of the involvement of a public sector institution in the construction of Cargo Centre Graz

The public funds covered (within a different project) the construction of an overpass above the motorway and railway line facilitating access to the logistics centre. The company with the land was granted public funds which covered all investments connected with the ground and underground infrastructure.

The public sector leased to the managing company (in which 51% of shares are owned by private transport, shipping and logistics companies) the land of the logistics centre along with its infrastructure with instalments amounting to 53% of the value of the logistics centre, payable within 30 years. In this way the managing company can purchase the logistics centre after 30 years for 58.3 million euros, which equals to 53% of its nominal value.

2.3.2 Holland

For many years, the legal basis for subsiding the intermodal transport in Holland has been the state legislation in the form of specific regulations prepared for the Ministry of Transport. Holland's Ministry of Transport formed The Foundation of Intermodal Transport which organizes the cooperation between consigners, operators in terminals, intermodal transport operators and carriers. A special Unit for Intermodal Transport has been created within the Ministry of Transport that plans the basic policy directions and coordinates different legal and financial initiatives for intermodal transport.

Financial aid is granted mainly from the national budget in the form of subsidy, low-interest loans, credit guarantees and credit and partly from regional/local budgets. The state's financial aid is granted for:

- Projects in public terminals and logistics centres (construction and modernization);
- Modernization of railways lines and reloading equipment at railway stations;
- Modernization of inland water connections and reloading equipment at inland water ports;
- Co-financing the purchase of intermodal transport units;
- To a limited extent, operational costs of intermodal transport, mainly for opening new connections.

The source of the funds can be the national budget as well as regional or local budgets. The Ministry of Transport has is regional branched which have budgets for promoting intermodal transport in the region. The financial aid is given to: public terminal operators, Railway, inland water shipping companies, intermodal transport operators, shipping agents and road carriers as well as consigners and logistics companies.

2.3.3 Italy

The first document regulating financial aid for intermodal transport was the state Act of 1990, amended in 1995 with similar principles and criteria for granting the aid since 1996. The Act determines the share of the state in implementation of reloading points at the junction of different transport branches (*interporto*) designated for intermodal transport.

Financial aid for intermodal transport is granted mainly from the national budget in the form of subsidies, low-interest loans, credit guarantees and loans. It is given for the construction of new terminals and modernization of the existing ones as well as for equipping the terminals in reloading machines, and in some cases for purchasing special cars for intermodal transport and intermodal transport units.

Financial aid is granted to intermodal transport operators, railway and terminal operators (in some cases).

Logistics center in Padwa—a case study

Logistics center Interporto di Padova S.p.A. is part of a long-term project implemented by the public sector institutions: the authorities of the Veneto region, the city of Padwa and Chamber of Commerce. The project started in the 1950s and its aim is economic activation of the Veneto region and Padwa vicinity as well as supporting small and medium-sized entrepreneurship.

The industrial zone managed by Consorzio ZIP is the biggest industry zone in Italy and second largest in Europe (1,050 ha in the zone and 200 ha in the vicinity of Padwa, outside the zone). ZIP is special kind of public institution—joint-stock company formed in 1956 belonging to the public sector: the Veneto region, the city of Padwa and Chamber of Commerce. The shareholders brought in 150,000 euros each and hold 1/3 of shares each (Fig. 5).

The purpose of ZIP was to stimulate the economic growth of the region by creating a transport infrastructure, purchase and technical development of land and their resale to companies and providing additional services which would make the land owned by the consortium more attractive for other investment. The purchase of agricultural land was not a problem—only few farmers refused to sell but they were expropriated under a special Act.

The effect of ZIP operations is an industrial zone—about 1,050 ha—where 1,400 companies opened business and employed 27,000 people. 18% of this land is covered by greenery. Moreover, ZIP has other land which it prepares for habitation in the Rovigo region (the so-called 13—about 100 ha) and Cittadella (the so-called Zitac—about 100 ha). ZIP's goal is creating industrial zone of over 10 km^2. Since the establishment of the zone in 1956, its goals has changed and today ZIP's main role is providing added value to the companies operating there, mainly by building synergy cooperation with other industrial zones in Italy and other countries.

The industrial zone includes production companies from different sectors: metallurgy, machine, biotechnology, telecommunications, high-tech and others, where over 27,000 are employed. ZIP is the owner of the interchange railway station and railway infrastructure with 7 km of rail lines. It also owns two entrance ramps. The whole are is wired with 30 km long fibber optic cable.

The whole area has five service centres with post offices, hotels, restaurants and self-service bars, insurance companies and other providers of services for the public and companies.

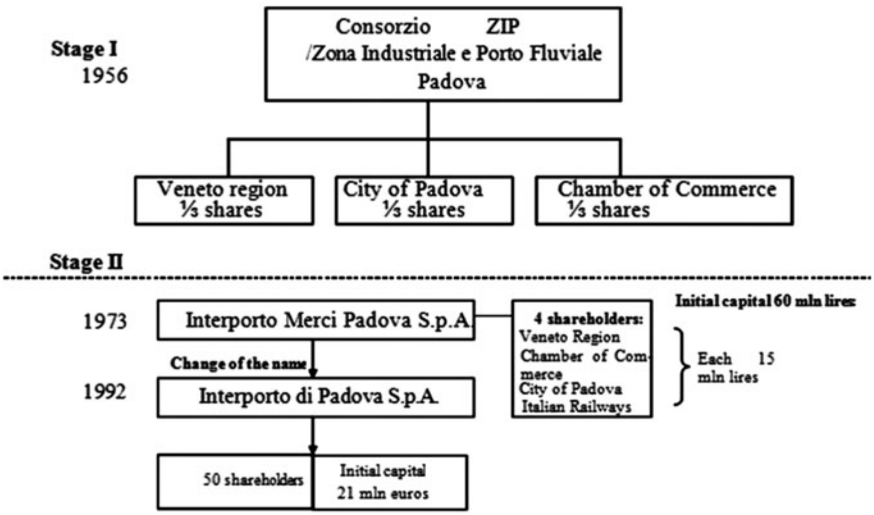

Fig. 5 Public sector share in shareholder structure of ZIP Consorzio Zona Industrialne e Porto Fluviale di Padova

ZIP has not received any state subsidies. The funds originally came from a bank loan, and later form land sale. At the moment ZIP has the following sources of income: real estate sale, infrastructural projects, design works.

So far, ZIP has not changed its area of business—it acquires land and makes it available to investors with no preferences given to any sector, the main indicator being that companies in the industrial area are production-based in $\frac{1}{3}$, logistics-based in $\frac{1}{3}$ and service-based in $\frac{1}{3}$. It also takes actions to integrate with other industrial zones.

Sale of real properly is tariff-based established by the shareholders—at the moment the price of land for sale is about 100 euro/m^2 and it is a preferential price. Apart from the price, ZIP does not over any other benefits or incentives. Almost 99% of companies operating in the industrial zone buys land for ownership, 1% has it in long-term lease.

Sale of real properly depends on the type of business a buying company does and projected number of jobs. ZIP sets the following criteria for the buyers:

- Within 1.5 years the company must implement the planned project;
- If the company ceases its operations the land cannot be re-sold without ZIP's consent.

Employment: Consorzio ZIP employs 20 people and cooperates with 15 more.

Logistic Center Interporto di Padova S.p.A.

Logistics Center Interporto di Padova was created on June 6, 1973 as a joint-stock company under the name of Interporto Merci Padova S.p.A with the capital of 60 million lires, with 4 shareholders: the city of Padwa, Veneto Region, Chamber of Commerce and Italian Railways. Each shareholder put in 15 million lires. In 1992 the company changed its name to Interporto di Padova S.p.A. At the moment the company's capital is 21 million euros and here are 50 shareholders.

The business objective is the promotion, coordination, development and management of all types of logistics activities but the company provides reloading services at container terminal while other services are left for other logistics operators.

Interporto di Padova is the largest rail-road container terminal in Italy. There is a conventional division: Interporto di Padova reloads containers while Interporto di Verona mainly trailers and swap bodies.

The area of the logistics centre is about 200 ha. The land has been bought by ZIP according to general rules. At the moment the area is developed. There is a container terminal where rail-road reloading takes place and warehouses of logistics operators. All buildings belong to IdP and are leased to their users. The operator in the container terminal is Nord-Est Terminal S.p.A.—the first company formed by the Italian Railways and the Board of the logistics centre for reloading at the container terminal.

Nord-Est Terminal S.p. A company was created in June 31, 1998 by the following shareholders: IR Cargo 51%, Interporto di Padova S.p.A 49%. Since 1999 the shareholder structures is as follows:

- IR Cargo 51%;
- Interporto di Padova S.p.A 19%;
- Interporto Bolonia 15%;
- Consorzio ZAI—Interporto Quadrante Europa di Verona 15%.

Logisitic Centem in Verona—a case study

Consorzio ZAI—(la Zona Agricolo Industriale di Verona) was formed in 1948 on the initiative of public sector institutions: Veneto region, city of Verona, Chamber of Commerce to support the industrial development in the vicinity of Verona. The basis for the operation of ZAI was Legislative Regulation of 24/04/1948 subsequently modified by the Act of 26/07/1975 n. 378.

ZAI Consortium is a special type of public financial and organization institution for industrial development of Verona, whose main task is spatial planning and supporting economic development of Verona (Fig. 7). ZAI buys out land from the owners (also by means of expropriation) merges them, provides underground infrastructure and builds roads and then sells or leas it to production, logistics and service companies.

The first effect of ZAI operations is the industrial zone ZAI UNO created on the area of 600 ha. In 1955, 42 production companies settled there and took over the area of 23 ha. At the beginning of the 1960s, there were as many as 230 companies, 137 of which were production ones, 61 connected with metallurgy and mechanics and 67 were trade companies with 49 dealing in fruit and vegetable trade. 15 companies were service providers (shipping, marketing, advertisement).

At the beginning of the 1970s, there were 409 companies, 263 of which were production companies. Eventually, the ZAI UNO zone, also called “STORICA”, became the settlement place for 600 companies, mainly from the agricultural and industrial sectors, with 20,000 employees.

The other initiative taken by ZAI is the ZAI DUE industrial zone created in 1978 and located in the Basson area on 100 ha, where 120 companies settled their business with 4,000 employees. In 1980 the zone covered 75 ha with 130 companies. The ZAI DUE mainly includes advanced high-tech companies. The third initiative by ZAI is the logistics centre Interporto Quadrante Europa covering 250 ha, where 100 companies operates with 1,800 employees. The fourth initiative is the Marangona area designated for high-tech companies. The business area of Verona in total covers 1,000 ha and is the place of business for 1,000 companies and 46,000 employees.

Interporto Quadrante Europa logistics centre

In the second half of the 1960s, ZAI marked out another portion of land—400 ha—for logistics activity. It was given the name “Quadrante” due to a specific geometric shape. Brenner and Serenissima motorways cross here and roads connecting Brenner with seaports of the Tyrrhenian and Adriatic Seas branch out here. Verona is also the first airport where airplanes land after crossing the Alps.

The official start date for the zone is 1973 when the customs office was transferred from the city centre to the Interporto Quadrante Europa zone and free customs zone was created, which currently covers 6.5 ha.

In 1977 Consorzio ZAI marked out land for the intermodal service centre for production and distribution companies to transport goods using railway and road. Interporto Quadrante Europa is heavily developed with logistics infrastructure and suprastructure where 100 companies—mainly logistics ones with 1,800 employees has settled. The logistics centre covers 250 ha (Fig. 6).

2.3.4 Germany

According to “Plan of German transport roads” (BVWP’92) and the Act on railway lines extension of November 15, 1993 (BGB1) as amended, interest-free loans or subsidies to construction costs of reloading terminals for intermodal transport were offered. The BVWP’92 projected 4,085 million euros for this aim till 2012. In addition, these funds were to provide additional costs for the transport system in door-to-door deliveries: double reloading in terminals, transport costs on the terminal-client-terminal route, manoeuvre processes, etc.

The scope of state’s financial aid is stipulated mainly in the “Programme of intermodal transport development” approved by the Cabinet of Germany in the form of a proper legal act.

Financial aid is granted mainly from the state’s budget in the form of subsidies, low-interest loans, credit guarantees and loans and partly from the local budgets

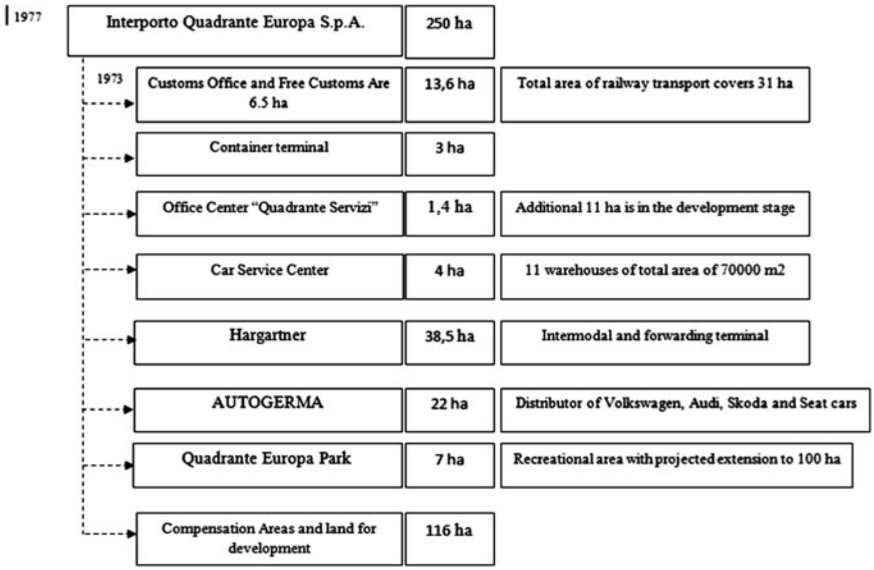

Fig. 6 Interporto Quadrante Europa S.p.A. logistics centre

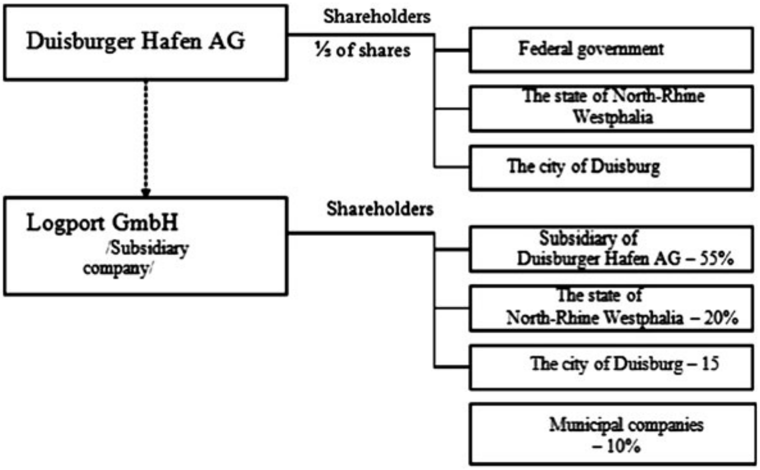

Fig. 7 Ownership structure in the logistics centre in Duisburg

(Länder). State's budget participates in co-financing of the construction and modernization of intermodal transport terminals in Germany via low-interest loans and subsidies. Subsidies to operational costs from the central budgets are given only in individual cases. Financial aid is granted to intermodal transport operators, railways and, in some cases - terminal operators.

Logistics centre in Lübeck—a case study

Logistics Centre in Lübeck was created in 2001 as a non-profit institution. Its aim is to obtain financial aid for the development of the infrastructure by creating design groups out of the interested members which prepare and file an application to relevant financial institutions. Lübeck is the participant in the application and share up to 30% of the costs (for most of the projects the applicants must have at least 50% of funds). An example of such a project is the development of the infrastructure on the land adjacent to the port. The city participates in such projects with non-cash contribution in the form of a land while the other participants provide cash contributions. On the developed land the superstructure is built and financed by the board of the port (roads, squares, etc.) as well as applicants for their own needs.

The board of the logistics centre purposefully gives up the form of commercial partnership in order to have better access to funds, especially granted by the EU. The centre does not conduct business operations, it does not record any revenue. The activities of the Lübeck logistics centre are financed from membership contributions.

Logistics Centre in Bremen—a case study

In 1985 in Bremen a logistics centre was opened in order to relieve the city from freight transport. A land near the railway line was selected, 8 km away from A1 motorway, Cologne-bound. The city offered the farmers—the owners of the land—6 or 10 DM/m^2, with the real value of the land for agricultural purposes at 1.5 DM/m^2. The price was supposed to encourage the farmers to sell. Lands of those farmers who did not want to sell were included in the city boundaries and the city threatened them with involuntary buyout at lower prices. This forced the farmers to sell the land. The city encouraged a group of logistics operators to create a developmental limited liability company in 1986. The city is not a shareholder and did not give the company any land but instead gave the company, for the first three years, 150 000 DM/year and for the following 3 years—50,000 DM/year, and after that the financing of the company was taken over by 25

To reduce investment risk the land was divided into five parts and each was subsequently improved. Then an offer was made to 12 operators for the purchase of 10 ha lots f 30 DM/m^2 (about 15 euros), or lease for 40 years. Eleven companies bought the plots while Roland (container terminal operator) leased the land. Then, the plots were sold at 25 euros/m^2, and at the moment at 30–35 euros/m^2.

In 1995 indicators projected for 2,000 were reached: 200 settled companies, including 52 logistics operators, 5,000 permanent jobs and 400 internships

Supervisory board: three representatives of the city; one expert—the originator and the author of the concept of the logistics centre, five representatives of the shareholders. Management: one CEO, one secretary, part-time (½) temporary employees (1–2, depending on the needs).

ENORDIA is a company which on the request of the Management of the logistics centre deals with planning and designing the provision of media and acts as an intermediary in its supply and cost settlement. Its responsibilities include:

- Planning and designing the energy media infrastructure;
- Gathering demand for electricity, water, gas, heat, AC and ventilation and sewage disposal;
- Negotiating collective supply of the media with the suppliers;
- Usage readings and billing with users and suppliers;
- Marking of access roads and the inside of the logistics centre.

Logistics centre in Duisburg—a case study

Since 1995 the Duisburg authorities started actions to transform the land after the metallurgical plant into a logistics centre and to generate new jobs. In 1998 Duisburger Hafen AG bought 265 ha designated for an international logistics centre. The shareholders in DH AG were: federal government, the state of North-Rhine Westphalia, the city of Duisburg. Each shareholder has $\frac{1}{3}$ of shares in the company (Fig. 7).

In 1999 a subsidiary company Logport GmbH was created (formed by another daughter company belonging to DH AG) and the "LOGPORT" started, financed by the EU.

The goals of LOGPORT:

- Elimination of unnecessary infrastructure and suprastructure;
- Infrastructural preparation of land for the construction of the logistics centre (roads and railway lines);
- Construction of infrastructure for container terminal water-rail-road;
- Creating conditions for logistics service of Duisburg;
- Creating industrial zone.

Measurable goals of the "LOGPORT" project:

- In 1999–2010, 200 million euros invested in infrastructure;
- Sale of the whole area till 2015;
- Creating 5,000 jobs till 2010.

Public entities—shareholders of Duisburger Hafen DG got involved in the "LOGPORT" project, because development of the infrastructure without the EU funds would not be possible. On the other hand, presence of commercial entities in the project gave grounds to fear that the EU will not provide enough funds for the implementation of the project or will reject the project altogether.

Logistics centre in Leipzig—a case study

There are 500,000 people living the Leipzig metropolitan area and the unemployment rate reaches about 22%. The government of Saxony expects that the companies settling the logistics centre will generate new jobs and the centre itself will attract various investors. The implementation strategy projects obtaining investors from production, distribution, logistics and other services. Obtaining manufacturers is considered key factor to success.

The land under the logistics centres covers two communes: the city of Leipzig and the adjacent rural commune. The authorities of Leipzig made an agreement with the commune in 1998 and included the land in question within the city borders and then created conditions for the construction of the logistics centre. This facilitated the company managing the centre—GVZ Entwicklungsgesellschaft mbH—cooperation with investors since so far the city competed with its own land offer in other locations. As part of the agreement large plots are offered in the area of the logistics centre for specific business activity plots are offered in other part of Leipzig. Moreover, the government of Saxony allocated funds for communicating the logistics centre with the road and railway infrastructure by financing road and overpass construction and internal roads in the whole area covered by the logistics centre. Investors received land with utilities and German Railways (Deutsche Bahn) built a container terminal which attracted further operators interested in supplies via railway. The government of Saxony gave direct support for the logistics centre by granting subsidies and supporting the project via dependent institutions (such as Sachsen Bank).

In 1992 the government of Saxony formed a design group which was to prepare the conversion of rural areas, without owners after the economic transformation, into the logistics centre. The group prepared a development plan and commissioned Sachsen Bank—the national bank of Saxony—the implementation of the logistics centre.

In 1993 the bank formed a limited liability company—GVZ Entwicklungsgesellschaft mbH—whose aim was to obtain land, its improvement and sale or lease to the investors. To do that the bank bought 340 ha of land which was handed to the company and 200 ha as reserve land. The company employed 17 experts in different fields (engineers, architects, designers, financial, advertisement and marketing advisors) to prepare the land and obtain users.

In 1997 340 ha was improved and the sale began. The contracts of the 17 people were not prolonged and the bank commissioned the managing of the company to three people employed directly by the bank. The developmental company was incorporated as a subsidiary to the limited liability company Prisma Projekt—und Investitionsmanagement GmbH, created by the bank to coordinated projects (Fig. 8).

