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Eva Savelsberg

Innovation in European Freight Transportation

Basics, Methodology
and Case Studies
for the European Markets



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For Rhea and Robin

Preface

During the past two centuries, the impact of technology on society has been more fundamental and far-reaching than any visionary, philosopher or science fiction author of the past could have ever imagined. The world as a whole and all its societies have been changing through the processes of developing, adapting and implementing very different kinds of technology. Particularly those enterprises engaged in transportation across national borders are highly complex systems in terms of specific dynamic interrelations between people, the organizations they work in, and the technology they work with. Furthermore they are embedded in very specific ways into these different societies which are taking advantage of transportation. Such enterprises are complex socio-technical systems. They need to continuously develop and redesign themselves in order to meet all the requirements of their tasks, under ever changing conditions. Introducing new transportation technology and new software tools into this market means instigating such fundamental change processes. These change processes are in themselves highly complex and need to be dealt with in a very conscious and multi-facetted approach.

These aspects are discussed in this book based on about 10 years of research which has mainly been funded by the German Federal Government and the European Union.

I owe special thanks to Prof. Dr.-Ing. Klaus Henning for a decade of learning and research possibilities. My professional career in research and industry is decisively based upon these years. Furthermore, I am much obliged to our different research teams and especially Rahel Danielzik for so many fruitful years of co-operation. I would also like to thank Prof. Dr.-Ing. Karsten Lemmer and Prof. Dr.-Ing. Henning Wallentowitz for accompanying and supporting the development of this book.

I am particularly grateful to Dr. Dietrich Brandt with whom I discussed on many occasions my scientific views, problems and visions. He has always been a source of inspiration.

Last but not least I would like to thank my parents Cäcilia and Winfried Preuschoff for taking care of their daughters and for giving their education the highest priority, Susanne and Petra Preuschoff for their friendship and support, as well as Robin and Rhea Savelsberg for their care and encouragement during the past years of research and writing.

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Chapter 1

Introduction

1.1 Problem Statement

Today we experience the possibility to participate in nearly unlimited mobility¹ – spanning the full meaning of this expression. It has become the *savoir-vivre* of the last two decades. Our values and hence, our thinking and acting are shaped by both our claim and our duty to be mobile (Petry 2006). This conclusion is decisive in order to understand the importance of the discussion around this topic.

For our research purposes, mobility means the movement of people, goods and information (Vester 1990; Henning and Schmid 1998). Even within this definition mobility is still one of the most decisive economic factors, and simply a common leisure activity².

Mobility is called the engine of our economy. The increase of the Gross Domestic Product and the growth-data of freight/passenger transport are linked as shown in Fig. 1.1, for the 25 European countries (EU 25). The transport sector is the employer of 10 million people (TREN 2004). Its share in the Gross Domestic Product is 1000 billion³ EUROS which equals 10% of the GDP (White Paper 2001). Freight transportation needs particularly to be considered here.

During the last decades the European economy has benefited from the fact that the costs of *direct* freight transportation carry marginal economic weight⁴. Therefore all national markets have strongly expanded and production and dis-

¹ Originally, the Latin expression “*vulgus mobile*” describes an obnoxious mass of people. This led during the 17th century to the swear-word “*Mob*” (Padrutt 1991; Novy 1993).

² 35% of all passenger car movements are for recreational reasons (Vester 1990; Novy 1993).

³ 1 billion = 10^9 .

⁴ The economic development and the process of deregulation since the mid eighties allowed a cutting of transportation costs of 25% up to 50% (Aberle 2003).

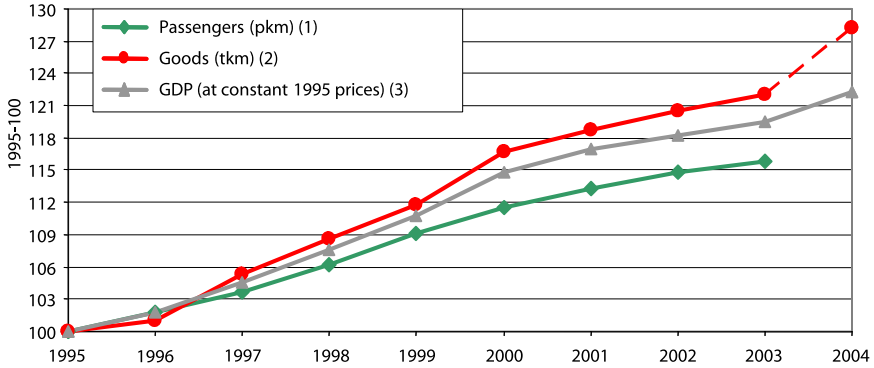


Fig. 1.1. Growth of transport and Gross Domestic Product EU 25 (1995–2004, 1995 = 100) (Directorate-General Energy and Transport 2005) (1) passenger cars, powered two-wheelers, buses & coaches, tram & metro, railways, air, sea; (2) road, sea, rail, inland waterway, pipelines, air; (3) GDP: at constant 1995 prices and exchange rates

tribution processes have fundamentally changed. Our freight transportation system today offers a highly efficient organisation which all European citizens have been experiencing during the last decades when the ways and standards of living have been continuously improving about everywhere in Europe.

There are, however, some serious problems and risks to be observed in such European mobility. According to the European Union the major difficulties are: “the imbalance in the development of the different modes” (Fig. 1.2), “congestion on the main overland routes and in cities”, and furthermore “the major impact which transport is having on the environment and on citizens’ health” (European Commission 2004:9).

Hence, on European and national level, major efforts and investments are performed to optimize and improve the freight transportation system. The main aims are to continue the successful development of mobility across Europe while achieving reduction of its detrimental effects and avoiding damage to the national economies (Savelsberg 2006a).

On this background, the first of four main priorities has been listed by the European Union within the Energy & Transport Report as follows: “Adjusting the balance between the different modes of transport”. It hints specifically at the following issues:

“Breathing new life into the railways, (...), and the development of intermodality are presented as being the keys to the success of a policy aimed at changing the balance, in particular for the transportation of goods. The paper also stresses the need to improve the quality of road transport by modernising its operations, while respecting social legislation. (...).”

(European Union 2004:9)

For these far-reaching goals, a decisive contribution is expected to be offered by innovation in technologies and logistic services. The corresponding fields of

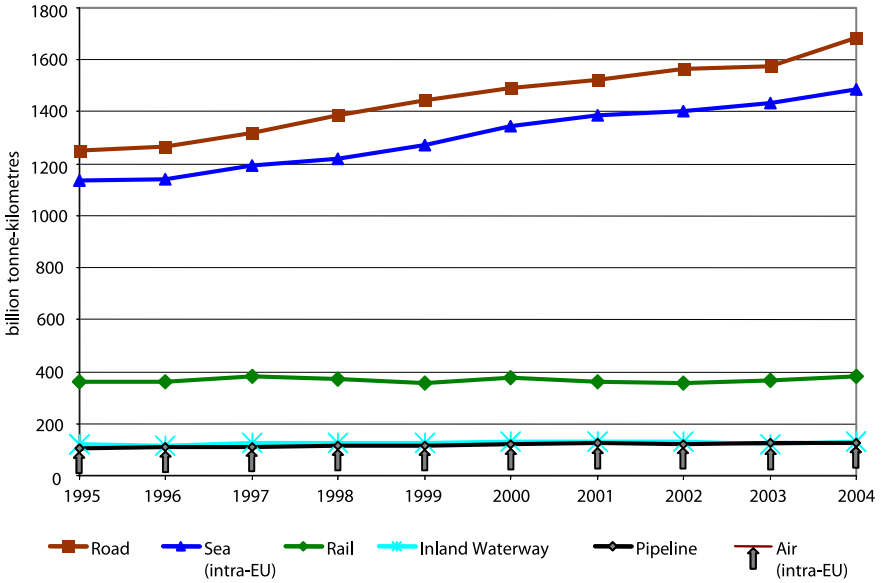


Fig. 1.2. EU 25 performance by mode of freight transport (1995-2004 in billion tonne-kilometres) (European Union 2003)

research concern metropolitan areas (*city logistics*) and national/transnational transport networks or corridors (*long-distance freight transport*).

The topic *city logistics* has to be solved mainly by regional and local authorities. Today it is well taken care of by several national support programmes⁵. The *land-based long-distance freight transport*, however, may be considered a serious national and international challenge. Particularly Germany is affected by these challenges since it is already today and will be even more so in the future, one of the most important European freight transportation hubs. Hence, this sector of European freight transportation is the focus of the research described here.

During the 6th Framework Programme of the European Union, 680 million EUROS were invested in the sub-programme *Sustainable Transport*. Furthermore the German Federal Government has supported several different improvement projects of the freight transportation system. But so far it has obviously not been possible to realize decisive changes on the land-based long-distance freight transportation market.

Therefore it may be considered a major task to implement innovative technologies and logistic service innovations into the freight market. One main obstacle against such innovation has been emphasized by the “Bundesministerium für

⁵ <http://www.mobiball.de>.

Bildung und Forschung”⁶ (BMBF) of the German Federal Government. It is the lack of tradition in utilising systematic *innovation management* within the transport and logistic sector as it is stated by the subsequent German quotation:

„Die Branche hat aber keine ‚Tradition‘ und wenig Erfahrungen systematischen Innovationsmanagements.“

(BMBF 2004:3)

The transport and logistic sector is, therefore, called *a turnover giant but innovation dwarf* (BMBF 2004). As a result innovative concepts may exist but they repeatedly seem to fail to get implemented.

One specific reason for the failure of implementing innovative technologies and logistic service innovations is the fact that the processes of technology design do not take sufficiently into account the complexity of the logistic and transportation system as a whole (Dellmann 2004; Lemmer 2004).

“A good freight transport policy starts by understanding logistics. (...). Logistic problems (are): Difficult to understand complex, conflicting and overlapping supply chain trends. There are excellent supply chain management practises in Europe – but the average standard is low (...). Environmentally un-sustainable logistics is a problem for society at large. Competition rather than co-operation tradition (...).”

(TREN 2004:59, 60)

1.2 Objectives and Strategic Questions

Due to this complexity of the freight market, *cooperative development of technological innovations* seems to be required in order to gain very early the support of all stakeholders for successful migration of such innovations. Therefore this research focuses on innovation processes and products which are based on *cooperation*. This cooperation integrates the different professional groups involved in developing, organising, managing and innovating freight transportation, e.g., vehicle/technology engineering companies, transportation product suppliers, customers of transportation products, and research scientists.

This research does not take into consideration large-scale innovations which are dependent on European political efforts (e.g. Galileo⁷, ETCS⁸). Furthermore the research here deals mainly with improving land-based transportation across Europe, i.e., transport by road and rail. It does not take into account warehousing.

This research aims at suggesting a *Systemic, Migration-Oriented Innovation Management Method* and the supporting tools related to *innovative technologies*

⁶ Federal Ministry of Education and Research (BMBF). Up to 2006 the transport sector was part of this ministry. Today it is part of the “Bundesministerium für Wirtschaft und Technologie” (BMWi) – Federal Ministry of Economics and Technology.

⁷ European satellite navigation system.

⁸ European Train Control System.

and *logistic service innovations*. The innovations discussed deal with the *land-based long-distance freight transport*. Those innovations are described by several case studies which visualise the outcome of different innovation processes. Thus the case studies demonstrate how implementations of innovations may be successful by using the *Systemic, Migration-Oriented Innovation Management Method* suggested. Additionally this research may contribute to making certain recent *research on land-based long-distance freight transport more visible* for interested European researchers and practitioners.

The following research questions are discussed in this report:

1. Which political objectives and innovation-related requirements have to be considered concerning the land-based long-distance freight market, separately for each carrier?
2. Which Fields of Action should be focused on in order to contribute towards continuous development and improvement of the European freight sector?
3. Which are the basic principles of the *Systemic Migration-Oriented Innovation Management Method* and which steps have to be conducted within this *Method*?
4. Which tools can be used to support the steps of this *Method*?

1.3 Structure of the Volume

This report deals, firstly, with deriving the *Systemic Migration-Oriented Innovation Management Method* to be applied to *innovative technologies* and *logistic service innovations* in the *land-based long-distance freight transport*. For this task it starts by analysing in some more detail the present state of the freight sector in Europe. Thus Chap. 2 illustrates selected aspects of land-based long-distance freight transportation. Political objectives and innovation-related requirements are pointed out regarding the land-based long-distance freight market.

Secondly, the *Systemic Migration-Oriented Innovation Management Method* is to be based on certain theoretical concepts. Hence Chap. 3 presents selected aspects of the System Theory and Innovation Management as the basis of this Method. Thus the structure of the suggested Method is constituted as being systemic and migration-oriented. It consists of eight steps. A series of tools are suggested in Chap. 4 which may be required to accomplish those steps.

The subsequent chapters of the volume deal with the different case studies in order to demonstrate how implementations of innovations may be successful through the method suggested here. Seven case studies are described in Chaps. 5, 6 and 7 (Fig. 1.3). The case studies are grouped according to the following topics:

- innovative technologies in European freight transportation,
- innovative technologies to improve the intermodal transport chain⁹, and
- logistic service innovations.

⁹ In the following chapters named: innovations to improve the intermodal transport chain.

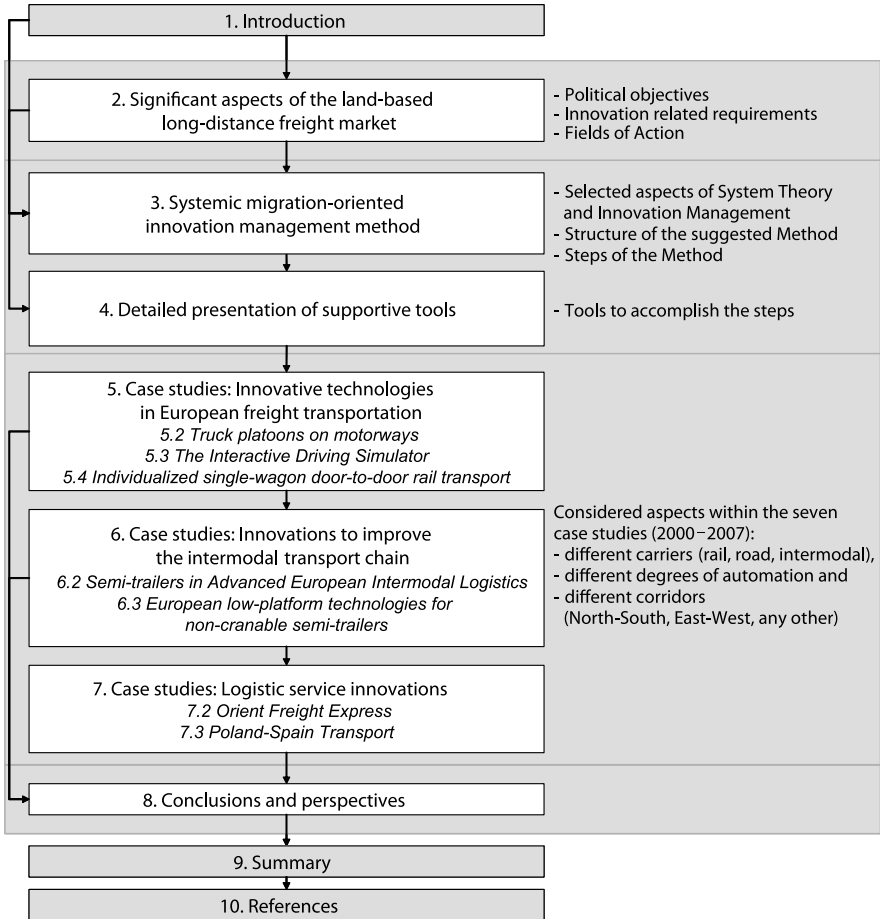


Fig. 1.3. Structure of the volume

The author of this research has been involved – mostly in a leading position – in all of these case studies and the corresponding research, development and implementation projects. These case studies offer a broad and comprehensive up-to-date view concerning the following themes:

- different carriers (rail, road, intermodal),
- different degrees of automation, and
- different corridors across Europe (North-South, East-West, any other).

The overall experiences of the different research projects are reflected and discussed in Chap. 8 where some future developments and recommendations are also suggested. The Summary is finally presented as Chap. 9.

Chapter 2

Significant Aspects of the Land-Based Long-Distance Freight Market

2.1 Overview

Chapter 2 points out significant aspects of the freight market considering the topic of this research. An overall European picture is presented. More detailed information is targeted on Germany. For further information some publications have been additionally mentioned in this report.

The recent developments of the freight market in Europe are strongly influenced by political decisions. Hence, *political objectives* are described in Sect. 2.2. The freight market involves numerous players, procedures and technologies. Therefore in Sect. 2.3 important aspects of the following topics are discussed: carriers, intermodal transport, infrastructure, market demands and corridors. *Requirements* regarding innovative technologies and services are derived. In Sect. 2.4 three *Fields of Action* are pointed out which result from this first analysis.

Further details of European land-based, long-distance freight transportation are discussed in the context of the case studies which are described in the Chaps. 5, 6 and 7 of this volume. Those offer a comprehensive picture of possible improvements considering the European and specifically the German *land-based, long-distance transportation system*.

2.2 Political Objectives

In 2005, the European Union published its mission statement regarding *Energy & Transport*. It points out that all different interest groups are to benefit from responsible development of these two areas.

“Mission Statement: To ensure that energy and transport policies are designed for the benefit of all sectors to society, business, cities, rural areas and above all citizens. The energy and transport sectors are pivotal to the European way of life and the functioning of our economy; as such their operation has to be responsible in economic, environmental, safety and social terms.”

(Karamitsos 2005:2)

These *social and environmental, economic and organisational, and technological aspects* will be outlined in the following paragraphs.

Social and Environmental Aspects

Here some aspects of the *relevance* of freight transportation for the European society will be pointed out. The strong concerns regarding the social and environmental effects of transportation are reflected in surveys analysing the *external costs* of freight transport. The following statistics offer a brief overview of the kinds and origin of these costs.

In Europe 40,000 people die in road accidents every year (European Commission 2003). The probability that a fatal accident occurs is 1.54% *without* involvement of a truck, and 3.17% *with* involvement of trucks (BAST 2004). Likewise trucks play a decisive role in energy consumption. The engine technol-

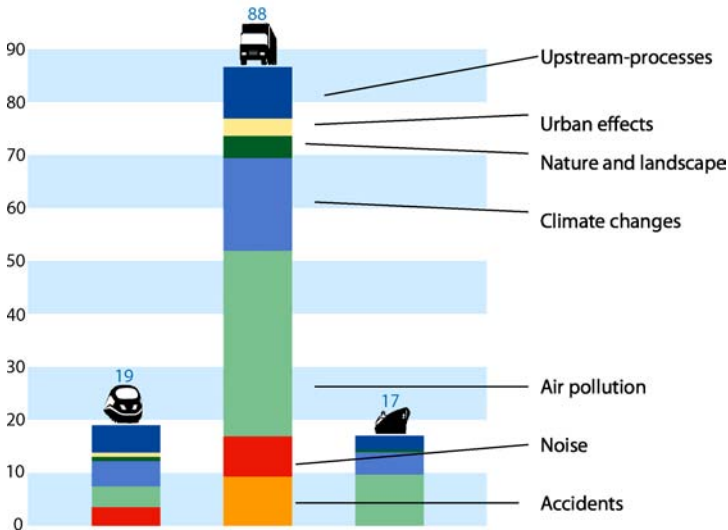


Fig. 2.1. Combined presentation of different kinds of external costs, Europe (EURO per 1,000 tkm)¹, (NABU 2006)

¹ Processes preceding the transportation process.

ogy of heavy goods vehicle (HGV) has improved considerably over the past years. Still the consumption by trucks is five times higher than the consumption by rail (calculating the diesel equivalent in kg/tkm) (Allianz pro Schiene 2006).

A combined visualisation of different kinds of external costs for different means of transport is presented in Fig. 2.1. It shows that freight transport by *trucks* is the main cause of external costs (Mayinger 2001). Research institutes, however, have pointed out that freight transport by rail is generally underestimated regarding the social and environmental impact.

“They² require large amounts of land for yards and terminals for shunting and train formation/break down and can impose noise problems.”

(Mortimer 2006:2)

Furthermore, the rail benefits from the area-wide service of the road transport (Trost 1999). This aspect will be further explained in the following chapters.

Economic and Organisational Aspects

Logistics and transportation are important for Europe. Statistics are not unanimous regarding the definition of “logistics”^{3,4} and “transportation” but they stress the significance of this sector. The whole sector may be considered extremely successful up to today. According to official estimations, expenditure for “logistics” equals 13.3% of the GDP (Koskinen 2006). In other statistics the share of the “transportation sector” equals 10% of the GDP (White Paper 2001). Those figures can offer only an orientation due to the non-unanimous definitions.

The European economy depends on the well-functioning of this logistics and freight transportation sector in order to stay competitive in the accelerating globalisation. For economic purposes any declining productivity of road transport would cause problems. The perspective is alarming that the European freight transportation sector may not be able to cope with the future increase of European freight transport (+ 55% road and + 13% rail by 2020) (European Commission 2006).

Logistics and transportation are decisive for most companies. In Europe costs for logistics have a share of 10–15% of the final product costs. The impact of transport costs is often underrated (Fig. 2.2). Costs of direct freight trans-

² conventional freight trains.

³ „Es gibt ... keine gefestigten, einheitlich gebrauchten Definitionen.“ (Klaus 1999:47). Consistent, non-ambiguous definitions do not exist.

⁴ Conventional logistic services are: vehicle clearance, assignment of freight and dispatch of goods (German: Kommissionierung), handling of return shipments, freight transport, packaging disposal, conduction of inventory, labelling, warehousing, charging of racks, organisation of transport and logistics, redemption, quality control, production disposal (Jahns and Langenhan 2004).

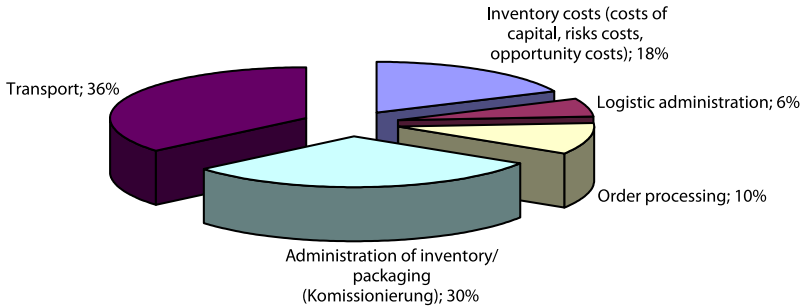


Fig. 2.2. Typical allocation of costs for logistics regarding European companies (according to Klaus 1999)

port have declined during the last decades⁵. But the share of transportation costs – in overall logistic costs – has increased. Over the last years immense reductions of warehousing expenditure have been realised. Today companies aim especially at cost cutting regarding the expenses of freight transportation (Mayer 1999).

Companies which offer logistic and transportation products have 64 employees in average. 70% of the companies have less than 50 employees. The following characteristics of this sector stated almost 30 years ago, is still valid. Seidenfus (1977) refers to the situation of those companies as a latently ruinous competition. Klaus (1999) states that although the performance in tkm will grow faster than the GDP there will be no increase of the revenue because of the grim price-competition⁶.

Thus for companies, *logistics* and therefore *transport* are, first of all, business. Any modification and innovation must lead to increasing business profits. Hence, strong consultation with stakeholders and industries is demanded of those who want to implement innovations. Furthermore strong economic analysis and impact assessments are required (Koskinen 2006).

Technological Aspects: Freight Transportation Technologies and Products

This brief discussion of the economic and organisational impact of the freight transportation sector may suffice here. Presently EU officials highlight that the EU is “world leader and important exporter of many transport technologies and systems” (European Commission 2006). From their point of view it is nec-

⁵ The economic development and the process of deregulation since the mid eighties allowed a cutting of the transport costs of 25% up to 50% (Aberle 2003).

⁶ Average revenue EURO/tkm rail: DB AG 0.05; SNCF 0.04; British Rail 0.04. Average revenue EURO/tkm road: Germany 0.14; France 0.13 Great Britain 0.10 (Klaus 1999).

essary to develop *innovative technologies* and *logistic services innovations* for the pressing issues in freight transport. Those interrelated topics are (European Union 2003; European Union 2004; Koskinen 2006):

- improved transport efficiency and logistics throughout the supply chain (reduction of congestions on road and rail, development of intermodality and co-modality⁷),
- harmonization of the modal split (increase of the attractiveness of rail and intermodal transport), and
- reduction of the external costs (especially safety and emissions).

Conclusion

Europe needs a well functioning transportation sector. Innovative transportation technology has to be *attractive* in a comprehensive sense:

- Innovative transportation technology has to be *socially* and *environmentally attractive* to reduce the external costs.
- Innovative transportation technology has to be *economically attractive* to improve the development of European economy.
- Last but not least the new *technology* itself has to be *attractive* to be competitive to other already existing transportation systems.

Figure 2.3 summarizes the statements of the preceding paragraphs.

	Social/environmental attractiveness	Economical attractiveness	Technological attractiveness
Political objectives	• Reduce external costs	• Ensure the competitiveness of the European economy Measures to enforce the economical attractiveness of innovative technologies and services: => stronger consultation with stakeholders and industries as well as stronger economic analyses and impact assessments	▪ Improved transport efficiency & logistics throughout the supply chain (reduction of congestions on road and rail, develop intermodality and co-modality), ▪ Harmonization of the modal split (increase of the attractiveness of rail and intermodal transport), ▪ Reduction of the external costs (especially safety and emissions), ▪ Competitive to already existing transportation systems

Fig. 2.3. Political objectives regarding land-based long-distance freight transport

⁷ Co-modality refers to the necessity to make use of the strength of each mode of transport.

2.3 Innovation Related Requirements

2.3.1 Carrier Rail: Full-Train and Single-Wagon Business

In freight transport, terms are often used ambiguously and different classifications are used for the same issue. The following classifications apply for this research.

Rail transportation comprises both full-train business (direct train, shuttle train) and single-wagon business (grouped train). The term full-train states that train composition is not changed between two destinations, e.g. terminals. For example, a certain customer with railway sidings sends one whole train to another plant of his company. There is no shunting/wagon manoeuvres in-between (Fig. 2.4).

Single-wagon business describes that train composition has to be arranged and rearranged according to the destination of the single wagons. There is no set wagon group transported between two terminals (Fig. 2.5). For shunting processes a hub-and-spoke system can be used (UIRR 2001; Vrenken, Macharis et al. 2005).

It is important to realise that today, the main proportion of money is earned by full-train business⁸. Yet, 70% of full-train business and intermodal business “require last mile production services by single-wagon” (McKinsey & Company 2005). According to the German Rail DB Cargo and DB AG, the full-train business is to be improved by new trains and special wagons. The DB AG states that the single-wagon business does not comply any longer with modern necessities of logistics (Deine Bahn 2001). Hence, collecting points and, therefore, the area-wide DB services are being reduced by DB. As mentioned above shrinkage of single-wagon business will reduce the attractiveness of full-train business as well as the attractiveness of intermodal transport. It means: single-wagon business is “critical for customer interface” (McKinsey & Company 2005). The first innovation-related requirement R1 follows from here.

R1: It is important to develop innovative technologies and services to improve the profitability of single-wagon business.

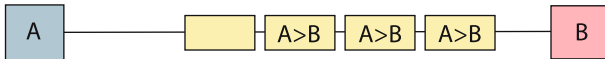


Fig. 2.4. Example of a conventional full-train business (terminal A to B) (UIRR 2001)

⁸ Single-wagon business realizes a deficit of a triple-digit-million-sum. 85% of the turnover of DB Cargo is based on 4% of its customers, further 10% on 7% other customers and 5% turnover is conducted with 89% customers (Heinrici 2002).

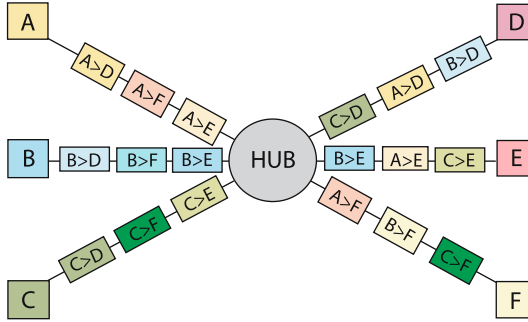


Fig. 2.5. Example of a single-wagon business using a hub-and-spoke system for shunting and transshipment procedures (UIRR 2001)

Further strategic aspects which may improve freight transport by train are not addressed here. Those are, e.g., Galileo⁹ and ETCS¹⁰.

2.3.2 Carrier Road: Vehicle Fleet Development

In the previous section, decisive problems of road transport have already been pointed out: congestion, emissions, safety etc. The following recommendations can be derived accordingly.

R2: Reduction of the external costs is especially necessary in road transport.

R3: Those technological and logistic approaches are favourable which make better use of the existing road capacity.

Considering investment in freight transport technology, the vehicle fleet development is interesting¹¹. A comprehensive survey regarding this development was conducted prior to the European research project “Semi-trailers in Advanced Intermodal Logistics” (SAIL) in 2000. It is described in Chap. 5 of this research. The author was chairing the consortium of this project SAIL. The results of the survey are summarized in the following paragraphs.

The number of semi-trailers registered within European countries has grown strongly between 1990 and 1998 (Fig. 2.6). In 1990 almost 692,000 semi-trailers were registered in the relevant countries. Until 1998 this number increased to

⁹ European satellite navigation system.

¹⁰ European Train Control System.

¹¹ European statistics inherit the problem that in different countries, e.g., different classifications and different groupings (weight classes) are made.

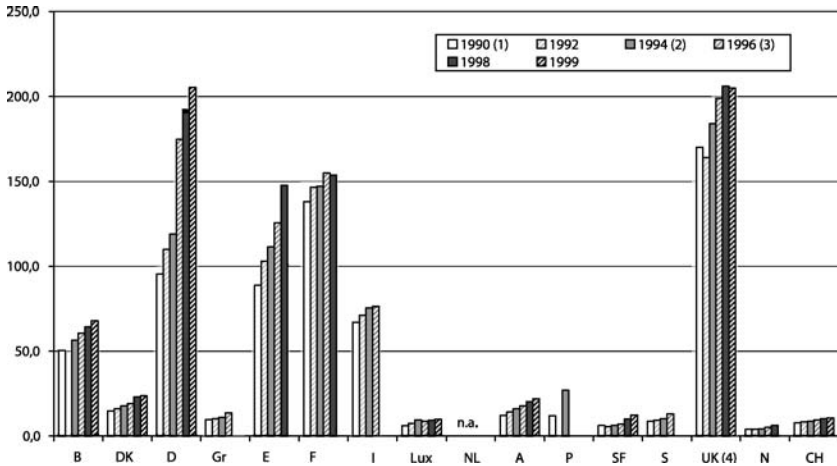


Fig. 2.6. Numbers of semi-trailers registered 1990-1999 (in 1000) (1) B: 1989; (2) B: 1995; (3) B: 1997, I: 1995; (4) Numbers of specified heavy goods vehicles

over 914,000 semi-trailers in total¹². Most of these semi-trailers are registered in Germany where the highest growth rates are also evident. Moreover France and Spain are main players regarding the numbers of semi-trailers. While France shows relatively low growth rates, the numbers registered in Spain are increasing significantly. Behind this leading group Italy and Belgium have also high numbers of semi-trailers. The UK data cannot be taken into account as mentioned above. The other countries play a minor role.

As an average each German semi-trailer (tractor¹³) travels far more kilometres than any conventional truck¹⁴ (Fig. 2.7). This stresses the importance of semi-trailers for long-distance freight transportation.

The significance of the growth rates of semi-trailers in road transport and further conclusions will be pointed out in the following chapter.

¹² It has to be taken into account that these figures do not contain data for the Netherlands. Thus, the stock is probably higher. Moreover the United Kingdom does not separate between conventional trailers and semi-trailers. That means that the UK figures are too high with respect to semi-trailers.

¹³ The succeeding statistic in Fig. 2.7 focuses on semi-trailer tractors.

¹⁴ Semi-trailers are pulled by tractors (German: Zugmaschine); conventional trucks are one-part vehicles.

It is common in publications that the expression truck or heavy goods vehicle (HGV) in general refers to both kinds of vehicles. This will be the same here. If a separation of both kinds is implied the terms semi-trailer and conventional truck are stressed.

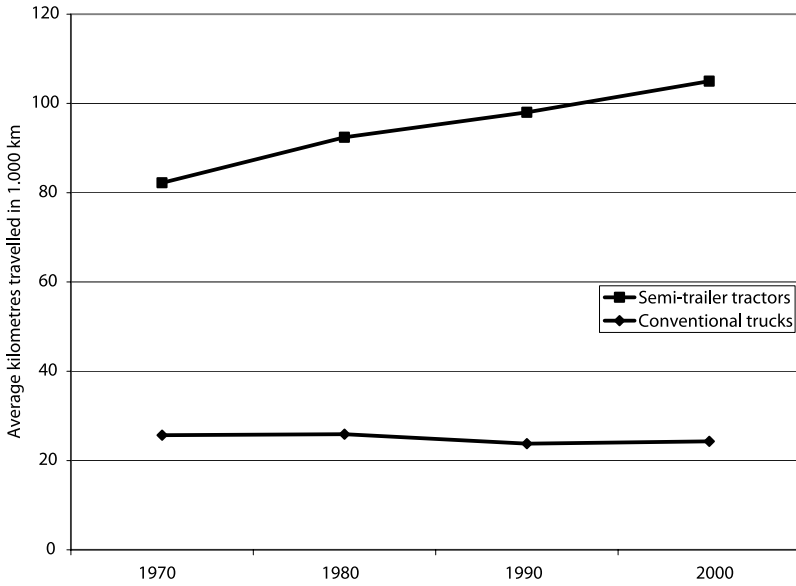


Fig. 2.7. Average kilometres travelled by German semi-trailers (tractors) and trucks in Germany and other countries (Data: BMVBW 2006)

2.3.3 Intermodal Transport

Both road and rail are land-based transportation carriers. The so-called *inter-modal transport* combines both modes and in addition, maritime and inland waterway transport.

“Intermodal Transport: The movement of goods in one and the same loading unit or road vehicle, which uses successively two or more modes of transport without handling of goods themselves in changing modes.”

(UIRR 2006a)

Intermodal transport stands out because of the high numbers of different loading units used and because many different players are involved (Vrenken, Macharis et al. 2005; Savelsberg 2006b). The transportation process can be subdivided into pre-haulage, transshipment, main haulage, transshipment and post-haulage (Fig. 2.8).

In intermodal transport the following loading units are mostly used: containers, swap-bodies, semi-trailers with and without tractor¹⁵ (Fig. 2.9). Bimodal

¹⁵ German: Zugmaschine.

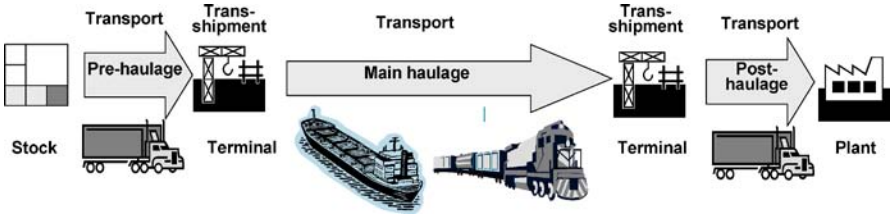


Fig. 2.8. Characteristics of the intermodal supply chain (according to Stölzle and Hoffmann 2006)

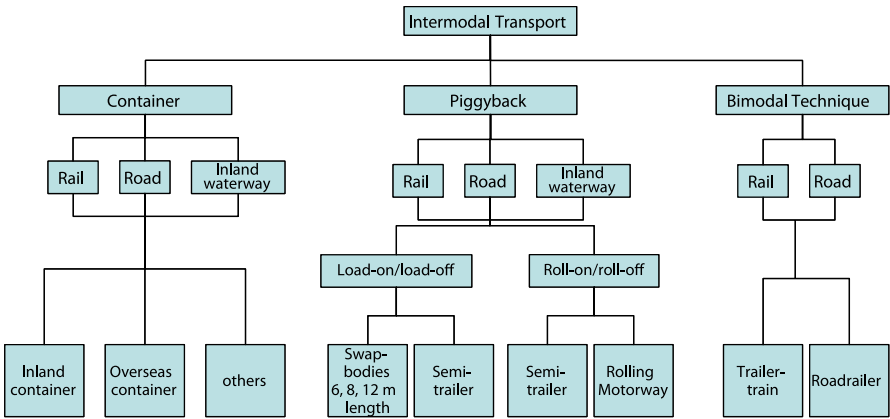


Fig. 2.9. Intermodal transport units and techniques (according to Aberle 2003)

techniques¹⁶ are exceptions. Load-on/load-off procedures describe the horizontal transshipment. Roll-on/roll-off indicates vertical loading which can be accompanied by drivers, or unaccompanied.

Statistics combine swap-bodies and containers. The share of the different piggyback systems is presented in Fig. 2.10.

Particularly the containers are important for intercontinental transport and shortsea shipping. The significance of this freight-transportation segment as well as the decisive innovations which are just about to take place in automation of sea-terminals, are pointed out by Savelsberg (2007). Nevertheless, for any innovation and related improvement of the *modal shift road/rail* of *land-based transportation*, piggyback systems are significant. Hence, in the following paragraphs the focus is on those systems, i.e. swap-bodies and semi-trailers with or without tractor.

¹⁶ E.g. vehicles equipped with running gear for road and rail or vehicles which can be lined up.



Fig. 2.10. Piggyback systems in European intermodal transport, national and international traffic (UIRR 2006b)^a

^a Rolling Road = Rolling Motorway

The production process in *intermodal freight transport* can be structured as follows. Freight is picked up by the truck at a component supplier (shipper). A freight forwarder¹⁷ is responsible for the road transport. Not all freight forwarders have trucks of their own. Hence the freight forwarding company might assign a haulier¹⁸. The handling at the terminal, transshipment, transport by rail and again the procedures at the terminal can be supervised by a service company, e.g. an intermodal freight operator. If the whole process is supervised by one company it has to be a logistics service provider (logistic operator).

Hence, diverse interrelations of *supplying transportation* and *demanding transportation* exist (Fig. 2.11). Those two sides of any business relation are called *supply side* and *demand side*. Different business relations create different assignments regarding those two sides. A freight forwarder can be member of the supply side (demand side: shipper) as well as a member of the demand side (supply side: terminal operator).

Intermodal transport is mostly associated with single-wagon business. But intermodal transport can also be conducted using full-train business. As an example, freight is collected for one customer regularly at a certain terminal. A whole train leaves the terminal and reaches the terminal closest to the customer's plant without any wagon manoeuvres. The pre- and post-haulage is conducted by truck (Fig. 2.12).

The so-called *door-to-door* service can be realized, e.g., by freight forwarders commissioning intermodal freight operators. As an example, Kombiverkehr is a well-known German intermodal freight operator with business all over Europe. It offers the organisation and handling of the main haulage. It can include the supervision of the loading and unloading as well as the transport by

¹⁷ Exemplary services conducted by freight forwarders: short- and long-distance freight transport, vehicle clearance and assignment of freight (German: Kommissionierung), groupage freight, organisation of multi-stage transports, warehousing (Dünner 1980).

¹⁸ 42% of the freight forwarders do not possess vehicles (Helmke 2005a).

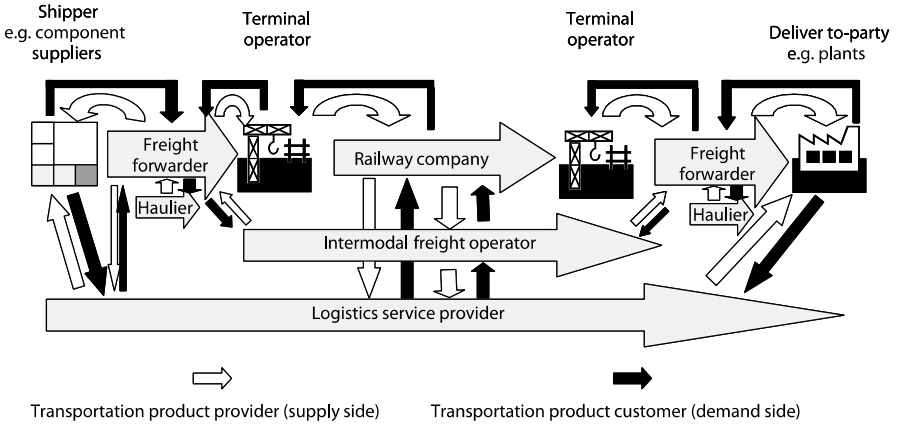


Fig. 2.11. Players in the intermodal transport chain (based on Stölzle and Hoffmann 2006)

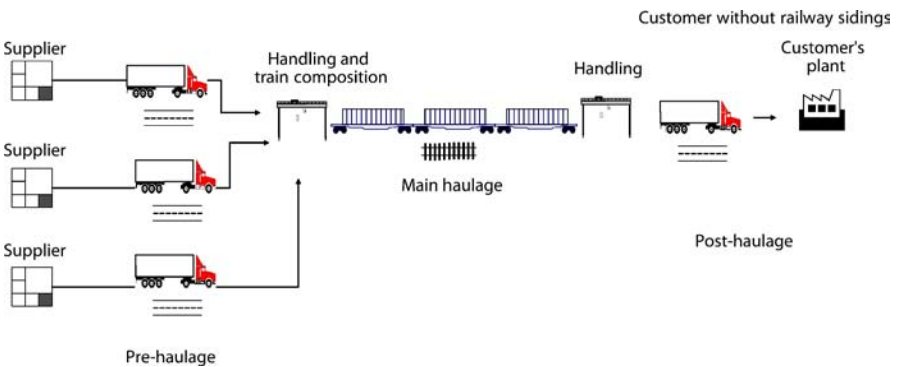


Fig. 2.12. Example of full-train business in intermodal transport

rail (Fig. 2.13). It is to be assumed that the significance of door-to-door service in intermodal transport will increase (IVSGV 2002).

The considerable growth rate of semi-trailers has been pointed out before. Among others the following facts have been derived from an intensive data analysis considering the importance of semi-trailers for intermodal transport (Henning, Stumpe et al. 2000):

- The total number of semi-trailers has considerably increased in the EU during the eight years between 1990 and 1998.
- The numbers of semi-trailers are growing faster than the numbers of other road transport equipment which grows as well (in Germany most significantly).
- The majority of all new semi-trailers have the maximum-permitted capacity in weight and/or volume. Until 2002 semi-trailers equipped for intermodal

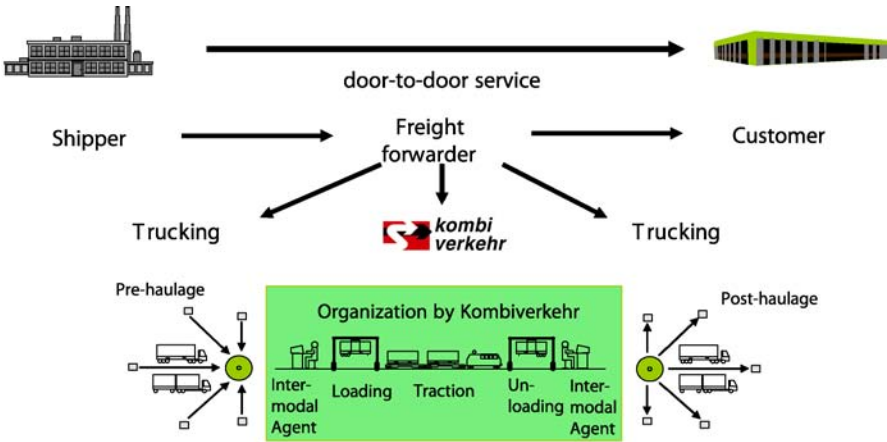


Fig. 2.13. Market position as a service provider for freight forwarders (Kombiverkehr 2004).

transport were not adapted to realise those features since they offered less volume and less pay-load.

Gottschalk¹⁹ (as quoted in RoRoRail 2005) stated that 98% of all semi-trailers are only equipped for *road transport*. Only 2% are adjusted to *intermodal transport*. Hence here follows the recommendation concerning intermodal transport.

R4: It is recommended to support the usage of semi-trailers in intermodal transport. This can be based on load-on/load-off or roll-on/roll-off techniques.

Regarding the intermodal *terminals*, numerous problems of their complex handling procedures need to be stressed. Some of them are listed below (Läpple 1993; ZLU 2003; Ruesch, Abel et al. 2005).

- | | |
|---------------------------|--|
| Organisational problems: | Lack of cooperation among the actors, poor information management, extensive handling times and in general, lack of adjustment towards the rail and road transport necessities. |
| Infrastructural problems: | Insufficient freight locating strategies and space at the terminals, unfriendly track topology and layout, poor crane and handling capacity; incompatibility of “transport means/loading units/terminal equipment” (Ruesch, Abel et al. 2005). |

¹⁹ President of the German Association of the Automotive Industry.

Technical problems: Insufficient adjustment of the interfaces between the different technical equipments of transportation, transshipment, shunting and storing²⁰.

Here follows the recommendation concerning intermodal terminals.

R5: Innovative intermodal technologies should fundamentally improve terminal processes.

Further *technological problems* are concerned with the transport units per se: too many kinds of loading units, and – as mentioned above – too little pay-load capacity of some intermodal transport units compared to transport units for road transport only (Vrenken, Macharis et al. 2005). Hence the following recommendation is suggested:

R6: Innovative intermodal transport units should realise the same capacities as units for road transport only.

Some problems of intermodal transport do not necessarily need innovations. Customers complain about *quality and service*, e.g.: high prizes, not being on time²¹, extended transport duration, inappropriate information management, and too many different players in business transactions. Furthermore *rail tracks* are being *dismantled all over Europe*, hence the “last mile connections” to customers are vanishing (ZLU 2003). A decisive problem is the different *way of thinking and acting* of road and rail operators who are expected to cooperate (ICM 2003). This might be one reason for the *lack of knowledge* regarding intermodal transport products.

R7: It is strongly recommended to support and develop cooperation between road and rail actors.

R8: Educational measures are needed in order to get intermodal service options closer to the road transport managers.

Incentives like road charges might be necessary for increased acceptance of intermodal transport (Läpple 1993; McKinsey & Company 2005). But in general such incentives in freight transport always hold considerable risks, e.g. the supported system may end up losing its links with market requirements, and

²⁰ The mapping of the complex handling procedures for comprehensive supportive IT-systems has been followed further by new innovative IT-systems, e. g., of the company INFORM GmbH in Aachen (www.inform-ac.com).

²¹ According to BMW research on the corridor Germany–Spain, 48% of the trains are late and 23% have even a delay of more than six hours (ZLU 2003).

subsequently the demand side (the customers) will have to cope with quality losses (Engel 1996).

Despite these observations, however, it is to be pointed out that “intermodal transports gain importance and become efficient in almost every aspect when distances rise” (ZLU 2003:38).

2.3.4 Infrastructure: The Degree of Modernization (Germany)

Regarding the infrastructure only one aspect will be pointed out²²: the development of the *Degree of Modernization*. It is shown in Fig. 2.14. The Degree of Modernization offers the possibility to estimate the quality of the existing infrastructure (Aberle 2003). This *Degree* is based on the proportion of the assets before and after deductions (gross and net). It comprises the information about the amortizations and investments which in this case are estimated as being linear.

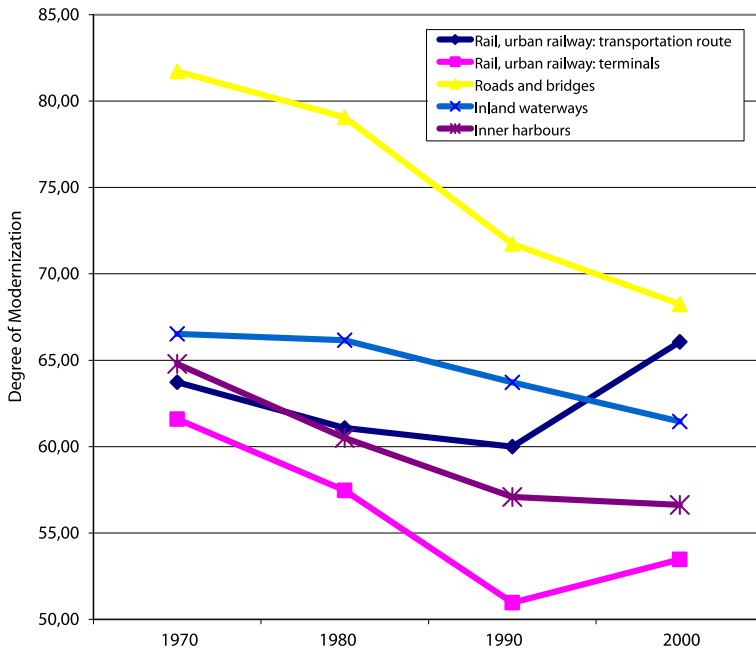


Fig. 2.14. Degree of Modernization considering the German transport infrastructure 1970–2000 (until 1990 – West German States only) (Data: BMVBW 2003)

²² Considering Germany since this work is focused on this country.

For the first analysis, only the data until 1990 should be taken into consideration. The subsequent data for ten years later (the year 2000) apply for the reunited Germany which makes the picture look even worse.

Aberle (2003) states that in the long run, the degree of modernization regarding the German infrastructure is declining even further. In the European context, different calls for proposals considering innovations in freight transport follow the recommendation R9.

R9: It is recommended to primarily develop technological innovations which are not creating new infrastructure demands.

The development of freight transport on road and rail based on tkm have already been presented in Chap. 1. Fig. 2.15 presents the performance of the different carriers considering Germany.

The connection of both data: *modal split* and *Degree of Modernization* is shown in Fig. 2.16. Eisenkopf (2005) points out that “in recent years, there has not been any discrimination against the rail sector with regard to financial support for infrastructure” (Eisenkopf 2005:76). This stresses that a large infrastructure investment in road infrastructure has not been the reason for the modal shift from road to rail (Dörrenbacher 2003). The following section presents market developments which contributed to the presented development.

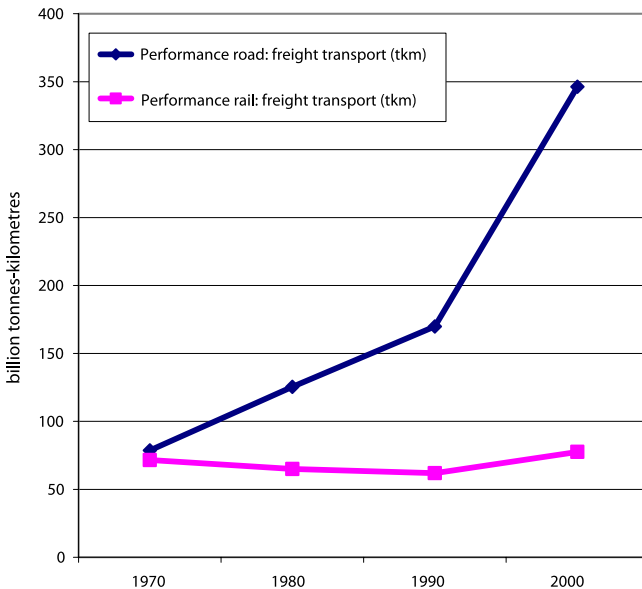


Fig. 2.15. Performance of the carriers road and rail considering freight transportation in Germany, 1970–2000; until 1990 – West German States only (Data: BMVBW 2003)

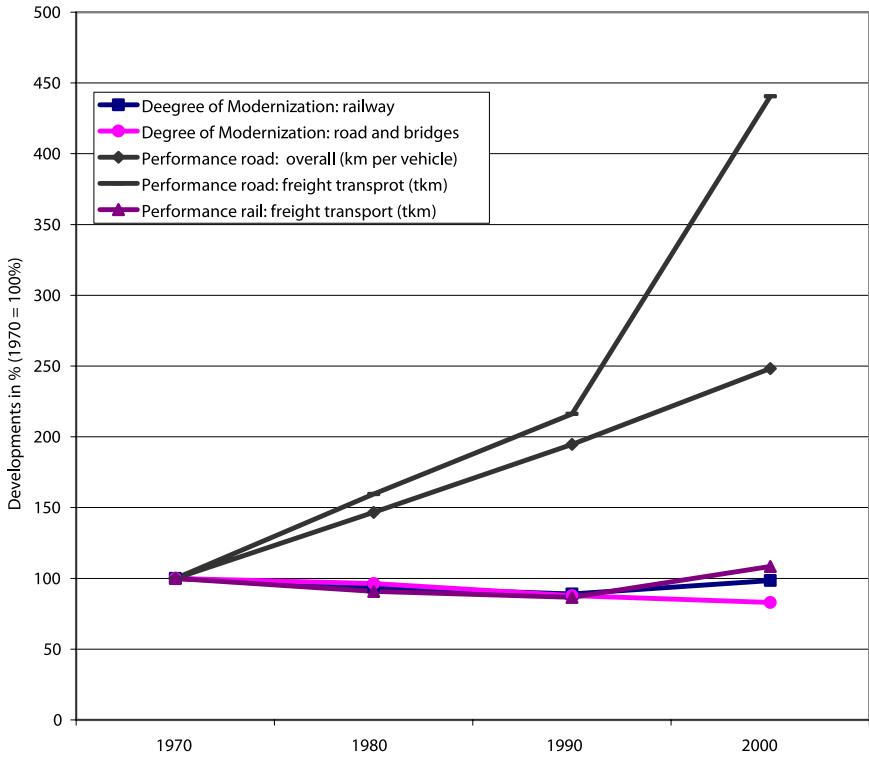


Fig. 2.16. Development of different Degrees of Modernization considering the German infrastructure of road and rail, 1970–2000 (until 1990 – West German States only), and the performance of the different carriers (Data: BMVBW 2003)

2.3.5 Demands of the Market

During the last decades the significance of bulk products has decreased. The share of products has increased which are characterized by small lot sizes, high values and small volume. This change is caused, e.g., by the lower vertical range of manufacturing (Hesse 1998). In the year 1950, ~50% of freight transport was shipped by the coal, iron and steel industry; regional retail goods²³ had a share of ~8% (measured in tonnes). For the year 2015, transports of ~17% coal, iron and steel industry, and ~37% regional retail goods are forecasted (Backhaus 2004).

²³ Small amounts of mostly upscale products with the necessity of an area-wide distribution. The German expression is: Kaufmannsgüter. A congruent translation in English does not exist.

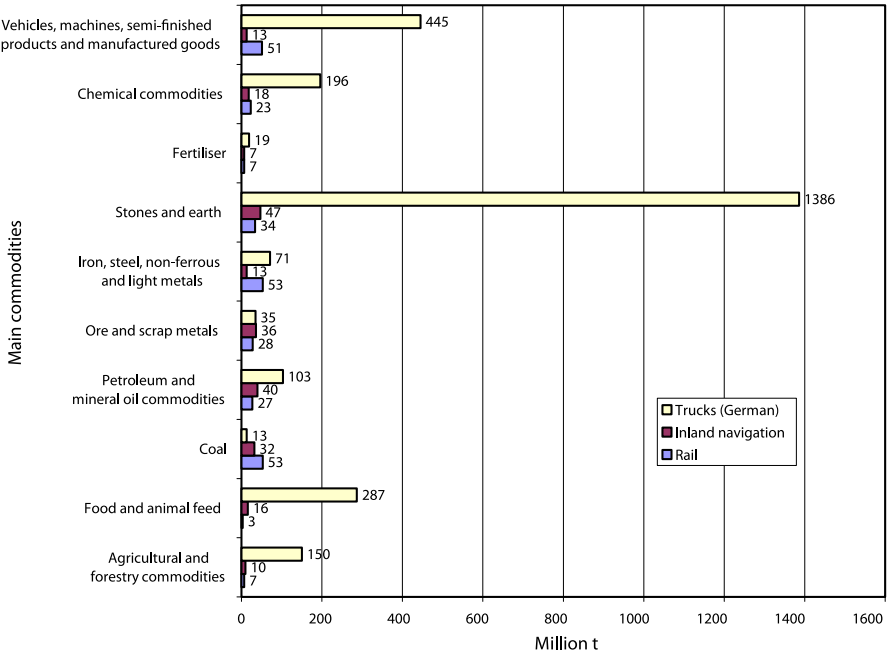


Fig. 2.17. The volume of traffic in Germany related to the ten main commodities – million t (total volume 2002: 3223 million t) (Data: BMVBW 2003)

The kinds of goods determine the ways of transport. The following characteristics apply to rail transport (full-train service): high weight, regularly high amount of goods, and no time restrictions. Sensitive commodities described by small lot sizes, being time sensitive, and Just-In-Time services, are mostly transported by truck. The estimated value of commodities using long-distance transport by road is on the average 40.90 EURO per tonne²⁴. The estimated value of commodities transported by rail is on the average 11.56 EURO per tonne (Klaus 1999).