Logistics centre in Kassel—a case study

Four entities: the district and the city of Kassel, the communes of Lohfelden and Fuldabrüuel commissioned the preparation to the goal-oriented union which formed a development company to directly implement the construction of the logistics centre. The development company formed two other limited liability companies: design company and operating company.

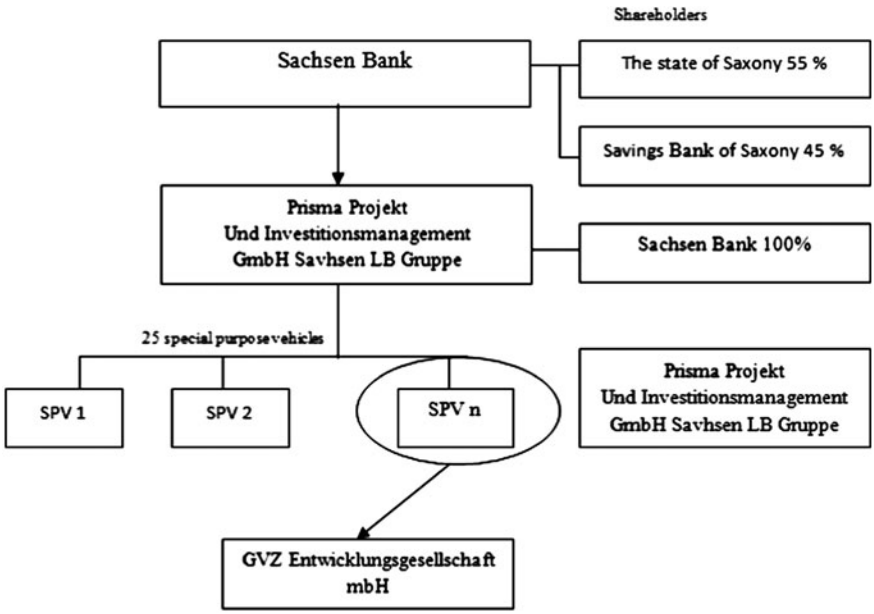

Fig. 8 Ownership structure in logistics centre in Duisburg

The development company incurred the following costs of preparation of the project in the total amount of 55 million euros.

Financing preparatory works:

- Five million euros: subsidies of local governments and the city of Kassel;
- 15 million euros: EU funds—special purpose funds Purpose number two—infrastructure development;
- 35 million euros: sale of improved land to investors.

The implementation met wit difficulties due to low-interest from the operators to buy the land. The president of the Chamber of Industry and Commerce of Kassel claimed that the preparatory works took too long and some of the potential investors implemented their project elsewhere. It is estimated that the real properly within the logistics centre will be sold but at a later date. Thus, the cost of the investment loan taken to improve the land must be carried by the local government and the city of Kassel which were the originators of the project.

Reasons for difficulties with selling the land to logistics operators:

- Unwillingness of DB S.A. to build regional logistics centre in Kassel which was treated by the operators as sign of possible problems in using the railway transport in the region;
- Long period of planning and construction;
- No reloading terminal during the sale of the real property to potential users of the logistics centre;

- No direct connection of the logistics centre with the motorway adjacent to it.

Difficulties with the sale of land caused problems with loan financing and in a long-term will force the company to raise the price of the land. Since this cannot be done endlessly, the resulting loss will be covered by local governments—the originators of the project of the logistics centre.

Centre of Logistics Competence in Kornwestheim (KLOK)—a case study

Centre of Logistics Competence in Kornwestheim (KLOK) is a network-oriented promoter of the logistics development, a company owned by the city of Kornwestheim. It is supported by the authorities of the Stuttgart region (WRS GmbH) and acts as the official centre of logistics competence for the Stuttgart region (Enders 2005). KLOK is a centre for all logistics-related matters in the Stuttgart region.

KLOK is a solution aiming at facilitating public–private projects in logistics. It represents companies oriented towards regional logistics. As the Centre of Logistics Competence, it is located at the regional level between the public and private entities. KLOK act as:

- An integrating agent between different institutions;
- An entity supporting development through common private projects of optimization of strategies of individual companies;
- An organization supporting creation of regional policy of transport and logistics systems, spatial planning and innovations aimed at improving the competitiveness of the regions.

KLOK's main tasks:

- Supporting cooperation between the administration and the main players in the logistics of the region;
- Supporting the region's economic development by solving infrastructural, organizational and technological problems;
- Coordinating logistic projects;
- Implementing the logistics goals of the region.

2.3.5 France

The state's financial help for promoting intermodal transport development was based on a special "Governmental plan of combine transport development" which is a part of "General programme of transport development in France" and including 5 year contracts with individual regions on promoting intermodal transport as well as agreement between SNCF and the government. Under these contracts, financial aid is granted in the form of subsidies for French Railways for the development of intermodal transport. The Minister of Transport founded a fund to subsidize yearly leasing fees for road carriers to purchase a specialist fleet and intermodal transport units for intermodal transport. All partners in the intermodal transport chain signed a special "Chart on intermodal transport development" which includes: representatives of the government, especially the Ministry of Transport, representatives of the principal entities of intermodal transport and transport experts.

Promoting intermodal transport is focused on supporting projects involving construction, modernization and equipping the terminals and infrastructure of this transport. In some cases it is possible that the state co-finances the purchase of intermodal transport units. Financial aid is granted mainly from the state's budget in the form of subsidies, low-interest loan, credit guarantees and loans as well as from the local budgets—even up to 30%. Financial Aid in the form of subsidies makes up about 50% of the projects' value, of which 70% is granted by the central budget and local budgets, while 30% by the Railway. Equipping and furnishing of the terminals is subsidized up to 50%, including 30–40% by the regions under special contracts made by the government with the regions.

Apart from the central budget, the local (mainly regional) authorities also provide financial aid to the development of intermodal transport. Some regional councils subsidize local transport companies to promote the purchase of body swaps and chassis.

The state's financial aid is granted to intermodal transport operators, railway, terminal operators (in some cases only) and also road carriers (co-financing purchase of intermodal transport units by the state).

3 Conclusions

Transport market is dominated by road carriers, including long-distance carriers, especially in international traffic. Roads and border check-points in the east are not adjusted to the increased road transport, which decreases traffic safety, increases infrastructure usage, prolongs waiting at the border, and increases negative effects as well as external costs of road transport.

A decrease in railway transport at the beginning of the 1990s caused considerable reserves for the railway capacity—which potentially means that the railway will take over some of the road transit in the intermodal transport.

The prospects for the intermodal/intermodal transport development are good both in terms of domestic and international transit. Whether this development will be dynamic or ordered and controlled largely depends on the transport policy, good will and readiness to cooperate with interested parties.

If the transport system in Central Europe is to develop according to the principles of sustainable development and distribution, it is necessary to eliminate the existing obstacles and introduce comprehensive means promoting intermodal/intermodal transport development.

It must be stressed that the existing obstacles and lack of promotional means are the main causes of low level of intermodal transport whose share (as previously stated) in railway transport was 1.5% in 2003 while in the EU countries it makes up 10–20%.

In most EU countries exist development programmes for intermodal/intermodal transport as part of the transport policy. To coordinate the developmental projects various structural, coordinating and monitoring structures have been created. The governments of those countries found that without a programmed help from the sate it is difficult to see the development of this eco-friendly transport subsystem.

In most countries there are separate legal regulations for financing intermodal/intermodal transport development. In general, financial aid goes to the terminals—its construction, furnishing in reloading equipment, purchase of intermodal units and some operational costs.

State's aid includes: investment outlays for terminal infrastructure, equipment and furnishing in the form of subsidies, low-interest loans, return of credit interest rate, special loans, leasing instalments payments for fleet purchase, faster amortization of fleet and loading units. This help can reach from 20 to 50% of incurred investment outlays.

Some countries provide aid in the form of "loss compensation" if intermodal transport is imposed by the state as an obligation of the public service (Switzerland, Austria).

In most EU countries, intermodal transport development is affected by: road traffic law more restrictive for drivers and freight cars in terms of safety, ecology, drivers' time of work; preferences of carriers and operators under international agreements; possible aid from the state for projects developing intermodal transport (Wronka 2001).

Individual countries promote intermodal/intermodal transport differently, depending on their needs by:

- Subsidies to terminal projects;
- Granting low-interest loans for constructing and extending terminals;
- Traffic ban for freight cars with total mass over 7.5 tons on weekends and holidays, excluding supplies to/from terminals;
- Exemption from vehicle tax;
- Exemption from fees for using the roads in road on-carryings in intermodal transport provided they take place on toll roads.

The main criteria for granting financial aid by the states for specific projects of intermodal connection include:

- Traffic load "taken over" from road transport (% share of intermodal transport on a given route/connection);
- Benefits such as reducing environmental degradation;
- Benefits for the road safety;
- Increased price and quality competitiveness of intermodal transport compared to road transport;
- Project's profitability;
- Financial and operational effects for other services;

- The ability to create further connections, coherent with trans-European network;
- The ability to obtain new clients.

The existing obstacles are connected to low quality of railway services, poor technical conditions of rail in many countries, non-competitiveness of prices compared to road transport resulting from too large railway freight and high prices of reloading operations and road on-carryings. The problem is also scarcity of logistics centres, what causes dispersion of cargo flow and makes difficult to open trainload transit within intermodal/intermodal transport system. Lack of unified and comprehensive information system in the land and water chains of intermodal/ intermodal transport is also on important obstacle. In selected Central European countries (like Poland) there is still gap of comprehensive legal regulations on intermodal transport.

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Pursuant to § 3 of the Act on Austrian Federal Railways of 1992, pursuant to Regulation of EC Council no. 1191/69 of 26 June 1969, modified by Council Regulation no. 1893/91 of 20 June 1991, transport which for environmental reasons, are in the public interest, can obtain financial aid in accordance with their execution as public services. For those benefits, within intermodal transport (including Ro-La) the compensation is set depending on the number of shipments
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Development of Intermodal Train Concepts as a Method for Sustainable Regional Development

Philip Michalk and Bertram Meimbresse

Abstract As the public awareness for the environment grows and road infrastructure reaches its capacity limits, regional administrations want to establish more environmental friendly freight transport solutions in order to address regional goals like accessibility, economic development and reducing emissions. But such solutions have to be designed not only with reference to technical and ecological issues. A key element to a successful implementation is also the consideration of economical aspects. If a concept is not tailored to market needs, it will be rejected by market actors and operators who are the ones which will have to implement these solutions. This chapter presents a thorough methodology on how to design new freight train services starting from the right point: the economical one.

Keywords Sustainable regional development · Intermodal transport · Intermodal services · Intermodal train

1 Introduction

In times were environmental awareness is rising, while transport demand is increasing, alternatives to road transport become more and more important. One main alternative is rail transport. Rail transport offers a high transport capacity per

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trip, thereby substituting numerous trucks, through its economic of scales it is usually cheaper, if enough load can be provided, and the steel-wheel/steel-rail combination offers a possibility to transport large masses with a comparatively low energy demand. In comparison to road transport however, railway networks can by far not provide a similar areal cover.

A solution to this problem can be provided by intermodal transport: Standardized load units, such as standard shipping containers, swap-bodies or trailers can be easily and economically transhipped from truck to train, thereby combining the good areal coverage of road transport in pre- and post-carriage with the economical and environmental advantages of rail transport. Intermodal transport in Europe is dominantly provided by companies that act on a free market. This also means that they choose by themselves which relations to serve and which regions to connect.

However, (political) regions represented by their administrations should have an obvious interest in fostering intermodal connections to develop their own transport systems:

1. Increasing the accessibility of a region for freight transport

In former decades regions tried to improve the accessibility of passenger transport providing new infrastructure and ordering new trains and busses. These approaches are based on an economic theory: Better accessibility makes regions more competitive. Regarding the development of new services the administrations in the European Union often used the cooperative framework INTERREG, provided by the Directorate General for Regional Policy of the European Commission (Community Initiative Programmes funded by the European Regional Development Fund). In the last years the picture changed; more and more projects also considered freight transport as an issue to increase the accessibility of a region or a cooperation of regions. In 2006 the project AlpFRail designed and implemented freight trains crossing the Alps with the help and on behalf of regional administrations. The great success cumulated in a presentation in front of different regional and national governments. Other regions adapted the successful approach and started in the last years a couple of projects like SoNorA, FLAVIA (both CENTRAL EUROPE) and SCANDRIA (Baltic Sea Region). But a review of the results achieved implies that concepts only basing on an evaluation of technical capacities and disregarding economical aspects have a weak standing with possible operating companies.

2. Making a region more competitive in economical terms

Lower transport costs have a positive effect on the attractiveness of a region for investors, as products manufactured in the region can be exported for lower costs and material needed for production can be imported for lower costs, making the overall production cheaper. Furthermore, a region which is well connected in terms of freight transport has also advantages regarding transport time and number of offered transport services. This makes it easier for companies to develop their own supply chains and to benefit from the availability of more environmentally friendly transport modes than road transport.

With the disproportional growth of road transport demand, road capacities reach their limits quicker, thereby increasing transport time and causing congestions. A shift of parts of this traffic to rail transport would relieve the road system, and lead to savings in the field of road construction and maintenance.

3. Rising the importance of sustainability and "greener logistics"

Most of the regions in Europe have set up emission reduction plans to meet the targets to reduce greenhouse gases and other harmful pollutants. Now the transport sector stands into the focus as it is the sector (in contrary to industry and households) which did not reduce absolute emissions in the last decades. Therefore, regions address this sector also with the goal to reach a considerable reduction in emissions. A shift of freight from road to environmentally friendlier modes of transport like rail and inland navigation is the number one choice on their agenda. In addition, less road transport leads to fewer road accidents, thereby increasing the quality of life in a region.

The development of intermodal train concepts can therefore, not only be an interesting transport solution for logistics providers but also a measure for regional development. The idea is that a region could assign the design of train concepts as part of a transport or regional development plan. Additionally, regions following the idea should be able to reduce their emission burdens in a conceptual cooperation with the transport companies. The concept could then be offered to potential operators, who would implement the concept as part of their production system. To convince an operator it will be necessary to draft a concept that is economically feasible and attractive. The chapter at hand shall give an introduction in how such a train concept can be developed, and what design features are necessary to make the concept appealing to an operator.

2 Methodology

2.1 Production Concepts

A number of different production concepts are known in intermodal transport, each with its own unique advantages and disadvantages:

A *shuttle train* is the—from an operations point of view—most simple production concept. This concept connects only two terminals, without any intermediate stops. Shuttle trains are extremely efficient as the production system is simple and by that the risk for production disturbances is small. Wagon sets are usually not disassembled. Also the efficient point to point traffic makes them relatively fast, as intermediate stops are omitted. On the other hand they need to attract cargo solely from the catchment area of those two terminals they serve and this cargo naturally also needs to be directed towards the catchment area of the respective other terminal. This increases the load factor risk (i.e. the risk that the demand is too low to defray costs. Special types of the shuttle train-concept include the *y-train* and the *antenna train*. The y-train-concept connects one terminal on one end of a run, with two terminals on the other end. The train is split to serve the two terminals on the opposing end. The antenna train also connects two terminals, but wagon-groups from other terminals are coupled at one or both connected terminals on the actual run. The y-train and antenna train-concepts are more complex than the original shuttle train and therefore reduce the advantages of the original concept. On the other hand they increase the demand for the service, by connecting more terminals.

Conventional *liner services* (in the definition used here) are also composed of wagons sets that are not disassembled. As opposed to shuttle trains they do not just serve two terminals, but a number of terminals more or less along their path between the first and the last terminal. Due to the additional stops their average transport time is somewhat longer than that of a shuttle train and the additional stops also increase costs. Furthermore, every stop introduced increases the vulnerability of the transport chain to disturbances and delays, as the number of processes that could be impaired rises. The advantage of this concept towards the shuttle train, is that they can attract additional cargo from the catchment areas of each terminal served. Through the larger number of terminals served, the cargo can be directed to any of the other terminals, by that increasing the demand for this service and therefore decreasing the load factor risk.

If the transport volume between regions is asymmetrical, a *triangular service* (also called a circular service) could be the solution. If the volume from A to B is much larger than the Volume from B to A (i.e. the transport volume is asymmetrical), a third region C could be involved. A service would only run in the Direction A to B, then run further to Region C and then run back to A, instead of running back from B to A.

Single wagon traffic is the classical production system in railway cargo transport. Instead of container or swap-bodies, the complete wagon constitutes a load unit. It can be loaded at a freight yard or a company railway siding. The wagons are then transported to shunting yards and combined to complete trains. This trains usually run between shunting yards are disassembled and reassembled for further distribution to other shunting yards, freight yards or railway sidings.

Such a production system is highly complex and transport times are increased by waiting times of the wagons at shunting yards. The advantage lays in a low load factor risk, as wagons for a particular train can come from a large variety of terminals, shunting yards or railway sidings. However, a road pre- and/or post-carriage increases costs and transport times, so that such a system is usually reasonable when most customer actually do have railway sidings at the starting- and destination-points of the freight and can load or unload the wagon at the actual starting or destination point. This also means that the respective customers should have enough freight to actually fill a wagon. Also the overall demand needs to be high enough to regularly guarantee a large enough demand on the trains running between the shunting yards, so that this system is usually only used by large train operators, that can afford the costs of operating shunting yards.

To utilize the advantages of more simple concepts like the shuttle train, connections can be combined via certain terminals, thereby increasing the number of total connection available. The simplest kind of such a concept would be a single-hub *hub-and-spoke* system, where a large number of terminals can be connected with a minimum number of connections. If G_{HS} is the number of connections in a hub and spoke system, G_{DC} the number of direct connections and n the number of Terminals (Diestel 2010):

$$G_{HS1} = n - 1 \tag{1}$$

$$G_{DC} = [n \times (n - 1)]/2 \tag{2}$$

For example, connecting four terminals only with direct connections would require six connections, connecting these four terminals, by facilitating one of them as a hub, would only require three connections. Figure 1 shows the different production systems discussed above.

Figure 2 shows the different intermodal train production systems compared to one another in respect to their load factor risk[1] and their economy of scales (cost decrease per production unit). One production unit in the case of an intermodal train would be one transported TEU. The cost decrease can be attributed to the fact, that less complex concepts also have lower fixed costs (e.g. for shunting yards, fees for terminal stops etc.) Generally, the simpler systems have lower transport times and lower operations costs, but therefore have a higher load factor risk.

There is a distinctive trend going towards the utilization of shuttle trains instead of more complicated liner services. Larger operators usually interconnect these trains through hubs.

For example HUPAC Intermodal SA, exclusively operates shuttle trains on its German inland connections (HUPAC 2011). To design a train concept that fits the existing production strategy of a train operator it could be advisable to concentrate the design of train concepts for regional development to shuttle trains, if the ascertained demand allows this. If demand for transports to and from a certain region can only be retrieved by connecting more than two points, a liner service must be considered.

Customers usually demand high frequencies and equal departure and arrival times at all service days (Kreutzberge 2008). HUPAC for example usually does not start a new intermodal service with less than four departures per relation and week, and they aim for at least daily connections on a relation.

[1] The load factor risk is the risk of not achieving a high enough load volume to cover the costs of a transport service at a given price.