Fig. 2.17 and Fig. 2.18 visualize the following facts: *vehicles, machines, semi-finished products (pre-fabricated products)* and *manufactured goods (final products)* are placed first to be transported by trucks regarding *tonnes per kilometre*; but they are placed second regarding *tonnes* transported by trucks. The reason is as follows: it is not only the composition and value of transported commodities which have a decisive input. Freight which has to be transported more than 500 km constitutes 50% of the additional amount of freight (Hesse 1998). Again this market is dominated by truck transportation.

²⁴ Applies to: transport conducted by German companies, status 1997.

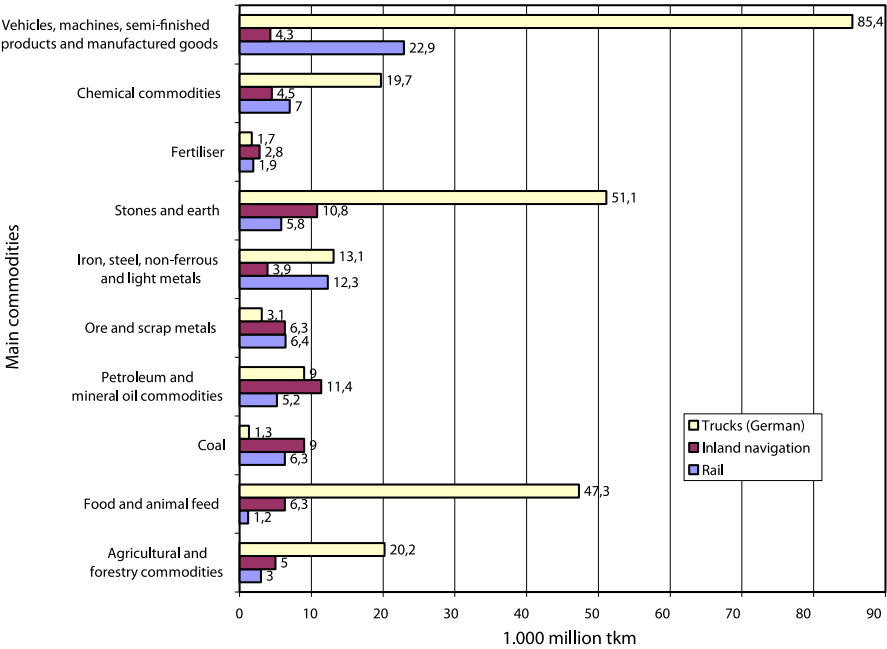


Fig. 2.18. The traffic performance in Germany related to the ten main commodities – 1,000 million tkm (total performance 2002: 388.9 billion tkm) (Data: BMVBW 2003)

Fig. 2.19 focuses on transport markets regarding different groups of commodities. The data are presented considering the relative market share of rail transportation in relation to road transportation and the expected market growth (%).

One freight group is again *vehicles, machines, semi-finished products and manufactured goods*. The relative market share of rail transportation regarding this group is only ~0.1 – calculated by the proportion of transport by rail compared to transport by road. This group of commodities is assumed to be the most prosperous (market growth of 5 to 10%). On the other hand, rail transport is most successful with commodities which have a rather low market growth, e.g. firm mineral combustibles: relative market share ~10, market growth ~0%; ore and scrap metals: relative market share ~4, market growth ~-8%.

The German Federal Government (BMBF) recently funded a research project which pointed out that regional retail goods which have to be transported more than 500 km, are most likely to be transferred from road to rail. But even under ideal conditions only 10–20% of the volume of truck traffic may be shifted in this way (BMBF 2003).

R10: Rail transport has to become attractive to the upcoming markets of regional retail goods and furthermore, for prospering commodities.

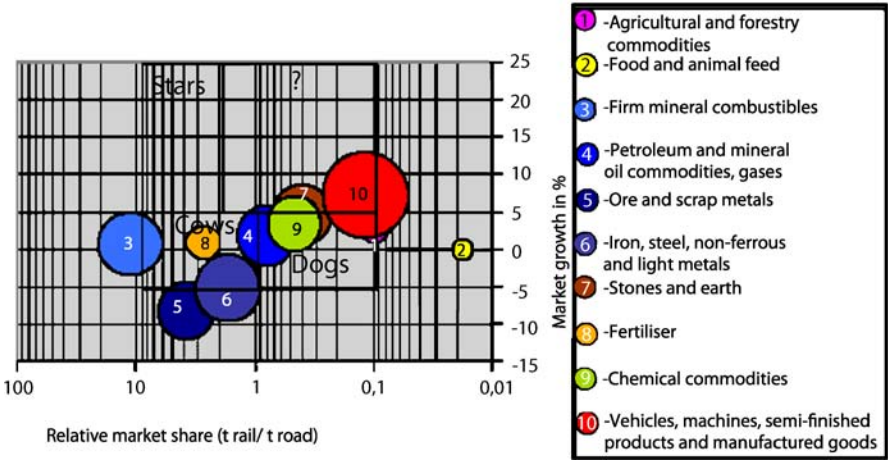


Fig. 2.19. Market shares of rail compared to road, based on t (according to Dellmann 2006)

It implies for freight services to become more attractive to upcoming markets by meeting the criteria of the potential customers. The established criteria for successful services used to be: quality, costs and time. According to Mayer (1999) these criteria are not the only deciding criteria anymore. Shippers of high-value goods demand further that the suppliers are agile, and able to respond quickly to changing demands, and to realise lean processes. Thus here follow the recommendation R11:

R11: Innovative technologies and logistic service innovations have to consider the following criteria: quality, time, cost, being agile and being able to respond quickly to changing demands, and to realise lean processes.

2.3.6 The Freight Transport Corridors Across Europe

The enormous amounts of freight transported daily across Europe, usually follow certain well-defined routes or corridors. They take into account particularly the geographic obstacles, e.g. mountains and rivers etc.; also some political borders; or technological difficulties, e.g. the change of train gauge between France and Spain. Some of these geographic corridors have been in use already for many centuries by transport means which were fairly different from the means of today. In the near future, especially Germany will develop to be one

of the most important “hubs” in Europe²⁵ transferring freight between Western and Eastern European countries. Therefore Germany – and the whole of Europe – should have an existential interest in technologies and services which may help to considerably improve performance of freight transport. It has been mentioned that particularly the *intermodal transport* would need to be improved in Europe. This is especially important regarding the different demands of the various freight corridors in Europe.

On the background of the research reported so far, it would not work to define one general criteria catalogue for choosing the most appropriate way of freight transport. The requirements for such transport are too specific and have to be discussed for each business case separately taking into account the goods to be transported and the corridors to be chosen (Preuschoff, Happe et al. 2003; Savelsberg 2006a).

“(…), it does not appear logical to use a general weighting system to determine the best transport system. As shown, this is closely related to the extremely different requirements of each transport, depending on the type of goods, the quantity to be transported and the frequency or distance of the transport, to name only a few examples.”
(Bauer 2001:66)

Furthermore ETCS will probably have a decisive impact on the performance of the carrier rail. Anyway, even if ETCS will be fully realised and the rail will meet successfully the necessities of the market this would not be enough to compensate sufficiently the expected growth in freight transport. Road transportation will keep its leading role. Therefore, decisive improvements have to be realised considering reduction of external costs which may be caused by road transportation, and better use of road capacity.

Hence this research has followed the track to analyse and evaluate several different research projects which have aimed at implementing innovations in freight transport in Europe. These case studies are presented in Chaps. 5, 6 and 7. They deal with introducing innovative technologies and services including the problems of using different European transport corridors. From here, the last but one of the innovation-related requirements follows.

R12: It will be decisive for future freight transport to make optimum use of the strengths of each carrier and each technology regarding the problems and challenges of each corridor, and regarding the demands of the transported commodities.

²⁵ According to Klaus (1999), 2980 million tonnes are transported by road and 296 by rail in Germany; second in Europe is Great Britain with 1670 million tonnes per road and 109 per rail; third is France with 1350 million tonnes per road and 135 per rail.

2.4. Introducing the Three Fields of Action

Chapter 2 started out with the demand that new technologies and logistic services have to be developed and implemented. Technology development, however, has to consider social and economic attractiveness. Specifically the technological attractiveness would need to be mainly realised through such social and economic concerns.

In this chapter, innovation-related recommendations have been suggested which take care of these issues of social, economic and technological attractiveness. These recommendations are summarised here as follows:

- R1: It is important to develop innovative technologies and services to improve the profitability of single-wagon business.*
- R2: Reduction of the external costs is especially necessary in road transport.*
- R3: Those technological and logistic approaches are favourable which make better use of the existing road capacity.*
- R4: It is recommended to support the usage of semi-trailers in intermodal transport. This can be based on load on/load off or roll on/roll off techniques.*
- R5: Innovative intermodal technologies should fundamentally improve terminal processes.*
- R6: Innovative intermodal transport units should realise the same capacities as units for road transport only.*
- R7: It is strongly recommended to support and develop cooperation between road and rail actors.*
- R8: Educational measures are needed in order to get intermodal service options closer to the road transport managers.*
- R9: It is recommended to primarily develop technological innovations which are not creating new infrastructure demands.*
- R10: Rail transport has to become attractive to the upcoming markets of regional retail goods and furthermore, for prospering commodities.*
- R11: Innovative technologies and logistic service innovations have to consider the following criteria: quality, time, cost, being agile and being able to respond quickly to changing demands, and to realise lean processes.*
- R12: It will be decisive for future freight transport to make optimum use of the strengths of each carrier and each technology regarding the problems and*

challenges of each corridor, and regarding the demands of the transported commodities.

The importance of the final requirement will become obvious in the following chapters. It is particularly important to complement the catalogue of requirements listed here because it is necessary to enforce educational and training measures considering the challenges of European freight transportation. Those measures have to focus on the different interest groups. Therefore the corresponding requirement R13 is added here:

R13 It is necessary to introduce innovations in freight transport at an earlier stage to users, organisations and society. Educational and training measures can support this demand.

The requirements are summarized in Table 2.1. They are structured in a thematic way and considering the different carriers. The rail transport is differentiated by single-wagon business and full-train business.

Table 2.1: Summarized thematic presentation of the requirements considering the different carriers and business approaches

	Road	Intermodal	Single-wagon	Full-train
External costs	R2 – Reduction of external costs.			
Infra-structure	R9 – Avoid additional demands for new infrastructure.			
	R3 – Better use of road capacity.	R5 – Improve/support terminal processes.	R1 – Improve the profitability of single-wagon business.	
Demands of the market		R4 – Increase usage of semi-trailers. R6 – Innovative transport units with competitive capacity. R8 – Service possibilities closer to the actors of road transport.		
	R7 – Cooperation between road and rail actors.			
		R10 – Attractiveness to upcoming markets.		
	R11 – Consideration of the criteria: quality, time, cost, being agile, high ability to respond to changes and lean processes			
Corridors	R12 – Optimum use of the strengths of each carrier and technology.			
Education/training	R13 – Get innovations in freight transport closer to users, organisations and society.			

The requirements show that *actions* have to be taken to raise the attractiveness of freight transportation in a social/environmental, economic and technological sense. This challenge can be met by *innovative technologies* and *logistic service innovations*.

Certain *Fields of Action* can be derived from these discussions. Those should meet the requirements listed, and support the political objectives of future freight transport across Europe. These Fields of Action specifically take into consideration the demands for *innovative technologies* and for *logistic service innovations* in freight transport. Beyond these two fields, the *intermodal transport* is one very specific transportation sector which is followed further in this report. Hence the three Fields of Action are suggested as follows (Fig. 2.20):

- *innovative technologies in European freight transportation*, (Field of Action I)
- *innovations to improve the intermodal transport chain*, (Field of Action II), and
- *logistic service innovations*, (Field of Action III).

The results of the discussions of Chap. 2 are integrated in the *Impact Table* (Fig. 2.21). In this Impact Table the political objectives (Fig. 2.3), the innovation-related requirements (Table 2.1) and the Fields of Action (Fig. 2.20) are emphasised. The foci: *social/environmental*, *economical* and *technical attractiveness* are visualised in the Impact Table.

The three Fields of Action are the structuring themes of the different case studies which are the research core of this report. In the following chapter, the *Systemic Migration-Oriented Innovation Management Method* is presented. This method has been derived in order to support the realisation of innovations which meet the requirements discussed here.



Fig. 2.20. Fields of Action and types of attractiveness to be met

Political objectives	Social/environmental attractiveness	Economical attractiveness	Technological attractiveness		
	• Reduce external costs	• Ensure the competitiveness of the European economy Measures to enforce the economical attractiveness of innovative technologies and services: => stronger consultation with stakeholders and industries as well as stronger economic analyses and impact assessments	▪ Improved transport efficiency & logistics throughout the supply chain (reduction of congestions on road and rail, develop intermodality and comodality), ▪ Harmonization of the modal split (increase of the attractiveness of rail and intermodal transport) and ▪ Reduction of the external costs (especially safety and emissions), ▪ Competitive to already existing transportation systems		
Innovation-related requirements		Road	Intermodal	Single-wagon	Full-train
	External costs	R2 – Reduction of external costs.			
	Infra-structure	R9 – Avoid additional demands for new infrastructure.			
		R3 – Better use of road capacity.	R5 – Improve/support terminal processes.	R1 – Improve the profitability of single-wagon business.	
	Demands of the market		R4 – Increase usage of semi-trailers. R6 – Innovative transport units with competitive capacity. R8 – Service possibilities closer to the actors of road transport.		
		R7 – Cooperation between road and rail actors.			
		R10 – Attractiveness to upcoming markets.			
		R11 – Consideration of the criteria: quality, time, cost, being agile, high ability to respond to changes and lean processes			
		Corridors	R12 – Optimum use of the strengths of each carrier and technology.		
	Education/training	R13 – Get innovations in freight transport closer to users, organisations and society.			
Fields of Action	Innovative technologies				
	Innovations to improve the intermodal transport chain				
	Logistic service innovations				
	Social attractiveness	Economical attractiveness	Technological attractiveness		

Fig. 2.21. Impact Table of the land-based long-distance freight market

Chapter 3

Systemic, Migration Oriented Method of Innovation Management

3.1 Overview

In Chap. 3 selected aspects of System Theory and Innovation Management are presented (Sects. 3.2 and 3.3). Subsequently these are transferred into two hypotheses (Sect. 3.4.1). Based on these aspects the ***Systemic Migration-Oriented Innovation Management Method*** is explained which is the structuring concept of the research described in this volume. Subsequently eight Steps of the method are described (Sect. 3.5).

3.2 Selected Aspects of System Theory

In this section, certain aspects of System Theory are discussed as they are related to Innovation Management. System Theory is not to be understood as an additional science in parallel to the traditional sciences, e.g. physics, chemistry or social sciences. System Theory has rather been established as a horizontal approach. It makes use of the results of traditional sciences but focuses on different topics. The System Theory analyses problems and generates solutions without respect of any borders of disciplines. This scientific approach does not concentrate on individual elements but on the *relations* among those elements within a system. Therefore in System Theory, the system *structure* is focused on (Veldkamp 1989).

This perception was already taken up by Aristotle. Hence he used the term “pan” to refer to a mere accumulation of individual elements, and the term “holon” to stress the wholeness of such elements and their relations which make up what we today would call a “system”. The mere accumulation of elements implied that their relations are of no importance. If these relations are

important, however, Aristotle called it “wholeness” (Aristoteles 330 v. Chr., 1 et seqq. as quoted in Ropohl 1999: 71).

Based on these considerations, Isenhardt (1994) calls the System Theory a *meta-science*. This stresses the change in perspective towards a macroscopic view of systems. It can be used for generating system models¹ which may be helpful to more deeply understand the system. According to Ropohl (1999), such models of systems are achieved by the following strategies:

- by mapping the original system,
- by reducing and selecting certain attributes, and
- by substituting certain features of the original system.

Considering the process of generating models two approaches can be followed: the *analytical approach* or the *systemic approach*².

The *analytical approach* complies rather with a microscopic view of the system. It focuses on details. Interactions and relations are analysed by looking at and experimentally changing, individual variables within the system. The phenomena observed are assumed to be reversible and independent from the time of analysis. The resulting models are precise and detailed. They can only be used if the relations and interdependencies are of a linear kind, and have minor influences on the system as a whole.

The *systemic approach* complies rather with a macroscopic view of the system, e.g. it analyses interdisciplinary interdependencies among individual system elements, and system coherences. The effects of those interdependencies and coherences are of special importance for understanding the system’s functioning. For this analysis, groups of variables are modified. The duration of the examination and other resulting irreversible conditions are to be integrated in the final analysis. This approach is particularly helpful if the interdependencies are non-linear and their influences on the system are considered pronounced.

A system can be split up into *partial-systems*. These partial-systems allow the research to focus on certain aspects of the system. Partial-systems are used to analyse the system through a kind of filter (Hübner 2002). In the context of this research, the specific *partial-systems* *Human*, *Organisation* and *Technology* are important and helpful as will be discussed in detail further on. For

¹ For more information refer, e.g., to the following references, which – among others – have been used as resource materials for this research:

Emphasis on biology – Bertalanffy (1950; 1968); Maturana and Varela (1991).

Emphasis on control engineering: Wiener (1948); C. Shannon and W. Weaver (1948).

Emphasis on psychology: W. Ross and Ashby (1956), McCulloch (1943).

Emphasis on organisations: Forrester (1961), Meadows (1972), Henning and Marks (1990), Strina (2006).

Emphasis on systemic aspects of innovation management: Hübner (2002), Ropohl (1999).

History of system theory: Ilgauds (1980), Strina (2006).

² (Ochterbeck 1988; Marks 1991; Ropohl 1999; Henning and Preuschoff 2003; Happe 2005).

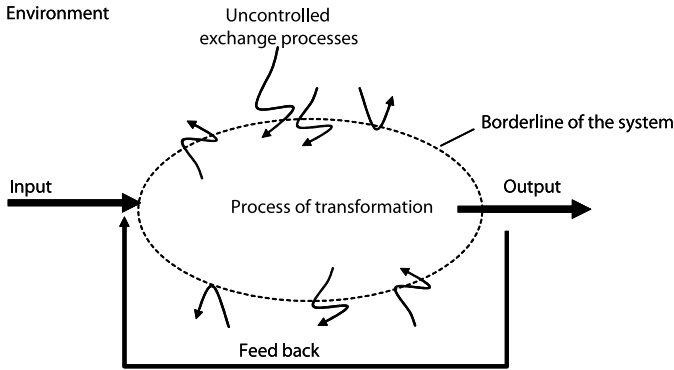


Fig. 3.1. Schematic visualisation of a system (based on Henning 1991; Preuschoff 2002)

the final results of the system research, the different partial-systems have to be brought together again and the system has to be taken into consideration as a whole. Furthermore it needs to be noted here that such partial-systems are to be distinguished from the so-called *sub-systems* which are sub-units within the system.

A system separates itself from its environment through its borderline (Fig. 3.1). This borderline is comparable to a membrane (Henning and Marks 2000). Hence a system continuously performs interchanges with its environment. Furthermore, systemic models integrate feedback loops. Therefore they can be modelled by using the concepts of control circuits. It means in particular that the output of the system is reintegrated into the input of the system. These selected aspects of System Theory lead to the different system axioms which are summarised in the following paragraph.

Axioms of Systems

Marks (1991) states several general axioms of a system. They are listed as follows.

- The system is composed of several elements. Those elements feature different characteristics.
- The elements are defined in relations to each other. These relations feature again different characteristics, they are linked and they determine certain configurations and coherences of the system.

- Corresponding to the term “wholeness”, the system possesses features which cannot be traced back to individual elements. Those features result from the whole composition of the system.

Furthermore Marks uses here the special axiom of the *socio-technical systems*. These systems comprise the *social* and the *technical* partial-system³. Both partial-systems are interrelated by non-negligible relations. These relations shape the organisational structure of the whole socio-technical system. The relations among the elements comprise different feedback loops. These loops are able to stabilize and renew the system.

Here the comprehensive scientific approach of Maturana/Varela (1991) needs to be referred to. It is based on recent biological considerations and research. It will not be followed in detail but some important aspects of their approach are to be mentioned. These aspects give thought-provoking stimuli regarding systems and their ability to assimilate innovations. Maturana/Varela stress that systems of a certain kind can establish their own guiding principles of performing either steady-state processes, or renewing and innovating these processes. In particular the effects which are provoked by any interchange with the environment, are defined by the composition of this system as a whole, particularly its coherences. In the context of the research described here, the following observation is specifically important:

The specific features of any new element entering the system from outside, are not decisive per se for its acceptance by the system; but the acceptance of the new element depends on the kind of perception the system has built up of this new element.

(Maturana and Varela 1991:60)

These aspects of System Theory and system change will be discussed further in the following section as they are related to Innovation Management.

3.3 Selected Aspects of Innovation Management

Considering systems, the term *innovation* is closely related to one specific issue mentioned above: the entering of new elements into the established system. Such new elements usually instigate change processes from within the system. The system needs to employ specific management strategies to cope with such changes if they are somewhat complex. Research on this kind of Innovation Management is still fairly fragmented (Hübner 2002; Lemmer 2004; Henning 2006). Up to now, it is the economic research which plays the decisive role in

³ Regarding analysing and modifying socio-technical systems in a technological context, it has proved to be sensible to choose the partial-systems Social/Human, Economic/Organisation and Technology.

this research on Innovation Management. Especially the engineering sciences, however, are not sufficiently represented here (Hübner 2002). Some aspects of this research are discussed as follows, they are mainly related to economy and engineering.

The Phases of Technological Ontogenesis

Economic sciences subdivide the technological development process generally into four phases (Ropohl 1999; Hübner 2002). The characteristics of those four phases are listed in the following paragraphs:

Cognition (discovery):	Scientific awareness of natural phenomenon.
Invention:	Establishing technical, applicable knowledge.
Innovation (technological):	“Technological innovation activities are all of the scientific, technological, organisational, financial and commercial steps, including investments in new knowledge, which actually, or are intended to, lead to the implementation of technologically new or improved products and processes.” (OECD 2002). According to Schumpeter an innovation does not need to be based on new scientific discovery. The term innovation can be applied to any new quality or feature of goods or procedures (Schumpeter 1993).
Diffusion:	Process of dissemination regarding the spatio-temporal diffusion of an innovation in a socio-areal system (Arentzen 1997, as quoted in Hübner 2002: 21).

Hübner (2002) points out that economic aims are prior to technical aims. Hence, the innovation process is only concluded with the start of the diffusion phase which is the economically successful dissemination of the innovation.

Differentiation of *Technical* Development Processes and *Technological* Development Processes

Bullinger (1997) refers to *technical* development processes and *technological* development processes as being different, but they are performed as parallel and linked procedures. The technical development makes use of, e.g., commodities and components (*input*). The *output* of this process is a *material technical solution*. In parallel the *technological* development is conducted. The *input* of this process is *knowledge* of cause and effect and the *output* are *technologies* and *technological know-how* (Bullinger 1997). According to Henning (1997) *techno-*

logical development is always connected with development of both the *organisational* and *human* partial-systems.

Classifying the Start-Up Situations of Innovation Processes

Concerning any innovation, the start-up situation is particularly important. Such start-up situations of innovation processes differ considerably. Eversheim (2003) provided the visualisation to classify the different kinds of innovations. This classification is based on the initial conditions of the innovation process during the start-up situation.

Eversheim chooses four coordinate systems which can subsequently be merged into one such system. The names⁴ of the coordinate systems can be translated in the following way: *time orientation*, *competence orientation*, *outward orientation*, and *change management*.

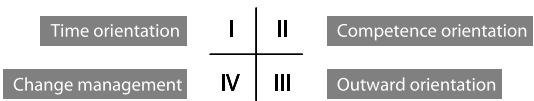


Fig. 3.2. Visualisation of the clockwise merging of the four coordinate systems

In the following the four coordinate systems are explained. These can be merged and different types of innovation process start-up situations can be visualised. According to Eversheim the systems are combined clockwise (Fig. 3.2).

Time orientation:	The <i>time orientation</i> is characterized by the <i>timing</i> of the process and the <i>validity of information</i> (Fig. 3.3, square I).
Timing:	The <i>timing</i> of the process expresses whether the innovation process is <i>long-term</i> or <i>short-term</i> oriented.
Validity of information:	The <i>validity of information</i> rates whether the internal knowledge of internal and external facts is <i>precise</i> or <i>diffuse</i> . Those facts are, e.g., technology, production capacities and market situation (Eversheim 2003).

⁴ German names: Zeitliche Ausrichtung, Kompetenzorientierung, Außenorientierung, Planungssystematik. Based on Eversheim’s description of the fourth coordinate system, its title is translated with change management. A translation of this specific tool by Eversheim himself was not available.

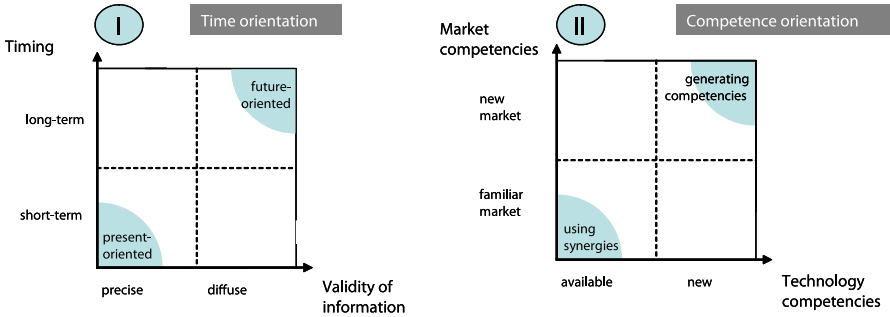


Fig. 3.3. Coordinate system to classify the start-up situation of the innovation process, square I: *Time orientation*, square II: *Competence orientation* (according to Eversheim 2003)

Short-term timing and precise information lead towards a present-oriented time orientation. Long-term timing and diffuse information add up to a future-oriented time orientation.

Competence orientation:

The *competence orientation* of the innovation start-up situation is classified by the *market competencies* and *technology competencies* which have to be gained by the involved organisation(s) (Fig. 3.3, square II).

Market competencies:

The *market competence* is *high* if a *familiar market* is approached, and it is *low* if a *new market* will be entered.

Technology competence:

The *technology competence* might be already *available* in the company, or it is *new* and therefore has to be acquired.

A familiar market and available technology competencies describe a competence orientation where synergies are used. If the innovation is to be placed into a new market and the technology competencies are new, then the competence orientation is based on generating competencies.

Outward orientation:

The *outward orientation* describes the degree of cooperation with other suppliers or customers (Fig. 3.4, square III). Hence, the *outward orientation* is classified by the *supplier orientation* and the *customer orientation*.

Supplier orientation:

The *supplier orientation* distinguishes between *ordering* and *development cooperation*.

Customer orientation:

The *customer orientation* is different if the products or services are tailored to the average

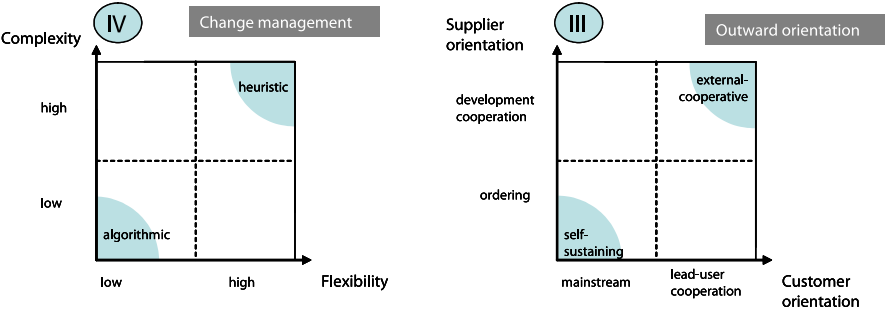


Fig. 3.4. Coordinate system to classify the start-up situation of innovation processes, square III: *Outward orientation*, square IV: *Change management* (according to Eversheim 2003)

customer who represents the *mainstream*, or if a *lead-user* is part of the development consortium.

The innovation process might be conducted by members of one company or even a single department. The value chain might be based on contributions by *ordering*, aiming at solutions for the *mainstream*. This would establish a *self-sustaining outward orientation*. A consortium with members of other supplying companies constituting a *development cooperation* and involving *lead-users*, would be *external-cooperative*.

Change management:

The final square is called *change management*. It describes the necessary approach to conduct the development process (Fig. 3.4, square IV). Therefore, this square partly results from the ranking within the preceding squares. The kind of *change management* considered here, is characterized by the *complexity* of the design of the innovation process, and the *flexibility* which has to be accomplished during this process.

Complexity:

According to Eversheim this dimension focuses on the complexity of the requirements. Schuh (2006c; 2006b; 2006a) distinguishes the complexity of the *innovation process* (e.g. involvement of different institutions, countries), the complexity of the *innovation product* (e.g. professional demands) and the complexity of the *innovation effects* (e.g. changes in the market, changes of business procedures).

Flexibility:

According to Eversheim this dimension reflects the demand on the development process for flex-

ibility (e.g. time pressure, unforeseen obstacles, problems which have to be solved in different countries).

Low complexity of the innovation process, and *low demand on flexibility*, justifies an *algorithmic approach*. The necessity to cope with *high complexity* and to employ *high flexibility* leads to a *heuristic approach*. According to Eversheim the heuristic approach is based on a few rules only. A strong problem orientation allows to cope with complexity and to realise the essential flexibility. This approach suits best for systemic endeavours (Eversheim 2003). Eversheim points out that systemic demands particularly exist if the knowledge of input, output and cause-and-effect chains is little. Furthermore strong interdependencies and/or interdisciplinary demands make a heuristic approach recommendable.

Based on these considerations, Eversheim suggests the concept of *integrated Innovation Management*. This kind of Innovation Management is based on the *balanced adaptation* of the different dimensions of the planning process. Hence the merging of these four squares allows the visualisation of this adaptation. This *balanced adaptation* implies that more or less a *circular shape* is to be realised as shown in Fig. 3.5. For this view, Eversheim explains two extreme profiles, as follows.

The first profile results from the *present-oriented timing*, *competence orientation* based on the use of *synergies*, and *self-sustaining outward orientation*. Here

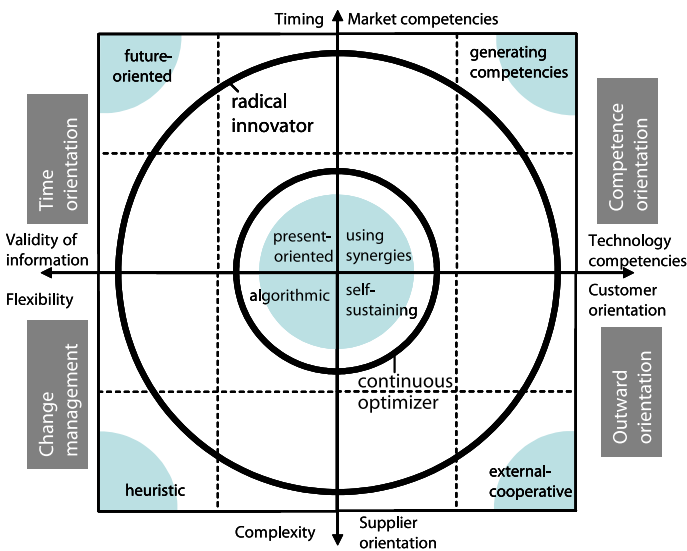


Fig. 3.5. Extreme profiles of the orientation of organisations towards innovation processes (based on Eversheim 2003)

an algorithmic approach is to be used. The innovation process of this kind is called ***continuous optimizer***. It is shown as the inner circle in Fig. 3.5.

The second extreme profile is based on *future-orientation*, strong *competence orientation* as well as *outward orientation*, and a *heuristic change management* approach. The innovation process showing this extreme profile is called ***radical innovator***. It is shown as the outer circle in Fig. 3.5.

It has to be pointed out that Eversheim recommends that companies which mainly conduct innovation processes of the kind of *radical innovator*, may orient performance gradually towards the *continuous optimizer*. This period of consolidation will reduce complexity, increase efficiency and support establishing market barriers against competitors.

Acceptance of Technological Innovations

Hübner (2002) stresses that market acceptance is ultimately decisive for the success or failure of any innovation. According to Petry (2005b) acceptance⁵ is the absorption of technological innovation, and the subsequent continuous and smooth use of this innovation as tangible application. Two biases should be avoided here. The *pro-innovation bias* is characterised by strong orientation towards the requirements of the producer, or the supply side of the innovation. The *individual-blame bias* shifts the blame of failure on the user, or the demand side of the innovation. Therefore Petry recommends realising innovation processes which are acceptance-oriented from the start. These *acceptance-oriented processes* have to take into account the individual, organisational and social issues within the system considered. Hence, the acceptance process has to focus, e.g., on the *individual* user who uses the innovation, the *organisation* which implements the innovation, and *society* which shapes assessment of the innovation, and which therefore includes also the political dimension.

Here, Maturana/Varela may be recalled as they are quoted above: the effects which are provoked in the system by any interchange with the environment, are defined by the composition of the system as a whole. The features of an entering element are not per se decisive for the development of the system, but the kind of *perception* the system has of these new elements. In the context of the research discussed here, society is to be considered as a system in the sense as described. It follows that society also accepts any innovation only if its *perception* of this innovation makes it *appear* acceptable.

Migration of Technological Innovations

Engineering sciences have originally used the term *migration* for any incremental development and implementation of technology without regard of the

⁵ Here acceptance regarding technology.

non-technical aspects of this change process. The last decades, however, have revealed that such mainly technology-oriented migration approaches have frequently not been successful (Dellmann 2006). Therefore any comprehensive migration concept always needs at least to include the parallel introduction of both innovative technologies and changes of organisational structures, within the existing working environment (Dellmann 2006; Henning 2006).

Lemmer (2004) points out that such migration concepts comprise a scientific area which affects different sciences. Migration and its effects include technological, economic, legal, political, historical, communicational, topological and educational demands. Interdisciplinary approaches can, therefore, reduce implementation problems of new technologies (Henning and Preuschoff 2003; Dellmann 2006). Hence Lemmer (2004) recommends the *socio-technical system* approach. He points out, however, that the processes which take place while introducing new technology in an existing technological environment, are not yet completely understood.

In the following sections, these different aspects are transferred onto innovations within the European freight transport market.

3.4 Transfer Onto the Long-Distance Land-Based Freight Market

3.4.1 *The Two Hypotheses of Innovations*

In this section certain aspects of the previous Chap. 2 and Chap. 3 are combined and narrowed down to two hypotheses. They are transferred onto the system of the *land-based long-distance freight market* which can here be considered a sub-system of society as a whole.

Hypothesis H1: The innovation processes concerning land-based long-distance freight transport technologies and logistic services, can be understood as a special kind of *socio-technical system* in themselves as they concern humans within certain organisations who are dealing with complex technologies under market conditions (Fig. 3.6). These innovation processes are embedded within the socio-technical system of the land-based, long-distance freight market. The interaction between the two systems aims at changing the system of the freight market through the innovation. Hence first of all, it is recommended to take the *Social*, *Economical* and *Technological* partial-systems into account in order to successfully influence this freight market system. Thus the fundamental knowledge and deep understanding of the system and the system coherences are necessary as mentioned above.

Hypothesis H2: *Innovative technologies and logistic services* are considered here as the main components of the *innovation processes* required today within the freight market system. They have substantial change input on the freight market. Hence the innovation processes have to be designed *differently* compared to *continuous product modifications and improvements* as usually considered in production engineering. Thus a *heuristic approach* is necessary including continuous focus on the migration process and the embedded acceptance process within the freight market. Such migration processes always imply fundamental change processes which require specific management strategies. Therefore an experienced and strong *innovation management* has to be established.

Those two hypotheses are to be the *guidelines* considering the orientation and the project management of systemic, migration-oriented innovation processes in land-based, long-distance freight transportation.

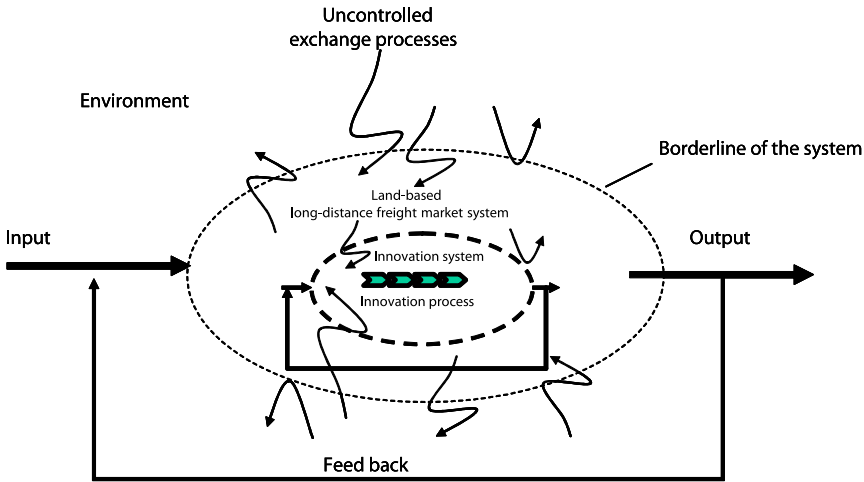


Fig. 3.6. The socio-technical innovation system embedded into the socio-technical system of the land-based long-distance freight market

3.4.2 *Expected Characteristics of the Start-Up Situations*

In the following paragraph, the expected characteristics of the start-up situations of the innovation processes are specified taking into consideration the Europe-oriented *political objectives* and the *requirements* (R1 – R13) of the long-distance freight market shown in the *Impact Table*.

Time Orientation – Square I

Timing:	The development processes of the demanded innovative technologies and services are estimated between one and ten years. Hence, it might be a <i>short-term process</i> leading up to (<i>but not exceeding</i>) a <i>long-term development</i> (Fig. 3.7).
Validity of information:	There will be two kinds of innovations. The first kind will imply <i>moderate innovations</i> regarding technologies or services. It will be based on <i>rather precise</i> demands and requirements. The second kind of <i>thorough innovations</i> will aim at decisive impact on the long-distance freight market. This innovation process might start with a somewhat fuzzy solution space. Intensive surveys might be necessary. Hence, the validity of information is <i>diffuse</i> in the beginning.

Competence Orientation – Square II

Market competencies:	All innovations are created to be implemented in the land-based long-distance freight market. Thus the innovation process aims at changes in this particular market. Even experts might not know all necessary facts and cannot estimate in advance all changes in market behaviour. Therefore an interdisciplinary approach might be recommendable since the market might be unfamiliar for some experts involved.
Technology competencies:	Again two cases have to be considered. In the first case, the specific technology competencies are <i>mostly available</i> since a clearly outlined transportation product is developed. Still, this product is supposed to be innovative. Probably there will be technological features which demand a <i>moderate gain of competency</i> .

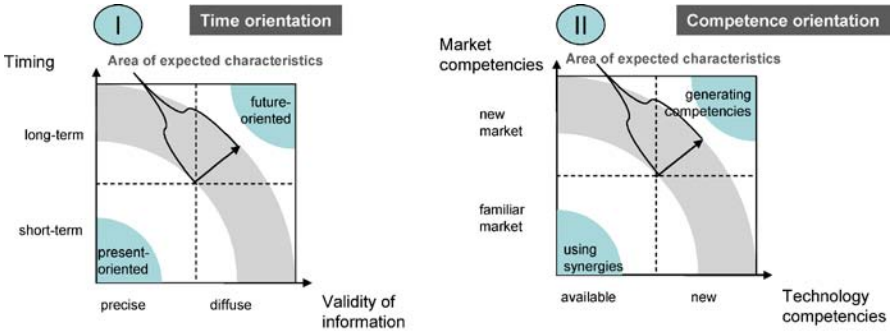


Fig. 3.7. Areas of expected characteristics within the coordinate system to classify the start-up situation of innovation processes, square I: *Time orientation*, square II: *Competence orientation*

In the second case, defined technology competencies are in principle available. The technological innovations, however, will exceed the state of the art. Hence, decisive competencies have still to be gained. Furthermore, comprehensive knowledge has to be established in order to find migration-oriented solutions. Therefore numerous companies have to be involved and new kinds of technological knowledge have to be developed and integrated.

Outward Orientation – Square III

Supplier orientation: The innovations considered might have contributions which are organised in a simple way. But those are not the most decisive contributions regarding the migration of the innovation. The socio-technical system *freight market* demands strong and broad development cooperation within the socio-technical *innovation system*. Still the number of contributing parties and the degree of involvement might change decisively during the project (Fig. 3.8).

Customer orientation: The bias regarding acceptance, and the demands regarding continuous adjustment of the migration processes are to be pointed out. The lead-user cooperation is decisive for both these linked aspects. Still the number of contributing parties and the degree of involvement might change decisively in the course of the project.

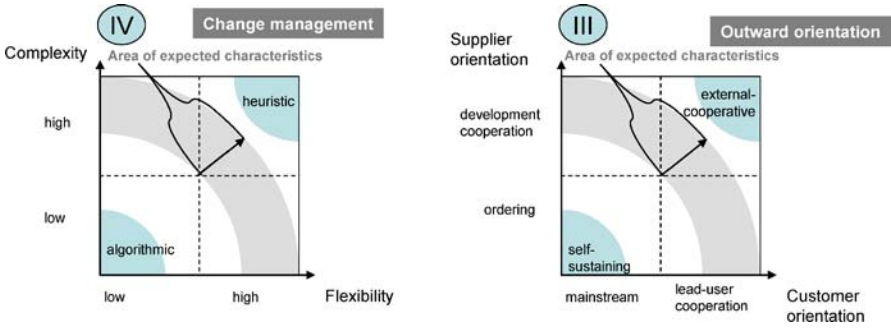


Fig. 3.8. Areas of expected characteristics within the coordinate system to classify the start-up situation of innovation processes, square III: *Outward orientation*, square IV: *Change management*

Change Management – Square IV

Complexity:

Even moderate innovations lead to considerable change processes (H2), particularly concerning thorough innovations (Henning 2006). The socio-technical system *freight market* is characterised by numerous participants with different backgrounds. The system coherences are decisive. A substantial comprehensive cause-and-effect knowledge has to be developed for each innovation – even if it is a moderate innovation. But it will not be possible to achieve ultimate system knowledge.

The following aspects have already been pointed out: the complexity of the innovation process (e.g. involvement of different institutions, countries), the complexity of the innovation product (e.g. professional demands) and the complexity of the innovation effects (e.g. changes in the market, changes of business procedures). They can considerably raise the general complexity of system changes envisaged.

Flexibility:

It is a challenging task to develop and implement innovations during a period of up to ten years. The process complexity implies that unpredictable problems will occur. Problems might have to be resolved involving different countries. Therefore the innovation strategy has to be adjusted flexibly to these problems.

The terms *radical innovator* and *continuous optimizer* have been used above (Fig. 3.5). Those terms point at rather production-oriented innovation processes. The *radical innovator* is one extreme innovation approach, symbolized

by the outer circle. The *continuous optimizer* describes continuous improvements on a smaller scale, symbolized by the inner circle.

According to the aims of this research, a different area of possible innovations will be described. On the one hand, the innovations focused on in this research, will be aiming beyond the *continuous optimizer*. They include decisive innovations rather than small-scale continuous improvements. Thus they may be characterized by the term ***moderate innovator***. On the other hand, the term *radical innovator* does not reflect the necessities of the system *freight market* discussed here. Hence the innovations related to new technologies in freight transport have to be adapted to the needs of this system. Those innovations need to be *thorough* rather than *radical*. The term suggested here is the ***thorough innovator***. Therefore the innovations which are focused on in the case studies of this research, will cover the area of the concentric circular ring between two different circles. These are: the ring of the *Moderate Innovator*; and the ring of the *Thorough Innovator* (Fig. 3.10). These new two rings define as its borders, the concentric area which integrates all case studies discussed in this report.

Hence in the following discussion, two kinds of innovations are distinguished:

- the Type A Innovation which corresponds to the Moderate Innovator, and
- the Type B Innovation which corresponds to the Thorough Innovator

Innovations which may be considered to be located between these two kinds of innovations, can be shown in the area shaded in soft gray between the two four-corner shapes of the *Moderate Innovator* (Type A) and the *Thorough Innovator* (Type B), as illustrated in Fig. 3.9.

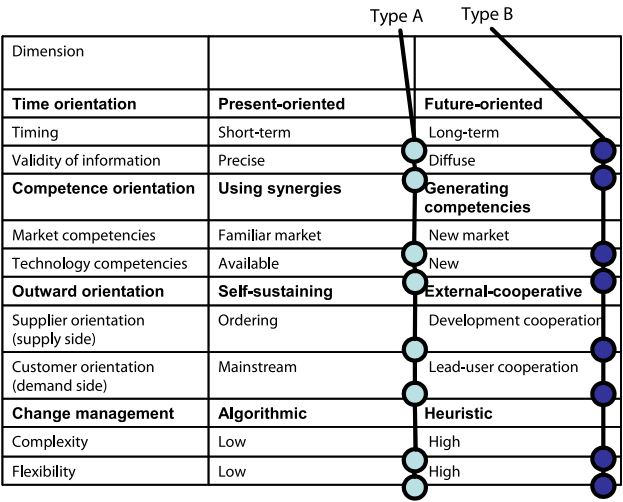


Fig. 3.9. The main characteristics of the innovations

3.5 Introducing the Steps of the *Method*, Applying the Findings

The Continuous Foci on Social, Economical and Technological Attractiveness

According to Hypothesis H1, the Systemic Migration-Oriented Innovation Management Method has to consider in parallel the *Social*, the *Economical* and the *Technological* partial-systems. In dependence on the Impact Table, the balanced focus on those partial-systems enforces the realisation of *social attractiveness*, *economical attractiveness* and *technological attractiveness*. Hence, those aspects will be considered *continuously* during the whole innovation process.

Following Hypothesis H2, the innovation process has to have strong *migration orientation during every stage*. Furthermore experienced and capable *innovation management* has to accompany the *whole process* particularly in order to take care of unexpected change effects.

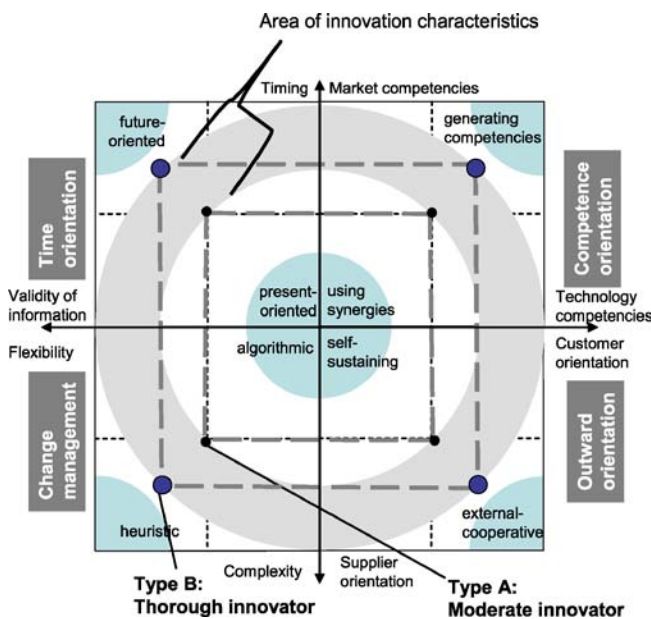


Fig. 3.10. Types of innovations comprising the four squares of innovation orientation, and the shaded concentric, circular area of innovation characteristics (Type A and Type B Innovators)

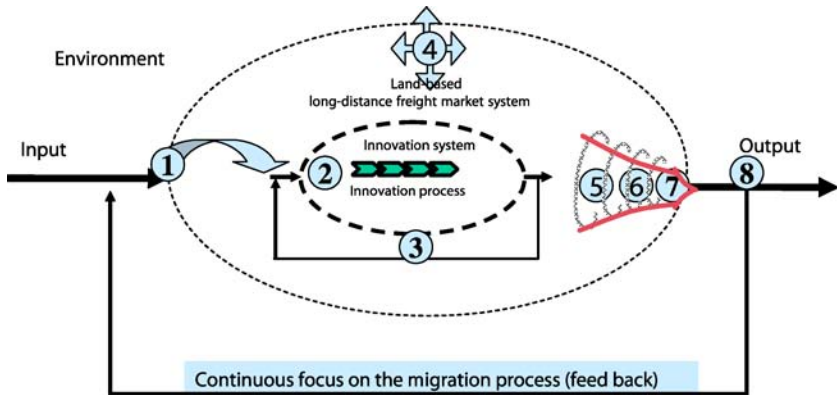


Fig. 3.11. Meeting the systemic character of the socio-technical system by using the Method

Visualisation of the Eight Steps of the Method

To meet the demands of Chap. 1 to 3, eight Steps of the Systemic Migration-Oriented Innovation Management Method are suggested. Those Steps can be mapped considering the socio-technical innovation system embedded into the socio-technical system of the land-based long-distance freight market visualized in Fig. 3.6. Based on this system-orientation the Steps support (Fig. 3.11):

- to take comprehensive information on the system into consideration (Step 1),
- to establish the innovation system and to integrate the key players, (Step 2),
- to match the expected features of the innovation with market demands (Step 3),
- to take the cause-and-effect relations and the system coherences into account (Step 4),
- to merge and evaluate the findings (Step 5),
- to transfer the demands into technical specifications (Step 6),
- to realise the innovation (Step 7) and
- to demonstrate the innovation (Step 8).

The eight steps are described in the following paragraphs.

Step 1: Understanding the system

A socio-technical system represents a complex system. Hence, the *fundamental understanding* of the system is necessary in order to specify the problem and to plan the process in accordance with Hypotheses H1 and H2. The understanding of a complex system as the freight transport market cannot be gained on short notice. It might be necessary to include experts already during this first step of innovation management. At the same time, the system understanding can profit from external views and questions. The outcomes of this step are the

problem specification and the *visualisation of the start-up situation of the innovation process*. They allow to determine the further steps to be accomplished. The partial-systems leading towards the social, economical and technological attractiveness, have to be taken into account already here.

Tool 1: Visualisation and classification of the start-up situation within Step 1

Eversheim (2003) offered the visualisation to classify the different kinds of innovations as already described. This tool can be used to receive the first impression of the innovation process and its special implications. The description of this tool will not be repeated here since it has already been described in detail in Sect. 3.3. It is to be considered *Tool 1*. Hence, Chap. 4 starts with the description of *Tool 2* which is comprised within Step 3. But before entering this description, the consortium of the innovation project has got to be established.

Step 2: Establishing the consortium

In accordance with hypothesis H1, all interest groups have to be involved in the consortium as far as possible. The actors of the different transport chains have been described in Chap. 2, as they are part of the research field of this volume. Thereby the demand of the political objectives included in the Impact Table is met:

Measures to enforce the economical attractiveness of innovative technologies and services: → stronger consultation with stakeholders and industries as well as stronger economic analyses and impact assessments (political objectives, Chap. 2).

Consequently representatives of both carriers have to be part of the consortium if the new technology involves both road and rail transportation. This would support requirement R7.

Step 3: Analysis of the market

It is essential to gain market knowledge considering the problem specification. General questions need to be asked regarding the value proposition, the value chain and the revenue model. They help to establish the Business Model. The draft of the future *Business Model* has already now to be kept in mind from this very early stage onwards in order to stress the migration focus (political objectives and requirements, Impact Table). However new information might come up at a later stage. Hence, the Business Model will be complemented throughout the whole innovation process.

The Business Model will be introduced in the following paragraph.

Tool 2: Business Model within Step 3

A basic Business Model consists in principle of three components:

- Value Proposition: Which customer needs are answered by the new product/service?
- Value chain: In which way are the customer demands satisfied? Which partners are necessary? Which strategies make sense?

- Revenue-model: How can money be earned by offering this product/service? Who are the competitors/competitive systems? What is the market like? Are there special customer clusters to be focused on?

Further details of this tool are described in Sect. 4.2.

Step 4: Analysis of the system coherences

If a *thorough technological innovation* has to be implemented in a complex market it is necessary to analyse the system coherences as suggested in Hypothesis H1. This applies mainly to the Type B Innovation, the Thorough Innovator.

Hence in this step, different strategies and approaches have to be applied to describe the system coherences and the interrelations of system elements. Such tools are needed in cases when the system is to be changed fundamentally through implementing innovations which may affect the system as a whole. These cases correspond to the Thorough Innovator (Type B Innovation). The tools suggested in this research have been chosen with the particular aim to support innovation in the European freight transportation market. These tools are briefly discussed here. The detailed description is provided in the subsequent paragraphs 4.3.1, 4.3.2, 4.3.3 and 4.3.4.

Tool 3: The Sensitivity Analysis within Step 4

Sensitivity Analysis is the first tool suggested here to analyse any system as a whole. It was originally suggested by Frederic Vester (1995). It particularly refers to hypothesis H1 to consider the system as determined by its elements and their relations. The sensitivity model allows determining the key factors for the behaviour of complex systems and for influencing and changing the behaviour of such systems. For this aim, it needs only a few central data determining these factors. Furthermore the quality and orientation of relations and interdependencies between these factors need to be described. The Sensitivity Analysis integrates the numerous details of the observed system into sets of variables whose interplay is shown in terms of a cybernetic model. Thus, the aim of the Sensitivity Analysis is to show the “sensitivity” of this complex system under the impact of changing some of these variables. It is achieved through data reduction and networking. Hence, it makes system behaviour more comprehensible and predictable. The sensitivity analysis, therefore, allows to answer the following question: which system effects will be provoked if the system is modified by changing some of these variables? This Sensitivity Analysis uses a software tool for documentation, visualisation and categorisation of the different variables which characterise the system. Details of the tool are described in paragraph 4.3.1.

The second tool to be suggested here is the Value Benefit Analysis.

Tool 4: The Value Benefit Analysis within Step 4

The Value Benefit Analysis (VBA) was originally suggested by Zangenmeister (1994). It is an economic efficiency estimation which can be used as basis for

strategic decisions. This procedure is quite elaborate. But it offers the advantage to assess alternative solutions by means of several different criteria including such criteria which are difficult to quantify if at all (Lück 1984). This approach is conducted in 7 stages which are also described in detail in paragraph 4.3.2.

Tool 5: The Technical Attractiveness within Step 4

The tool to estimate *Technical Attractiveness* of certain system innovations, represents the combination or integration of both tools mentioned before, the *Sensitivity Analysis* (Tool 3) and the *Value Benefit Analysis* (Tool 4).

The *Sensitivity Analysis* on the one hand, reflects the cybernetic role of a certain variable regarding the whole system. But this approach does not indicate which of the different solutions possible may be most advantageous for the innovation in question. The *Value Benefit Analysis* on the other hand, concentrates on the benefits of a certain solution but does not consider effects concerning the realisation of any alternative solution. Hence the tool *Technical Attractiveness* has been developed in order to evaluate the *benefits* of a certain solution as well as the effects which influence the *realization* of this solution. This tool has been suggested specifically to support innovation in the European freight market (Stumpe 2003). This tool is described in more detail in paragraph 4.3.3.