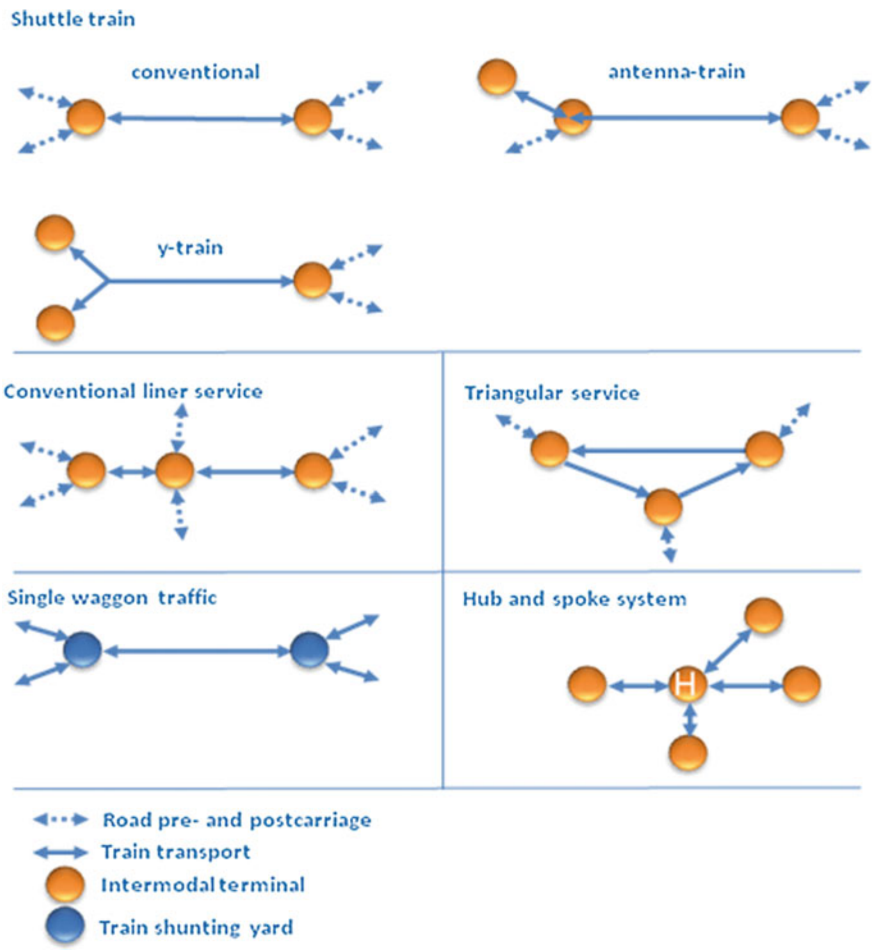

Fig. 1 Different production concepts in railway freight transport (own depiction)

2.2 Demand and Selection of a Production Concept

The chapter at hand is concerned with the question how to connect a certain region with one or more other regions. When a service shall be designed to connect a certain point, the number of destinations can be first narrowed down by considering a reasonable distance for the connections. As the main competition to an intermodal train can be found in road transport, a first step would be to find a distance from which on a train has a distinctive competitive edge—or is at least not impaired in terms of transport time towards road transport. Given the fact that a truck driver is allowed to drive a maximum of 9 h per day, before taking an obligatory break of 11 h in Germany and at an assumed average speed of 75 km/h

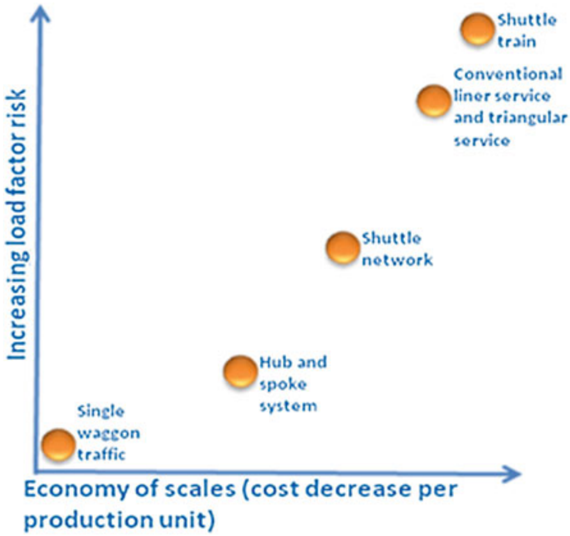

Fig. 2 Different intermodal train production concepts compared to one another and to single wagon traffic (own depiction, adapted from Baumgarten and Ihde 1999)

(which seems realistic for a highway trip), a truck would have an optimal range of (9 h × 75 km/h =) 675 km. Distances of more than 675 km would take considerably more time for a truck, as the driver would be obliged to take a break of nearly half a day. At an average speed of 60 km/h of a truck, intermodal transport is advantageous at a distance of already 540 km. Other authors conclude from statistical data that intermodal rail transport is not competitive below a distance of 300 km, but that it can be competitive at distance beyond 300 km (Clausen and Eiband 2010). So it can be assumed, that intermodal transport can be competitive from a distance of 300 km on, but that a distance from 600 to 700 km is clearly favourable.

On the other hand economically feasible distances can be even shorter than 300 km, as the practical distance for a new service depends on numerous other factors as well (for examples compare Allianz pro Schiene 2007) If such special factors are not known it still seems advisable to narrow down the number of possible destinations by assuming distances longer than 300 km, respectively 675 km. These distances however, depend on the qualities of the existing rail- and road-infrastructure. To determine the practical competitive distances from a given location, GIS software that supports accessibility analyses, such as the web based SoNorA tool, can be used (SoNorA 2011).

Time-distance graphs for different intermodal-train speeds (40, 60 and 80 km/h) and for pure road transport at average speeds of 60 and 75 km/h are shown in Fig. 3. It was assumed, that pre- and post-carriage (including transhipment at the terminal) would take a total of about 3 h, so that trains start with a time disadvantage of about 3 h. However, it needs to be noted, that the time advantage of a train due to the truck-drivers brake melts away, with a longer distance, until a

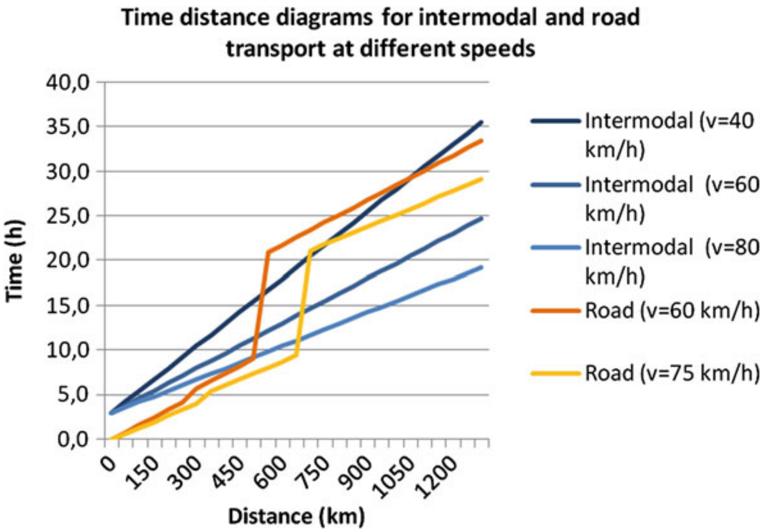

Fig. 3 Time-distance graphs for intermodal transport and pure road transport

distance is reached where a truck driver would need a second 11 h brake (at about 1,350 km at a average truck speed of 75 km/h).

For example: At a speed of 40 km/h for a train and 60 km/h for a truck, the train would need about 35.5 h for a 1,300 km trip, while the truck would only need about 33 h. At a distance of 700 km the train would need 20.5 h while the truck would need 23 h.

In a next step connectable regions in a relevant distance could be narrowed down further by analyzing the economic-geographic features around terminals beyond the given minimum distance. The road-side catchment area of an inland container terminal can be assumed to have a radius of about 100 km (Hohls 2008; INFO 2010). Using a gravitational model the most attractive point-to-point relations can be found, by feeding the model with the necessary economic data from the catchment areas of the concerned terminals. This could result in a ranking, starting with the terminal with the most potential (according to the gravitational model). The catchment areas of terminals with high rankings could then be further examined for industries that could have transport relations with industries in the region which shall be fostered by implementing a train service. For example: In the Europeans Unions SoNorA project a demand analyses showed potential for transports from Regensburg to Ljubljana. Further analyses showed that a number of 3rd and 4th tier suppliers for the automotive industry were located in the catchment area of the Ljubljana terminal and that a number of automotive fabrication sited existed in Regensburg (Behnke 2010). Such findings can be used to specifically aim at certain shippers as customers for the future train service.

The third step should contain surveys at companies in the region that shall be developed by the project, as well as in the catchment areas of terminals that have appeared to yield promising connections. The number of necessary interviews can vary greatly. Few companies with a large transport demand could easily occupy a complete train service. On the other hand it is quite possible that only companies with very small demand of perhaps 1–2 TEU per week can be retrieved. In that case a much larger number of companies would need to be interviewed. Within the European Unions SoNorA project 134 companies with very different shipment sizes (ranging from 1 TEU to 85 TEU per week) were interviewed. The retrieved demand was enough to occupy a liner train service with two departures per week in one direction. To find enough demand for a shuttle train with four departures per week, the number of necessary interviews could be much larger. On the other hand the SoNorA project concentrated on relation from East Brandenburg to Southern Germany and the Adriatic region. If the aim is solely to find any promising transport potentials then the number of promising connection-regions is more likely to include customers with a larger demand, thereby reducing the number of necessary interviews. However, it is difficult to give an exact number of necessary interviews to find enough demand, as too many unknown factors interfere. Such a survey could include interview questions that retrieve stated preferences, by suggesting given values for certain service features (such as transport time and transport prices). Such an approach would raise important information about necessary parameter values to design the service.

The ideal case would be to retrieve enough potential cargo on one relation to utilize the capacity of a shuttle train that runs four times a week through the interviews. Such a train would correspond to the usual production systems of large intermodal rail providers, such as HUPAC or DB Intermodal. However, the interviews could also reveal a very scattered geographic demand, made up of several demanded destinations, none of them large enough to utilize the capacity of a shuttle train to an economically feasible extent. In this case another production concept would need to be selected. Depending on the geographical pattern of the demand one of the above described systems (y-train, antenna train, liner service or triangular service) could be implemented. Different demand sources in one region would imply a y-train or antenna train. Demand sources which are spread between the first and last destination of a train would imply a liner service. Another option would be the connection to an existing hub system. This could be a promising approach, if several of the potential destinations are already connected via a hub. In that case it would be sufficient to connect the region that shall be fostered with the hub.

If a survey cannot be conducted to an extent where enough demand would be acquired to utilize a train in both directions of its run (for example due to a restricted examination-budget), the aim should be to at least acquire enough potential to utilize the trains potential in one direction. This could be achieved by simply interviewing enough companies within the catchment area of the terminal in the region that shall be fostered. If enough potential cargo can be ascertained this might be enough to convince a rail transport company to operate a train and search for transport demand in the opposite direction by themselves.

Fig. 4 Transport demand ascertained within the SoNorA and SCANDRIA projects and possible liner services (Michalk 2011)

Figure 4 shows an example of the results of a survey of the demand for intermodal block trains in the regions around Wustermark (West of Berlin, Germany) and Frankfurt (Oder) (East Brandenburg). In this case no demand was found that would justify a shuttle service. But there was sufficient demand found to justify two trains which would run as intermodal liner services:

2.3 Selection of Rolling Stock

The rolling stock of an intermodal train comprises of a locomotive and several intermodal wagons. The selection of wagons depends on the type of intermodal cargo transported and the type of the connection (seaport-hinterland connection or inland connection); furthermore the mass of the load units needs to be considered.

2.3.1 Wagons

If trailers are being transported, wagons need to be utilized, that allow for the transportation of trailers (unaccompanied intermodal transport). In the standard case this would be a pocket wagons such as the Sdgmns (also known as T3).

If containers and trailers shall be transported it would be advisable to chose a pocket wagon that has a length which does not waste to much train length by not utilizing the full length of a wagon for the container load. A wagon that meets these criteria would be the T4 which is currently only used by HUPAC.

If only containers or standard swap bodies shall be transported, a standard container wagon with twist locks would suffice. Wagon selection should also be based on the length of the load units transported: In port-hinterland transport a majority of the containers is made up by 40′ container units, a train composed of 80′ container wagons would be utilized to a maximum, according to Remie (2010). However, these wagons are less flexible if other container types (e.g. 45′units) shall be carried. As swap bodies are normally longer than 20′container units (usually between 7,150 and 7,820 mm vs. 6,058 mm), 40′or 80′container wagon would be not utilized optimally. A 60′wagon such as the Sgns 691 would be able to carry three 20′units or two swap bodies (or a mixture of either swap bodies and 20′units or 20′and 40′units). Such a wagon might be a decent choice for an inland connection were swap bodies and 20′units are dominant but 40′units have a share as well.

On the other hand higher rental or purchasing prices of optimal wagons could outweigh the revenue lost by using a non-optimal wagon. However, Remie reciprocates that higher rental prices are usually negligible in contrast to the lost revenue which he claims to be in a four-digit Euro range (Remie 2010).

Mass needs to be considered in terms of maximum axle load of the track used (mostly 22.5 t in Germany) and in regard to the maximum load capacity of the wagon. Wagons with a small number of axles in relation to their length might reach the axle load restriction of the track sooner than wagons with a larger number of axles in relation to their length. On the other hand the mass of a container in intermodal transport in Germany is already restricted by the maximum gross mass of intermodal trucks (44 t). At an empty weight of 16 t a truck could carry a load unit with a maximum mass of 24 t. However, the average mass per TEU of maritime containers lies more around 12 t.[2] The mass of containers seem to be indeed a small problem, considered the fact that 90′container wagons with only four axles are currently in development (Carillo 2010).[3]

2.3.2 Locomotives

If a train passes through different railway systems (i.e. different traction energy systems, different signalling and train protection systems) it is necessary to either

[2] Own calculation based on data from Eurostat.

[3] Special transport systems such as—for example—ACTS (“Abrollcontainer-Transportsystem” a horizontal transshipment system that requires special wagons), or special wagons and transshipment systems such as the Cargobeamer or Megaswing wagons (innovative systems for the transport of non-intermodal standard trailers) might also be considered, but shall not be the subject of this work.

change the locomotive at the system border or use multi-system locomotives. Multi system locomotives are usually more expensive when purchased. On the other hand the changing of a locomotive at a border costs time and shunting processes become necessary. In such a case the costs per roundtrip of both alternatives (with a multi system locomotive C_{RMS} and with a locomotive change C_{RLc}) need to be compared. Such a comparison will often be in favor of the locomotive change (against the use of a multisystem locomotive), thereby ignoring the impact of the additional transport time and the additional risk of further delay through additional processes.

For a rail transport company the monetary impact of such delays will be of particular interest. To include the costs associated with the delay, the impact on the revenue can be estimated, by using an elasticity function. In a first step the total time delay at a system border through a locomotive change (t_{tdb}) needs to be estimated. It can be assumed that t_{tdb} is composed of the regular additional time the processes of changing a locomotive take (t_{dbr}) and of a second time component that describes delays through unforeseen incidents (t_{dbi}). The average t_{dbi} needs to be estimated (for example through expert knowledge or data obtained through observations). Then the chance for the occurrence of such unforeseen incidents (p_{bi}) needs to be estimated as well. The total average time delay occurring through a locomotive change at a system border can then be calculated as:

$$t_{tdb} = t_{dbr} + t_{dbi} * p_{bi} \tag{3}$$

The time elasticity ε_t is defined as the quotient of the relative time variation (in comparison to an alternative) Δt/t and the resulting relative variation of demand for a service which takes Δt/t more time: Δx/x.

$$\varepsilon_t = (\Delta t/t) / (\Delta x/x) \tag{4}$$

If ε_t is known[4] and Δx is seeked, the function can be converted to:

$$\Delta x = ((\Delta t/t) / \varepsilon_t) * x \tag{5}$$

In the case at hand Δt equals t_{tdb}. The additional cost through the time delay are caused by a lower revenue R. Revenue is a function of price P and load x (for reasons of simplification demand is assumed to be equal to load).

So the actual costs of the alternative with a mono-system locomotive and therefore a change of locomotives at a system border could be estimated to be:

$$C_{RLc}\varepsilon = C_{RLc} + \Delta x * P \tag{6}$$

If $C_{RLc}\varepsilon > C_{RMS}$. The use of a multisystem locomotive would be favourable.

Naturally C_{RLc} and C_{RMS} have to include possible additional cost for acquiring the locomotive(s).

[4] Bühler calculates ε_t for intermodal transport in Germany to be at about −0.46 (Bühler 2006).

2.4 Cost and Energy Consumption

The operations costs per roundtrip are an important feature to assess the economic feasibility of a train service. Roundtrip costs have to be covered by the revenue generated through transported load units and the transport price of the intermodal transport chain should not be higher than the alternative of pure road transport.

To calculate the operations cost per roundtrip, it is sensible to first calculate the annual operations costs C_A, as some values are easier obtained on an annual level and are not depending on the number of roundtrips (e.g. investment costs for rolling stock, interests on borrowings etc.). The roundtrip costs C_R can then be easily calculated from this value.

The annual costs are composed of *Investment or leasing costs for rolling stock*, which are can be expressed through an annual value like an annuity, including yearly depreciation as well as interests or an annual monetary leasing rate. Leasing costs can vary depending on the leasing contract and should be researched depending on planned service duration and utilization. Annual investment costs (annuity) C_{SIa} can be calculated based on acquisition costs and interests. Interests can occur through outside capital as well as through equity capital. The interest rates underlying the annuity calculation can be estimated by using typical (or if available actual) interest rates for borrowed capital and using the interest rate of a possible investment alternative on the capital market for the interest rates of the equity capital (interest rates could be derived for example from federal bonds). A weighted average of these two interest rates could then be used to calculate the interest rate for the annuity calculation. The weight for the average calculation could be derived from the typical ratio between outside and equity capital in a rail transport company (or from the known ratio if calculations are done with a particular company).

Annual maintenance costs of a train C_{Ma} usually depend on the utilization of the rolling stock. So it is necessary to draw up a schedule to determine the annual mileage of locomotives and wagons. In the simplest case, maintenance costs can be expressed as a simple linear function of mileage. Statistic analyses that deliver a constant cost rate per kilometre have been conducted by Bente et al. (2006). Another possibility to estimate maintenance cost would be to analyze purchasing contract that include maintenance services (in such a case it would be helpful to know which average mileage was assumed for the contract). In some cases information about maintenance contract with fixed prices for a given mileage are published and can be used as well to estimate maintenance costs. When data in large quantities exist it also would be possible to create a model which would estimate maintenance cost based on various variables. Such approaches have been undertaken in the airline maintenance business, evidently with some success (compare for example Mildt 2000).

Manpower costs occur in various processes of a train operation. However, they can be mostly estimated cumulative with other costs related to certain processes (for example: maintenance costs as described above usually include the manpower costs as well). However, manpower costs for a train driver C_D have to be calculated separately. They can be assumed to be directly proportional to the time a train driver is needed. This does not only include the time the train is actually running on a track, but also times were the train journey is being prepared and during certain shunting services. It is reasonable to first calculate an hourly cost rate, based on the average income of a train drive, average sick leave, average vacation times and obligatory paid breaks etc. This rate can then be multiplied with a time value derived from the assumed schedule.

Traction Energy costs C_E have two influencing variables, one being the energy consumption, the other one being the energy price. Both variables also depend on the kind of traction (usually electric or diesel-electric). Energy consumption can be estimated in different ways. The simples would again be to use an average value per km and train gross-mass. Such values have been published for example by Baumgarten (2001). A first refinement would be possible, if average values for acceleration, constant speed and brake energy recuperation are available. In such a case the energy consumption E_T could be calculated as the sum of all Energy consumptions through acceleration E_a, constant driving E_c and breaking E_r:

$$E_T = \sum(E_a,\ E_c,\ E_r,) \tag{7}$$

From the evaluation of energy-consumption diagrams of a train ride, the following rules of thumb could be derived (Michalk, 2009, Mit Gewinn auf der Schiene—Eigenwirtschaftlichkeit von Schienenpersonenverkehren in Deutschland, “Unpublished”):

$$Ea = 0,00125 * \ m \ * \ dv \tag{8}$$

$$Ec = 0,000179 * \ m \ * \ v \tag{9}$$

$$Er = -0,00025 * \ m \ * \ dv \tag{10}$$

Hereby m is the gross mass of the train in tons, v the constant speed in km/h and dv the speed-difference in km/h from the beginning of the acceleration to its end, respectively from the beginning of the braking process to its end.

A much more precise determination of the energy consumption is possible if the exact physical traction work can be calculated and the efficiency of the traction engine is known (Wende 2003). However, this method requires a certain amount of effort and a large number of variables need to be known or estimated. The rule of thumb method ($E_T = \sum(E_a, E_c, E_r,)$) as well as the exact physical calculation have both one disadvantage in common: They require the input of how often a train brakes and accelerates during a ride. This is not a trivial problem, as especially freight trains (which for example have a lower priority than passenger trains in Germany) are often obliged to stop or slow down, to allow faster trains to overtake them. The numerous brake and acceleration manoeuvres increase the energy consumption and not including them in the calculation would lead to a too low result and thereby to too low costs. This problem can be avoided by using an average consumption value per km and gross ton.

Electrical traction energy is usually provided separately from other electrical energy supplies. In Germany "DB Energie" provides most of the electrical traction energy and maintains the electrical supply network. Prices therefore often differ from usual industrial electrical energy prices and have to be researched accordingly. Diesel prices for rail traction on the other hand will usually be similar to the market prices.

Infrastructure costs C_I are comprised of fees for using the railway networks, station and terminal fees, fees for using sidings to park the train and possibly fees for using shunting yards. Some network providers take additional fees if trains with electrical traction use the catenaries, other include this in the regular network fee or in the price for delivering energy. Calculating these costs depends on the pricing model of the provider, so that no general procedure can be described. However, it will be necessary to have a route and a schedule prepared, in order to calculate the amount of services that need to be purchased (e.g. how many km of which tracks need to be used).

As conventional intermodal terminals usually tranship either with a crane or with a reachstacker, trains need to be shunted to take them to the loading and unloading site. Often the line locomotive will be decoupled and the train will be further shunted by a shunting locomotive. In some cases the train will be further disassembled, as not all loading tracks can accommodate a complete train in its total length. After the transhipment process the train will need to be assembled again. The costs for these processes can be estimated by allocating each cost rates to known processes. This can include further calculations to determine operation costs of shunting locomotives, which would be similar to the calculations of the operation costs of the actual intermodal train. In some cases shunting services are provided at fixed prices, which are then to be used as *shunting costs* C_S. To calculate the shunting costs of a year it again is necessary to have an operations schedule for the train already prepared to determine type and number of shunting operations.

Train operations and movements on a network need to be monitored and controlled. The *train monitoring costs* C_{Mo} are usually comprised of technical and of personnel costs.

As no technical system is a 100% reliable, reserves need to be included in the planning process. In terms of rolling stock these reserves will be probably part of an operational fleet that is dispatched in a way that a malfunctioning vehicle can be replaced in an appropriate time. The additional *train reserve costs* C_{RE} can be calculated for each vehicle as a function of its known reliability d_k, the desired reliability d_d and the regular maintenance C_{MaR} and acquisition costs C_{SIar} of the vehicle:

$$C_{RE} = (C_{MaR} + C_{SIar}) * ((d_d / d_k) - 1) \tag{11}$$

Overhead costs C_O occur in every organization as the part of the costs which cannot be directly accounted to the creation of a product (in the case at hand the product is the train roundtrip). Overhead costs are for example aroused by the administrative functions of a company, such as the personnel management or the accounting department. They need to be estimated and usually depend on the size of the company.