Tool 6: The Scenario Technique within Step 4

The Scenario Technique is a strategy to draft concrete descriptions of systems *in the future*. Starting with today's situation, scenarios are meant to design systematically some conceivable developments into the future. The nearest future (up to three years) is already almost determined by today's conditions. But it becomes more and more difficult to predict what the system considered will be like in this future. To develop useful scenarios it is advisable to clearly define the limiting scenario funnel, and to develop different scenarios which illuminate different system possibilities in the future, within this limiting funnel. This tool is described in more detail in paragraph 4.3.4.

Step 5: Requirement specifications

When all involved parties have agreed on a shared picture of the system, they have to choose possibilities for solutions. Requirement specifications are to clarify what has to be done. They serve not only as a roadmap but also as a kind of written contract among the consortium to which everybody commits himself. Thus serious problems within the consortium, e.g. security risks, are expected to be exceptions.

The requirement specifications describe what will be done and for which purpose, i.e. the aim, and the reasons for doing so (Henning and Kutscha 2003). The requirement specifications are a kind of contract among the consortium which is the basis of the subsequent steps (Savelsberg 2005b). The requirement specifications offer the decisive possibility to focus on the social, economical and technological attractiveness.

Focusing on the social attractiveness, the economical attractiveness and the technological attractiveness especially within Step 5

According to hypothesis H1, any socio-technical system will only be successfully influenced by such innovation if the *social attractiveness, the economical attractiveness and the technological attractiveness* are considered in parallel. Hence, it might be sensible to subdivide the requirement specifications with regard to those perspectives. This procedure forces the involved parties to use different perspectives and to consider all aspects and questions regarding these particular perspectives. This approach is described in more detail in Sect. 4.4.

After accomplishing Step 4 the solution space is narrowed down. Hence, monetary calculations should be applied. There are several tools available which specifically support this step. These tools are briefly discussed here. The detailed description is provided in the subsequent paragraphs 4.5.2, 4.5.3 and 4.5.4. In the following paragraphs, the economical attractiveness is briefly discussed by looking at both economic *feasibility* and economic *profitability* of innovations.

Economic Feasibility

The systemic innovation management method discussed here, is strongly concerned with the *economic feasibility* of any innovation to be implemented in a system. The task is to economically evaluate any technological innovation: Thus specific economic assessment approaches are needed. Two different strategies of such Economic Feasibility Analysis may be taken into account. They are the *Traditional Economic Feasibility Analysis (TEFA)*, and the *Extended Economic Feasibility Analysis (EEFA)*. Both are dealing with investment which in the context of this research includes dealing with investing in complex technical innovation.

Tools 7 and 8 for the Economic Feasibility Analysis: Return on Investment (ROI), Net Present Value (NPV) within Step 5

The *Traditional Economic Feasibility Analysis (TEFA)* evaluates profitability of investment processes. The two tools of this Traditional Economic Feasibility Analysis (TEFA) are the Profitability Calculation using the *Return on Investment* tool (ROI)⁶, and the *Net Present Value* tool (NPV)⁷.

Tools 9 Profitability Estimation Focused on Benefits (PEFB) within Step 5

The *Extended Economic Feasibility Analysis (EEFA)* distinguishes between cost and benefit effects in dealing with investment. For this purpose, the tool *Profit-*

⁶ “A measure of income or profit, divided by the investment required to obtain that income or profit.” (Horngren, Sundem et al. 1999)

⁷ “A discounted-cash-flow approach to capital budgeting that computes the present value of all expected future cash flows using a minimum desired rate of return.” (Horngren, Sundem et al. 1999)

ability Estimation Focused on Benefits (PEFB) has been designed which is particularly suitable for technical innovations of the kind considered here.

Step 5 concerns the requirement specifications of the Systemic Migration-Oriented Innovation Management Method discussed here. It deals with the investment related to a certain technological innovation. Therefore it is recommended to use this last tool (PEFB), or a combination of the last one and the other two tools (ROI, NPV). This combination makes sense because the type of technical innovation considered requires wide-spread analysis of different costs and benefits within systemic processes. Hence in the context of this research, those three approaches or tools are considered part of the comprehensive Method suggested.

These tools are described in more detail in the paragraphs 4.5.2, 4.5.3 and 4.5.4.

Step 6: System specifications

System Specifications: The *requirement specifications* (Step 5) explain *what kind of innovation* has to be realised, *and for which purpose*. The *system specifications* describe in detail *how* everything will be realized (Henning and Kutscha 2003).

Step 7: Designing prototypes

In cases of technical innovations, it is usually necessary to build prototypes. Such prototypes are to be built according to the system specifications.

Step 8: Demonstration and Evaluation

It is necessary to conduct commercially viable demonstrations of prototypes accompanied by evaluations, in order to prove the economic advantages of the innovative system. Technical aspects which have to be improved have to be documented meticulously. Migration can be accomplished only if necessary prototype improvements are discussed in the consortium. They are realized as far as possible through well-evaluated demonstrations of the prototypes. Sufficient time has to be allocated to this Step 8 – *demonstration and evaluation*. Here important information has to be gained and probably modifications may be necessary. If those are neglected the migration may finally fail.

The Visualisation of the Eight Steps

All steps are integrated as a *spiral process* which is describing the project progress. This means: developments and findings of any step might raise the necessity to modify results of an earlier step, and to repeat certain steps. Since the starting point of any iteration is based on more information becoming available it is considered to be this spiral process rather than a loop process (Strina and Uribe 2003).

According to hypothesis H1 the *social attractiveness*, the *economical attractiveness* and the *technological attractiveness* have to be taken into account in

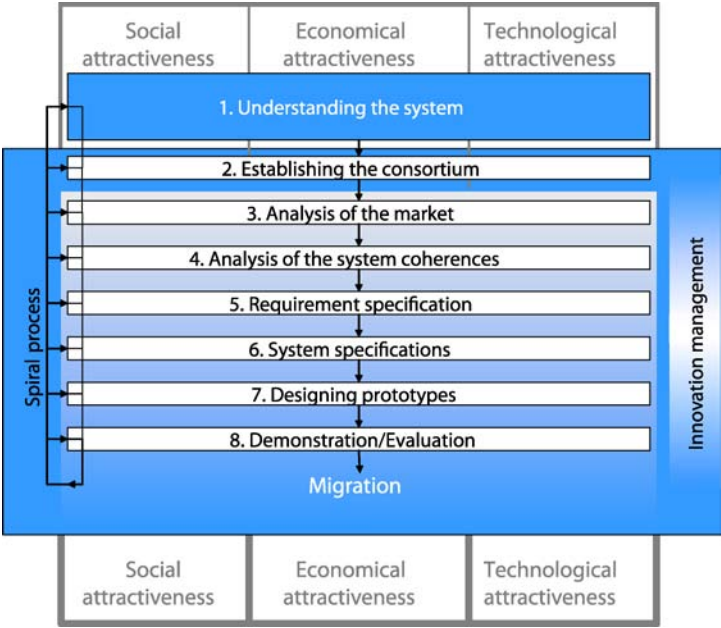


Fig. 3.12. The structure and steps of the Systemic Migration-Oriented Management Method

order to successfully influence this freight market system. This demand is visualised in Fig. 3.12. Furthermore hypothesis H2 states that such migration processes always imply fundamental change processes which require specific management strategies. Therefore experienced and strong *innovation management* has to be established as mentioned before. The continuous innovation management is also visualised in Fig. 3.12.

Chapter 4

Detailed Presentation of Supportive Tools

4.1 Overview

In this chapter the tools are presented in detail which have been suggested to perform the eight steps described before. These tools are of different kinds. Hence, specific tools or groups of tools and approaches are allocated to different steps of the Method. Tool 1 was already presented in detail in Chap. 3. It is used to analyse the characteristics of the planned technological innovation and to choose the appropriate steps of the Method. Tool 2 enforces migration-orientation considering the whole innovation process (Sect. 4.2). Tools 3-6 help to analyse the system coherences and to choose competitive solutions (Sect. 4.3). Especially the requirement specifications offer a good possibility to focus on the social, economical and technological attractiveness (Sect. 4.4). Tools 7-9 are used to evaluate the Economic Feasibility of the selected technological solutions (Sect. 4.5).

4.2 Enforcing Migration Orientation: Business Model (BM) (Tool 2, within Step 3)

The systemic method shows a spiral of information updating. Therefore the Business Model has to be started early in order to focus on the migration process. Different customers of the technological or logistic service solution have to be considered. The questions already listed are modified in the following considerations to be applied to the specific topic of this investigation.

Value Proposition: Which need of the demand side of transportation business is answered by the new product? In this case a double perspective can exist: firstly regarding the transport chain,

	different companies may represent the demand side of transportation; secondly, further customers of the innovation project can be the government or the European Union representing society.
Value chain:	In which way are the requests of the demand side and the customer Government satisfied? Which further partners are necessary? Which strategies make sense? In which way do the innovative technologies or the logistic service innovations contribute towards the optimisation of the transportation market? The technologies and services should be designed in a way that further customers can be convinced to invest.
Revenue-model:	How can money be earned by offering these innovative technologies or logistic service innovations? Who are the competitors, which competitive systems exist? What is the market like? Are there special customer clusters to be focused on? In which way and by which measures is money to be earned?

Furthermore the innovation might change the business processes of some companies. This is a crucial point. The innovation does not only have to be competitive compared with the former business. The direct and indirect costs to change or even innovate the business processes, have to be calculated when the competitiveness is estimated. A successful team will be able to give advice to potential customers how to change their business processes. Procedures should be as far as possible already prepared. Hence *migration* includes the whole change process. A consortium should include those competencies.

It can be advisable to conduct surveys in order to answer the questions above. The Business Model cannot be finished during this step because further important information may be gained during the following steps. But it is strongly recommended to start the Business Model early in order to determine the strength of the consortium concerning both the economically sensible approaches, and the success of the migration.

4.3 Understanding the System Coherences and Choosing Migration-Oriented Solutions

4.3.1 *The Sensitivity Analysis (SA) (Tool 3, within Step 4)*

In the following sections, four different tools are described in some detail which are suggested for performing Step 4 of the Systemic Migration Oriented Innovation Management Method. They have been specifically chosen to corre-

spond to the requirements of innovation in the European freight transportation market.

The first approach has been chosen to analyse a system as a whole according to hypothesis H1. It is the *Sensitivity Analysis* of Frederic Vester (1995). The Sensitivity Analysis allows determining the key factors for the behaviour of complex systems by using only a few central data, and to derive the quality and direction of relations and interdependencies between these factors. It integrates numerous details of the observed system into predictable variables whose interplay is shown in terms of a cybernetic model. Thus, the aim of the Sensitivity Analysis is to show the *sensitivity* of a complex system through data reduction and data networking and to make its behaviour more comprehensible. The Sensitivity Analysis supports answering the following questions: which effects will be provoked if certain variables of the system are modified; or will certain efforts be worthwhile to modify one factor in order to achieve certain changes and innovations within the system (Henning, Stumpe et al. 2000; Henning and Preuschoff 2003; Happe 2005).

This Sensitivity Analysis uses a specific comprehensive software tool for documentation, visualisation and the categorisation of factors. Three phases are performed within this software:

- Definition of variables,
- Assorting the variables according to system criteria,
- Assorting the variables according to their systemic roles.

Phase 1: Definition of variables

All involved parties define together the important aspects of the system, the borders of the system and the important aspects of the system environment. The different variables can be derived from a very rough draft of the system as a whole as shown in Fig. 4.1. Subsequently the system is subdivided into certain system areas. These are the first thematic descriptions of the system and frame the first hierarchical level of system analysis. The second more detailed level subdivides the system areas into system clusters. The subsequent analysis results in defining the system elements. Finally these elements are transferred into variables which determine certain system behaviour. They can be assessed or measured by indicators which can be derived from these elements.

Phase 2: Assorting the system variables according to system criteria

The objective of phase 2 is to check whether the essential aspects of the system are described with adequate emphasis. Therefore Vester suggested 18 system criteria which are divided into four groups: *sectors of life*, *physical categories*, *dynamic categories*, and *system relations* (Table 4.1). The group *sector of life* is subdivided into seven sub-sectors. Each of them should be reflected by at

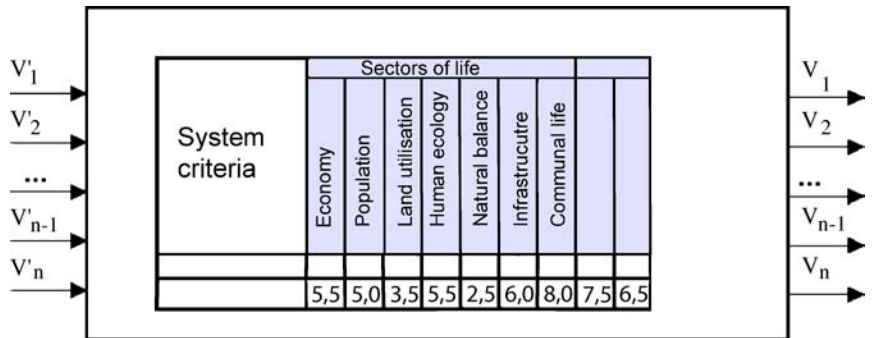


Fig. 4.2: Evaluating the balance of the system description – example: *sectors of life* (Preuschhoff and Happe 2003a)

least three variables. Hence, there have to be at least 21 variables to describe a system. Therefore the lower limit of the number of variables according to Vester is $n=20$ (although $n=21$ would be more appropriate). The upper limit is suggested to be $n=40$ variables (V'_1 up to V'_n) as they are considered necessary to describe a system appropriately without overstretching the calculations required.

The variables are assorted according to those criteria. The result is the Criteria Matrix. Here the system *criteria* are displayed along the horizontal axis, the *variables* V along the vertical axis.

Now the balance of the system description needs to be evaluated. It means that it has to be assessed how far a certain system criterion applies to a certain variable. If it applies completely: “1” is noted in the table; if it applies partly: “0.5” is noted. The balance of the system description is checked by calculating the sums of the different columns (Fig. 4.2). If these sums do not correspond to the expected and acceptable balance the set of variables has to be reviewed.

Phase 3: Assorting the variables according to their systemic roles

The systemic roles of the different variables are analysed by developing the so-called “Impact Matrix”. All variables are listed horizontally as well as vertically.

The proportional interrelation can be defined as

$$V_j = I_{ij} \cdot V_i$$

- V_i : Influencing variables
- V_j : Influenced variables
- I_{ij} : Degree of influence of the variable V_i on the variable V_j
- i, j : Index of the variables

$$\overline{\overline{\text{IM}}} = \begin{bmatrix} I_{1,1} & I_{1,2} & \dots & I_{1,j} & \dots & I_{1,n} \\ I_{2,1} & I_{2,2} & \dots & I_{2,j} & \dots & I_{2,n} \\ \vdots & \vdots & \ddots & \vdots & & \vdots \\ I_{i,1} & I_{i,2} & \dots & I_{i,j} & & I_{i,n} \\ \vdots & \vdots & & \vdots & \ddots & \vdots \\ I_{n,1} & I_{n,2} & \dots & I_{n,j} & \dots & I_{n,n} \end{bmatrix}$$

with

$\overline{\overline{\text{IM}}}$: Impact Matrix
 n: Number of variables
 i: Index of influencing variables
 j: Index of influenced variables

It is stated that the influence of a variable on itself is zero.

$$I_{ij} = 0 \cdot \text{if } i = j,$$

Therefore: $\overline{\overline{\text{IM}}} = \begin{bmatrix} 0 & I_{1,2} & \dots & I_{1,j} & I_{1,j+1} & \dots & I_{1,n} \\ I_{2,1} & 0 & \dots & I_{2,j} & I_{2,j+1} & \dots & I_{2,n} \\ \vdots & \vdots & \ddots & \vdots & \vdots & & \vdots \\ I_{i,1} & I_{i,2} & \dots & I_{i,j} & I_{i,j+1} & & I_{i,n} \\ \vdots & \vdots & & \vdots & \vdots & \ddots & \vdots \\ I_{n,1} & I_{n,2} & \dots & I_{n,j} & I_{n,j+1} & \dots & 0 \end{bmatrix}$

Using the resulting matrix $\overline{\overline{\text{IM}}}$ the influence of each variable on every other variable is evaluated. The strength of the influences between variables is rated with numbers between 0 and 3. As a result, the completed Impact Matrix allows the classification of variables according to the following properties: *active*, *reactive*, *critical*, and *buffering* (Fig. 4.3). These properties show whether the variables are suitable to be used as control instruments within the whole system.

For this purpose *active-sums* AS (the sum of all values in a row) and *passive-sums* PS (the sum of all values in a column) are calculated. Variables that feature

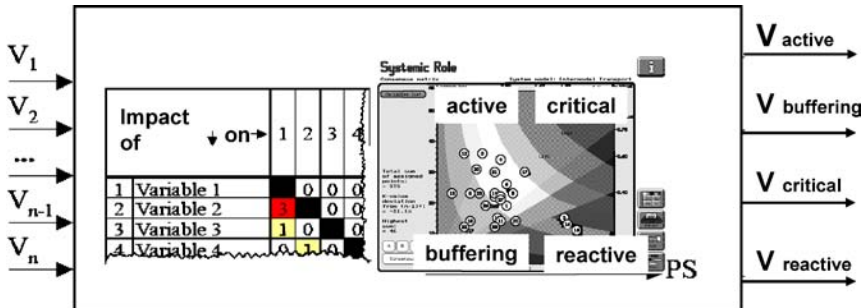


Fig. 4.3. Generating the Impact Matrix

a high active-sum have a strong effect on other variables whereas variables with a high passive-sum are, in turn, strongly influenced by other variables. The variables can be categorised additionally by calculating the product $P = AS \times PS$ and the quotient $Q = AS/PS$ (Henning, Stumpe et al. 2000).

- *Active* variables highly affect other variables, and they are weakly influenced by other variables (high Q-value).
- *Reactive* variables weakly affect other variables, and they are highly influenced by others (low Q-value).
- *Critical* variables highly affect other variables, and they are highly influenced by others (high P-value).
- *Buffering* variables weakly affect other variables, and they are weakly influenced by others (low P-value).

The different roles reflect how certain variables can be used efficiently as control instruments within the system and thus, as one possibility to influence the system. *Active* variables are efficient levers, they strongly affect the system. As they are almost independent from influences of other variables the system stabilises after the intervention of the active lever. *Reactive* variables have only weak effect on the rest of the system. However, reactive variables can be used as indicators to detect the effect of the intervention of active variables. *Critical* variables should only be used with care. They have high influence on other variables; and they are highly influenced by other variables. Hence, effects may be generated which were not planned and which are difficult to control. *Buffering* variables are less important for influencing the system.

4.3.2 *The Value Benefit Analysis (VBA)* (Tool 4, within Step 4)

The Value Benefit Analysis (VBA) was originally suggested by Zangenmeister (1994). It offers the advantage to assess alternative solutions to certain changes and innovations within systems, by means of assessing sets of several different criteria. These criteria include particularly such criteria which are difficult to quantify if at all (Lück 1984). This approach has been developed further for usage in the system analysis of the European freight market (Stumpe 2003). Here it is conducted in 7 phases which are described as follows.

Phase 1: Establishing a set of project goals

Concrete and specific project goals (G) are gathered, whether quantifiable or difficult to quantify. These goals are, firstly, described in detail; subsequently they are defined by specific indicators C. Any goal has to be defined at least by one such indicator but more than one indicator can also be used to describe one of the goals.

$$G_i, (i = 1, \dots, n)$$

$$C_{i,k}, (i = 1, \dots, n); (k = 1, \dots, e_i)$$

$$C_{i,k} \in G_i$$

$$0 < k \leq e_i$$

$$\text{if } e_i = 1 \Rightarrow C_{i,k} \equiv G_i$$

G: Goals

i: Indices of the goals

$C_{i,k}$: Indicator

k: Indices of the indicators

e_i : Number of indicators of the goal G_i

Phase 2: Development of different alternative solutions

This system is to be changed under the impact of changing certain system variables: Thus different solutions S have to be discussed in parallel. These solutions need to be compared and evaluated concerning their *Value Benefit* for the system as a whole.

$$S_j, (j = 1, \dots, p)$$

j: Indices of the solutions S_j

Phase 3: Definition of the Degree of Performance for each alternative solution

In this phase the Value Benefit of the different solutions is assessed as it is shown through the performance measurement. It means that any solution A_j is assessed concerning the corresponding indicators $C_{i,k}$, by using the measurement of the *Degree of Performance*, here called *DoP*. The different indicators C and thus, the different *DoP* might be measured firstly on different kinds of scales.

$$dop_{j,i,k}, (j = 1, \dots, p); (i = 1, \dots, n); (k = 1, \dots, e_i)$$

Phase 4: Standardisation of the Degree of Performance

Here the measurement of the indicators and thus, the *DoP* have to be standardised in a way to be based on a common scale: Thus they offer the possibility of comparison.

$$DoP_{j,i,k}, (j=1,...,p); (i=1,...,n); (k=1,...,e_j)$$

Phase 5: Rating the criteria

The investment decisions have to be based on different criteria. But those criteria might be of different importance or weight in the decision-making process. Hence, a weighting coefficient is included: the *Personal Value PV*.

$$PV_{i,k}, (i=1,...,n; k=1,...,e_i)$$

Phase 6: Calculation of the Value Benefit leading to decision-making

After introducing and evaluating the different weighting coefficients it is possible to determine the Value Benefit of each alternative solution (Table 4.2).

$$VB_j = \sum_{i=1}^n \sum_{k=1}^{e_i} PV_{i,k} \cdot DoP_{j,i,k}$$

VB_j : Value Benefit of one of the alternative solution S_j

$PV_{i,k}$: Personal Value (weighting coefficient) of the indicator $C_{i,k}$ (0 for low value, 10 for maximum value)

$DoP_{j,i,k}$: Degree of Performance of the solution S_j regarding the indicator $C_{i,k}$

The Value Benefit Analysis is strongly discussion-oriented. Hence, it is not necessarily the *calculated* optimum solution which is chosen as the best solution even if it is based on the average value of the different numbers resulting from the Value Benefit Analysis. Finally the involved members of the group have to choose the value which for them represents their results in the best way (Brezinka 1972). Thus they are expected to agree on the values to be used further on.

Phase 7: Derivation of the Value Benefit regarding different interest groups

If an innovation is to be realised within a complex system the main interest groups have to be involved. The project goals reflect the demands of the main groups: e.g. the *supply side* and the *demand side*¹. Therefore the Value Benefit Analysis has been adapted to this specific demand (Stumpe 2003).

¹ Concerning the projects of freight transportation discussed here, the main groups are as follows:

Demand side => e.g. Shippers, freight forwarders, customers.

Supply side => e.g. Railways, intermodal operators, terminal operators, wagon operators.

Table 4.2: The approach of the Value Benefit Analysis

Project goals G_i , ($i = 1, \dots, n$)	Operatio-nalisa-tion of the goals by indicators $C_{i,k}$ ($i = 1, \dots, n$) ($k = 1, \dots, e_i$)	Subjective weighting (sepa- rated according to involved inter- est groups) of the indicators $C_{i,k}$ by Personal Value $PV_{i,k}$	Alternative Solutions ($j = 1, \dots, o$)					
			A_1			A_2		
			Degree of perfor- mance $dop_{1,i,k}$ of the solution A_1 concerning the indicators $C_{i,k}$	Standardized degree of perfor- mance $DoP_{1,i,k}$ of the solution A_1 concerning the indicators $C_{i,k}$	Partial Value Benefit of solution A_1 concerning goal G_i vb and final Value Benefit of solution A_1			
G_1	$C_{1,1}$ $C_{1,2}$ C_{1,e_1}	$PV_{1,1}$ $PV_{1,2}$ PV_{1,e_1}	$dop_{1,1,1}$ $dop_{1,1,2}$ $dop_{1,1,e_1}$	$DoP_{1,1,1}$ $DoP_{1,1,2}$ $DoP_{1,1,e_1}$	$vb_{1,1} = \sum_{k=1}^{e_1} PV_{1,k} * DoP_{1,2,k}$			
G_2			$dop_{1,2,1}$	$DoP_{1,2,1}$	$vb_{1,2} = \sum_{k=1}^{e_1} PV_{2,k} * DoP_{1,2,k}$			
G_3			$dop_{1,3,1}$...	$DoP_{1,3,1}$...				
Summation of the weighting		1	Value Benefit of A_1			$VB_1 = \sum_{i=1}^n vb_{1,i}$		

$$VB_j = \sum_{i=1}^n \sum_{k=1}^{e_i} PV_{i,k} DoP_{j,i,k}$$

VB_j : Value Benefit of one of the alternative solution S_j

$PV_{i,k}$: Personal Value (weighting coefficient) of the indicator $C_{i,k}$ (0 for low value, 10 for maximum value)

$DoP_{j,i,k}$: Degree of Performance of the solution S_j regarding the indicator $C_{i,k}$

For this aim, phases 1 to 3 of the Value Benefit Analysis are not to be varied. The Degree of Performance (DoP) is also determined in common for both groups. It has to be mutually agreed on by both groups as mentioned above.

Concerning the Personal Value (PV), however, the weighting has to be done separately for each of those interest groups. Hence for each solution, two Value Benefits exist: the Value Benefit of the *demand side* and the Value Benefit of the *supply side*. They are derived here and also shown in the subsequent Fig. 4.4, as one example. The basis for this specific discussion is the set of six different solutions which were actually used in one of the case studies described in Chap. 5 of this research: the project SAIL (Stumpe 2003). These different calculations take into account the weighting of the indicators as required by this tool.

Derivation of the *Supply Side* Value Benefit

$$VBS_j = \sum_{i=1}^n \sum_{k=1}^{ei} PV_{i,k} \cdot DoP_{j,i,k}$$

VBS_j : Value Benefit of the Supply side regarding the alternative solution S_j

$PV_{i,k}$: Personal Value of the indicator $C_{i,k}$ (0 for low value, 10 for maximum value)

$DoP_{j,i,k}$: Degree of Performance of the solution S_j regarding the indicator $C_{i,k}$

Derivation of the *Demand Side* Value Benefit

$$VBD_j = \sum_{i=1}^n \sum_{k=1}^{ei} PV_{i,k} \cdot DoP_{j,i,k}$$

VBD_j : Value Benefit of the Demand side regarding the alternative solution S_j

$PV_{i,k}$: Personal Value of the indicator $C_{i,k}$ (0 for low value, 10 for maximum value)

$DoP_{j,i,k}$: Degree of Performance of the solution S_j regarding the indicator $C_{i,k}$

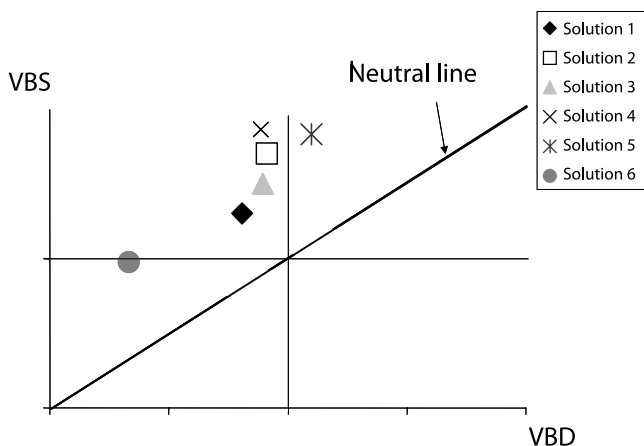


Fig. 4.4. Diagram presenting Value Benefits for the *supply side* (VBS) and *demand side* (VBD), for 6 different example solutions in comparison

Those two Value Benefits are represented by a two-dimensional graph (Fig. 4.4). Here the x-value represents the *demand side* of the Value Benefit; the y-value represents the *supply side* of the Value Benefit concerning any particular solution. This diagram can be generally used for the visualisation of the VBS (supply side) and the VBD (demand side). It can be divided into four squares (Fig. 4.4) which allows to categorise the different solutions. First one solution may be considered which shows the two Value Benefits in a way to end up in the first square. This particular solution represents an innovation which would be of benefit for each of the interest groups. Here both groups of the *demand side* and the *supply side*, would find high values of their Value Benefit Analysis. The opposite applies for the third square.