The annual costs for the operation of one or more trains on a given route can then be calculated as:

$$C_A = C_{SIa} + C_{Ma} + C_D + C_E + C_I + C_S + C_{Mo} + C_{RE} + C_O \quad (12)$$

As already mentioned the roundtrip costs C_R can then be easily calculated by dividing the annual costs by the number of roundtrips n_R:

$$C_R = C_A / n_R \quad (13)$$

To calculate the costs of the complete intermodal transport chain it is also necessary to calculate the costs of pre- and post-carriage and the costs of transhipment.

As the load capacity as well as the load factor of the different transport modes in an intermodal transport chain can vary greatly, costs need to be calculated on a comparable base. It stands to reason to choose the costs per transported TEU as a base (in case of swap bodies larger than a standard 20′unit conversion factors could be used or the swap body size itself could be used as a calculation base). The cost per TEU self-evidently depend on the load and therefore on the demand.

Figure 5 shows the typical incremental costs per km of intermodal trains running between the Berlin-Brandenburg region and the ARA ports,[5] as well as Western Germany on the y-axis. On the x-axis the graphic shows the numbers of TEU transported. The blue line indicates the incremental costs for different load-volumes, while the orange block shows the typical load trains on these routes usually have (Michalk, 2009, Mit Gewinn auf der Schiene—Eigenwirtschaftlichkeit von Schienenpersonenverkehren in Deutschland, "Unpublished"). It is evident the costs per TEU can vary greatly (in this case between 0.21 € and 1.15 € per km) depending on the load.

If the average load of a train is given as d_R, the costs for the transport of one TEU can be calculated as:

$$C_{CR} = \tfrac{1}{2} * C_R / d_R \quad (14)$$

Transhipment costs C_{ti} usually just comprise of the transhipment fee at the terminal, which is mostly accounted for per TEU (Table 1).

Very similar models to the one above used for train transport can be used to calculate the operation costs of trucks. Costs for truck operations can then be used to calculate the costs of pre- and post-carriage by road per TEU C_{PPi}, as well as the

[5] ARA ports: The ports of Antwerp (Belgium), Rotterdam and Amsterdam (both Netherlands).

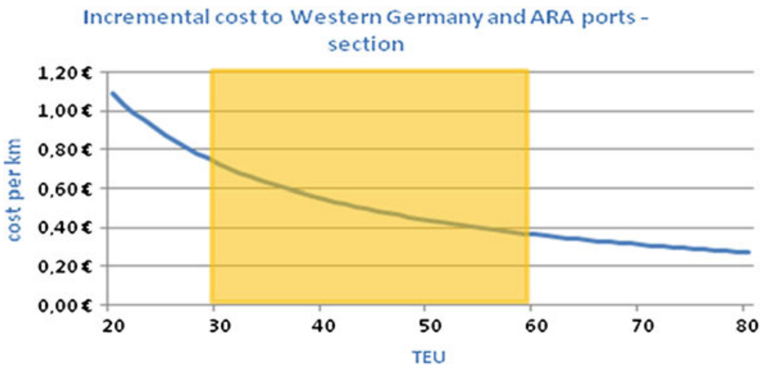

Fig. 5 Incremental cost degression per train for transports from the Berlin-Brandenburg region to Western Germany and the ARA-ports (Remie 2010)

costs of pure truck transport per TEU C_{PR} (as the main competition to intermodal transport).

The transportation costs per TEU (with C_{ti} describing the costs of transshipment) can then be calculated as:

$$C_{IT} = C_{CR} + \sum C_{PPi} + \sum C_{ti} \qquad (15)$$

2.5 *Revenue and Profit*

Revenue per roundtrip R_R is a function of price P and average revenue-transport load per roundtrip x_R:

$$R_R = x_R * P \qquad (16)$$

Prices can be determined by researching actual fares on similar routes or by creating statistical models. They describe the price as a function of different factors, such as transport time, transport distance and possible further service features. The load is determined by demand. As these two values can be estimated in advance it is possible to give a first prognosis if a service will be economically feasible, by comparing the total costs per roundtrip with the total revenues per roundtrip. The requirement to an economically feasible service would be that revenues are at least as large as costs:

$$R_R \geq C_R \qquad (17)$$

To actually convince a train operator or a logistics provider to implement a train service in order to foster a region, a profit for the provider becomes crucial, as long as no other incentives can be offered (such as subsidies to guarantee a certain

Table 1 Overview of cost components

Cost component	Description	Possible sources
C_A: Annual operating costs	Operating cost of one train over the period of a year	Calculation
C_R: Roundtrip costs	Costs of the roundtrip of one train	Calculation from Annual operating costs.
C_{SIa}: Annual investment cost	Investment cost of rolling stock calculated as an annuity	Purchasing contracts, annual business reports, and business terms of financial institutions
C_{Ma}: Annual maintenance costs	Annual costs for maintenance, repair and overhaul of rolling stock	Studies, statistical models, maintenance contracts, operations model
C_D: Personnel costs for train driver	Annual train driver costs, based on salary, sick leave, vacation, breaks etc	Human resources studies, labour unions, operations model
C_E: Traction energy costs	Costs for traction energy, based on energy consumption, energy prices and other price components	Consumption models, business terms of traction energy providers
C_I: Infrastructure costs	Costs for rail and other infrastructure used, necessary for train operations.	Business terms of infrastructure providers, operations model.
C_S: Shunting costs	Costs for the shunting processes of the train operation	Process models, calculation based thereon
C_{Mo}: Train monitoring costs	Costs for monitoring the train on its tour	Studies, process models, calculation based thereon
C_{RE}: Costs of train reserve	Costs to operate a rolling stock reserve, to increase the availability of rolling stock	Calculations based on maintenance and investment costs, known reliability of the rolling stock and desired availability
C_O: Overhead costs	Costs not directly accountable to the production	Business report analysis

revenue). Therefore the requirement for an economically feasible and realistically implementable service would be:

$$R_R > C_R \tag{18}$$

2.6 Emission of Pollutants

An important aspect for the creation of a sustainable transport service with a positive impact on a region is the emissions of pollutants and greenhouse gases. A value often used to give an estimation of the environmental sustainability is the CO_2 emission of a transport (Hecht 2011). Numerous studies and methods have been published to calculate the CO_2 emissions of different transport modes (for example: Hecht 2011; Wildau 2005). Usually the estimation of CO_2 emissions are based on the energy consumption of the vehicle concerned and the type of traction machine the vehicle uses. A short description of methods to estimate the energy consumption of trains has been given above and similar methods can be used to estimate emissions of trucks as well. When the average CO_2 emissions per trip (CO_t) are known, they need to be converted to a standardized value to allow the comparison. Similar to the calculation of costs per TEU, the average emission per trip and TEU CO_{tS} can be calculated by dividing the average emission per trip by the average number of standardized load units transported per trip x_t:

$$CO_{tS} = CO_t / x_t \tag{19}$$

This calculation can be conducted for rail as well as for road transport and when the same basic dimension (in this case TEU) is used, they become comparable [(kg)CO_2/(TEU)]. This values can then be used to make a statement which mode of transport is favourable in terms of emissions of pollutants and greenhouse gases

3 Practical Application

Numerous intermodal train services exist that run from the Berlin-Brandenburg region in an east–west direction. No intermodal services however, exist in a north south direction. So it can be expected, that implementing intermodal train services in a north–south direction from the Berlin-Brandenburg region, would in general benefit the region, as these services would substitute a large number of truck tours, thereby relieving the road network and reducing the volume of emitted pollutants and greenhouse gases. A region could particularly participate in the benefits of an intermodal hub which connects transport flows from different directions and therefore can provide additional services related to transhipment, storage and finishing of products. This may result in more and specialized jobs.

If the intermodal services would be less expensive than conventional truck service, they also would improve the attractiveness of the region as an industrial location, as companies located in Berlin and Brandenburg would have lower transport costs in a northern or southern direction. Concerning the economic “location theory” such reduction in specific transport costs will create an advantage of this location in comparison with other competing locations (Puu 1997).

It was already argued, that an intermodal train would have the biggest advantage towards road transport on distances between 500 and 700 km (compare Fig. 3). To show the applicability of the developed methodology an example shall be calculated connecting the terminals Ulm and Wustermark. Ulm in Southern Germany is located in a rail-distance of about 665 km from the Terminal Wustermark near Berlin. The road distance amounts to about 610 km. A train running at an average speed of 40 km/h would need 16.5 h for the trip. If it is assumed, that

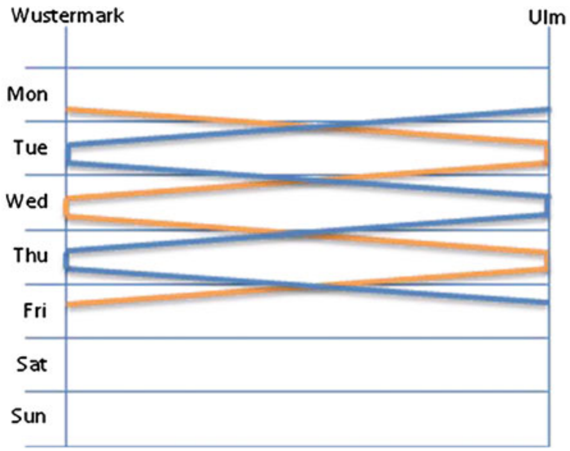

Fig. 6 Schedule for two trains (one blue, one orange) for a regular intermodal service between Berlin (Wustermark) and Ulm

pre- and post-carriage and transhipment would accumulate to an additional 3 h, the transport of an intermodal transport unit would take 19.5 h. A truck (including all obligatory driver brakes) would need about 21 h at an average speed of 60 km/h. The average truck speed was determined by calculating with different speeds for different road types.

Four departures per day in each direction could be realized with two train-sets, as shown in the schedule-graphic in Fig. 6. Each train would depart at 18:00 h in Ulm, respectively Wustermark and would arrive at 10:37 h the next day, at its respective destination.

It is assumed that the train would be 600 m long (thereby utilizing the maximum possible train length as dictated by the infrastructure) and composed of a Bombardier TRAXX F140 AC1 (a common locomotive for freight train traction in Germany) and 29 Sgns 691 wagons (60′ intermodal wagons, as described above as favourable on inland intermodal relations), giving the train a capacity of 87 TEU.

By using the model described above, the annual costs of operating one train-set were calculated to be:

$C_A = 3{,}495{,}995$ €

This translates to costs per roundtrip of:

$C_R = 33{,}615$ € (at two roundtrips per week, equalling 104 roundtrips per year).

At a load factor of 80% the train would carry 70 TEU. The costs for the transport of one TEU can therefore be calculated to be:

$C_{CR} = 240{,}11$ € per TEU

Pre- and post-carriage (over a distance of 50 km each) by truck and transhipment can be calculated (with a very similar model used to calculate the train costs) to cost:

$\sum C_{PPi} + \sum C_{ti} = 80{,}39$ € per TEU

The cost for the transportation of one TEU on this intermodal chain would then be:

$C_{IT} = 320{,}50$ €

Table 2 Comparison of key values between an intermodal transport chain and road transport between Berlin (Wustermark) and Ulm

	Intermodal	Road
Transport time:	19.5 h	21 h
Transport cost per TEU:	320,50 €	388,64 €
CO_2 emission per TEU	282 kg	610 kg

In contrast: The transport of one TEU by pure road transport over the same distance would cost:

$C_{PR} = 388{,}64$ €

A statistical model was used to calculate a typical price for an intermodal train transport (excluding transhipment and pre- and post-carriage). On a relation like the one between Ulm and Wustermark, a typical price would be P = 336 €[6] per TEU. So at an average load factor of 80%, revenues per roundtrip would accumulate to:

$R_R = 47{,}040$ €

The service can therefore be deemed economically feasible, as the condition is clearly fulfilled:

$R_R > C_R$

CO_2 emissions of the train can be calculated to be at about 11,504 kg per trip. Additional CO_2 emissions for pre- and post-carriage and transhipment accumulate to about 118 kg per TEU. The CO_2 emissions per TEU of the transport chain can therefore be calculated to amount to:

$CO_{tS} = 282$ kg

In contrast, the emission per TEU of one truck would amount to 610 kg. The intermodal service can therefore be deemed superior to pure truck transport, according to the indicators described in this chapter (Table 2).

4 Conclusions

Intermodal train concepts can be a superior transport solution to road transport in terms of economy and transport time but also in aspects of sustainability. However, not every transport relation is suitable to be developed with an intermodal train. Careful considerations and thorough studies are necessary in order to create a transport chain that uses the potentials of intermodal railway systems to a maximum and thereby provides a transport solution that fills the gap where road transport is a sub-optimal solution. However, regions that pursue the development of intermodal trains in the right way, can greatly benefit from the economic, environmental and social effects of intermodal connections. The example of the

[6] The breakeven point of this particular train, at the given price would be reached at a load of about 50 TEU or a load factor of 57%.

Berlin (Wustermark)—Ulm connection highlighted the potentials: Transport time decrease of 8%, transport operation costs decrease of 18% and a CO_2 emissions decrease of 54% would greatly improve the economical and environmental aspects of transport on this relation. Also, one train would substitute 35 trucks (at a load factor of 80%), thereby relieving the road system substantially.

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Innovative Freight Transport Systems for Ports and Terminals

René Schönemann and Timo Plattner

Abstract This chapter gives an overview of currently emerging innovative systems for freight transportation in port regions. All stages of development, from visions to market ready solutions have been researched. After the introduction to innovation for ports and terminals, new and innovative transport systems are classified and described by their technology (e.g. rail, maglev, monorail, tube etc.) and their designated application area. Later, requirements of terminal operators to those new systems are determined. In the end, technologies which are applicable for the usage in ports and terminals have been filtered and assessed against economic, social and environmental criteria in a benefit analysis.

Keywords Innovative technologies · Freight transport · Ports · Terminals

1 Introduction

Logistic service providers, ship-owners, freight forwarders, transportation companies, and customers expect a seamless transition of goods through the European inlands. The quality of the operating procedures in ports and inland terminals has a direct effect on the efficiency of the entire transport chain and thus, a certain influence on the attractiveness of business locations or the European traffic flows.

Acting as interfaces and hubs for intermodal transport, terminals in ports as well as inland freight terminals play a central role in freight forwarding. Traffic flows of

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different modes, mainly rail, truck, barge and sea ship have to be coordinated among each other and with those within the hub. Also, the numerous actors which are involved in the transports meet with their single requests at the interfaces and have to be coordinated.

European cargo hubs generally expect a strong growth in the near future. They might benefit from these forecasts but only if they are able to handle the future freight traffic. Often European cargo hubs face a lack of expansion potential. To preserve market potentials, it seems obvious that they must offer transport solutions which are capable of handling the future traffic more efficient than the conventional ones today. Scarce spaces, the vicinity to urban areas and the need to reduce emissions require distinct changes of freight transportation concepts. For environmental reasons the growing freight traffic must not lead to a higher consumption of land and resources.

Much research has been done in the fields of alternative freight forwarding technologies in the recent past. Innovations range from minor changes of conventional transport systems up to the development of completely independent solutions. However, hardly ever a new transport system has been applied successfully to the market or to daily practice. Then again, ports and other transhipment hubs characterize a perfect area for the implementation of innovative and alternative transport systems. Certain innovative systems could be established as a demonstrator in an isolated application or integrated in existing transport chains and thus would enable the owner to gain a leadership position on the market.

Hence, this chapter examines innovative and alternative transport systems for freight transportation and benchmarks them in accordance to their utilisability in ports and terminals. The following chapter overviews innovations in freight forwarding, new technologies, and transport systems under development, but not applied to practice yet. Further, we define possible fields of application for these systems and transport demand scenarios from and to hubs as well as for hub-internal transports.

2 Innovation in Freight Forwarding

Today's production techniques in freight forwarding, especially those for rail freight transportation base upon technologies already in use for decades. Innovative and alternative transport systems could not become accepted in spite of partly remarkable developments. In the light of the predicted growth in freight transport demand, it becomes apparent that the conventional transport systems will not be able to manage it unlimited, neither qualitative nor quantitative. To keep systems running and to minimize disruptions in the transport chains, development in two ways is possible:

- Enhancements of conventional modes of transport;
- Development of alternative transport systems.

Besides the high qualitative and quantitative capability, certain key factors can describe the different innovations. One key factor for innovations throughout the entire freight market is the need to reduce emissions. A change in drive technology can enable a zero emission transport for the time renewable energies are available sufficiently. As a consequence most developments for land transport technologies are somehow using electric drives. This is not feasible for waterway transport though due to long distance travels and the need to store the energy, which today's poor battery technology cannot cope. However, the efficiency of the engines has improved. Furthermore automated sails are recently being tested on big cargo ships on intercontinental routes.

2.1 Innovation in Land Freight Transport

Regarding the different modes of freight transport, different stages of development and innovation are apparent. Since air transport does not concern ports and hinterland transportation, the focus here is on vessel, rail and road transportation.

Transport by rail is generally based on traditional technologies of the nineteenth and twentieth century. Because it is a very complex system, having a strong interrelation between the track system, vehicles and operational structuring, major changes are difficult to accomplish. Train movements in the system are externally controlled by operation control centres and thus, a general compatibility of control and safety technologies among all users is evident. The same applies, for example, to the connectivity of cars and locomotives. One example for failed enhancements in railways is the introduction of central buffer coupling devices in Western Europe. Originally developed in the end of the nineteenth century, several approaches of its introduction failed and until today the conventional screw-type coupling is the standard with all its disadvantages.

Transport by road can register a more successful migration of enhancements. Since the interactions between track and vehicles are less complex and the system is self-controlled, innovations are easier to establish. Where here, the track contains no technology, all intelligence is vehicle-borne which makes innovations less dependent from surrounding conditions. The further development of trucks in the recent decades made road freight transport the most flexible and competitive one. Of course, as we know today, it also induces severe harms for the environment and leads to congestion on motorways and in cities.

Transport by inland water vessel actually plays a minor role in hinterland transportation in Europe. Nonetheless it is well seen as an alternative to road haulage. Due to its low speed and the limited areas of action, transport by vessel is rather attractive for non-urgent and for bulk cargo. Innovation concentrates only on the boats comparable to trucks in road transport but due to their long life cycles improvement is much slower. Hence, inland water transport is not very compatible with the logistics for high-value goods which represent the majority of transported items today. Innovative transport systems do not consider inland transport by water wholehearted.

2.2 Innovation for Ports and Terminals

Innovation in ports has been forced by the introduction of big container ships, reaching a capacity of more than 15,000 TEU today. With the landing of such a ship at a port several thousand container units are washed ashore so that the following instances are in need to handle them as fast as possible. Operational processes as well as transhipment technologies in the sea ship terminals have been improved widely in the 1980s and 1990s. In modern terminals several gantry cranes work on one ship, each of them equipped with one or more spreaders. In-terminal transports are performed by automated guided vehicles (AGV), driverless transporters.[1] Both sub-systems are optimized in interaction to allow a maximum throughput of cargo units from the quay to the storage area.

On the landside, those or comparable innovations cannot be discovered yet. From the storage area, cargo units are transferred to trucks directly or transferred to the railways terminal where they will be loaded onto freight trains. The throughput of cargo units on this side of the transhipment system is significant lower than on the quay side.

Obviously, the bottleneck of present transhipment interfaces at seaports is identified here. To increase the efficiency of hinterland transportation processes from and to seaports, major changes are necessary in transport technology and operational process management. Putting innovative and alternative transport systems into consideration compared to an extension of the conventional systems might be one option to increase transhipment and transport speed. Those systems seen as suitable are described in the following section.

3 Innovative Systems for Freight Transportation

There are numerousness concepts with different innovations on the market. We will focus on systems suited for standard container transport as it has become the most important loading unit in sea shipment and allows easy intermodal transport. As mentioned before, the waterway transport systems will not be looked at more closely.

3.1 Systematic Classification of Innovative Transport Systems

We are looking at a big variety of different transport systems. As a consequence one system is not necessarily better than another; maybe it is just more suited for a

[1] A good introduction to ports and container logistics is given in (Schönknecht 2009) or (Kim and Günther 2007).

certain applications field. To get a better overview, possible classifications are introduced here. The system's descriptions will refer to these.

One very important criterion, systems can be categorized by is their development status. The development status gives information on how fast a system can be implemented, whether homologation issues are expected or how reliable it will be. Concepts that have not reached a demonstration phase leave a great number of doubts on these issues whereas during demonstration the reliability can be proven. Some of the regarded systems are new developments; others are further developed and adapted existing systems. Therefore the degree of existing technology used under the target condition is another good description for this issue.

A very general way is to categorize the systems by the type of infrastructure they move on. This shows their compatibility to the existing infrastructure. Conventional infrastructures are rail or road systems. There are several ways to handle this question. Some systems can physically share the existing road or rail infrastructure, this refers to terminal infrastructure as well, but does not necessarily meet some regulations, for instance due to exceeding the permitted loading gauge. As for the railway infrastructure in Germany for example, the space between the rails has to be kept clear, and therefore would not allow a linear motor being installed there. This is no physical constraint but a national regulation which may be changed with the upcoming technologies. In this chapter, all systems that are technically able to travel together on the same infrastructure without disturbance are categorized as rail mounted systems, no matter of permission, certifications, or other regulations. The same is for road systems. Beyond conventional track infrastructures, there are systems using alternative ones. Some of these track infrastructures are taken over from other application fields, such as maglev systems, others are using overhead carriers. A characteristic of those infrastructures is that the track often contains parts of the propulsion.