4.3.3 *Technical Attractiveness (TA) (Tool 5, within Step 4)*

In this chapter, a new tool is described which may serve to estimate the *Technical Attractiveness* of certain system innovations. This term of *Technical Attractiveness* has been newly introduced. It represents the combination or integration of both tools mentioned before, the *Sensitivity Analysis (Tool 2)* and the *Value Benefit Analysis (Tool 3)*.

The *Sensitivity Analysis* on the one hand, reflects the cybernetic role of certain variables regarding the whole system. The different variables are chosen in order to describe the system as such. The interactions of these variables are evaluated. Thereby their systemic role can be visualized. But this approach does not indicate which of the different solutions offered for any innovation, may be *most advantageous* for the innovation in question.

The *Value Benefit Analysis (VBA)* on the other hand, concentrates on the benefits of a certain solution for the users of some innovation. Key procedures of the Value Benefit Analysis are to define the goals of the innovation. These goals are subsequently weighted by means of indicators. The Value Benefit of a certain solution can then be determined based on the subjective Degree of Performance of the solution related to any of these indicators. But this approach does not consider further effects which may come up with the realisation of any alternative solution. Thus it does not easily allow the future users to weigh the probability that one particular solution may be *implemented* at all, for this particular innovation.

Hence the tool *Technical Attractiveness* has been developed in order to both evaluate the *benefits* of certain solutions in comparison, as well as the systemic effects which influence the *realization* of this solution (Stumpe 2003). This new tool means the combination or integration of both previous tools. It is performed based on the two different procedures. These procedures have to be adjusted to the more comprehensive aims of this integrated approach of *Technical Attractiveness*. In this case the variables and goals need to be defined which characterise the system to be investigated (here: the European freight market).

These variables are the same as for the approaches mentioned before. Hence, the variables are chosen as described before; furthermore certain indicators are used to define those variables in more detail. The orientation of systemic element relations are also added into the evaluation process.

Derivation of the Tool *Technical Attractiveness*

The mathematical integration of both tools is described as follows (Table 4.3).

$$G_i \hat{=} V_i$$

$$C_{i,k} \in V_i$$

$$0 < k \leq e_i$$

$$\text{if } e_i = 1 \Rightarrow C_{i,k} \equiv V_i$$

- V: variable
- i: indices of the variable
- $C_{i,k}$: indicator (criteria)
- e_i : number of indicators of the variable V_i
- k: indices of the indicator

Table 4.3: Relation of variables and indicators

Variable V_1	Indicator $C_{1,1}$	Variable V_i	Indicator $C_{i,1}$
	Indicator $C_{1,2}$		Indicator $C_{i,2}$
	...		...
	Indicator $C_{1,k}$		Indicator $C_{i,k}$
	...		...
	Indicator $C_{1,e1}$		Indicator $C_{i,e1}$
		...	...
Variable V_2	Indicator $C_{2,1}$	Variable V_n	Indicator $C_{n,1}$
	Indicator $C_{2,2}$		Indicator $C_{n,2}$
	...		...
	Indicator $C_{2,k}$		Indicator $C_{n,k}$
	...		...
	Indicator $C_{2,e2}$		Indicator $C_{n,en}$
...	...		

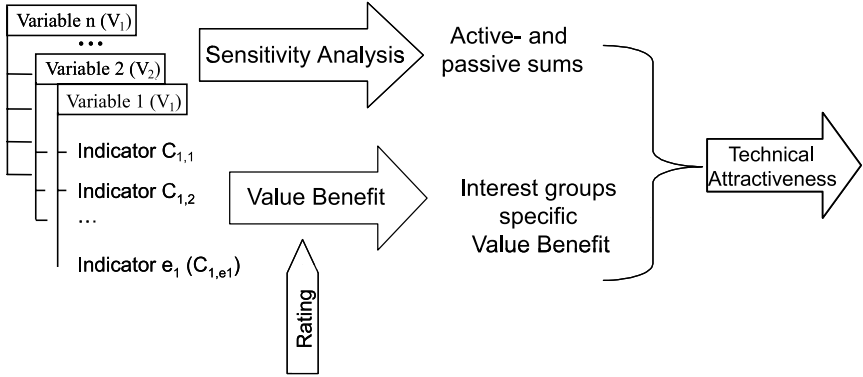


Fig. 4.5. Combination of Sensitivity Analysis and Value Benefit Analysis towards Technical Attractiveness

As in the *Sensitivity Analysis*, the systemic roles of the variables are defined by their *active* and *passive sums*. Subsequently the *Value Benefits* are considered specifically for all different interest groups involved. They are determined by means of the Value Benefit Analysis. These specific Value Benefits are linked with the active and passive sums in a way to result in one certain value for the *Technical Attractiveness* of this specific solution as it is related to the innovation considered (Fig. 4.5).

Motivation and Technical Attractiveness

The Technical Attractiveness is based on the construct of *motivation* (Simon 2001). The motivation of a person to perform a certain activity is the product of different factors. Those factors are specifically the *Personal Value of the expected outcome* for the person, and the *Degree of Probability for this outcome* to be realised at all (Rosenstiel 1975). This realisation probability is assessed as a subjective value by the person concerned. Thus the motivation can be approximately expressed by the following equation (Henning, Stumpe et al. 2001; Stumpe 2003).

$$M_a = \sum_{b=1}^c P_{a,b} \cdot W_b$$

M_a : Motivation to conduct a certain activity a

W_b : *Personal Value of the expected outcome* b (Rosenstiel 1975)

$P_{a,b}$: *Degree of Probability of realisation of this outcome* b as the result of the activity a

a : Index of the activity a

b : Index of the expected outcome b

c : Combinations of the value of the outcome b (W_b), and the Degree of Probability ($P_{a,b}$)

According to this construct of motivation, the term *attractiveness* means to consider the *impact of something on someone*. Hence, the specific attractiveness of a technical artefact means that the person *prefers* a certain solution in comparison to any other solution (Graumann 1968). This is particularly important if its realisation probability is estimated high.

On this background, the *Personal Value* is represented by the *Value Benefit* as derived above. The *Realisation Probability* is represented by the *active-sums* and *passive-sums* of system variables which also have been derived above. Those sums are based on the inter-subjective assessment and judgement of all parties involved within the project consortium. These sums reflect both the influence of a certain variable on the socio-technical system as a whole, and vice versa, the influence of the system on this variable.

Thus the *probability* of realising a certain solution can be derived. Active-sums and passive-sums reflect the estimation of all involved parties regarding the coherences and mutual influences among the different system variables as mentioned before. Therefore the sums reflect the different influences on the system as a whole. A high active-sum means high influences of these variables on the system. As mentioned before, if a system is to be changed it is advisable to use these active variables comprised in the active-sums. If a certain solution is based on variables with a high active-sum it is probable that subsequently this solution will be realised successfully.

As derived above, the *Value Benefit* of a certain solution is defined as follows:

$$VB_{Sol1} = \sum_{i=1}^n \sum_{k=1}^{ei} PV_{i,k} * DoP_{1,i,k}$$

- i: Indices of the goals
- k: Indices of the indicators (used for: the Personal Value of an indicator, the Degree of Performance of a solution regarding an indicator)
- ei: Number of indicators of the goal Gi

To reduce complexity it can make sense to define each variable in a way that it is at the same time its own indicator. This simplification leads to the following equation.

$$VB_{Sol1} = \sum_{i=1}^n PV_i * DoP_{1,i,k}$$

- i: Indices of the variables/goals

Resulting from this calculation of the *Value Benefits*, a certain Variable may be considered here for one certain solution *Sol1*. This solution *Sol1* may have been suggested for some innovation. It is characterised by several values: both the *active-sum* and the *passive-sum* and furthermore, a certain *Personal Value* which is related to a certain *Degree of Performance*. In this way, this solution is connected with certain active-sums and passive-sums. Thus the Value Benefit of this solution is combined with the systemic role of the variable considered. This

leads towards the mathematics to estimate the Technical Attractiveness which may give some indication whether this particular solution might be successful.

The mathematics to be performed here, are again different for the *supply side* and the *demand side*. Therefore a specific assumption is proposed. The Technical Attractiveness of the *supply side* is based on the **active-sum** of the variables since the supply side has to realize the technical products/offers/services. The *demand side*, however, can react and buy/refuse or submit new proposals. But in this case this side is supposed to be rather passive. Hence, the Technical Attractiveness of the *demand side* is based on the **passive-sums** of the variables. This assumption seems to be particularly valid if considering the European freight market. Here certain kinds of innovation are repeatedly offered by the *supply side*. But they are not easily accepted by the *demand side* even if they appear to be needed. This behaviour of the freight market and the problems corresponding have been mentioned in Chap. 2 of this report. It is now used as the basis for further development of estimating the Technical Attractiveness.

Estimated Technical Attractiveness – *Supply Side*

The Technical Attractiveness *Supply Side* regarding the Solution 1 (*Soll*), is composed by multiplying the partial Value Benefit of the Solution 1 $vb_{Soll,i}$ related to the variable V_i with the active-sum AS_i

$$TAS_{Soll} = \sum_{i=1}^n AS_i \cdot vb_{Soll,i}$$

The partial value benefit of the Solution 1 $vb_{Soll,i}$ consists of the Personal Value *Supply Side* of the variable V_i (former indicator) PVS_i multiplied with the Degree of Performance of the Solution 1 regarding the variable V_i .

$$TAS_{Soll} = \sum_{i=1}^n AS_i \cdot PVS_i \cdot DoP_{Soll,i}$$

Estimated Technical Attractiveness – *Demand Side*

The Technical Attractiveness *Demand Side* regarding the Solution 1 (*Soll*), is composed by multiplying the partial value benefit of the Solution 1 $vb_{Soll,i}$ related to the variable V_i with the passive-sum PS_i

$$TAD_{Soll} = \sum_{i=1}^n PS_i \cdot vb_{Soll,i}$$

The partial value benefit of the Solution 1 $vb_{Soll,i}$ consists of the Personal Value *demand side* of the variable V_i (former indicator) PVS_i multiplied with the Degree of Performance of the Solution 1 regarding the variable V_i .

$$TAD_{Soll} = \sum_{i=1}^n PS_i \cdot PVS_i \cdot DoP_{Soll,i}$$

Standardisation of the *Technical Attractiveness*

The values of Technical Attractiveness need to be standardised for further comparisons. Two possibilities of scaling exist. The first one is based on the maximum which may be *theoretically possible*, the second one on the *achieved maximum*. According to Beitz and Küttner the second possibility is chosen (Beitz and Küttner 1995):

$$N_{\text{Norm}} = \frac{N}{N_{\text{compare}}} \cdot B$$

$$N_{\text{compare}} = \max(N) \Rightarrow N_{\text{Norm}} = \frac{N}{\max(N)} \cdot B$$

with

B: Basis of standardisation
 N: Numeric value
 N_{compare} : Numeric value for comparison
 N_{Norm} : Standardized value

Here it is helpful to reach easy comparability. Hence the basis $B = 10$ is used in the following calculations. The standardisation is to be applied to the example of Solution 1 *Soll* which has been introduced above. This standardisation of the *Technical Attractiveness* of the Solution 1 leads to the following equations for supply side (tas), and demand side (tad):

$$\text{tas}_{\text{Soll}} = \frac{\text{TAS}_{\text{Soll}}}{\max(\max\text{TAS}, \max\text{TAD})} \cdot 10$$

$$\text{tad}_{\text{Sol}} = \frac{\text{TAD}_{\text{Sol}}}{\max(\max\text{TAS}, \max\text{TAD})} \cdot 10$$

Here the standardised values are written in small letters.

It follows the standardisation of the *Value Benefit* for the Solution 1 *Soll* leading to the equations for the supply side (vbs), and demand side (vbd):

$$\text{vbs}_{\text{Soll}} = \frac{\text{VBS}_{\text{Soll}}}{\max(\max\text{VBS}, \max\text{VBD})} \cdot B$$

$$\text{vbd}_{\text{Soll}} = \frac{\text{VBD}_{\text{Soll}}}{\max(\max\text{VBS}, \max\text{VBD})} \cdot B$$

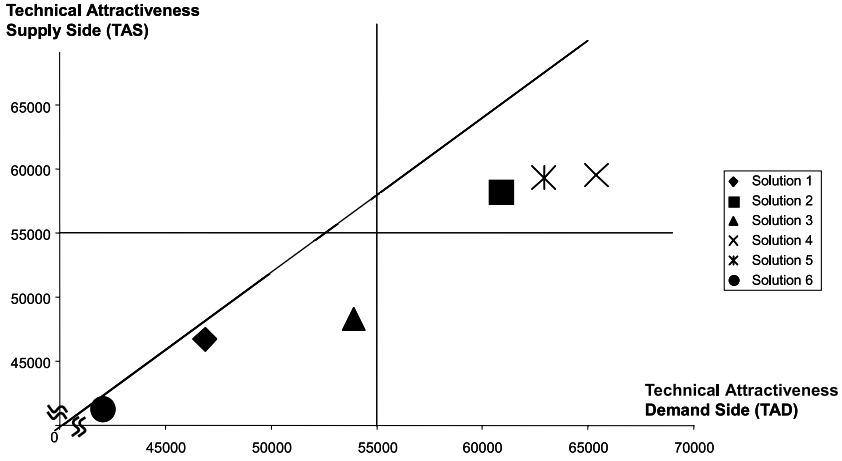


Fig. 4.6. Visualisation of the Technical Attractiveness for both the *supply side* (y-axis: TAS) and *demand side* (x-axis: TAD)

These values of the *Technical Attractiveness* for the *supply side* and for the *demand side* can be visualized in the same way as previously the *Value Benefit supply side* and *demand side* (Fig. 4.6).

Interpretation of the Solutions' Positioning

The results of this *Value Benefit Analysis (VB)* and this *Technical Attractiveness Estimation (TA)* can be visualized in a joint diagram by using these standardized values derived above. The Fig. 4.7 shows the outcome of such superimposing of the two different sets of values. In the diagram, different relations of the 2x6 values can be observed.

In this example, six different solutions to one certain problem are considered. Each of the six solutions is represented by four values: the *VB values* and the *TA values* for both the *supply side* and the *demand side*. Here these four values lead to two points in the joint diagram. These two corresponding points of one particular solution may be somewhat near to each other in the joint diagram. Now there are several cases to be considered (Stumpe 2003).

The first case is as follows. The two points *VB* and *TA* of one certain solution are close to each other (Fig. 4.7). In this case the groups of the *supply side* and the *demand side* agree largely on the *Value Benefits* as well as on the *realisation probability* of this solution (e.g. Solution 1).

The other cases are as follows. The two points *VB* and *TA* of one certain solution are not close to each other. Thus the following cases may be considered:

- The *TA* value is located on the *left* of the *VB* value: In this case, the *demand side* (here: the customer and buyer of the innovative technology) tends to rate the *realisation probability low* (e.g. Solution 2).

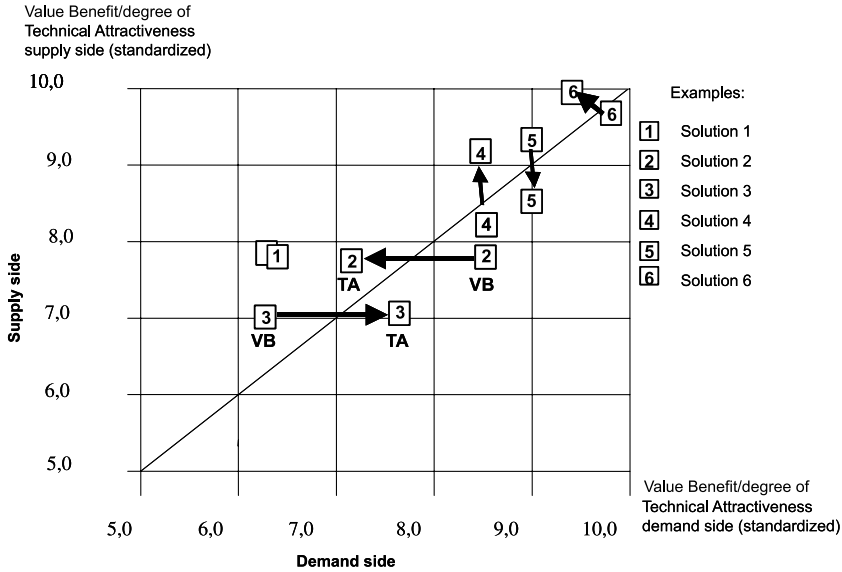


Fig. 4.7. Combined visualisation of the Value Benefit and the Technical Attractiveness

- The TA value is located on the *right* of the VB value: In this case, the *demand side* tends to rate the realisation probability *high* (e.g. Solution 3).
- The TA value is located *above* the value of the VB: In this case, particularly the *supply side* (here: the designer and provider of the innovative technology) tends to rate the realisation probability *high* (e.g. Solution 4).
- The TA value is located *below* the value of the VB: In this case, particularly the *supply side* rates the realisation probability *low* (e.g. Solution 5).
- The TA value is located *diagonally above and left* of the value of the VB: In this case, the *supply side* is convinced to meet its expectations with this solution and the *demand side* rate the realisation probability of this particular solution *low* (e.g. Solution 6).

4.3.4 The Scenario Technique (ST) (Tool 6, within Step 4)

The Scenario Technique is a strategy to draft concrete descriptions of systems in the future. A lot of different approaches exist to develop such scenarios of the future. In general these approaches are based on System Theory. Therefore the scenario technique is often referred to as *Applied System Theory* (Henning and Preuschhoff 2003). Kahn and Wiener (1967) stated that scenarios are “a hypothetical sequence of events constructed for the purpose of focusing attention on causal processes and decision points”.

Starting with today's situation, scenarios are meant to design systematically some conceivable developments into the future (Geschka and Hammer

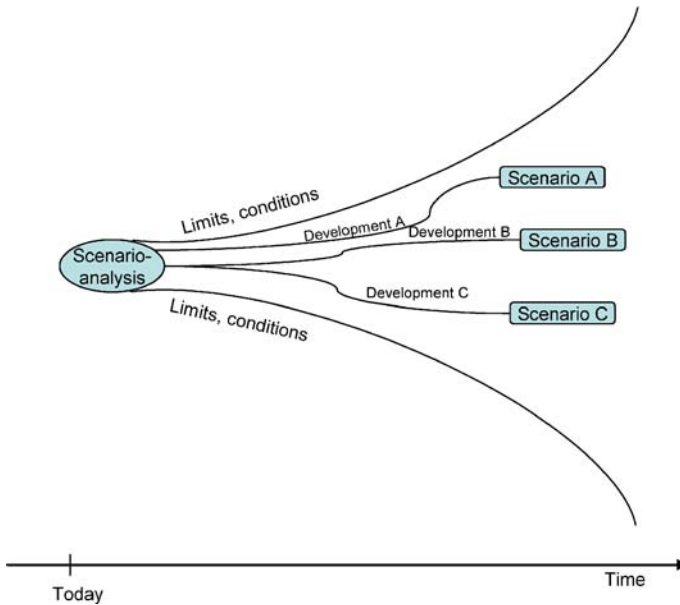


Fig. 4.8. Different developments leading towards different scenarios within the limiting scenario funnel (according to Reibnitz 1991)

1992). The nearest future (up to three years) is already almost determined by today's conditions. Those are, e.g., infrastructure, laws, standards, knowledge etc. (Happe 2005). But the influence of today subsides as the scenario reaches into the future. Hence, it becomes more and more difficult to predict what the system considered will be like in this future. To develop useful scenarios it is advisable to clearly define the limiting scenario funnel, and to develop different scenarios which illuminate different system possibilities in the future, within this funnel (Fig. 4.8).

According to Reibnitz (1991) scenarios have to meet the following criteria:

- As coherent as possible, i.e. the different developments towards the different scenarios should not contradict one another.
- As stable as possible, i.e. the scenarios should not collapse if small changes of development occur.
- As different as possible, i.e. extreme scenarios are recommended to be located close to the outside border lines of the limiting scenario funnel.

Characteristics of scenarios are as follows: they have to be holistic, creative and intuitive; participative and communicative; transparent; distinguishing between different developments; political, multidimensional and interdisciplinary as well as normative (Henning and Preuschoff 2003).

The scenario technique is used in the following case studies comprising four phases:

- analysis of the problem to be resolved in the future,

- analysis of the system conditions and its environment starting from the overall picture and leading towards system details (Vester 1995),
- working out the scenario details,
- developing strategies and measures to be implemented today and by moving into the future, to resolve the problem corresponding.

4.4 Focussing Especially on the Social, Economical and Technological Attractiveness

According to hypothesis H1, any socio-technical system will only be successfully influenced by such innovation if the *social attractiveness*, the *economical attractiveness* and the *technological attractiveness* are considered in parallel. Hence, it might be sensible to subdivide the requirement specifications with regard to those perspectives. This procedure forces the involved parties to use the different perspectives and to consider all aspects and questions regarding these particular perspectives.

A systematic approach is needed to support the preparation of those subdivided requirement specifications. It depends very much on the topic and the degree of change which it will introduce into the system *freight market*. It furthermore depends on the qualifications of the people involved. At this point it becomes again obvious how crucial it is to combine different qualifications in the consortium in order to implement such a technological innovation in the system *freight market*. The procedure to realize such challenging requirement specifications will be described in detail in one of the case studies.

4.5 To Estimate the Economic Feasibility

4.5.1 Demands

The Systemic Migration-Oriented Innovation Management Method discussed here, is strongly concerned with the economic feasibility of any innovation to be implemented in the system. For this task of evaluating the technological innovation, specific economic assessment approaches are needed. In detail, such economic feasibility analysis should meet the following demands (Weydandt 2000):

- To consider costs which are directly quantifiable, and also such costs which are difficult to quantify.
- To orientate the analysis towards participation of different stakeholder groups, including future users of the innovation considered.
- To offer calculation approaches which require comparatively little effort and are easy to apply.

- To allow keeping track of investment progression over time.
- To integrate detailed target systems of innovation implementation.
- To include assessment of side effects and consequences of the innovation considered.
- To allow comprehensive ex-ante evaluation of innovation impact.

Two different strategies of such Economic Feasibility Analysis may be taken into account for analysing the European freight transportation market. They are the *Traditional Economic Feasibility Analysis*, and the *Extended Economic Feasibility Analysis* (Fig. 4.9). Both are concerned with investment which in the context of this research includes specifically dealing with complex technical innovation. They are to meet the demands of the specific innovation management method discussed. Hence certain tools have been chosen which are suggested here. Two of them are assigned to the *Traditional Economic Analysis* (TEFA): ROI, NPV. One further tool has especially been designed for technical innovations. It has been assigned to the *Extended Economic Feasibility Analysis* (EEFA): PEFB. Here, the TEFA approach is described. It is followed by the description of the EEFA in the succeeding section.

The *Traditional Economic Feasibility Analysis* (TEFA) employs approaches to evaluate static and dynamic investment processes, specifically their profitability. These approaches assume that the *profit target* is the main guideline when evaluating the economic feasibility of the investment project. The use of these traditional methods, therefore, assumes that no other important benefits need to be considered in the investment project. Two tools have been assigned to this Traditional Economic Feasibility Analysis (TEFA). They are:

- the Profitability Calculation using the *Return on Investment* tool (ROI) to deal preferably with static processes,
- the *Net Present Value* tool (NPV) dealing preferably with dynamic processes.

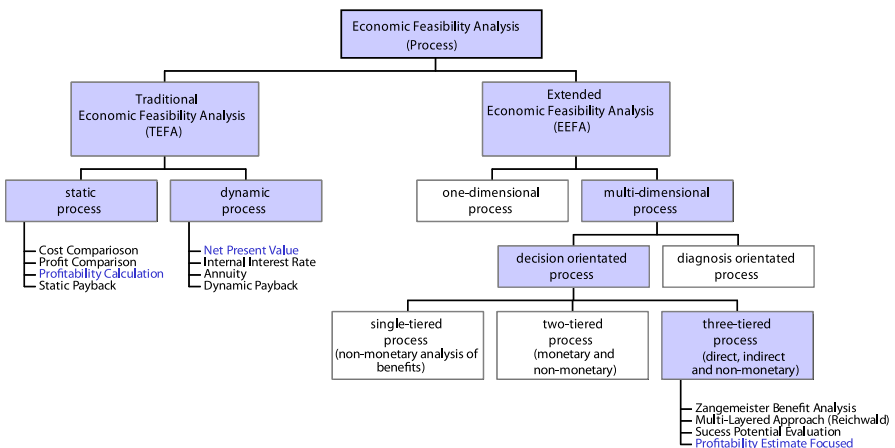


Fig. 4.9. Processes and tools of Economic Feasibility Analysis (Weydandt 2000; Henning, Preuschoff et al. 2001)

These two tools, *Return on Investment (ROI)* and *Net Present Value (NPV)* are briefly described as follows.

4.5.2 *Return on Investment (ROI) (Tool 7, within Step 5)*

The Return on Investment is calculated in the following way:

$$ROI = \frac{P}{C_{Inv.}} \times 100$$

ROI: Return of investment
 P: Profit at present value
 $C_{Inv.}$: Invested Capital (Euro)

The profits (P) are the net present values of the expected profits during the investment period. C_{inv} is the capital invested at the beginning of the investment period. This step avoids the typical criticism of this tool that the comparison of profitability is made only over a short period.

4.5.3 *Net Present Value (NPV) (Tool 8, within Step 5)*

The NPV method concentrates on cash flows rather than profits. The NPV equation commonly used is shown below:

$$NPV = \sum_{t=0}^n \frac{EVA_t}{(1+i)^t}$$

NPV: Net Present Value based on yearly EVAs
 EVA: Economic Value Added
 EVA_t : Cash inflows and outflows at the end of the period t (Euro)
 i: Discount *return interest* rate² (minimum desired rate of return, based on the company's cost of capital) (%)
 t: Period (t = 1, 2, ... , n)
 n: Useful life of the investment object (years)

² Kalkulationszinsfluss.

4.5.4 *Profitability Estimation Focused on Benefits (PEFB)* (Tool 9, within Sep 5)

The second strategy of Economic Feasibility Analysis is the *Extended Economic Feasibility Analysis* (EEFA). It specifically distinguishes between cost and benefit effects in dealing with investment. The corresponding tool is the *Profitability Estimation Focused on Benefits* (PEFB). This tool has been designed to be particularly suitable for assessing technical innovations. Hence it is here assigned to this Extended Economic Feasibility Analysis (EEFA). It is multi-dimensional, decision oriented, and it comprises a three-tier analysis process. The PEFB process is based on the Benefit Analysis originally introduced by IBM. It was then redesigned and developed further for the evaluation of any complex technical innovation. In the references, it is characterised by the German name NOWS (Weydandt 2000). The approach mainly consists of a differentiated cost and benefit estimation (Henning, Preuschoff et al. 2001).

In this tool, the different cost and benefit effects are divided into those which can be quantified in monetary terms, and those which cannot be quantified in this way. Therefore this approach aims particularly at *non-monetary benefits* of a certain investment to be assessed. Furthermore it allows to clearly integrate uncertainties of future developments into the decision process. This is achieved through the weighting of the different costs and benefits by their probability of occurrence. The tool works as follows.

Different costs and benefits (short, medium, long-term) of the planned innovation investment are identified. They are rated by different levels of probability of their realisation. The different investment alternatives are compared and presented graphically. The PEFB process includes specific investment calculation and its evaluation, as well as problem-solving processes. Both activities are to be performed under participation of all groups involved. It is important that specifically the evaluation is carried out by different representatives from the relevant stakeholder groups, e.g. within the project consortium.

The evaluation within the PEFB process involves different steps which are presented in Fig. 4.10.