The last classification of the systems is according to their purpose or target application field. Transportation of containers in ports can be of the following four types. The first and well-automated transport mode in modern terminal is the inner-terminal transport, usually between the quay and the storage. The second application field is connecting terminals, depots and logistics centres within one port. The common distance for this is between several kilometres and twenty kilometres. In some areas hubs are built to stop congestions due to excessive truck traffic entering the port region. For this scenario the transport system would link the hub to the terminals. The last purpose is the hinterland traffic that connects ports to the continental areas with distances between several hundreds to a thousand kilometres.

3.2 *Portraits of Innovative Transport Systems*

During the evaluation phase around hundred innovative transport systems have been identified worldwide. Evidently, not all of them can be presented here.

Moreover, the differences between some systems are quite slight for the purpose of this chapter. Consequently, this part contains the descriptions of selected of innovative transport systems, aiming to illustrate the wide variety of technical innovations. First starting with common infrastructure modes, the innovations of the systems will be presented getting to the most innovative ones in freight transport.

3.2.1 Road Systems

Firstly we get to some systems that are already in use within terminal areas, but can also be employed for an extension to link terminals over a few kilometres distance. With top speeds of less than 30 kph they are not suited for longer distances though. The automatic guided vehicles (AGV) are well approved connecting the quay with the container storages in sea terminals. As it is a closed area, there are no homologation issues due to automated operation. The infrastructure adoptions are minimal as the orientation works with passive transponders. There are different attempts to improve their efficiency and thereby reduce cost: TTS Port Equipment AB for example tries to raise the transported net load and has created a removable structure to carry double stack containers. The Gottwald GmbH, in contrast, has a focus on the process flow optimization. The Lift AGV can lift its platform to autonomously collect containers from a rack Gottwald Port Technology GmbH (2011). This reduces or in the ideal case eliminates the waiting time for the crane. Both companies are developing an electric version of their AGV. Gottwald is using an 8 ton exchange lead acid battery, which is easy to recycle (Modler 2011). TTS charges the onboard super capacitors with inductive energy transmission in the loading areas (TTS Group 2011).

One more system used in terminals for loading and unloading is the Straddle Carrier. An adoption of it has been created for short distance transport, the **Sprinter Carrier**. The major change is the reduced height to enable a better driving performance. In this version the Sprinter Carrier is capable to lift double stacked containers. The Sprinter Carrier is manually driven and all elements are approved during the use in container handling. Consequently no unexpected reliability issues are expected.

The firm Götting is known for their automation devices and sensors that are also used for operation control of AGVs. They have equipped a serial truck with sensors and automated steering and driving devices and are operating it with a top speed of 5 kph for in-plant traffic at UZIN in Ulm, Germany. This is a shared space with manually driven vehicles and pedestrians (Götting 2011a). It can reach higher speeds of up to 80 kph with an alignment tolerance of less than a driver can achieve. The new concept implies an electric engine with power supply via catenary line as known from railways systems or trolley busses. Depending on whether you have an electrified version or maybe a hybrid and how large the energy storage is, the Automated Truck has the best opportunities of using the existing infrastructure. Along with the option of changing to manual driving, it enables a great flexibility in process planning. The system will most likely only be feasible if the trucks can drive automated most of the time as it is quite costly to carry the equipment and remain in manual mode. The Truck can pull up to three trailers and the automated mode allows building convoys. Most of the technology has been successfully used within different transport systems for many years, never in this combination and at such a high level. There is only little risk for reliability issues.

Another system that is able to drive on conventional roads is the dual mode system CargoTram from MegaRail. MegaRail has developed a new concept for the infrastructure, the CargoWay, and vehicles. The infrastructure is a simple steel structure with the necessary wires for automation and inductive power supply. There are several alternatives for different loading units resulting from the different sizes. Three of the solutions are suited for container transport. The cargo trains and individual automated cargo carrier vehicles are designated for the long distance transport on its own infrastructure. The CargoTram is more suited for short distance and more flexible entering the terminals as it is a dual mode vehicle. The CargoTram consists of a lead car coupled with up to five carrier cars. While driving on the CargoWay, the power supply is ensured through inductive transmission to all wheels and an automated operation can be enabled. All wheels on all cars are propelled by permanent-magnet electric motors and can be steered individually. This allows a small turning radius. The rubber wheels permit high acceleration and climbing grades of over 10% with a travelling speed up to 120 kph. When leaving the CargoWay, the CargoTram is manually driven through the lead car and batteries ensure the power supply. The CNG-powered generator can be used for longer distances or as a backup. The system can be implemented in 30–45 months without the automated operation (Henderson 2011). The technical elements are standard elements with very little risk to reliability issues due to the new configuration. The vehicles are designed to be waterproof to protect the loaded goods.

3.2.2 Railway Systems

Not only the long lifespan of railway equipment and vehicles, but also the high degree of regulations is an enormous barrier for innovations in the railway market. The regulation shall not be seen as prohibiting the technologies in order to keep this field open as it is something that can be changed and varies looking at different countries.

Another dual mode system is the ASAPP ONE, which was developed for connecting port terminals with a hub at a distance of up to 50 km. The ASAPP ONE can travel on the conventional railway system as well as on roads. Driving on the railway systems, it can travel at 50 kph, whereas on the road or in the terminal area it only reaches 12 kph. The power supply for the electric engine works through a conduction rail when travelling on the railways. The train-borne batteries allow a thirty minutes free drive inside the terminals. The vehicle is prepared for an automated operation (Milesi 2004). Most equipment is known from railway systems and therefore expected to be reliable. Due to a higher number of equipment components for dual mode operation, a significant increase in wear and tear as well as need for maintenance is expected, however, reliable values are not well-know yet.

Being in competition with road transport, one attempt to improve the wagonload traffic in Germany was through developing an automated wagon that can autonomously travel to the siding tracks and be coupled to a train for the main run. The CargoMover was a project by RWTH Aachen and the Siemens AG. The main focus was on developing a sensor technology that ensures safe operation and can detect items on the track. The operational systems allowed the wagon to be contacted by sending a SMS and it would autonomously find its way to the destination. The operation is based on the new European standard ETCS level 3 and GSM-R. When facing an obstacle on the track, the CargoMover would stop and wait for the track to be free again before continuing the trip. It never reached homologation for automated operation as the German regulations require a train driver, the testing was successful though. The prototype was equipped with two truck engines, but they can easily be exchanged with electric drives (Mairhofer and Janßen 2003). The onboard units used for the prototype was standard computer equipment, but this can be exchanged with more proven equipment to increase the reliability.

A project that was derived from the CargoMover is the CargoSprinter. The CargoSprinter is a self-propelled flat car with driver cabins on both sides. The short trains were intended for easy and flexible access to siding. For the main run they can be coupled to long trains. By information of Windhoff, adoptions for the use in port regions have been made, unfortunately as by today there is no information available. The CargoSprinters were based on technical equipment that has either been approved in railway or roadside truck transport. As there is no sensitive sensor technique, no severe reliability issues are expected.

Besides automation, there is one other major innovation on railcars. Several developers design their concepts with linear motors. Linear motors enable the option to climb grades greater than 10% as there is no more dependency on friction and at the same time it improves the driving dynamics. On top, those systems are not weather dependent and a significant noise reduction can be achieved. There are two main types, the linear induction motor and the linear synchronous motor. One concept using the long stator linear synchronous motor is MagneRail. The so called tow vehicles are simple bogies with coupling devices and passive magnets installed. They either pull single freight cars and swap bodies, when on paved railway, or can be sized to be able to pull up to 100 freight cars at speeds of higher than 100 kph. The control system can achieve headways of about 10 s. This way MagneRail is very flexible with common railway trains as a simple tow vehicle can pull any type of existing freight wagon. This makes it suitable for shunting and connecting terminals before building trains for the long run. The technology is expected reliable and weather proof at any conditions. An implementation can be achieved within 18 months (Shapery 2011a, b).

The University of Paderborn has developed the RailCab, which is running as a scale model on a 540 m test track for about 10 years. It was originally intended for the passenger transport and has a high degree of technical equipment. Together with the firm Rotte, usually working in custom built machinery, a container freight car of the RailCab is in development. The RailCab can travel on conventional railway infrastructure and only requires a metal plate in between the rails for the short stator linear induction motor. The power supply is planned through a conductor rail known from subway systems. The local operation control on the vehicles enables high flexibility and the option to merge to a convoy and leave it at any stage. The flat wheels in combination with active steering allow the use of passive switches and thereby faster change of direction and shorter headways (Rustemeier and Gockel 2011). The equipment is mostly taken from existing systems, for some items reliability still is to be proven in operation though.

One railways system is designed as a tube concept. The idea was to undergo homologation issues for automated transport and ease construction issues as no passengers or drivers will be using the infrastructure. There are two designs of the CargoCap, one for intermodal transport and one for less than container loads. The CargoCap travels on standard gauge rails and is propelled by asynchronous motors. The power supply is via conduction rail. The vehicles are designed to travel at speeds of 80 kph and can climb grades of up to 1.25%. The single vehicle can be mechanically coupled to trains. As the technology is known from railways systems it is regarded as approved in terms of reliability. The technology is ready for implementation. Last technical questions can be overcome during construction phase (Stein 2011).

3.2.3 Alternatives to Rail and Road as Transport Medium

Some transport technologies not using rail or road, have been developed and could seriously be adopted for the usage in container handling. Most of them are adaptations from other applications.

Not all types of infrastructure in this chapter are really new. Some have just never been used for freight transport, but for passenger transport only. A number of them are magnetic levitation systems (maglev). Some concepts have been followed for many years and eventually have been dropped as not feasible for heavy weight transport though. The benefit of magnetic levitation systems is the greatest at high speed and on long distances. One system originally developed as an extension or partly substitution to highways is Auto shuttle. The Auto shuttle was initially designed to carry cars, trucks and busses, so they can travel parts of their trips in a cabin on the new infrastructure instead of driving on the highway. The cabins are propelled by a long stator linear synchronous motor to up to 180 kph and can build convoys. Being designed for trucks, the systems have no weight or structural issue carrying container loads. After all the system is not exclusively developed for freight transport, but suited for containers and allows mixed traffic (Krevet 2011). Many technical elements are approved in existing systems, but some in different application fields. Therefore effects on maintenance and reliability cannot be foreseen.

The Freight Shuttle System was known as the Safe Freight Shuttle in its earlier development. It is designed for the long distance transport as well. The single freight cars are aerodynamically optimized and can travel up to 100 kph. It can transport swap bodies as well as standard containers. The track guidance for the automated vehicles is through a central guidance rail that contains the inductive energy transmission as well as the passive parts for the short stator linear induction motor. The steel wheels roll on a steel platform. A prototype is planned for 2012 (Roop 2011).

Ropeways are mostly known for passenger transport in mountainous areas, but can also be found in freight transport, for instance in mining industries. During the European project ISETEC II a container ropeway was developed to transport standard containers with up to 20 t over short distances. During the project homologation issues occurred. The area underneath the containers would have to be kept clear for safety reasons at any time (Pallasch et al. 2010). Ropeways reach greatest benefit for short distances where high grades have to be overcome.

Two other projects followed the idea of overhead transport of containers. The Auto-Go system is an extension to GRAIL, which in fact is a high performance container handling system. GRAIL was developed for high performance container handling in terminals. The extension developed as Auto-Go was intended as a link between terminals. There is no recent activity on it though (Dougherty 2011). A similar project in Germany is Concar. Two overhead conveyer trolleys carry one container. As the trolleys are split in two independent halves they are very flexible in the size of the loading units. On the way the trolleys operated automated Arnold and Rall (1996).

The Containerway is a roller conveyor way sized for transporting standard containers. Similar systems for smaller cargo units are well known, such as luggage handling systems in airports or parcel sorting systems. Each roll (wheel) has an electric motor and can be individually operated by the central operation control for the best performance of the system. As containers may be sensitive to damage due to torsion and other forces, it will be held by a metal plate that is running on the wheels. Using different sizes of metal plates gives a high degree of flexibility in the type of freight being transported. The concept design plans a full cover of the Containerway with solar cells to propel the wheels (Grilli 2011).

Besides the CargoCap there is another underground system that has been examined for freight transportation in urban areas. The Pneumatic Capsule Pipeline is derived from the postal pipelines that have been built in big cities more than a century ago. A capsule that is well-fitted in the tube is either being pulled by negative pressure or pushed by positive pressure. As by today some systems with diameters of more than one meter have been built (Roop et al. 2000). Building a pipeline for standard intermodal containers with width of almost 2.50 m and a height of up to 2.90 m for high cube containers is yet another dimension and it is very difficult to control the forces. The firm TubeXpress has started developments of a tube concept propelled by linear motors. Magplane Technology Inc. created the first demonstrator with a linear synchronous motor that is travelling at 65 kph. This technology also leaves options for squared pipelines that after all can do with smaller tunnels. Pneumatic pipelines require minimal clearance which is only possible with round diameters (TubeXpress 2011).

4 Evaluation and Needs for Ports and Terminals

Several plots are thinkable to introduce alternative transport technologies for ports and terminals. Although a concrete field of application depends highly on individual requirements and local structures, two sample plots are defined here. They are characterized by the transport length and the resulting requirements.

4.1 Intra-Areal Traffic

The easiest way of disseminating new technologies is their implementation in a closed area, such as for in-plant transportation or transportation between two neighbouring terminals. Certainly, in the scope of this chapter this affects only bigger ports with a complex production structure but factories with railway sidings might also be possible beneficiaries. Characteristics of this plot are:

- Short distances to get over;
- High frequency of transports.

Generally, the idea of considering alternative transport systems for in-plant transportation arises from the lack of space for further infrastructure extension in an area. A good example for successful introduction of unusual transport systems is the *Volkswagen Sailbahn* ropeway in Bratislava, Slovakia (Volkswagen 2011). Partly, the need of installing track systems mounted on pillars or in the underground is one of its drivers. Some of the alternative transport technologies take advantages from this plot as it will be explained later. The biggest issue here is the need to integrate a new system into the course of the processes inside the plant that they go coherent with preceding and succeeding operations.

4.2 Inter-Areal Traffic

The implementation on long distance relations describes the second essential way of disseminating alternative transport systems on the context of this chapter. While the installation of new infrastructure systems over long distances is all but impossible, it is necessary that the relevant alternative transport systems are compatible to existing infrastructures. If other infrastructure is required by an innovative system, conventional systems (truck, freight train) at least must be able to run on it. An example for this issue is the ex-post installation of linear motors in existing railway infrastructure.

Besides the higher demands to track compatibility, inter-areal transport requires compatible loading and unloading facilities in knots. The installation of a two point shuttle service as a first attempt sounds comprehensible but might be economically unsuccessful because the most of the innovative transport system benefit from their full abilities in automated operations in networks (e.g. formation of convoys, autonomous driving). Giving them only functions like the shuttle trains have today, big advantages in efficiency and operation cannot be expected from innovative transport systems. As soon as networks shall be served or transports shall be bifurcated the tide turns: Many innovative systems pick up the big disadvantage of the classic railway system of not being network-capable.

5 Evaluation Criteria for Alternative Transport Systems in Ports and Terminals

To determine which alternative and innovative transport systems are suitable for transhipment hubs and hinterland transportation it is useful to determine criteria which are important for the operator of those systems and which enable an objective comparison. Economic and performance criteria are essential but others play an important role as well. When a new system is to be introduced, important parameters to examine are also safety, durability, reliability, and fallback policies. Therefore, it is necessary to estimate their effects on:

- **Operating efficiency:** e.g. performance and capacity of the system, integration within the port;
- **Business-management:** e.g. efficiency of transhipment processes, cost of acquisition and operation;
- **Ecology:** energy, e.g. emissions, resources, and land consumption;
- **Economics:** e.g. effects on labour market, external effects.

For an easy comparison of systems, those criteria must be stated more precisely and can afterward be used within a benefit analysis. A scheme for such an analysis is display in the following section.

5.1 Benefit Scheme

A benefit analysis is a decision support approach to compare contemplated alternatives with the help of certain criteria. Thus, pros and cons can be measured and a more objective inspection is possible. For a detailed description of the technique we refer to the established literature, for example (Brent 2006).

A benefit analysis has been created to determine the suitability of innovations for their usage in port and hinterland transportation. A cost-benefit analysis has not been generated premeditatedly because for the most of the innovative concepts researched, information about costs is not available or even not possible to estimate. Regarding the criteria for a benefit analysis of innovative transport systems, the four major criteria are split up into the following subcategories:

5.1.1 Operating Efficiency

The efficient handling of cargo is the key criterion for a successful introduction of a transport system. However, common sub-criteria like driving speed or acceleration are not crucial. Especially for intra-areal traffic the speed is insignificant due to the short distances to get over. Furthermore, all regarded systems have the aim to speed up cargo transport and thus they all tend to higher operation speeds.

More important than speed and acceleration are the capacity (processed cargo units per time unit) and the transhipment efficiency (fast loading and unloading of cargo units). This goes along with the compatibility to preceding and succeeding processes and systems. A good integration of planned and present subsystems is essential.

Other important categories of the operation efficiency are availability and expandability. The dynamic structures of logistics require a fast modification if necessary. Also life expectancy, weather resistance and security are important. The systems are required to operate in port areas under certain weather conditions (e.g. rain, wind, salty air). Existing safety and security standards must be met as a matter of course. However, many innovative transport systems do not fit into current legislation frameworks and thus, it is not clear whether their operation in public areas is permitted today. The introduction of an alternative system which is not in operation yet, will cause a series of administrative challenges.

5.1.2 Business-Management

This criterion comprehends mainly the investment costs and the cost of ownership as two main key indicators. It may be useful to distinguish between the costs of track and vehicles. Depending on the length of the track, the costs of several innovative systems may differ considerably since their infrastructure contains parts of the propulsion system, e.g. maglev systems or those with linear induction motors. Consequently, those systems raise the costs of track disproportionate to the length of the tracks in comparison to others like automated trucks on simple roads. However, systems with higher infrastructure investment costs may have lower running costs, use less energy, or have a higher capacity.

Among the two cost criteria, the business-management also comprises the development time and the adaptability or flexibility. The development time explains how fast a system can be introduced. This goes along with the stage of development. The adaptability explains the expenses of modification in case of extensions.

5.1.3 Ecology

Other crucial sub-criteria are summarized as ecological concerns. The essential one is the pollution on-site which describes the emissions that cause damage caused to people's health. Electric systems will be higher rated than diesel driven systems, accordingly.

Effects on the climate are considered similar. They estimate the primary energy consumption and the possibility to use regenerative energies. The type of power transmission, the power efficiency and the roll resistance are additional factors.

As a third crucial factor noise emissions are considered. This was not straight forward because manufacturers use different measurement methods. Thus, a direct comparison was not possible. Based on technical attributes some differentiations are possible. While rubber tires are generally less noisy, steel wheels on rails can reduce noise due to active steering or when they are not used for propulsion, e.g. by using linear motors (less wear, no flat spots).

Other ecological criteria regarded are the land consumption and the integration of the system in the surrounding.

5.1.4 Economics

The economics criterion summarizes three sub-categories which are important for innovative transport systems. First, there are vibrations due to transport or transhipment operations which might have an impact on residents and the environment.

Second, effects on the labour market are researched. New systems require workers for operation, steering and maintaining. The impact of new established jobs compared to lost jobs due to optimization will be considered here.

The last sub-criterion is the impact on other institutions. It describes how others like terminal operators or forwarding companies can benefit from the introduction of innovative transport systems or what disadvantages can appear.

5.2 Evaluation Process

More than one hundred innovations in the field of transport systems have been reviewed to determine those, suitable for cargo transport and especially suitable for the usage in ports and terminals. The majority of recent innovations discovered deals with passenger transport. Most of these systems are not qualified for freight transport because they have a weak propulsion system, to fragile vehicle bodies, an improper track system or are just too small to load freight containers. However, for some systems upgrades for freight transport have been developed.

The innovative transport systems have been passed through a three-step-filter before they have been compared in the benefit analysis. The filter was to exclude inappropriate systems from further consideration. The following developments have been dropped by the filter:

- Theoretical studies and future visions without any assessment of feasibility or technical implementation;
- Systems which are technically insufficient for freight transport and not extendable;
- Systems which are not applicable in ports and freight terminals, e.g. indoor systems or those for goods smaller than TEUs.

After the filter process around forty single developments remained. They have again been merged by subsuming those using the same or similar technologies. For example the cargo tram systems have been summarized to one group. In the end around twenty systems and system groups remained and have been compared in the benefit analysis.

5.3 Results of the Benefit Analysis

The aim of the benefit analysis was to apply the pre-defined criteria to the relevant transport systems and system groups and to determine the usability of those systems for the transport of freight from ports to the hinterland. It became apparent which systems would be able to raise the performance in hubs but also among the whole transport chain. The results presented here do not explain every single researched system. They have been grouped to enable a well-arranged interpretation.

5.3.1 Modified Conventional Rail Mounted Systems

Systems in this group have the lowest degree of innovation among the researched transport systems. They are further developments or specific designs for the conventional rail freight transport but offering the highest degree of compatibility to it. One of the most famous developments of this kind is the CargoSprinter which has been described before. But also further developed freight wagons might be added to this group. The VEL-Wagon (Carrillo Zanuy 2011), currently under development would be a sample, accordingly.

The systems in this group have in common that they use a low or no level of automation. They operate on the conventional rail network, using the existing signalling and safety systems, and require a driver. There are no single running entities, only train-like formations of several units.

The systems do not consider ecologic issues actively. Ecologic benefits derive from a better capacity utilization of conventional structures. However, the usage of diesel engines is prevalent to be flexible on non-electrified tracks.

Due to the fact that these systems are very close to the conventional rail systems, their degree of performance enhancement is rather low; especially for intra-areal transport a profitable application is questionable. These systems represent the present state of application, currently trying to break into the market. Prototypes or demonstrators are available.

5.3.2 Rail Mounted Systems with Alternative Propulsion and Automated Control Mechanism

Systems which are a further development of railway systems are concentrated in the second group. They all use rails as guiding ways, even though they do not have to be compatible with the conventional one. Primarily, the incompatibility derives from the wish to make railway transport more flexible, alike to road transport. Hence, signalling and safety systems have been revised, control mechanisms for automated driving have been developed, and the possibilities to form convoys from single vehicles were worked out.

Also, new components like linear motors and active steering make lead to a high degree of innovation. It is to be mentioned that linear motors are noticeable less efficient than conventional electric drives which use the wheels for power transmission. Nevertheless, the performance of innovative rail freight systems is more efficient than of conventional ones.

Systems like the Freight Shuttle System use a propulsion technology which makes the track system incompatible for conventional trains. It is therefore only accessible for vehicles of that system. Others, e.g. the RailCab, require specially equipped rails but these are accessible for conventional trains. For economic reasons, the installation of a new, incompatible railway infrastructure is rarely reasonable. It is thinkable for certain isolated applications. For ports and terminals, having interrelations to other transport systems, it would be counterproductive.

New rail mounted transport systems bear a big potential, some of them are technically ready for the market and seek for a first application. Today, it is rather a matter of rules and regulations that they have not been introduced yet.

5.3.3 Rubber Tired Automated Truck Systems

The development in the automotive branch is one of the fastest, of which also freight transport by road benefits. Driverless vehicles are already in use in closed areas and in container terminals like Hamburg Altenwerder. Additionally, the formation of convoys using virtual drawbars is possible with technologies similar to those of innovative rail systems.

Driverless driving on public roads however, is not allowed today due to doubts in safety. For port-internal transports, e.g. the movements of empty containers, automated trucks can be establish in a new field of application that offers a higher acceptance. That goes beyond today's application fields of AGVs that are in service in ports.

Automated truck systems are very economic in implementation. They are based on conventional modern trucks which have been equipped with a set of sensors and the capability to drive alone. The track system consists of a regular road, equipped with passive transponders for the sensors.

From the ecologic point of view, these systems are obviously less favourably since their propulsion is based on diesel or gas engines. Also, the rubber tires lead to more friction that steel wheels on rails. However, during the today's hype of electro mobility, electric motors, powered by batteries or conductor rail are thinkable for trucks, too.

5.3.4 Magnetic Levitation Systems

There are considerations to adapt the main principle of the Transrapid for freight transport. However, the closest technology to this has been carried out as the CargoRAPID which runs on rails. The facts that weights of containers need to levitate is extremely energy consuming so that an economic operation is not possible.

Until now, only compromises using parts of the primary levitation technology, e.g. the ECCO system, have been brought to marketability (Shapery 2011a,b). Common railway systems are generally more suitable for container transport so that maglev systems will not be further regarded as an innovation for ports and terminals.

5.3.5 Systems Built on Stilts

Stilts move transportation to another level where it is less interfering with other activities. Land consumption is lower as only the stilts require some space. Since such a system can be operated in a closed area, certain legislative regulations are not in effect. Contrariwise, moving heavy containers over other objects may require new or adjusted regulations.

Which transport technology will be implemented on a stilt system is all open. All of the former mentioned system groups are able to run on it, even though the investment costs rise noticeable. However, certain systems require the elevated level because they have complicated technical components in their track system or they have vehicles hanging on a suspension rail. None of those systems has been regarded as serviceable for freight operation. Some inventions with suspension rails exist but only in very early stages. Hence, they have been dropped by the filter.

A special and feasible system on stilts is the aerial ropeway which uses the same technology as for ski lifts. Precisely, it is the application of an established technology on another field but it provides optimistic economic figures, at least for short intra-areal transport. A certain obstacle for the installation of an aerial freight ropeway over cultivated areas is the fact particles may fall down and injure people.

5.3.6 Tube Systems

Generally, tube systems are not a separate transport system since all kinds of vehicles can be driven through tunnels. However, some developments require a tunnel because they use all four walls (or round tunnels) as guiding ways. Examples for those systems are Pneutrans or TubeXpress. Other systems like the CargoCap do not require a tunnel necessarily.

The advantage of tube systems can be seen in the lower land consumption in crowded areas and the implementation in areas where the system shall not be visible. Using tube systems in ports would be thinkable for intra-areal transport, although the connectivity to other transport systems is difficult to realize due to the significant difference in elevation. For inter-areal transport the economic viability is questionable due to the very high track system costs for longer distances but would appropriate in very special cases.

The propulsion systems are similar to those of other innovative systems (mainly linear induction motors or conventional electric drives). Pneumatic systems like Pneutrans or TubeXpress are special cases related to the propulsion technology (air pressure). Reasonable applications for ports and terminals are not self-evident. However, there are very powerful systems already in operation in the mining industry.

For electric propelled tube systems the operational costs are similar to rail mounted systems with alternative propulsion. Also, formation of convoys and a high degree of automation is available. In operation, the ecological characteristics are just as the ones of systems with alternative propulsion. For the track, different view must be considered. While a tunnel system is environmentally less interfering in crowded areas, it would be harmful to the environment where natural habitat would be affected.

6 Conclusions

The focus of this chapter was on the evaluation of alternative transport systems. Researching minor detail improvements of conventional transport systems was not intended. From around hundred innovations in transportation at the outset, around twenty systems and system groups have been evaluated to be applicable for freight transport and the intended use in ports and terminals.

However, to say that a system can be used in freight terminals or not is a much generalized statement. Rather is it necessary to consider the concrete field of application. Two sample plots have been defined in this chapter: the intra-areal and the inter-areal transport demand. Others are of course possible. Both sample plots make different demands on transport systems. Thus, it has been assessed, which innovative transport systems suit to which field of application.

Intra-areal transportation is characterized by short distances to get over, the high frequent transport of single units and possibly the handling of a complex network structure. Hence, nowadays port-internal transports are performed by trucks or special traction engines.

Innovative transport system for internal movements must provide the same flexibility and additionally provide economic and ecologic advantages. Small individually running units with the ability to form bulks provide such flexibility while systems of large units are less practical. Improvements of conventional railway systems do not provide the needed flexibility for this case, improved road transport systems (electric driven/automated trucks) do quite well.

The most benefits can be achieved in situations, where infrastructure must be built newly. There, it is possible to introduce a new and innovative system without the need to be compatible to existing infrastructures. Due to the short distances, e.g. for a first two-point-relation, economic barriers are lower. That enables a demonstrator to be introduced as an isolated project. However, because of possible breakdowns of new technologies, redundancies should be considered.

Not only rail-mounted systems like the Container RailCab or CargoRAPID are thinkable, also the container ropeway could be a serious option where practical. Feasibility studies for the port of Hamburg have already been carried out; see (EUROGATE and BIBA 2010). Stilts and tubes are an option in dense areas. They could be a realistic alternative where is no space for additional infrastructure.

For the transport on longer distances and between hubs (e.g. a port and a hinterland hub) there are certain characteristics of transport systems to consider. The biggest obstacle for new transport systems here are the infrastructure costs. Accordingly it is illusory to build complete new infrastructure networks. Transport systems for this case are required to be compatible with existing infrastructures but also their vehicles must coexist beside today's conventional ones on road and rail. That means that systems like CargoRAPID are less attractive for long distance transport. The most important criterion for an implementation between two hubs is the integration of the innovative system into the process chains and with it the compatibility to preceding and succeeding processes.

Compromises that derive from conventional rail and road systems (e.g. automated trucks, CargoSprinter) offer a good basis to introduce innovative concepts. The technologies are nearly ready for use but legally issues need to be solved. However, the ecological benefit from those systems is not remarkable.

The highest degree of innovation for this case offer the rail mounted systems with alternative propulsion and automated control mechanism. Providing flexibility similar to road transport, most of them are compatible to the established railway network. They are realizable for manageable investment costs and offer high operational capacities. Since they use electric propulsion, energy sources can be flexibly chosen. Thus, the ecologic benefits are comparably well.

Using tunnel system over long distances is economically questionable, even though there are some studies for special cases. The same is for systems on stilts, although some high speed transport systems (maglev) require them. For the hinterland of Europe, high speed freight transport is not a matter yet so that rail mounted alternatives at ground level beat them on the price.

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Model for Road Traffic CO_2 Emissions Control by Means of Tradable Permits

Stane Božičnik

Abstract The chapter summarizes the theoretical aspects of tradable permits, compares tradable permits and tax schemes and explains options of initial allocation systems of tradable permits as well as the baseline issues. Fuel demand elasticity theory and empirical studies, as the basis for tradable permits price assessment, are summarized. A model for road traffic emissions control by means of tradable permits is presented for the case of Slovenia. The model considers the application of an electronic information system supporting a tradable permits scheme for fuel, based on a free of charge annual fund of tradable permits (different for individual motor road vehicle categories). The average fuel price increases caused by tradable permits for fuel (CO_2 emissions) for the assumed 5, 10, 20, and 30% annual reductions in fuel consumption, are calculated. The opportunities and threats of the potential introduction of tradable permits for fuel at the micro- and macro-economic level are assessed.

Keywords Tradable permits · Road transport · CO_2 · Taxes · Tradable permits allocation · Emissions control · Tradable permit fuel model for Slovenia

1 Introduction

The main idea behind tradable permits for emissions of CO_2 is to allocate the rights to emit a certain amount of CO_2 to economic agents and to make these rights objects of trade. In this way, the market for emission rights is developed and a

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market price for this right is formed. Under normal market conditions the price for emission rights provides the correct incentive for polluters to adapt emission levels to levels where the marginal costs of reduction among all the polluters are equal.

Road traffic is one of the most significant and fastest growing generators of CO_2 emissions. In OECD countries, the share of transport in the overall $C0_2$ emissions amounts to about 30% (OECD 2007), while 80% of overall transport emissions of CO_2 are attributed to road transport. Efficient instruments for sustainable emissions regulation and control are of crucial importance, particularly today, in the era of climate change. Market based instruments such as pollution taxes (subsidies have similar market effects) and tradable permits are the most appropriate instruments for emissions regulation.

Based on actual figures about the road traffic structure and volumes in Slovenia in 2010, a model for target level reductions (5, 10, 20 and 30%) of CO_2 emissions by means of tradable permits is developed and presented. The model takes into consideration all the organizational and technological solutions necessary for implementation. Hypothetical average costs faced by individuals involved in tradable permits schemes are calculated for various CO_2 reduction levels. The essential micro and macroeconomic effects are highlighted such as reductions of: CO_2 emissions, sold fuel volume, collected taxes, highway tolls, excise duties, etc.

The chapter is divided into two parts. In the first part, the theoretical foundations of tradable permits are presented, whereas in the second part, a model for CO_2 emissions control based on tradable permits for road transport in Slovenia is developed.

2 The Theoretical Foundations of Tradable Permits Schemes

2.1 Market Failures and Solutions

Economists consider the problem of pollution to be a result of “market failure”. An externality exists when consumption or production activities of one individual or firm affect another person’s utility or another firm’s production function, so that the conditions of an optimal resource allocation are violated (Button 1993). The externalities, which are the incidental effects of over production or over consumption activities are to be considered as an economic problem because the external costs were not reflected in the actual market costs or prices of the products or services (Stern 2007).

The best way to solve the problem of externalities is to provide a set of complete markets. This is a set of markets where prices ration resources to those who value them the most and no central decision maker is needed to allocate resources. In such a set of markets optimal individual decisions based on mutually advantageous exchange will lead to (Pareto) optimal social outcomes and there will be no externalities (Hanley et al. 1997).

The solution suggested by economists is to ensure that the external costs are internalized in order to correct the "market failure" and ensure normal functioning of the market mechanisms. In order to achieve this, economic theory proposes government intervention. While there are several different forms of government intervention that may be deemed to be appropriate in dealing with the externalities, there are two distinct market based solutions that can be perceived:

- Pigou (1932) proposes an approach which attempts to tax the value of the externality. This may be referred to as "internalizing the externality" (Pigouvian Tax);
- Coase (1960) offers an alternative approach that tries to increase the domain of property rights so that the environment has legally identifiable owners. Coase argues that any allocations of property rights (permits) are equally efficient since interested parties will bargain privately to correct the externality. (Tradable permits).

Dales (1968a, 1968b) is the first, and one of the most often cited authors, to propose environmental regulation by means of transferable property rights, although the main ideas underlying the theory of tradable permits actually originate from earlier writings of Coase (1960). According to Coase, the fundamental reason for externalities to exist is the lack of property rights. Coase (1960) pointed out that, under certain circumstances, voluntary negotiations would also lead to the internalization of external costs. In other words, a market in externalities can be set up. Trading of tradable pollution permits among emitters creates a market for permits with prices signaling external costs (Norregaard and Reppelin-Hill 2000).

2.2 Tradable Permits Versus Taxes

Tradable permits are more attractive than emission taxes in some respects: notably the regulatory authority does not need to know the marginal abatement cost schedules of polluters in order to assess the target level of emissions. Tradable permits also limit the target level of emissions (Hanley et al. 1997). Moreover, the quantity can be decreased over time as environmental targets become stricter.

Tradable permits have become established as the principal alternative to taxes as an efficient instrument for pollution control. By contrast, to secure a quantity target with an emission tax there must be fairly certain knowledge about the relevant price elasticities of demand for energy, transport, etc. Given that these magnitudes are uncertain, there will always be some doubt about whether the emissions target will be met (The royal society 2002). Finally, tradable permits are a less dramatic change in the manner of pollution control than emission taxes, and thus may be easier to introduce into practice (Hanley et al. 1997).

Taking into consideration that tradable permits represent the new institutional approach for coping with the problem of rationing access to the commons, they can be simply defined as: “a transferable right to a common pool resource” (Ellerman 2005).

Tradable permits address the commons problem by rationing access to the resource and privatizing the resulting access rights. The first step involves setting a limit on user access to the resource. This limit defines the aggregate amount of access to the resource that is authorized. These access rights are then allocated on some basis (described below) to potential individual users. Depending on the specific system these rights may be transferable to other users and/or bankable for future use. Users who exceed limits imposed by the rights they hold face penalties up to and including the loss of the right to participate (Tietenberg 2002).

The economic logic behind the tradable permits system is rather simple. In a perfectly competitive market permits will flow toward their highest valued use. Those that derive lower utility from using the permits have an incentive to trade them to someone who will derive higher utility from using them. The trade benefits both parties. The seller reaps more from the sale than he could from using the permit and the buyer gets more value from the permit than he pays for it (Božičnik 2002).

Montgomery (1972) holds that this theorem is true regardless of how the permits are initially allocated among competing stakeholders. It is true regardless of whether permits are auctioned off or allocated free-of-charge (see next chapter). Whatever the initial allocation, the transferability of the permits allows them to ultimately flow to their highest valued uses. Since those uses do not depend on the initial allocation, all initial allocations result in the same outcome and that outcome is cost-effective (Tietenberg 2002).

A system of transferable permits equalizes the marginal costs of reduction among all the polluters. Under certain assumptions this is a sufficient condition for minimizing the cost of achieving a given emissions reduction objective (Baumol and Oates 1988). This result is obtained independently of the initial allowance of the rights, which makes it possible to separate the questions of efficiency and equity.

However, Stavins (1995) has shown that when transaction costs are involved the initial allocation of rights affects the final balance and the total cost of reducing emissions. The authorities may therefore attempt to reduce these transaction costs, for example by avoiding finicky regulations or by facilitating the activity of intermediaries between vendors and purchasers (Hahn and Hester 1989).

Furthermore, tradable permits can become inefficient, leading to an increase in abatement costs, when emitters are allocated an incorrect amount of permits, or if a dominant polluter uses its position to control permit prices and therefore affects costs of competitors (The royal society 2002).

The literature on carbon tax and tradable permits mainly focus on the reduction of CO_2 emissions at the level of companies. The argument for political resistance against a carbon tax is none-the-less valid in the road transport sector as well. Goel and Nelson (1999) analyzed a panel data set from 1960–1994 for various US states and report that gasoline taxes are clearly motivated by political considerations. Hammar et al. (2004) also observes that increasing motor fuel tax is politically very difficult to implement, especially in countries with low prices and high demand, such as the USA. There is significant public opposition to raising fuel taxes in Europe as well, where the existing fuel taxes are already high (e.g. in the UK the gasoline tax is seven times higher than that in the USA, Parry and Small 2005). There is a limit to increasing fuel taxes further, as evident by the tax revolt in some of the European countries in 2000 (Lyons and Chatterjee 2002, Raux 2004). In addition, as Nordhaus and Danish (2003) argue 'the major problem with a GHG tax is that it is a tax.' Watters et al. (2006) report that consumers in the UK prefer a tradable permit approach where individuals are allocated permits freely, to a fuel price increase through increased taxes.

The political motivation for not increasing the gasoline tax is often justified by equity or distributional burden issues. Several studies in the United States (Casler and Rafiqui 1993, Sevigny 1998) have confirmed that a gasoline tax disproportionately burdens impoverished households (i.e. is regressive), as they spend a larger portion of their income on gasoline than wealthier households. It is possible to recycle gasoline tax revenues back to the poorer segment of the population to reduce the regressivity, but Bureau of Transport and Communication Economics (BTCE 1998) reports that recycling large revenues back to individual transport users through general government services and expenditures may not be optimal, a view shared by Starkey and Anderson (2005) as well (Wadud 2007).

2.3 Preconditions for Successful Introduction of Tradable Permits

A number of important issues in the design of tradable permit systems have been outlined in Tietenberg (1980). Among these, we mention the following:

- The policy target has to be defined. This target can be specified in terms of overall emissions or in terms of environmental standards (Verhoef et al. 1997).
- Introduction of tradable permits systems may not be successful if the market conditions are not right. Circumstances when the conditions may not be right include the possibility of overwhelming market power of one stakeholder (Hahn 1984), the presence of high transaction costs (Stavins 1995) and insufficient monitoring and enforcement. Even in the presence of these imperfections, tradable permit programs can be designed to mitigate their adverse consequences.[1]
- Without effective enforcement permit holders who don't get caught may gain more by cheating than by living within the constraints imposed by their

[1] In the case of market power in fisheries the maximum number of permits that can be held by any individual or defined group is routinely limited by regulation. (National Research Council Committee to Review Individual Fishing Quotas 1999) In the case of transactions cost it is possible to design administrative systems so as to minimize these costs. (Tietenberg Tietenberg 1998).

allocated permits. In contrast to the two previous mentioned imperfections, this one could lead to the degradation of the resource because the aggregate limit could be breached.

Another important precondition involves the absence of large uninternalized externalities. The presence of uninternalized externalities would imply that maximizing the net benefits of permit holders would not necessarily maximize net benefits for society as a whole even with a fixed environmental target (Tietenberg 2002).

2.4 Tradable Permits Baseline Issue

The tradable permits baseline can be classified into three distinct forms[2]:

- Credit trading,
- Averaging,
- Cap and trade.

The forms are presented below, respectively.

2.4.1 Credit Trading[3]

The credit program involves a relative baseline. With a credit program an individual access baseline is established for each resource user. The user who exceeds legal requirements (say emitting less pollution than allowed) can have the difference certified as a tradable credit (Tietenberg 2002).

As the name implies, credit trading awards exemplary behavior and allows compensating regulatory relaxations of a common requirement. Credit trading is also called an open market system because everyone with a capacity to reduce emissions can participate in it (Dolšak 2000).

2.4.2 Averaging

Averaging can be seen as automatic credit trading in which parties that do better than required in their permits automatically receive credits that can be used by others without any question from the regulator whether the firm (polluter)

[2] This typology is used and explained in greater detail with examples in Ellerman et al. (2003).

[3] It is often known also by other names such as: offsets, joint implementation, bubbling, netting, banking etc.

generating the credit would have reduced emissions anyway. The pre-existing standard about which emissions are traded is still in place, but in dispensing with certification, the regulator no longer attempts to make the abatement decision at the level of the firm. The common standard or technology is simply a reference point or benchmark about which differences are traded. Although averaging is a more precise term to describe what actually occurs, European terminology tends toward various formulations containing the term "relative", which imply trading around a limit relative to input or output instead of under an absolute cap as in an allowance system (Ellerman 2005).