The different phases of the PEFB process are characterised as follows (Weydandt 2000; Henning, Preuschoff et al. 2001; Strina 2006):

- *Comprehensive information gaining*: The consortium is responsible that all aspects of the investment project are included in the discussions, e.g. human concerns and issues, organizational options, different technical design options, assessments of efficiency and profitability etc.
- *System Analysis*: Research, investigations and surveys are conducted. This analysis additionally considers alternative suggestions for solutions, e.g. based on specifically developed scenarios.
- *Compiling of Measures*: Different measures are suggested for the implementation of the innovation leading to different investment plans.
- *Quantitative Evaluation Measures*: Each of the different investment plans is evaluated by means of quantifying data. It leads to incorporating all these

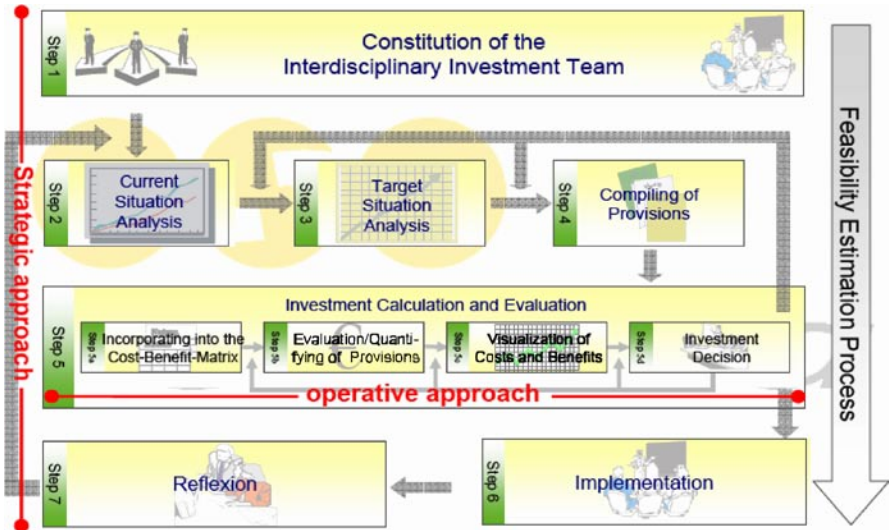


Fig. 4.10. Profitability Estimation Focused on Benefits (PEFB): the PEFB process (Henning, Preuschoff et al. 2001; Strina and Uribe 2003)

data into a series of Cost-Benefit-Matrices. This particular process phase is described in more detail as follows.

Quantitative Evaluation: Through each of the different Cost-Benefit-Matrices, a comprehensive list is created of all cost and benefit effects related to any one of the various alternative investment plans discussed so far.

The categories for the costs and benefits of the different investment plans are listed here:

Benefits

- Direct benefits (direct savings on existing costs or direct increases in cash inflows, e.g. decrease in capital costs).
- Indirect benefits (future savings or future increases in cash inflows, e.g. growth in productivity).
- Benefits which are difficult to evaluate (strategic benefits, e.g. improvements in company visibility).

Costs

- Direct costs/fixed costs: costs that are not immediately affected by changes in the cost driver (well-known costs, e.g. asset costs).
- Indirect costs/variable costs: costs that change in direct proportion to changes in the cost driver (expected future costs, e.g. external consulting costs).
- Costs which are difficult to evaluate (subsequent costs, e.g. costs arising from damages to health of employees).

Realisation Probability: In the next step, the costs and benefits are divided according to the appropriate categories as above. Subsequently for each of these costs and benefits, the probability of realising them is being estimated. This probability of realisation can be high, medium or low. Thus for each investment plan, the procedure results in two different 3 × 3 matrices, one each for costs and benefits. These two matrices are shown in the upper half of Fig. 4.11.

Risk Estimation: It follows a very important feature of this special approach: the risk estimation. A certain risk level is assigned to each of the nine boxes in the two matrices, for any one of the different investment plans. These risks are estimated corresponding to the expected probability of their successful realisation and implementation within the socio-technical system considered. The risks are rated from 1 to 9. They are assigned to the 9 boxes following the diagonal sequence of the boxes from top left downwards and on to upper right (Nagel 1990). Subsequently they are written once again separately along the lower row below the matrix. For the benefit matrix they are listed from left to right and related to the corresponding monetary benefit values (in EURO) which are summed up along this row. For the cost matrix, they are listed from right to left and again related to the cost values (in EURO) summed up along this row.

This risk estimation leads to the graphs in the lower half of Fig. 4.11. The x-axis shows the different values of risk. The y-axis shows the monetary values of both benefits and costs as they have been summed up before. For *costs*, the risk increases with increasing costs. Hence the highest cost risk values are to

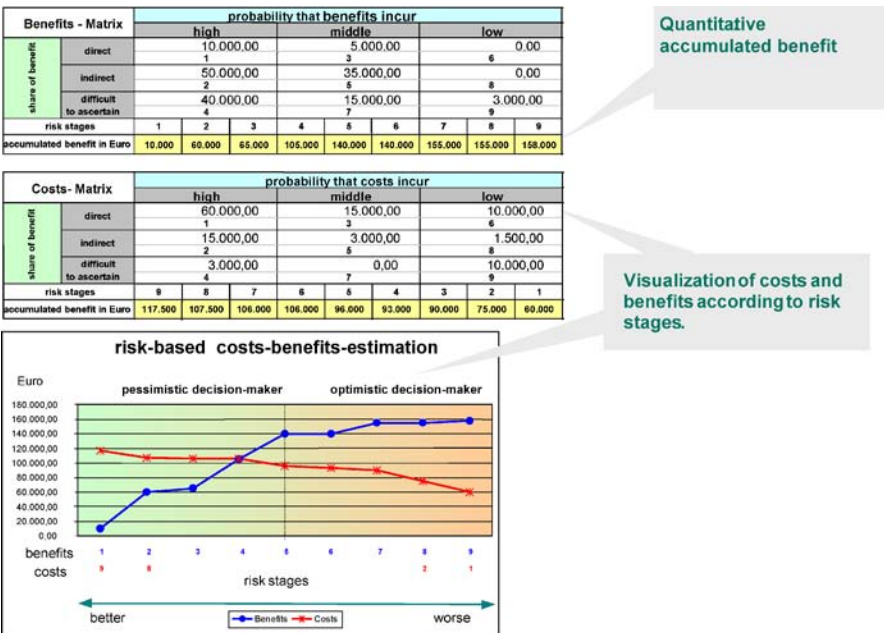


Fig. 4.11. The two Cost/Benefit Matrices and the Cost-Benefits-Estimation (Henning, Preuschoff et al. 2001; Strina and Uribe 2003)

be seen on the *left* of the graph (the cost risk values are increasing from right to left, the cost graph is shown by X). For *benefits*, the risk increases as the expected benefits (estimated in EURO) take higher values. Hence the highest benefit risk values are to be seen on the *right* of the graph (the benefit risk values are increasing from left to right, the benefit graph is shown by dots) (Fig. 4.11).

Investment Decision: After the costs and benefits have been presented graphically in this way, the investment team may reach a decision. The main criterion is the difference between the costs and benefits. The visualisation of costs and benefits in Fig. 4.11 leads to the development of two different areas: the *pessimistic decision-maker area* (left, benefits risk-grading 1 to 5) and the *optimistic decision-maker area* (right, benefits risk-grading 5 to 9). In the *pessimistic area*, the benefits to be expected are low while the investment costs are high, and these costs show high risk values. In the *optimistic area*, the maximum benefits are expected to be realised while in comparison only just those costs incur which are absolutely necessary, and these costs show low risk values. The difference between the two curves supports the decision at which level of risk the investment considered appears to be worthwhile. The following four statements can be made:

- The investment considered is economically feasible if the cost graph lies below the benefit graph at all nine levels of risk.
- The investment considered is not economically feasible if the cost graph lies above the benefit graph at all nine levels of risk.
- If the benefit graph intersects the cost graph within the pessimistic region, even risk-averse investors may find this investment attractive because the estimated benefits and costs are in balance even under conditions of unfriendly risk. Hence the safest investment decision may be located if the curves meet within the pessimistic area because the pessimistic view would keep expectations under control.
- If the benefit graph intersects the cost graph in the optimistic region, only risk-seeking investors would make the investment.

On the basis of these considerations, the investment team will decide for the safest, economically most feasible investment plan and begin with its implementation. If none of the investment plans are economically feasible the project must either be cancelled or further new investment plans must be organized, beginning again from Step 1.

Implementation: After a positive investment decision, the planned measures are to be implemented. At least one member of the investment team must check that the targets are being met in order to guarantee the further success of the project. Modern project management methods can be helpful at this point.

Reflection: The reflection serves to monitor the innovative process. The whole investment team must make sure that the set targets are fully achieved including

consideration of human, organisational, technical and economic aspects. The last step of the PEFB process is necessary for two reasons. Firstly, it needs to be established that the aims have been completely fulfilled in order to avoid re-organisation or repeat of the investment process. Secondly, the members of the investment team should record their positive and negative experiences so that these experiences can be used for future projects.

4.6 Intermediate Summary and Classification of the Seven Case Studies

In Chap. 2 of this report, the *Impact Table* has been derived. For the research discussed in this volume, it presents:

- political objectives,
- innovation related requirements, and
- three specific Fields of Action concerning the European freight market.

Chapter 3 has pointed out selected theoretical aspects and it has described specific features of the socio-technical system *freight market* and the socio-technical *innovation system* within it. The different types of innovations to be expected have been narrowed down. Finally the Systemic Migration-Oriented Innovation Management Method and the related performance steps have been recommended. Supporting tools have been presented in detail in Chap. 4.

This last section of Chap. 4 deals with the perspectives of applying the Systemic Migration-Oriented Management Method to freight transportation in Europe. A first overview of the seven case studies is presented here. The case studies are organized as follows.

In Chap. 5, several *innovative technologies in freight transport* (Field of Action I) are presented (Fig. 4.12).

- Introducing truck platoons on motorways: the sequential research projects EFAS, M F G, KONVOI
- The Interactive Driving Simulator: InDriveS
- Individualized single-wagon door-to-door rail transport: FlexCargoRail

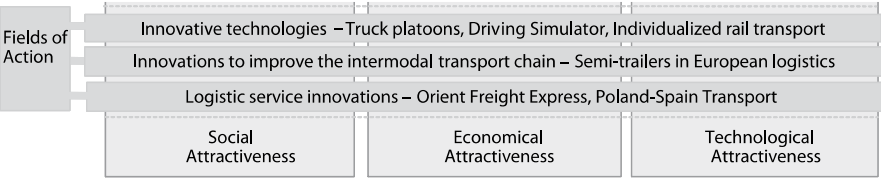


Fig. 4.12. Part of the Impact Table including the case studies

In Chap. 6, two *innovations to improve the intermodal transport chain* (Field of Action II) are described.

- Semi-trailers in Advanced European Intermodal Logistics: SAIL
- European low-platform technologies for non-cranable semi-trailers in Europe: RoRo-Rail

In Chap. 7, two *logistic service innovations* (Field of Action III) are presented.

- Orient Freight Express
- Poland-Spain Transport

The case studies include 10 innovative technologies and two logistic service innovations (Table 4.4, Table 4.5, Table 4.6). The project discussions are up to date because all case studies started in 2000 or later. All of those approaches – some of them are not finished yet – offer important information concerning migration-orientation during innovation processes. In addition they offer a broad view with respect to:

- different carriers (rail, road, intermodal),
- different degrees of automation, and
- different corridors across Europe (North-South, East-West, any other).

Table 4.4, Table 4.5 and Table 4.6 offer the overview of the different case studies, the carriers which are affected, the corridors which are focused on, the kind of innovation and the author's responsibility during these research projects.

The case studies of the *Field of Action I* focus on realising flexibility for customers and at the same time, to make better use of the infrastructure capacity existing today across Europe (Table 4.4). The case studies present one innovative road technology as well as one innovative rail technology. Both innovation processes can be supported by the new simulation laboratory which is presented in the second case study.

The case studies of the *Field of Action II* focus on possibilities to increase the attractiveness of intermodal transport considering freight forwarders, here specifically by using semi-trailers (Table 4.5). A highly frequented corridor is chosen. Hence, the introduction of innovative technologies can rely on sufficient amounts of freight. Furthermore one potential bottleneck of European transportation can in this way be relieved.

The case studies of the *Field of Action III* present innovative logistic services (Table 4.6). The goal is to transfer specific amounts of freight from road to rail. Two important corridors are described: Great Britain – Turkey and Poland – Spain.

Subsequently the seven case studies are described in detail, in the Chaps. 5 to 7. They are followed by the two final Chaps. 8 (Conclusions and Perspectives) and 9 (Summary).

Table 4.4: Characteristics of the case studies referring to the Field of Action I

Innovative technologies (Field of Action I): Chapter 5				
Dimension	Carrier	Corridor	Innovation	Author's responsibility
Introducing truck platoons on motorways: EFAS, M F G, KONVOI (Chap. 5.2)				
National	Road, platoon	Any (motorway)	Technological and logistic innovation, door-to-door	EFAS, M F G – head of consortium KONVOI – research support
The Interactive Driving Simulator: InDriveS (Chap. 5.3)				
National	Road	Any	Combination of driving and traffic-flow simulation	Development responsibility until 12/31/2004
Individualized single-wagon door-to-door rail transport: FlexCargoRail (Chap. 5.4)				
National	Rail, partly automated, single-wagon transport	Any	Technological and logistic innovation, door-to-door	Responsible for the economic evaluation approach

Table 4.5: Characteristics of the case studies referring to the Field of Action II

Innovations to improve the intermodal transport chain (Field of Action II): Chapter 6				
Dimension	Carrier	Corridor	Innovation	Author's responsibility
Semi-trailers in Advanced European Intermodal Logistics: SAIL (Chap. 6.2)				
European	Intermodal	Sweden-Italy	Semi-trailer-wagon combination	Head of consortium
	Intermodal		Swap-body-wagon combination	
	Intermodal, full-train		Low-platform technology	
European low-platform technologies for non-cranable semi-trailers in Europe: RoRo-Rail (Chap. 6.3)				
European	Intermodal, German system	Germany, Germany -Sweden, point-to-point, cyclic	Feasibility study: evaluation of low-platform technologies	Responsible for the economic evaluation
	Intermodal, French system			
	Intermodal, Norwegian system			
	Intermodal, German system			

Table 4.6: Characteristics of the case studies referring to the Field of Action III

Logistic service innovations (Field of Action III): Chapter 7				
Dimension	Carrier	Corridor	Innovation	Author's responsibility
Orient Freight Express (Chap. 7.2)				
European	Intermodal, full-train	Great Britain–Turkey	Logistic service and technology, door-to-door	Research support
Poland-Spain Transport (Chap. 7.3)				
European	Partly inter-modal	Poland–Spain	Feasibility study: logistic service and technology, door-to-door	Research support

Chapter 5

Case studies – Part I: Innovative Technologies in European Freight Transport

5.1 Overview

In Chap. 5, the first of the three *Fields of Action* is considered (Fig. 5.1): *Innovative technologies in European freight transport*. The case studies presented here are listed as follows.

- Introducing truck platoons on motorways: the sequential research projects EFAS, M F G, KONVOI (Sect. 5.2)
- The Interactive Driving Simulator: InDriveS (Sect. 5.3)
- Individualized single-wagon door-to-door rail transport: FlexCargoRail (Sect. 5.4).

Each of the subsequent Chaps. 6 and 7 follow the same approach as Chap. 5: The characteristics of the start-up situation and the types of innovation of the specific case studies are analysed (Step 1). Furthermore certain steps of the Systemic Migration-Oriented Innovation Management Method are recommended depending on the type of innovation. Subsequently those steps are described as they have been performed. Finally, after presenting all case studies of one Field of Action, the results of the Field of Action considered are matched with the objectives and requirements of the Impact Table (Resume).

Fields of Action	Innovative technologies – Truck platoons, Driving Simulator, Individualized rail transport		
	Innovations to improve the intermodal transport chain – Semi-trailers in European logistics		
	Logistic service innovations – Orient Freight Express, Poland-Spain Transport		
	Social Attractiveness	Economical Attractiveness	Technological Attractiveness

Fig. 5.1. Part of the Impact Table including the first three case studies

5.2 Introducing Truck Platoons on Motorways

5.2.1 *Research Considering Truck Platoons on Motorways (Step 1)*

Understanding the System

Objective of the Research Projects

Heavy goods vehicle traffic (HGV traffic) is increasingly being mentioned in public discussion as one cause for disruptions of the traffic flow on motorways, and as one cause of environmental damage. The attempts to unburden the roads of HGV through rail transportation have been going on for a long time but so far they have shown inadequate success. The roads will keep clearly their leading role in the freight business (BMVBW 2000). In order to achieve improvement in transport capacity, however, new technological and logistic concepts have to be developed (Preuschoff, Happe et al. 2003).

One concept is the formation of HGV platoons on motorways by using Advanced Driver Assistant Systems (ADAS). Such systems enable vehicles to follow each other with only a small distance in between. The technological assistance stretches from guidance, distance and speed control, to being able to follow another car or truck fully automatically. In the latter case the driver will be completely disengaged from controlling the vehicle on longer legs of the journey (Henning and Preuschoff 2003). Those systems will reduce the amount of space needed by the vehicles and therefore, optimize the usage of the infrastructure, reduce fuel consumption and increase safety on motorways. These goals are the reasons for recent project funding by the German Federal Government (BMBF)¹.

The first concepts of HGV platoon prototypes were developed in the projects promoted by the EU: “Promote Chauffeur I and II”. These research projects were rather technology oriented. Important questions for the implementation of Driver Assistance for platooning had still to be answered. Since technology in this area is developing fast, it seemed to make sense to use different technological approaches in the subsequent projects EFAS, M F G, KONVOI (Savelsberg 2006a). The author (Eva Savelsberg, maiden-name Preuschoff) was head of the consortiums of EFAS and M F G, and consulting researcher of the project KONVOI.

¹ Up to 2006 the transport sector was part of the Federal Ministry of Education and Research (BMBF). Today it is part of the Federal Ministry of Economics and Technology (BMWi).

Expected Characteristics of the Start-Up Situation of the Innovation Processes (Tool 1)

Dimension	Type A		Type B	
	Present-oriented	Future-oriented	Short-term	Long-term
Time orientation	Present-oriented	Future-oriented	Short-term	Long-term
Timing	Short-term	Long-term	Precise	Diffuse
Validity of information	Precise	Diffuse	Using synergies	Generating competencies
Competence orientation	Using synergies	Generating competencies	Familiar market	New market
Market competencies	Familiar market	New market	Available	New
Technology competencies	Available	New	Self-sustaining	External-cooperative
Outward orientation	Self-sustaining	External-cooperative	Ordering	Development cooperation
Supplier orientation (supply side)	Ordering	Development cooperation	Mainstream	Lead-user cooperation
Customer orientation (demand side)	Mainstream	Lead-user cooperation	Algorithmic	Heuristic
Change management	Algorithmic	Heuristic	Low	High
Complexity	Low	High	Low	High
Flexibility	Low	High		

Here the classification of Eversheim (2003) is used to describe the type of innovation. This classification supports the set-up of the research project. In particular the dimensions *time orientation*, *competence orientation*, *outward orientation* and *change management* should be balanced. As described later on, these specific projects discussed here are Type B innovations. Hence all steps of the method are recommended to be performed. Thus

in the following paragraphs, Tool 1 (*Visualisation and classification of the start-up situation*) is applied to the start-up situation of the research projects dealing with truck platoons on motorways as a focused project sequence.

The main aims of the sequence of projects were:

- developing scenarios for the implementation of HGV platoons,
- deriving both the requirement specifications and system specifications, and
- building the prototypes to be tested in real traffic.

These sequential research projects were the following:

- Scenarios for Advanced Driver Assistance Systems in Freight Transportation and their evaluation (Einsatzszenarien für Fahrerassistenzsysteme im Güterverkehr und deren Bewertung – **EFAS** – 2001–2002) (Henning and Preuschoff 2003)
- Requirement specifications for the implementation of Advanced Driver Assistance Systems in Freight Transportation (Vorbereitende Maßnahmen für den praktischen Einsatz von Fahrerassistenzsystemen im Güterverkehr – **MFG** – 2003–2004) (Savelsberg 2005b)
- Development and prototype evaluation of HGV platoons (Entwicklung und Untersuchung des Einsatzes von elektronisch gekoppelten Lkw-Konvois – **KONVOI** – 2005–2008).

Each of those projects was to be started only if the predecessor had been accomplished successfully. Thus the projects stressed that the focused advantages of those technical systems will finally be realised. A period of eight to twenty years – depending on the chosen scenario – was expected until platoons would be fully implemented for large-scale testing. There was no set solution space in the beginning of the project EFAS. An interdisciplinary approach was necessary since numerous aspects can be allocated to different disciplines and had to be discussed correspondingly. It was not expected that all experts involved would also be experts regarding the long-distance freight market. Specific technology competencies would have to be profoundly gained and developed during the research project. A broad cooperation in all aspects would be necessary in order to stress strong migration orientation from the beginning. A systemic

approach seemed to be appropriate because of the overall goal to introduce a certain new technology with severe influence on the market, and on the transportation system. The cooperation included several differently oriented university institutes and numerous well-known companies. It made a highly flexible approach necessary.

The following list describes the expected characteristics of the start-up situation of the innovation processes according to the coordinate systems of Everseim (2003). The characteristics are visualized in Fig. 5.2.

Time Orientation – Square I

The objective has been to develop a new technological system. In the beginning the three sequential projects were expected to cover a *long-term* period (Timing).

The new technological system will have *decisive impact* on the long-distance freight market (Validity of information). The *consortium* includes numerous institutes. They each see developments from a different angle. Information has to be exchanged and discussed as a continuing process. Regarding the approached technologies, there was no set solution space. The projects only aimed at improvement of road-based freight transport. For necessary further information, *surveys* and *meticulous analysis* had to be conducted. Hence the validity of information is rated *diffuse*.

Competence Orientation – Square II

The objective has been to optimize road transportation in order to improve fuel consumption, safety, and use of road capacity (Market competencies). Not everybody was familiar with the market. The technology will have *decisive impact* on the market. Hence, detailed information about the probable market response had and still has to be gathered. Scenarios considering different *Business Models* were the most decisive products of the first research project. Based upon this knowledge the *competitiveness* of the technology was judged in the second project. During the third project it is being evaluated again based on even more detailed information. The further gain of market competencies was and still is *high*.

The approached technological solution is a challenging innovation (Technology competencies). Defined technology competencies are in principle available but *holistic knowledge* has to be established in order to find migration-oriented solutions. Hence, numerous companies have to be involved and new kinds of knowledge have to be gained and integrated. *The Technological partial-system has to respond to the requirements of the Social and the Economical partial-systems*. Hence, the gain of technology competencies is high.

Outward Orientation – Square III

A strong and broad cooperation has been realized. The first of the sequential projects was rather research oriented. All research results were intensively discussed with suppliers who were involved during all three projects (Supplier orientation). Several representatives of the supply side are part of the consortium of the third project (*development cooperation*).

All research results are discussed in detail with customers (Customer orientation). Those have been involved during each of the research projects. Several representatives of the demand side are part of the consortium of the third project (*lead-user cooperation*).

Change Management – Square IV

The involvement of *numerous institutes, institutions and companies* increases the project complexity decisively (Complexity). A *challenging technology* is being approached. The new technological system has *decisive impact on the market* and therefore, on *business approaches*. The complexity can be rated *high*.

The strategy has to be adjusted flexibly to new results because of the challenging time table and the diverse contributions of the members of the consortium (Flexibility: *high*).

Figure 5.2 summarises these observations. All four squares show how the three sequential projects can be located within the coordinate systems corresponding. Concerning *Competence orientation* (II) and *Outward orientation* (III), the three sequential research projects show only slightly different patterns. This is due to the focus of the sequential projects. The first projects EFAS and M F G focus on the competitiveness and the feasibility of the new technology. The third project KONVOI focuses on the technological realisation of the new technology. Concerning *Change management* (IV), all three projects show the same pattern: high complexity and high flexibility expectations.

These four coordinate systems are merged in the way as described in Chap. 3. Fig. 5.3 shows how the characteristics of the three research projects are to be found partly within, but mostly at the outer positions of the concentric ring element. It corresponds to the analysis described before: this sequence of projects shows high values of almost all innovation characteristics. These characterisations are based on the different dimensions; they suggest a *Thorough Innovator* (type B innovation). It was pointed out before that there had to be especially strong focus on the *Social*, the *Economical* and the *Technological* partial-systems and their interactions. A severe influence through the new technology is expected to be exerted not only on the market but especially on the whole road transportation. Hence, all steps of the Method are recommended to be performed (Fig. 5.4). In addition, specific research considering legal issues should be conducted. These recommended steps are described here as a first project overview.

Recommended Steps of the Method

Due to the characteristics of the *Type B Innovation*, strong development cooperation and lead-user cooperation are recommended (Fig. 5.4) (Step 2). The main project aim is developing innovative technologies for platooning. Thus a substantial market share of transportation conducted with platoons, should be realized (Step 3). Hence, the project has to have a strong focus on the competitiveness of the technological solutions in comparison with road-only transport. Since lead-users should be part of the consortium the gaining of information and the design of the *Business Model* are made easier. The development of the Business Model is started with Step 3. It will continue until Step 8. The pla-

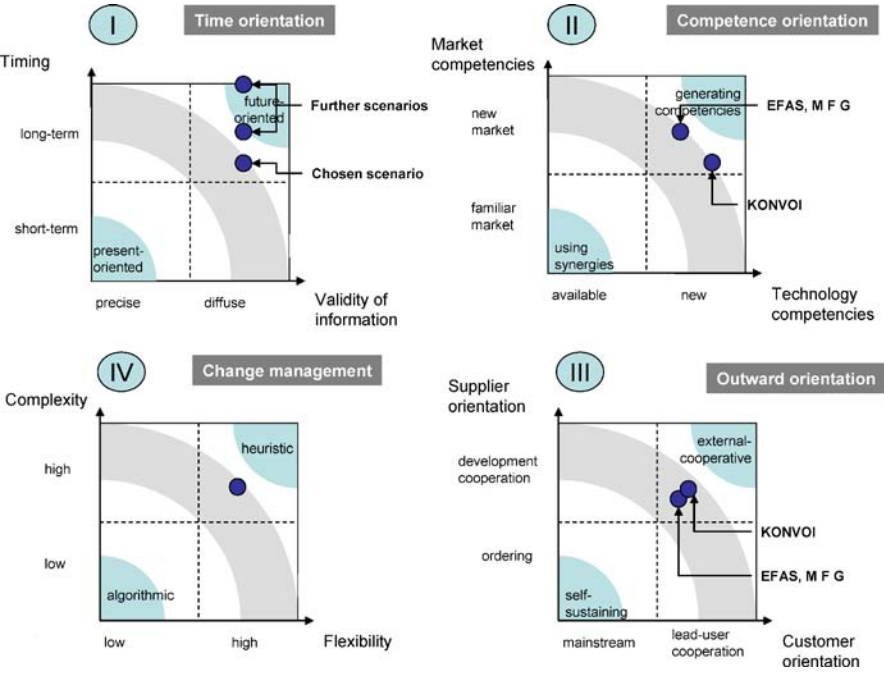


Fig. 5.2. Visualisation of the start-up situation of the innovation process (Sequential projects EFAS, M F G and KONVOI)

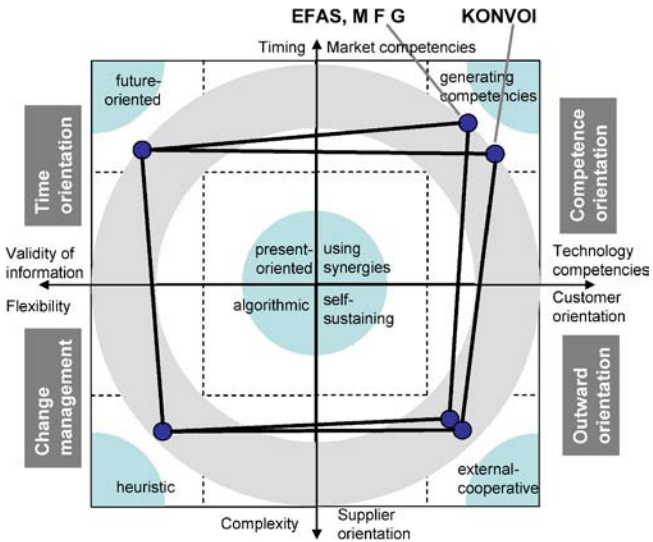


Fig. 5.3. Combined visualisation of the start-up situation of the innovation process

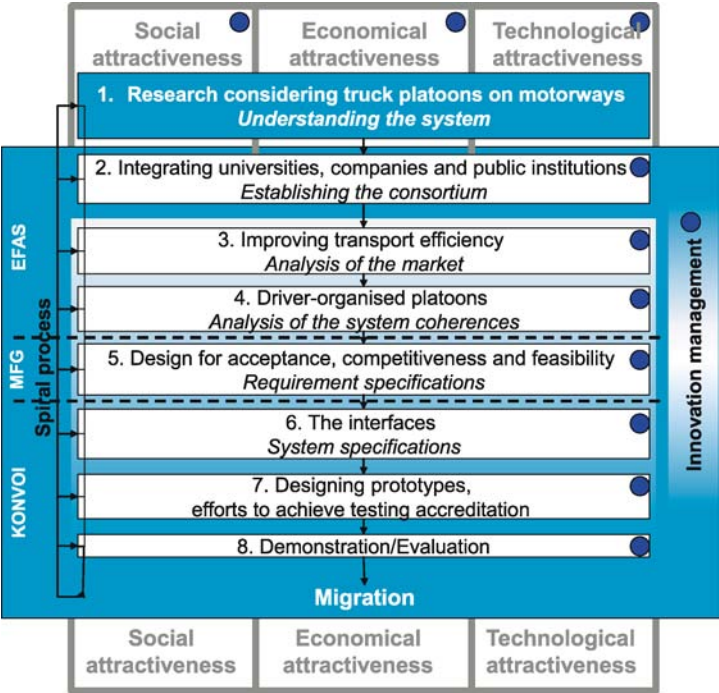


Fig. 5.4. Introducing truck platoons on motorways, recommended steps to be accomplished in the sequential projects EFAS, M F G, KONVOI

tooning technology will have a decisive input on the market and on the process of road transportation.