2.4.3 Cap and Trade -Allowance Trading

This program involves an absolute baseline and trades allowances rather than credits. In this case a total resource access limit is defined and then allocated among users.[4] Although a logical progression from credit trading and averaging, allowance trading is in several ways a radical departure. For one thing, the compliance requirement is entirely different. Instead of determining compliance by reference to a common standard and sanctioned or compensated deviations from it, polluters are required to surrender a permit for every unit of discharge. Although the cap may be very constraining in the aggregate, no polluter is expected to meet any specific standard. It must only obtain and surrender an allowance that can be readily bought or sold in the market. In effect, allowances have become essential inputs into production subject to the same marginal cost calculations as other inputs (Ellerman 2005). Two consequences flow from the allowance trading form of tradable permit. First, the regulator's task is not to specify an emissions standard, but a cap. This requires initial decisions concerning (1) an acceptable or optimal quantity of emissions and (2) the limits to trading, both spatially and temporally. Second, the rights to discharge are now explicit and must be allocated in some manner instead of being implicit and granted without question to the owners of the emitting facility. Credit trading depends on the existence of a previously determined set of regulatory standards. On the other hand allowances can be used even in circumstances where a technology based baseline either has not been or cannot be established or where the emission reduction is short lived rather than permanent. "Cap and trade" systems also generally establish an upper aggregate limit on the allowed emissions, while credit systems only set an upper limit for each user. The most important features of allowance trading ("cap and trade") are the following:

- **Efficiency:** the cap is a physical limit on emissions determined by the regulatory authority. The number of permits is limited accordingly and individual emitters can only increase their emissions if they are compensated by emission

[4] Air pollution control systems and water have examples of both types. Fisheries tradable permit programs are all of the cap-and-trade variety (Tietenberg 2002).

reductions elsewhere. This guarantees that the system will reach its goal (Koutstaal and Nentjes 1995);

- **Flexibility:** in a "cap and trade" system emitters actually have a choice of either complying with the target set (by reducing production or installing abatement equipment) or purchasing additional permits;
- **Dynamic efficiency:** there is a clear incentive to reduce emission costs by investing in cleaner technology. The system rewards participants who use cleaner technologies as the excess permits can be sold;
- **Static efficiency:** tradability assures that the permits will end up where they yield their highest value. In other words, trade will result in an efficient allocation of permits equalizing marginal abatement costs of emitters (Hahn and Noll 1981).

2.5 The Initial Allocation of Permits

Setting the initial allocation is the most controversial feature of the tradable permits systems (The royal society 2002, Tietenberg 2002).

Basically, there are four main methods by which tradable permits may be allocated initially: free distribution of permits, grandfathering, auctioning, and updating (Gunasekera and Cornwell 1998). These methods can also be used in combination with each other (a portion of the rights is distributed for free and the rest will be allocated via auctioning) (Evy and Vereeck 2003).

Furthermore, there are two possibilities for the allocation of tradable permits: they can be auctioned or granted for free to the involved entities. The allocation mechanism must also take into consideration the timing of the permits introduction and also representative and long enough time period for the analysis of the conditions prior to the tradable permits introduction (Evy and Vereeck 2003).

2.5.1 Free Distribution of Tradable Permits

The permits can be distributed for free to various polluters, whereby the total number of permits equals the overall cap. The most important benefit here is that the social acceptance is readily high because the emitters get the permits for free. The disadvantage of the free distribution of permits is that it will not raise any direct revenues for the government (Evy and Vereeck 2003).

The administrative costs under free distribution of permits are likely to be low. After the cap is set, the permits can be distributed among the emitters without taking into account past or future emissions. There are also some distributional impacts. Emitters who do not need their annual permits can sell them to others who do and so collect some revenue (Evy and Vereeck 2003).

Under the free distribution method new polluters typically have to purchase all permits, while existing polluters get an initial allocation for free (Tietenberg 2002). This problem has to be taken into account by the authorities before the primary distribution of permits.

2.5.2 Grandfathering

The permits can also be distributed on the basis of historical indicators. This principle is called "grandfathering" (Evy and Vereeck 2003). This is the most common method so far. It enhances the likelihood of adoption and it allocates permits to those who have made investments in resource extraction and so serves to recognize and protect these investments (Tietenberg 2002).

The total cap can vary over time, but since future allocations depend entirely upon historical data, the share that each emitter receives is fixed. This means that an emitter has no incentive to change his behavior. A very important benefit of this method is that the public acceptance will increase because they receive a certain number of permits for free (Evy and Vereeck 2003). An advantage is also that existing sources only have to purchase any additional permits they may need over and above the initial allocation (and not all permits as in the case of auctioning) (Tietenberg 2002). However, on a short-term, grandfathering can augment emissions because individuals are aware of the fact that current emission levels lead to a higher level of future permits (Evy and Vereeck 2003).

Under this method, new polluters who manage to enter the market are required to purchase all necessary permits. Incumbent polluters may have a distinct competitive advantage (incumbent polluters will be able to produce a given level of output for a lower unit cost than potential new entrant polluters). This is called ''new source bias'' (Gunasekera and Cornwell 1998).

2.5.3 Auctioning

An auction of permits answers two questions (1) who, on efficiency grounds, should get the permits, and (2) at what prices. The best answer depends on the government's goals whereby the primary goal is efficiency and the secondary goal is revenue maximization (Cramton and Kerr 1999).

Auctioning involves selling permits to the highest bidders and so also involves financial revenues to the government for the sold permits. Auctioning of permits would continue until all available permits have been sold (Gunasekera and Cornwell 1998). An auction gives a reference price for the tradable permits and the revenue raised by the government can then be used for various purposes e.g. tax reduction. In this way auctions can be relatively favorable for consumers and taxpayers.

Under auctioning all actors are treated equally, they must acquire permits regardless of whether they are new or existing actors. New entrants that need permits can buy these from other actors on the (TP) market (Cramton and Kerr 1999).

Under the assumption that all permits are sold at one price, the market equilibrium permit price is determined by the value of the aggregate marginal abatement cost at the level of abatement implied by the total number of issued permits.

2.6 Transferability of Tradable Permits

Most of the literature on tradable permits considers trading across entities within a given time period, but there may also be gains from trade across time if permit banking and borrowing is applied. The Kyoto Protocol (UNFCCC 1997) also allows for banking of permits, or mitigation in excess of commitments in some periods, with the prospect of mitigation at levels lower than commitments at some future date. Borrowing, however, is not explicitly mentioned. A number of studies have examined a subset of the various flexibility mechanisms, less so the dynamic ones, but none have examined all of them in a comprehensive context, including both theory and empirical simulations see, e.g., Buonanno et al. (2000), Weyant (1999), Zhang (1999).

While economic motivations emphasize unrestricted permit trading, non-economic considerations (potential cheating) have entered the policy debate to restrict flexibility. The main example, known as "supplementary," would limit the amount of permit purchases and sales.[5]

Transferability is crucial for successful functioning of the tradable permits system, it does not only assure that permits flow to their highest valued use, but it also provides a user financed compensation for those who decide voluntarily to decrease emissions. Therefore restrictions on transferability only serve to reduce the efficiency of the system (Tietenberg 2002).

Strategies of protections against ''unreasonable'' concentration of permits are known. One typical strategy involves putting a limit on the amount of permits that can be accumulated by any one holder. Another approach involves directly restricting transfers that seem to violate the public interest (Tietenberg 2002).

We may conclude that the trading of pollution rights is one of the more important innovations economists have contributed to environmental policy-making (Stevens and Rose 2001). Instead of Pareto efficiency, the goal of

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[5] Article 17 of the Kyoto Protocol limits emission trading to "supplemental to domestic actions for the purpose of meeting quantified emission limitations and reduction commitments under Article 3." Thus, under a strict interpretation, each Annex B country would have to mitigate up to its stated cap (see Appendix Table A) and could only buy permits for any supplementary action. Other than pure altruism or a strong focus on benefits, there would be little motivation for permit trading to take place under such a restricted condition. Several proposals to limit permit trading were presented at the recent Fifth Conference of the Parties to the Framework Convention on Climate Change (COP-5) in Bonn, though none go as far as the strict interpretation.

cost-effectiveness, which is only a necessary, but not sufficient, condition for Pareto efficiency, becomes the central criterion. Emissions trading emphasizes economic incentives and freedom of choice in the context of the workings of the market and thus capitalizes on the standard welfare economics result of achieving economic efficiency, or, under more modest goals, cost-effectiveness (Montgomery 1972). Equity, in its various forms, can also be promoted by tailoring the initial distribution of permits (Rose et al. 1998).

Tradable permit schemes are designed to achieve a given environmental goal at the lowest possible social costs. Hence the policy target is defined in the quantity space and the associated consistent equilibrium price of the permits will be determined by the market through free trade in the permits (Verhoef et al. 1997).

2.7 Allocation Concept and Transaction Cost of Tradable Permits in Transport Sector

A tradable permits policy within the transportation system can be implemented at various levels. The upstream level enables control of the total volumes of the focused area such as sales volume of the (individual) fuel refineries (Grubb 1990) or vehicle producers Wang (1994), Winkleman et al. (2000). Refineries or vehicle producers would have to possess adequate carbon permits to cover their total sales. For any extra sales permits have to be obtained through the permit market. The problem of the upstream system is that it enables no direct incentives for the industry to reduce carbon emissions since transport CO_2 emissions do not occur at the refinery or car manufacturers' level. Reducing output from the refineries would increase the price of fuel to downstream transport users due to supply constraints, and would act as a disguised fuel tax, with the associated disadvantages of a fuel tax. The presence of a small number of large upstream producers can also create a market where only few stakeholders may exercise their market power to manipulate the prices (Hahn 1984). The only attractiveness of an upstream system lies in the fact that the monitoring is less demanding due to the limited number of (bigger) stakeholders.

In the downstream approach the tradable permits would be allocated directly to the (vehicle) users, thus affecting directly their behavior through market based incentives. There is no theoretical barrier for implementing a tradable permit system in the (road) transport or any other transport mode. (Wadud 2007).

The decision making process determining the upstream or downstream allocation of tradable permits often manifests itself into the evaluation of transaction costs. The transaction costs, according to Stavins (1995), can arise in the tradable permit market because of the following three possible activities:

- Searching and collecting information;
- Bargaining and decision making;
- Monitoring and enforcement.

The first two activities are direct costs of the entities involved in the tradable permits trading process while the third one should be borne by the government authorities (Stavins 1995, Woerdman 2001). The presence of transaction costs reduces revenue received by the seller and increases the price for the buyers, thus suppressing a potentially beneficial volume of trading that would have happened if there were no transaction costs (Stavins 1995).

It should be pointed out that the tradeoff between environmental effectiveness, economic efficiency and distributional equity should carefully be studied before the implementation of a tradable permits scheme. Due to the fast progress in the field of modern information technologies, the potential transaction costs associated with the implementation of a large scale tradable permits scheme are not a significant hindrance anymore.

2.8 Fuel Demand Elasticity

Elasticity is the measure of responsiveness. It expresses the percentage change in one variable in response to a 1% change in another (Oum and Waters II 2000). There is a distinction between demand and supply elasticity. Here, only demand elasticity will be discussed. In general demand elasticity is a rather crude and approximate measure of aggregate responses in a market. However, it is attractive because it is empirically estimable, reasonably easily understood, tested by experience, and directly usable for policy assessment (Goodwin 1992).

In general it can be distinguished between income and price elasticity of demand. The income elasticity expresses the percentage change in quantity demanded with respect to a 1% change in income, all other variables including prices being held constant. It is expected to be greater than 1 for luxury or superior goods and smaller than 1 for inferior goods (Oum and Waters II 2000).

The price elasticity of demand expresses the percentage change in quantity demanded in response to a 1% change in its price. It is expected to be negative (a price increase decreases the quantity demanded) (Oum and Waters II 2000). The coefficient of price elasticity of demand can be calculated as follows:

$$\varepsilon_{\mathrm{d}} = \frac{\Delta q}{q} \cdot \frac{p}{\Delta p} \tag{1}$$

.

Where epsilon is the elasticity coefficient, q is the quantity demanded and p the price of a certain good or service (Lipušček 2006).

A special distinction has to be made between short-run and long-run price elasticities. According to Goodwin et al. (2004) short run price elasticities are defined as responses to price changes made within one period of the data used for the study, most commonly within 1 year. Long run price elasticities are defined by most of the transport literature as responses made in periods of 5–10 years

(Goodwin et al. 2004). Long-run demand tends to be more elastic than short-run demand because in the long run consumers (or firms) are better able to adjust to price signals than in the short run (Goodwin 1992). This is mostly due to fact that the range of responses open to people is greater in the longer run than immediately (Goodwin 1992).

Besides own-price elasticity, cross-price elasticity should also be mentioned. The latter expresses the percentage change in quantity demanded for one good/service in response to a percentage change in the price of another good/service. It is expected to be positive for substitutable goods and services, zero for two unrelated products and negative for complementary goods and services (Oum and Waters II 2000).

In practice the value of elasticity varies more widely than many people would expect. This is so because the results are sensitive to the specification and estimation procedures used to estimate demand functions (Oum and Waters II 2000). Estimates of price elasticities will vary substantially depending on the specific market situation being examined. In order to establish appropriate price elasticity estimates one should conduct a market-specific demand study and not only review existing studies of demand elasticities. Although it is convenient and inexpensive to make use of existing elasticity estimates of demand elasticities in doing a preliminary analysis, for important demand-related decisions only updated and accurate demand information should be used (Oum and Waters II 2000).

2.8.1 Transport Demand Elasticity

Demand elasticities (in respect to price or income) in the transport sector are usually calculated for: vehicle travel, vehicle ownership, freight traffic services, fuel consumption, etc. (Graham and Glaister 2004).

It is worth noting that, according to the results of different studies, fuel consumption elasticities are greater than car travel elasticities (mostly by factors 1.5–2) and that income elasticities are greater than price elasticities (mostly by factors 1.5–3) (Goodwin et al. 2004). The review of different studies done by Graham and Glaister also confirms the fact that car travel is much less responsive to fuel price changes in the long run, due perhaps to adaptations in mode choice, destination choice and land-use location (people make less trips, but travel in shorter distances) (Graham and Glaister 2004).

It is also important to distinguish between the overall market elasticity of demand for transportation (demand for transportation relative to non-transport sectors) and the demand facing individual modes of transport. In case of two modes that are substitutes the own-price elasticity of aggregate transport demand for a particular market is lower, in absolute value, than the weighted average of the mode-specific own-price elasticities because of the presence of positive cross-price elasticities among modes (Oum et al. 1990).

There have been numerous empirical studies regarding transport demand in the past decades. The results of most of them show that, since transport demand is in fact derived demand, it tends to be inelastic (Oum et al. 1990). In reality, however, competition between modes, routes, or firms gives rise to a wide range of price elasticities, often much more elastic than conventional wisdom would suggest. The demand elasticity becomes even larger as we take into account the long-run effects of a change. This suggests that there is no shortcut to obtaining reliable demand-elasticity estimates for a specific transport market without a detailed study of that market (Oum and Waters II 2000). Since it is very hard to conduct such a study for long run effects, long run elasticity proves as a very unreliable measure of responses to price changes.

2.8.2 Fuel Demand Elasticity Estimations

The results of studies (Harbour 1987, Mogridge 1983, cited in Goodwin 1992) demonstrate that a permanent 10% increase in fuel prices will lead to:

- a reduction of about 3% in the demand for fuel in the short term and
- a reduction of demand for fuel equal to or greater than 7% in the longer term (due to the use of smaller or more efficient vehicles) (Goodwin 1992).

As has been mentioned, long term elasticity of demand will be (absolutely) greater than short term elasticity. Dix and Goodwin (1982) suggested that this is applicable also to price-elasticity of demand for fuel. This is due to the fact that it takes some time to change numbers of journeys, vehicle ownership or destination. However, some minor adjustments can be made in the short run (e.g. changing driving habits and speeds, avoiding less economic driving behavior, etc.) (Goodwin 1992).

In Table 1 we present the estimates of the price elasticity of demand for fuel by different authors. It should be borne in mind that most estimates made express the average value of the results of studies made in a particular environment (e.g. Goodwin (1992) reviewed 13 studies).[6]

The above cited coefficients served as a basis in order to quantify the impacts of introducing a system of tradable permits for fuel. The results of Mrkaic (2004) were applied, since his study is the most suitable and most recent for Slovenia. The other results listed in table 1 were averaged, obtaining a benchmark of −0.3 for long term and −0.7 for the short term elasticity of demand for fuel.

The price elasticity in rural regions (−0.196) is absolutely lower than in urban areas (−0.289) (Wadud 2007). As will be seen, the implications are important for equity or distributional burden issues, but we will not consider this fact in the study because it not so important, as far as the overall impact on the economy is

[6] Ben-Aktiva et al. (1986), Bland (1984), Bonsall and Champernowne (1976), Commission of the European Communities (1980), Donelly (1985), Drollas (1984), Drollas (1987), Goodwin (1987), Mackett (1984), Thomson (1972), Vaes (1982), Wabe (1987), Zudak and Koshal (1982), cited by Goodwin (1992)

Table 1 Price elasticity of demand for fuel

Views of results by author	Short term	Long term
–Goodwin 1992 (time series data)	−0.27	−0.71
–Goodwin 1992 (data from different sectors)	−0.28	−0.84
–Espey 1998	−0.26	−0.58
–Goodwin et al. 2004 (time series data)	−0.25	−0.64
–Goodwin et al. 2004 (static evaluation[c])	−0.43[a]	
–Perrels 2006	−0.2 to −0.3	−0.4 to −0.8
–Graham and Galister 2004	−0.25	−0.77
–Webster in Bly 1980 (cited in Goodwin 1992)	−0.48[b]	
–Mrkaić 2004[d]	−0.2	−0.89

Comment: [a] total value
[b] Unweighted average value
[c] Dynamic methods are those which permit progressively increasing effects in well-defined time periods. Static methods are those which explicitly exclude time-related responses to stipulated change
[d] Average values for diesel and petrol fuel demand elasticities estimates

concerned. The mitigation of this problem is relatively simple, but politically sensitive, since it would require unequal distribution of TPs among residents from rural and urban areas.

3 Model for Road Traffic CO2 Emissions Control by Means of Tradable Permits

Based on the theoretical aspects of tradable permits presented in the previous chapter, a model for road transport emissions control in Slovenia will be developed in this chapter. The aim is to evaluate what effects a TP scheme for fuel would have on a national level. At this point, we have to point out that the national level is by far too small for an efficient application of tradable permits for fuel consumption. Implementation on a continental or even world level (for all CO_2 emitting sectors) would be the most appropriate, provided efficient CO_2 emission control is to be established (see more Bozicnik and Mulej 2010). However, we will limit ourselves to the case of just one country here because it is not possible to obtain all the needed data on a continental or even world level.

In the beginning, the chapter presents the organizational and technical aspects of the model, which is based on “Cap and trade” and “downstream allocation” concepts, since they perfectly fit to the case. Secondly, an information system model is outlined. Finally, the most important parameters showing the economic aspects of the model will be quantified. The data used to assess the economic implications is for the year 2010, or the most recent year of availability. The aim is to calculate all the relevant parameters for: 5, 10, 20 and 30% fuel consumption decreases on the national level and to indicate the basic results of the potential implementation of the model in the road transport sector of Slovenia.

3.1 Organizational Aspects of Using Tradable Permits

The model would work as follows:

- The authority in charge of implementation of the scheme and the main regulator would be the Ministry of Transport, or an agency for emissions regulation in its framework. Each year, a yearly quota of tradable permits would be earmarked according to emission reduction goals. A "fuel account" would be opened and a "fuel card" would be issued to each vehicle owner upon registration of a vehicle. If a person would not possess a vehicle, it could not hold an account.
- At the same time, a yearly quota of TPs would be allocated to his fuel account for free. The eventual surplus of TPs could be sold to other individuals.
- The card would have to be presented at the fuel station before refueling and the amount of fuel bought would be drawn from the "fuel card". This operation would be independent from the payment of the value of fuel to the fuel station operator.
- In case the holdings in a "fuel account" would be insufficient to purchase fuel, the following options would be possible:
- Additional TP's could be purchased at the current market rate on a terminal, installed at each fuel station, or
- a chosen quota could be acquired under pre-defined conditions as a loan. It would be settled with the next year's quota.
- A TP exchange would be organized. Companies for the management of fuel accounts would be established (brokers). Their duty would be to buy and sell TPs and manage the accounts of tradable permits in the name and for the account of road vehicle owners. They could also give short-term loans of trade permits. Individual agents (brokers) would manage trade in tradable permits for at least 300.000 vehicle owners.
- Users would be periodical notified regarding the holdings of TPs on account and the carried out transactions.

3.2 Information System Model for Trade with Tradable Permits[7]

A suitable information system for TP use is of utmost importance. The developed concept of the information system for potential management of TPs for fuel in the road transport sector in Slovenia is presented in Fig. 1.

Three distinct service providers are foreseen for the operation of the information system: the point of access provider (PoAP), the payment mechanisms provider (PMP), and the data intermediator (DI). The architecture of the information system is based on the use of chip cards and three program levels. This three level

[7] I am indebted to my colleague Andrej Tibaut for his contribution to this chapter.

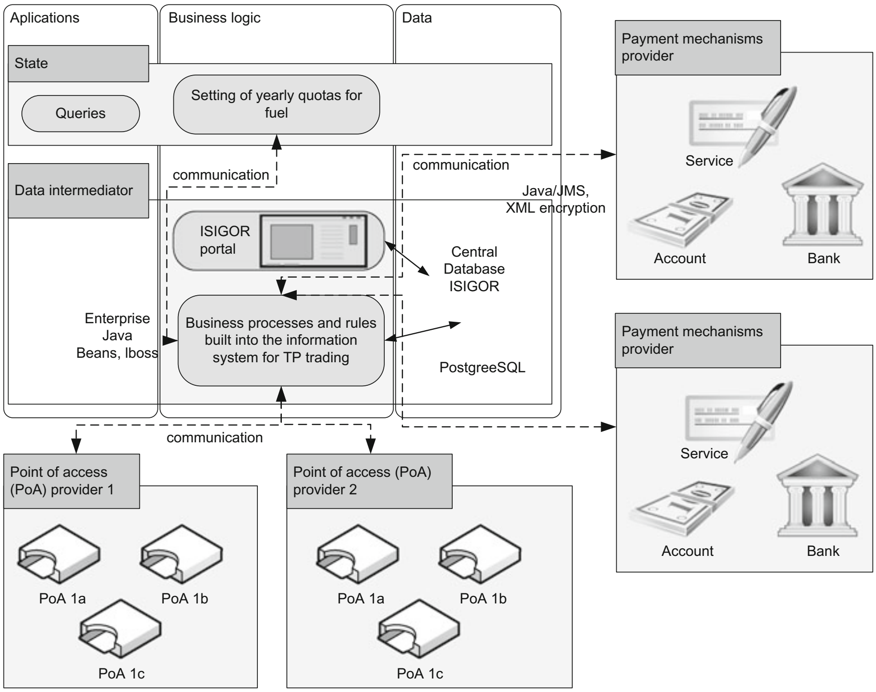

Fig. 1 Information system model scheme

software architecture allows for the inclusion of different providers of terminal access and payment mechanisms.

3.2.1 Business and Organization Model

In order to ensure security, competitiveness and cost-efficiency, it would be advisable to conceive the system in the form of a multi-level system, in which the following three key organizations would be involved:

- Point of access provider (PoAP): responsible for the installation and operation of "point of access" equipment and the entire associated infrastructure, which identifies (authorizes) the holder of the smart card and allows access and modification of data regarding the holdings of TPs.
- Payment mechanisms provider (PMP): responsible for the management of TP accounts (purchasing of fuel, sale/purchase on TP exchange, raising/settlement of loans of TDs).
- Data intermediator (DI): an independent organization working as an intermediary between PoAP and PMP; its function is the coordination of information flows between the two service providers.

- Such a system ensures the following characteristics:
  - Independence between PoAP and PMP, which ensures a high level of personal data protection;
  - The possibility of including a higher number of PoAPs in the system, which will spur competition and assure cost-efficiency, guaranteeing a high level of service for the users.
  - The possibility of including a higher number of PMPs, which will assure the application of the most appropriate technologies and spur competition and assure cost-efficiency.

To ensure security of user data, the DI could filter the received data from the terminal access points and remove the information about the location of the user. In such a way, the PMPs that would have information about the identity of the user and his account could not link the identity to the location of this user in a point in time.

3.2.2 Technology Requirements and Architecture

The system would be based on the use of smart cards, which are safer than magnetic cards, and allow more complicated procedures. A smart card has a personal identification number (PIN), which is encrypted in the card and used by the card reader to identify the user of the card. This prevents unauthorized use by a third party.

The architecture would ideally be decentralized. This would mean that the bulk of processing (e.g. identification of user) and operations (e.g. denial of access) would take place at the "Point-of-sale". This would prevent lags due to access to remote databases, which are most common during peak hours.

The advantages of multi-level architecture are strategically important (scalability, transactions, variability of providers, support of mobile devices). The decentralization of components and service oriented architecture (SOA) are also important advantages. The use of open source technologies is recommended (e.g. JAVA program platform) as they do not require the payment of license fees.

3.3 Other Considerations

3.3.1 Measures to Prevent Abuse and Speculation

In order to prevent possible irregularities in the Tradable Permits market we have foreseen the following precautionary measures:

- Periodical purchase quantities restricted for individual vehicle owners to certain amounts in order to prevent speculations (e.g. limit set at 500% of individual annual quota);

- Strict control of the number of registered vehicles with administrative and financial barriers for speculations regarding vehicle registration;
- Surveillance by competent authorities of use made of allowances and of the work of management companies (Tietenberg 2002);
- Data bank of permit users, volume and dynamics of TP used/vehicle owner—under supervision of a governmental body;
- Pre-determined strict penalties for non-respect of the rules governing the system;
- Restriction of any trade/banking with tradable permits, which might be harmful to the public interest (Tietenberg 2002);
- Fuel could be purchased with TP only for registered motor vehicles.

3.3.2 Distribution of Tradable Permits

Tradable permits would be distributed on a "free-of-charge initial distribution" basis to owners of vehicles. Such a distribution has two advantages:

- it is fairer to all motor vehicle owners, allowing the owner of each vehicle in any category to receive the same annual quota of tradable permits for the purchase of fuel (CO_2 emissions);
- it permits the definition of a reserve quota for public policy requirements, such as emergency vehicles, the army, the police, disabled people, new vehicle owners, special categories of vehicle owners–e.g. those who live in rural areas and do not have the same access to public transport, etc. (x% of total available annual fuel quantity).[8]

In order to avoid fluctuation in tradable permits prices at the end of the calendar year, the validity of permits would be related to the registration date of each vehicle.

Distribution of tradable permits would be different for the following vehicle categories:

- private cars,
- goods vehicles (up to 2 t, 2–10 t, above 10 t),
- buses, and
- motorcycles,

The initial volume on which we would base the annual amount of tradable permits for the purchase of fuel for each category of road vehicle would be the actual figures for the year 2010 for:

[8] We have deliberately left these details out of our calculations as they would not have a significant effect on the final result. Instead, the aim was on presenting the general features of potential TO model use.

- average annual distance driven (km),
- average fuel consumption (l/100 km),[9] and
- number of vehicles registered in each category in Slovenia.

Based on the data about the number of registered vehicles for the year 2010 provided by the Slovenian Ministry of Internal Affairs, the Quantity of tradable permits (QTP) per type of vehicle (personal cars, HGV, LGV, buses, etc.) was calculated using the average annual fuel consumption (AAFC) of each category of vehicle, number of vehicles in the category (NV) and an estimate (questionnaire) of average distances driven for each category of vehicle (AD). The applicable formula is:

$$QTP = \frac{AAFC}{100} * NV * AD \tag{2}$$

.

CO_2 emissions are linearly related to the amount of fuel consumption. For easier operation, one tradable permit (one unit) will correspond to the right to consume one liter of fuel. The reference values for CO_2 emissions produced through the combustion of fuel are 2.33 kg CO_2/l for petrol fuel and 2.68 CO_2/l for diesel fuel. Diesel fuel produces 16% more CO_2 per liter of fuel consumed than petrol. On the other hand, figures on average fuel consumption for vehicles registered in Slovenia[10] show that on average diesel engines consume 15% less fuel than petrol engines. It is true however, that diesel engine exhaust is more harmful to the environment because petrol engines produce much less soot than diesel engines.

In the model, the quantity of CO_2 emissions from fuel consumption is calculated on the basis of an assessment of annual fuel consumption and related values for CO_2/l for all registered petrol and diesel vehicles in Slovenia.

Following the above described criteria for initial distribution of tradable permits for fuel and according to the above defined basic unit of one tradable permit, the breakdown of needed tradable permits per vehicle category is presented in Table 2.

According to the calculations in Table 2, it would be necessary to distribute (without considering the reserves) a total ("CAP") of 1,972,045,657 Tradable Permit Units or authorize the sale of that many liters of fuel, if we want to maintain the level of consumption at the 2010 level.

Table 3. shows how the available TPs (liters of fuel, CO_2 emissions) would have been distributed by category of motor vehicles. In the same way, the table shows the quantity of available tradable permits per vehicle category at each reduction level.

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[9] Data obtained from: Božičnik et al. (Bozicnik 2007). Where official figures were unavailable we used expert assessments.

[10] Data obtained from: Božičnik et al. Bozicnik 2007. Where official figures were unavailable we used expert assessments.

Table 2 Number of tradable permits units per vehicle category (calculation Slovenia 2010)

Category	Average annual distance driven (km)	Average fuel consumption (l/100 km)	No. of vehicles registered in each category in Slovenia	Number of TPUs for 2010 per vehicle	Number of all TPUs for 2010 per vehicle category
Cars	17,930[a]	7.69[a]	1,060,615	1,351	1,432,855,915
Goods vehicles–under 2 t	21,373	12.00	56,070	2,565	143,806,093
Goods vehicles–2–5 t	30,998	15.00	6,897	4,650	32,068,981
Goods vehicles–5–10 t	35,675	18.00	5,351	6,422	34,361,447
Goods vehicles–over 10 t	52,601	20.00	6,803	10,520	71,568,921
Goods vehicles–haulers	70,192	30.00	8,620	21,058	181,516,512
Buses	82,000	35.00	2,400	28,700	68,880,000
Motor cycles–up to 150 ccm	2,100	3.00	70,448	63	4,438,224
Motor cycles–over 150 ccm	3,100	4.00	20,561	124	2,549,564
Total			1,237,765		1,972,045,657

[a] The number is calculated as average of subcategorized data, which is used to calculate TPU and other values separately by subcategory and then summarized in this table

Table 3 Numbers of TPU per vehicle

TPUs/vehicle category	Cars	Goods vehicles					Buses	Motor-cycles	
		Under 2 t	2-5 t	5-10 t	Over 10 t	Haulers		Up to 150 ccm	Over 150 ccm
Equal quantity	1,351	28,700	2,565	4,650	6,422	10,520	21,058	63	124
5% reduction	1,283	27,265	2,437	4,417	6,100	9,994	20,005	60	118
10% reduction	1,216	25,830	2,308	4,185	5,779	9,468	18,952	57	112
20% reduction	1,081	22,960	2,052	3,720	5,137	8,416	16,846	50	99
30% reduction	946	20,090	1,795	3,255	4,495	7,364	14,740	44	87

On the basis of the data presented in the table 3, we can conclude that in order to achieve a 10% reduction, car owners would be entitled "free of charge" to 1,216 tradable permit units, while for a 20% reduction they would receive only 1,081 TPU's (liters of fuel) and for 30% reduction 946 tradable permits (liters of fuel).

3.3.3 Calculation of Fuel Consumption Reduction Effects on Fuel Costs

The implementation of a tradable permits scheme would radically change the fuel costs of individual motor vehicle owners, if they would increase the consumption above the free of charge level of TP quota. The market price of tradable permits would have to be added to the price of fuel. Conversely, certain individuals would not use all tradable permits and could sell them to others and hence earn an income.

It is possible to give a rough estimate of the impact of fuel rationing on the average price of fuel faced by individuals. It is clear, that in case the cap would be set lower than the total consumption of fuel in 2010, adjustments would have to be made even by "average consumers" and that this would have an effect on the "theoretical average price of rationing" faced by individuals.

To arrive to estimates, demand elasticities estimations were used. The following basic formula was applied to obtain price changes estimates (see Sect. 2.7 for more details):

$$\frac{\Delta p}{p} = \frac{\Delta q}{q} \cdot \varepsilon_{\mathrm{d}}^{-1} \qquad (3)$$

Theoretical average prices for rationing at various levels of reduced fuel consumption: 5, 10, 20, and 30% were estimated. Since authors dealing with elasticity coefficients (e.g. Goodwin 1992, Espey 1998, Graham and Glaister 2004, etc.) differentiate between long and short term elasticity coefficients, long and short term prices were calculated taking into consideration the anticipated reduced consumption volume. The elasticity coefficients (according to 2.8.2) are drawn from:

- Goodwin (1992): short term elasticity −0.3, long term elasticity is −0.7
- Mrkaić[11] (2004) (Estimation elasticities of fuel demand in Slovenia): short term—0.2 long term—0.89

The results of the calculations based on the results of Goodwin and Mrkaić are summed up in the Table 4. Given that the average price of fuel in 2010 was 1,19 EUR, the "theoretical average prices of rationing" for different reduction levels are presented in Table 4.

Short term effects are stronger because individuals generally need time to adapt their consumption habits to new conditions (e.g. to change their vehicle for a more economical one). In the case of a 20% quantity reduction the (short term) estimated market price of a tradable permit would be between EUR 0,60 (Goodwin) and EUR 0,90 (Mrkaić) for a liter of fuel. To obtain a total price, the average fuel price in Slovenia of EUR 1,19 (in 2010) should be added. The long term effects would have been more moderate since long term elasticities coefficients are lower.

[11] The elasticity coefficients practised by Mrkaić (2004) it is important to mention that we have taken the average value of individual coefficients (for he differentiates between petrol and diesel).

Table 4 Short term and long term "theoretical average prices of rationing" for one liter of fuel

Reduction in fuel supply in (%)	Goodwin 1992		Mrkaić 2004	
	Short term (€)	Long term (€)	Short term (€)	Long term (€)
5	0.20	0.09	0.30	0.07
10	0.40	0.17	0.60	0.13
20	0.80	0.34	1.19	0.27
30	1.19	0.51	1.79	0.40

3.4 Estimation of Effects of Tradable Permits for Fuel

An overview of the most important macroeconomic effects will be given. There are also other positive and negative side-effects on the national economy as well as on the industries level, which result from the "cap and trade" model of tradable permits for fuel.

The main macroeconomic impacts are presented in Fig. 2 below in the form of a static linear model, (see Božičnik (2007) for further details). In reality, conditions would be significantly different, since TP's would lead to direct and dynamic changes in the market. Nevertheless, the static linear model can help us to illustrate the substantive market conditions prior to the introduction of tradable permits and the effects of their implementation.

In reality, the relationships in the case of a reduction or 10 or 30% of fuel would not be linear as one could mistakenly believe from the static diagram. The diagram (Fig. 2) allows us only to illustrate the causes of the resulting links, which we will also try to quantify in our conclusions.

Based on the (Fig. 2) we may conclude:

- The consumed quantity of fuel (CO_2 emissions) would be reduced from Q_1 to Q_2 (Cap volume of tradable permits);
- The price for fuel would be determined by the market, depending upon the relationship between supply and demand. We may realistically expect that the price would increase (at least in the short run) from P_1 to P_2, because of reduced supply of fuel. However, the price would be different for different individuals, depending on their total consumption of fuel and the fluctuation of TP prices;
- Because of reduced road traffic the "dead weight loss" (welfare loss) of the Slovenian society as a whole, is presented by triangle (M, B, N)–A5;
- The quantity of fuel sold on the Slovenian market would be reduced for quantity A11 and fuel trading companies would see their margins decrease by A21.
- The income of the Slovenian federal budget would be reduced by A31 (lost taxes, excise duties);
- The total market value of the tradable permits A4 would be used as stimulation for the tradable permits owners. They would be directly rewarded for consuming less fuel since they could sell the surplus of tradable permits on the market;
- Higher market prices of additional quantity of fuel would also have a positive effect on modal shift and a negative impact on the overall road freight volume

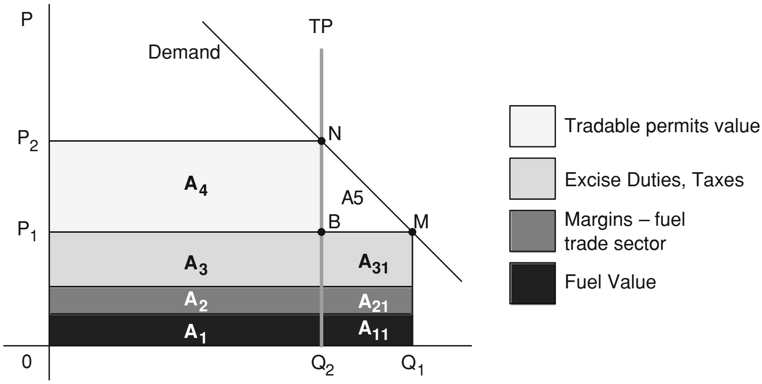

Fig. 2 Macroeconomic effects of “cap and trade” tradable permits for fuel implementation

(including the amount of collected highway tolls). The volume of road freight would be limited to the “free of charge” fuel volume limited by tradable permits. Additional freight activity would be more expensive so only high value and time sensitive goods would be transported by road, all the rest would be shifted to rail or inner waterways.

It is uncontested that the introduction of tradable permits would effectively reduce the targeted parameters, as for example a targeted reduction in fuel consumption, or CO_2 emissions. Achievement of such goals would imply, due to systematic interrelationships corresponding effects on other related subsystems. So we can also estimate the direct effects of implementing tradable permits such as reduced cash flows to the national budget (taxes, excise duties), reduced income for fuel distributors, lower income from road tolls, etc. Table 5 presents the quantified values for Slovenia of the above mentioned parameters provided that the volume of fuel consumption would be decreased by 5, 10, 20 or 30% in comparison to 2010.

Calculating other losses to the national economy arising from reductions in fuel sold exceeds the intention and goal of this enquiry. We estimate that various economic sectors would be affected, the most significant being:

- the car industry, where there would be reductions in:
  - car sales,
  - sales of spare parts,
  - tire sales,
  - income from car maintenance,
  - etc.
- road infrastructure maintenance (less maintenance required);
- lower demand for road widening and new road infrastructure construction;
- effect on tourism, hotels and restaurants, sport, recreation, etc.

Table 5 Quantitative effects of implementing tradable permits

Reduction volume		5%	10%	20%	30%
Fuel consumption reduction: volume/value	Million liters	98.6	197.2	394.41	591,61
	Million EUR	116.46	232.91	465.83	698,74
National budget income reduction	Excise duties (million EUR)	45.04	90.07	180.14	270,22
	VAT (million EUR)	21.19	42.37	84.74	127,12
Reduction of fuel trade margins (million EUR)		7.75	15.5	30.99	46.49
Reduction of revenues of highway tolls (million EUR)		7.96	15.92	31.83	47.75
Reduction of CO_2 emissions (thousand tones)		248.49	496.97	993.95	1,490.92

The potential reductions of CO_2 emissions are presented in table 6.

We can see that with a 20% reduction in fuel consumption, CO_2 emission are reduced by 933,946 t, while a 30% reduction would mean a reduction of 1,490,919 t of CO_2.

The benefits arising from the introduction of TP scheme for fuel in road transport could be evaluated from a number of different viewpoints. Since quantification of positive effects goes beyond the scope of this research, we will confine ourselves to a qualitative assessment of the advantages at individual level.

The implementation of a TP would, encourage all involved in transport to behave more rationally, particularly in two ways:

- In general, private vehicle trips would be made in cases, where the utility derived from using a personal vehicle would be comparatively higher;
- The number of trips with only one or very few passengers would be minimized. People would start sharing their vehicle capacities more widely. Hence, the occupancy rate would be greatly improved;
- The same logic goes for freight transport;
- Consumers would opt for vehicles with lower fuel consumption (while it is true this would not reduce mileage significantly, it would have a noticeable effect on harmful emissions).

Implementation of a TP scheme would also have a significant influence on the growth of inventions, innovation and investments, primarily in the field of development of a new generation of more environmentally friendly vehicles (lower fuel consumption, alternative fuels, etc.). This means an important business challenge for innovative businesses, which would also create new jobs. This would trigger a new cycle of economic growth and development in the transport and related industries.

Less motor vehicles on the roads would mean a reduction of all external costs of traffic such as congestion, particulate emissions, road accidents and noise. This would have a direct influence on human well-being, general health and the quality

Table 6 Scale of reduction of CO_2 emissions in Slovenia

Reduction in fuel consumption (%)	Reduction in fuel sales, in L	Reduction in CO_2 emissions in kg
5	98,602,282.83	248,486,645.13
10	197,204,565.67	496,973,290.27
20	394,409,131.33	993,946,580.54
30	591,613,697.00	1,490,919,870.80

of life. A reduction of traffic, particularly in urban areas would result in less damage to buildings, historic sites and monuments and to urban and other road infrastructures. This would also reduce costs and release financial resources for other purposes, which would help promote the creation of new jobs, etc. In the long term, fewer requirements for transport infrastructure, parking spaces, and garages would leave more areas available for green zones; this would also have a positive effect on the overall quality of life.

4 Conclusions

The theory on tradable permits as well as experiences with carbon markets prove that tradable permits are efficient market based instrument for sustainable mitigation of external effects, because they directly stimulate those who behave rationally and at the same time enable the reaching of the foreseen pollution "cap" using a free market mechanism. In a market economy, it is necessary to cap the growth of those linear systems, whose too dynamic growth would threaten harmonious sustainable development.

In the short run, a 20% reduction of the available fuel quantity in Slovenia (based on 2010 data), would, increase the average fuel price for a liter for EUR 0.80; in the long run the effects would be smaller between EUR 0.27 and 0.34. At the same time, the Slovenian state budget (2 mill. inhabitants) would receive EUR 180 million less excise duties and EUR 85 million less income from collected VAT; as well as EUR 31 million less collected highway tolls from trucks. Fuel trade margins would be decreased by EUR 31 million. The result would be about 1 million tons less CO_2 emissions.

On the private car user level the expected effect of the introduced "cap" TP system for fuel would be the shift towards cars with better fuel millage, increased demand for public transport and increased average number of passengers in cars. Low income car owners would take advantage of additional income by means of selling their TPs on the free TP market.

Higher average market prices of fuel would also have a positive effect on modal shift and a negative impact on the overall road freight transport volume. The volume of road freight would be limited to the "free of charge" fuel volume limited by tradable permits. Additionally, freight activity would be more expensive, so only high value and time sensitive goods would be transported by road, all the rest would be shifted to rail or inner waterways. Road transport shipments would be rationalized, load factor of the road transport rolling stock would be increased and the share of empty runs would be decreased.

Reaching sustainable objectives of the overall growth of interdependent, dialectically related economic and other subsystems also demands endurance of an economic loss to society in the form of a necessary slowdown in the growth of some economic sectors. This would decrease profitability of capital invested in those industries, employment would decrease and reduced tax revenues from these industries would have an impact on the state budget.

Restricting the level of road traffic emissions (fuel consumption) also provides a long term basis for its sustainable development. The restricted road transport emissions represent also the challenge for innovations, inventions and potential growth and/or development of new products and services which could on a long run replace, at least a part of the lost opportunities, caused by the emissions control.

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