As a *Type B Innovation* has to be realized, it is necessary to accomplish Step 4: *Analysis of the system coherences*. There is no set solution space in the beginning. *Comprehensive knowledge of the system coherences* has to be achieved in order to establish the *shared view of the transportation system* among the different parties; to develop *possible appropriate solutions*; to *evaluate* those solutions and finally, to *choose technologies* which can successfully migrate into the freight transportation system.

The Business Model will be decisively elaborated during the requirement specifications (Step 5). Each technological feature and the platooning system in general have to be checked on its effects considering the demand side of transportation. The system specifications describe in detail how the requirement specifications will be realised (Step 6). The prototypes have to be built and demonstrated (Step 7). This step will be conducted in the year 2008. Demonstration and evaluation are important for gaining information about the *Technological* and *Economical* attractiveness of the innovative technologies (Step 8).

Following this description of Step 1, the subsequent steps of the *Systemic Migration-Oriented Innovation Management Method* are described in some detail concerning these three sequential projects.

5.2.2 *Integrating Universities, Companies and Public Institutions (Step 2)*

Establishing the Consortium

In the consortium of the three sequential projects, the following partners are included: up to seven university institutes, eight companies and one public institution. Thus, the consortium represents the demand side as well as the supply side of freight transportation.

University institutes and their fields of activity:

- ZLW/IMA, Center for Learning and Knowledge Management/Department of Computer Science in Mechanical Engineering (Zentrum für Lern- und Wissensmanagement/Lehrstuhl Informatik im Maschinenbau) – coordination, project and change management
- IfP, Institut für Psychologie – work psychology
- BUR, Lehr- und Forschungsgebiet Berg- und Umweltrecht – laws and regulations in civil engineering and environment
- IRT, Institut für Regelungstechnik – automatic control
- VIA, Verkehrswissenschaftliches Institut – traffic research and development
- isac, Institut für Straßenwesen Aachen – traffic research and development
- ika, Institut für Kraftfahrwesen Aachen – car and truck research and engineering

Industry:

- MAN Nutzfahrzeuge – truck engineering
- WABCO, Fahrzeugbremsen – brake systems
- DaimlerChrysler – truck engineering
- Ewals Cargo Care – logistics and freight forwarding
- Offergeld Logistik – logistics and freight forwarding
- Hammer Internationale Spedition – logistics and freight forwarding
- Danzas – logistics and freight forwarding
- W.E.S Logistik und Personaldienstleistungen – logistics

Public institution:

- BAST, Federal Highway Research Institute – road transport

In this way the whole transport chain has been represented from the project start, and the main scientific disciplines concerned have also been integrated (Fig. 5.5).

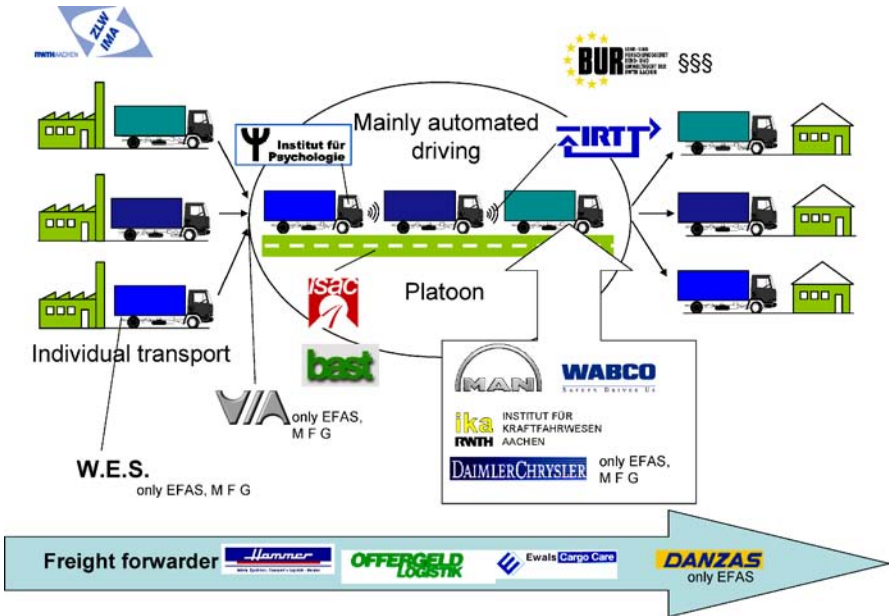


Fig. 5.5. Consortium of the three sequential projects EFAS, M F G and KONVOI

5.2.3 Improving Transport Efficiency (Step 3)

Analysis of the Market

Questions to be Answered

For this step, the Tool 2 *Business Model* (BM) is recommended. According to this tool, several questions are to be answered for the three research projects (Chap. 4.2). These questions will be answered, beginning with Step 3 and complemented during the Steps 4 to 8.

Value Proposition: In this case a double perspective exists. Firstly regarding the transport chain, the demand side is represented by the freight forwarding companies, the project partner BAST, and one supporting institution which conducts trainings for truck drivers; the engineering companies represent the supply side. Secondly, one further customer of the project is the German Federal Government (BMBF² and later the BMWi³) which represents society with the aim to improve freight transportation on roads across Germany and Europe.

² Federal Ministry of Education and Research (BMBF). Up to 2006 the transport sector was part of this ministry. Today it is part of the “Bundesministerium für Wirtschaft und Technologie” (BMWi) – Federal Ministry of Economics and Technology.

³ “Bundesministerium für Wirtschaft und Technologie” (BMWi) – Federal Ministry of Economics and Technology.

Value chain: The technology and the developed business processes should be designed in a way that further customers can be convinced to invest.

Revenue-model: Early traffic simulations of the truck platoons were conducted based on first data. Those tests suggested an increase of the travel speed by 10%, and a reduction of fuel consumption of 5–10% through platoon formation (Henning and Preuschoff 2003). From the beginning it was discussed how to calculate the working time of truck drivers if they are just following a leading vehicle. Their workload would be different from normal working hours. This would offer decisive savings for freight forwarders.

5.2.4 Driver-Organised Platoons (Step 4)

Analysis of The System Coherences

Tool 2: Sensitivity Analysis (Tool 3)

For this most complex step, the system was described in detail and 28 variables were developed. Their systemic role was visualized by the so-called Impact Matrix (Fig. 5.6).

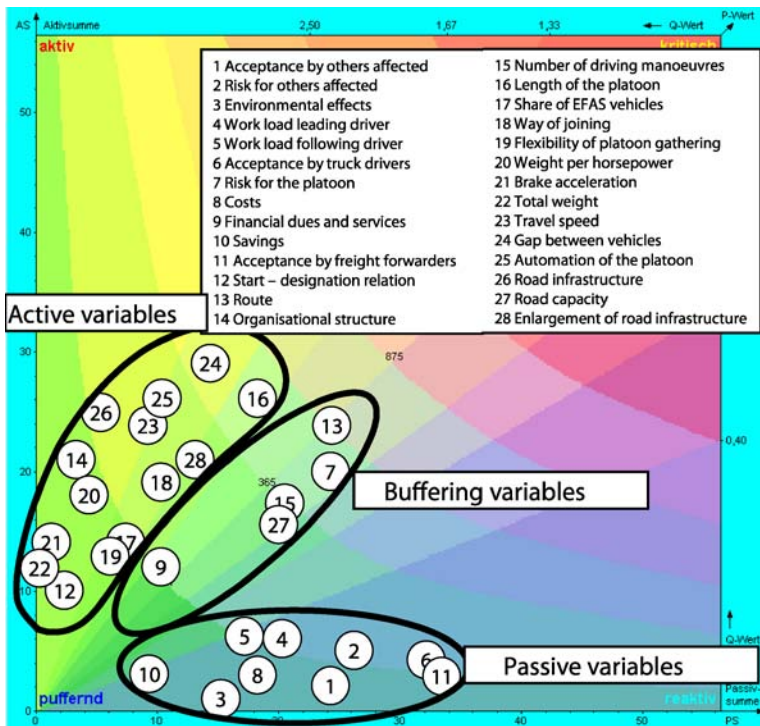


Fig. 5.6. Impact Matrix of the project EFAS

In the research project EFAS, the *active* variables were used to create different scenarios. Those variables are listed and wherever necessary, explained in more detail in Table 5.1.

These *active* variables focus mostly on the technical and organisational feasibility of joining a platoon, and driving in a platoon. Hence, to create the scenarios the possibilities of the *Economical* and the *Technological partial-systems* are stressed. The *passive* variables were used to evaluate the scenarios created in the project. Those variables are shown in Table 5.2.

Here, the *passive* variables focus on the *Social partial-system*. Aspects of acceptance and workload are pointed out. Hence, the effects on the *Social* partial-system are decisive to evaluate the scenarios and to select the most suitable scenario.

The buffering variables are not described in detail since they are not used for developing or evaluating the scenarios.

Table 5.1: Active variables according to the systematic approach of Vester (1995) (EFAS)

<i>Active variables</i>	<i>Explanation</i>
12 Start – designation relation	The route specified by the freight forwarder considering a certain assignment.
14 Organisational structures	Who determines the structure of the platoon?
16 Length of the platoon	
17 Share of EFAS vehicles	The percentage of platoon-compatible vehicles regarding the whole traffic.
18 Way of joining	How do the vehicles join in a platoon, or initially meet to organise the platoon.
19 Flexibility of gathering	Flexibility to include different goods into the platoon, e.g. hazardous material.
20 Weight per horsepower	
21 Brake acceleration	
22 Total weight	The total weight of a vehicle.
23 Travel speed	Average speed of the platoon.
24 Gap	Distance between the vehicles integrated in the platoon.
<i>Active variables</i>	<i>Explanation</i>
25 Automation	Determination which task is conducted by the driver, and which task by the automation system ADAS.
26 Road infrastructure	Aspects regarding the infrastructure of the used route (e.g. construction areas, junctions, bridges).
28 Necessary enlargement	Modification of the road infrastructure

Table 5.2: Passive variables according to the systematic approach of Vester (1995) (EFAS)

<i>Passive variables</i>
1 Acceptance of platoons by the other traffic participants.
2 Risks regarding the other traffic participants.
3 Environmental effects.
4 Workload on the leading driver.
5 Workload on the following driver.
6 Acceptance by truck drivers to participate.
8 Costs.
10 Savings.
11 Acceptance by freight forwarders/hauliers.

Scenario Technique (ST) – Medium-Term and Long-Term Scenarios (Tool 6)

Three scenarios have been developed based on the Sensitivity Analysis (SA). They stretch from medium-term to long-term perspectives (Table 5.3). They focus on the realisation horizons of eight years (scenario 1), 15 years (scenario 2) and 20 years (scenario 3). To point out the aspects stressed by the *active variables* the partial-system Technology was divided into *vehicle* and *road*. They differ in the options for the driver how to act, e.g.:

- to perform office work while his truck follows the *leading truck* (he is then the *following driver*), including his acceptance of this situation, and the specific risks he is exposed to;
- the way and flexibility of organising the platoon;
- the degree of automation;
- the possibility to use conventional motorway infrastructure, and
- the necessity to decouple the platoon if construction sites or tunnels come up.

At the end of the first project EFAS, scenario 1 was recommended, but including the new technology of automated lane guidance⁴ (Henning and Preuschoff 2003). Scenario 1 offers the following possibilities: to test prototypes while permanent awareness of the *following driver* is still guaranteed; to allow flexible organisation which was favoured by the demand side; to have manoeuvres which bare not automated; and not to need any changes of motorway infrastructure. This scenario is described in the following paragraph.

The Chosen, Modified Scenario 1: “Driver-Organised Platoons”

The evaluation of the scenario 1 has shown, however, that some minor modifications are required. This affects, above all, a necessary lane control so that

⁴ German: Spurführung.

Table 5.3: Specified characteristics of the partial-systems and the corresponding scenarios of EFAS (according to Savelsberg 2005)

	Scenario 1	Scenario 2	Scenario 3		
	1	2	3	4	5
Social	Permanent awareness of the following driver; work load acceptable; high acceptance; medium risk	Following driver can conduct e.g. easy office work; lane assistance if necessary; work load acceptable; high acceptance; medium risk	Following driver can conduct substantial office work; work load may be too low to keep up concentration; possible problem regarding acceptance; risk not predictable		
Economical	Who? Truck driver When? No schedule Where? Everywhere	Who? Freight forwarder/hauler When? Flexible schedule Where? Everywhere or at meeting point	Who? Service agent When? Flexible schedule Where? Everywhere	Who? Service agent When? Flexible schedule Where? Meeting point	Who? Service agent When? Flexible schedule Where? Meeting point
Technological: Vehicle	Manual/ conventional driving	The distance between the vehicles is kept automatically	Automatic lane guidance, the driver acts only during manoeuvres	Manoeuvres are automated	
Technological: Road	Operation only on roads with four or six lanes (both directions), the platoon has to decouple at construction areas and possibly at e.g., tunnels, bridges ...	Operation only on six lanes freeways, further measures to influence the traffic flow might be necessary, the platoon has to decouple at construction areas and possibly at e.g., tunnels, bridges ...	Operation on special lane, further measures to influence the traffic flow are necessary		

it is possible to drive at distances between the trucks of around 10 m. The description of the scenario includes three phases: platoon formation, driving in platoons and the decoupling of platoons. The possible driving manoeuvres will be discussed (Savelsberg 2005b; Savelsberg, Happe et al. 2005). Hence, the following paragraphs offer detailed information regarding the *value chain* and the *revenue-model*. Therefore it is a decisive contribution to the Business Model.

Platoon Formation

The HGV drivers themselves perform the formation and organisation of the platoon. They receive support through a special computer device, the so-called Organisational Assistant. This device is integrated into the truck and is a requirement for participating in a platoon. Thus, the driver takes over the organisation of the platoon in addition to the driving. He has to be trained for the related operating processes, and how to use the Organisational Assistant. The employer (the freight forwarder or haulage company), therefore, passes the responsibility for the formation of the platoon on to the driver.

For the platoon formation, the HGV driver drives with his platoon-capable truck at an arbitrary time to a motorway junction and puts the Organisational Assistant into use. This assistant calls up the data from the searching truck, i.e. destination, route, current location and power-to-weight ratio/weight per horsepower and thereupon it ascertains other platoon-capable trucks which are also travelling in the same direction. This is done by use of a close-range communication tool, within a search area of $1000\text{ m} < S < 5000\text{ m}$. Trucks which are suitable for the searching vehicle are chosen according to the following three criteria: The routes of both the searching and the offering trucks must fit together for at least 60 km; the power-to-weight ratio of the searching truck must not deviate more than a maximum of $\pm 10\%$ of the offering truck or leading vehicle of the platoon; furthermore, the maximum number 'n' of vehicles allowed to participate in platoons, must not be exceeded by this particular platoon at the time of the enquiry.

If no other platoon-capable vehicles are available in the search area, the searching truck itself will be classified as platoon-capable by the Organisational Assistant. Correspondingly it answers to requests from other vehicles to form platoons. If platoon-capable vehicles are found, their deployment is carried out according to the in previously specified priorities of the freight forwarder/the haulage company. Those priorities can be the exact fitting of the stretch of road, the power-to-weight ratio, and/or the best compromise for the stretch of road and the power-to-weight ratio.

After the searching driver has decided on one of the alternatives on offer, the relevant truck/platoon will be informed via the Organisational Assistant. If the request is answered positively, the position of the requesting truck in the platoon will either be decided autonomously or by use of a point-awarding system, whereby the participant with the longest stretch of route is found (high number of points). This vehicle will be a following vehicle in this platoon. The participating vehicle with the lowest number of points has then to be the leading vehicle. The requesting truck has to get to the junction or a mutual meeting point (e. g. a petrol station or a service area) at the agreed arrival time. From this point the vehicles drive together onto the motorway. Further trucks which want to add themselves to platoons will be coupled on to the platoon by their drivers, with the support of the IT system.

Driving in a Platoon

Once the platoon has joined forces, the communication modules of all following vehicles (max. seven) can be switched to *passive* for the purpose of data reduction, i.e. so that trucks enquiring for a platoon do not find a signal from this completed platoon.

The compliance with the speed and distance regulations of all vehicles behind the leading vehicle is carried out completely automatically during the platoon's journey. Additionally the automated system is fitted with automatic lane guidance. Necessary platoon manoeuvres are carried out by the driver with support of Driver Assistant Systems. Such manoeuvres include for example:

- the coupling and uncoupling of vehicles in the platoon,
- the overtaking of the platoon,

- the decomposition of the platoon, e.g. before junctions where such platoons are banned automatically.

It is a pre-requisite for the automatic platoon participation that the vehicle is equipped with actuators as well as corresponding sensors for automatic regulation of the vehicle's longitudinal and latitudinal dynamics.

The starting point is the production of long-distance trucks fitted with the following electronic infrastructure:

- ABS (anti-lock braking system),
- Electronic Stability Program for tractors and trailers,
- power-train control system with target values for engine torque and deceleration,
- integrated approach of sustained-action brakes and service brakes, and
- automated power train (automatic gearbox).

Furthermore, an actuator is to be provided for the electric power steering in the vehicles, which are not yet standard in current consumer's vehicles but which are available as prototypes.

The leading vehicle will have a distance sensor which functions in all weather conditions and is fixed to the vehicle. Information about the distance and the relative speed of the leading vehicle will be determined exclusively with the vehicle's own distance sensor (Fig. 5.7). This is based on a far-field range sensor in front of the vehicle (range of around 200 m, and 12° angle of beam spread, its design to be based on radar or laser technology), and also on a sensor for the close-up range (range of around 50 m, and 45° angle of beam spread, its design on the basis of scanning laser or camera-based image processing). A camera system will be introduced in order to recognise the vehicle's position in its own lane, and for lane support.

The drivers communicate with the help of CB-frequency. Inter-vehicle communication between the communication modules of the vehicles is based on technology which is already on the market (e.g. Wireless LAN). Only data will be broadcasted which are relevant to the vehicles' movement but are not detected by the environment sensor system (steering angle, gear rate, lateral acceleration, individual speed, deceleration, position of the accelerator, position of the brake pedal). Furthermore, comparison is made between the data delivered from the vehicle's sensor (e.g. the relative speed and decelerations) and the envi-

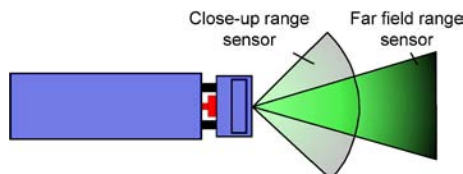


Fig. 5.7. Configuration of the sensors (according to Savelsberg 2005b)

ronmental sensors, under the condition of safety. Inter-vehicle communication within the platoon is carried out on the basis of communication structure similar to a bus system. In addition, the optimum route for the current traffic situation is made available to the platoons, for which internet-based communication between the vehicles is favoured. Thus it is expected that additional positive influence will affect the traffic flow.

Through the implementation of Differential-GPS (D-GPS) the current position of the vehicles can be ascertained down to one centimetre, and aligned with the digital map. Information about the traffic infrastructures which are suitable for a platoon journey is received on this map (e.g. the number of lanes, exact information about junctions, bridges, tunnels and construction sites).

The road infrastructure referred to here, complies with the current ones. Hence, no additional specific construction or traffic-related measures are necessary for the implementation of automatic truck platoons. The motorway network which is available today consists of three, or at least two lanes in each direction. It is to be assumed that some stretches are useable for platoons only in a limited way or not at all. The use of certain stretches is, among other things, dependent on the respective traffic flow and subsequently limited overtaking opportunities. Motorway junctions are similarly useable for platoons only in a limited way or not at all. Furthermore, a platoon on the main carriageway could sometimes also require disintegration of the platoon, e.g., when there is a high level of traffic at a junction. Traffic safety specifications will be decisive here.

It is also to be assumed that at narrow areas such as bridges and tunnels, there will be limited opportunity for automatic platoon operation. Existing bridges are (partly for constructional reasons) not usable; there are already higher minimum distances in force for HGVs. With regard to tunnels, traffic safety specifications are decisive here. This could also have the consequence that the use of tunnels is completely ruled out for platoons.

Moreover, it is to be assumed that generally considerable enlargement, reconstruction and maintenance will be required in the national motorway networks in the coming years in Europe, and especially in Germany. Consequently, a considerable number of both long-term and short-term construction sites on motorways will limit traffic flow. At construction sites disintegration of the platoons is essential due to traffic safety reasons.

The traffic volume forecast during the envisaged time span needs to be taken into account. Thus, no additional traffic strains due to the platoon traffic are to be expected. It is to be assumed that these existing burdens on traffic are known in advance and will be considered important for platoon organisation. Therefore the communication module integrated in the vehicle should provide corresponding recommendations particularly concerning the traffic in immediate vicinity of the platoons.

Here the following information is important for the platoons: available infrastructure (number of lanes, uphill stretches, tunnels and bridges etc.); legal information (e.g. where trucks are not allowed to overtake); the current and the to-be-expected traffic situations (traffic jams, construction sites etc.). These data must be processed for the participating drivers, and be on hand accord-

ingly in order to enable them to plan and carry out platoon travel. Sufficient databank capacity should be set up for these tasks.

Decomposition of Platoons

As soon as a truck in the platoon reaches its destination, the disintegration phase begins. With the help of the Organisational Assistant the necessary uncoupling manoeuvre of the truck corresponding is executed in this scenario by the driver. The driver is supported by the computer-based system to realize sufficient distance regarding the vehicle ahead of him. Only then the complete control of the vehicle will be given back to the driver. The individual HGV driver will then proceed with his journey manually.

If any driver of the platoon wants to leave early, he informs the other participants via the Organisational Assistant that he wants to leave the association. The necessary platoon manoeuvres follow. The remaining vehicles cross over into a short phase of platoon formation in which they fill the gap created.

Manoeuvres During the Platoon's Formation, Travel and Disintegration

During the three described phases different manoeuvres can be necessary, which can involve various different vehicles/participants. Some manoeuvres must be ruled out for the described scenario, as they have an adverse effect on traffic flow and safety. Above all, manoeuvres which make it necessary for the platoon to break or overtake should be avoided.

This means that for *platoon formation*, the following two manoeuvres are favoured: platoon formation from the *front*, the target position for the newcoming truck would be the leading vehicle of the platoon; and platoon formation from the *rear*, the target position of the new truck would then be the last vehicle. Through these manoeuvres it is ensured that neither the newcoming vehicle nor the platoon has to overtake each other.

During the *platoon journey*, the most important manoeuvre to consider is changing lanes. This situation arises when a slower vehicle has to be overtaken. As this manoeuvre cannot be fundamentally ruled out during light traffic, an alternative approach is chosen here: the last vehicle veers out of the platoon manually and thus, it keeps the lane free for the rest of the platoon members. After manually checking the traffic to their sides, the platoon can then change lanes. The *change of position* is only allowed for the leading vehicle. In case of an emergency (e.g. if a vehicle breaks down), the driver of the leading vehicle should bring the entire platoon to a standstill. This can be done both in the lane as well as on the hard shoulder.

With respect to the decomposition of the platoon, all manoeuvres are possible in theory. Both the detachment and the veering-out of individual vehicles and platoons illustrate no bigger drawback than it does in today's road traffic without platoons. The disintegration of the platoon at standstill is also possible, along the lines of the formation.

5.2.5 *Design for Acceptance, Competitiveness and Feasibility (Step 5)*

Requirement Specifications

The following requirement specifications were concluded in the project M F G. One crucial contribution was conducted by several law experts involved. Thus, besides the *Social*, *Economical* and *Technological* aspects, a special part regarding laws and regulations was added. Only in this way it was possible to realise the requirement specification by the diverse experts included in the project. Therefore the presentation is a summarization of the findings of those experts (Savelsberg 2005b). Hence, they are named at the beginning of each of the paragraphs following here.

Social Aspects Within the Requirement Specifications

The following subcategories are comprised in the *Social* aspects of the requirement specifications (Petry, Wille et al. 2005):

- Burden and stress
- The drivers' acceptance
- Enhancing the drivers' competence
- The haulage companies' acceptance
- The limits of human productivity
- Social acceptance

These aspects are discussed in some detail, as follows here.

Burden and Stress

In order to keep the stress of the driver at an optimum level, the following points are to be observed:

- The Human-Machine System must be ergonomically designed.
- Manual take-over has to be conducted after an adequate time period. The manual take-over after platooning has to be confirmed by the Organisational Assistant. Exact data have to rely on further simulator experiments.
- The drivers must be informed about reasons for necessary unplanned decoupling (e.g. construction sites).
- The installation of a camera in the leading vehicle provides the view of the road ahead. The image may be transferred to the other vehicles. This is recommended as a trust-building measure and to provide emotional well-being.
- The following driver has to conduct some different tasks during platooning in order to avoid boredom.

The Drivers' Acceptance

The drivers' acceptance regarding the automated system has to be evaluated during the whole realisation and implementation phase. In this context it is recommended to implement the following aspects:

- The drivers have to become familiar with the system by training. They should have a realistic impression of the possibilities of the system, especially its ways of supporting their daily routine.
- Furthermore, resentments may come up that the system might replace the driver and thus endanger jobs. They should be reduced by information and training experiences. It should be stressed that the system serves as a means of taking the strain off drivers in their strenuous job. Consequently it does not lead to loss of prestige.
- In order to build up faith into the system, exercises should be carried out in special extreme situations.
- The design of the Organisational Assistant is to be user-friendly and it is to allow the driver to take over control quickly from automation.
- When someone else demands a manual take-over, work overload is to be avoided caused by too short notice.

Enhancing the Drivers' Competence

The introduction of automatic platoon travel in the freight business provides the professional HGV driver with new demands. Training centres should develop concepts which convey the required skills and knowledge. The range of needs must be defined precisely in practice. Likewise, further tasks to be performed by the driver during the automatic phase, need to be found and specified.

The Freight Forwarders'/Haulier Companies' Acceptance

Within the project M F G, evaluations of questionnaires of freight forwarders/ haulier companies provided both positive and negative information regarding the introduction of automatic platoon journeys (Petry 2005a). Those practitioners made their judgments purely on hypothetical assumptions. Hence, their comments must be evaluated again after simulations and real tests.

As previously mentioned in the subcategories "Burden and stress", additional tasks for the drivers during the automatic phase need to be found. Thereby the whole technological concept becomes profitable for the freight forwarder/haulage company. The target group should also be informed by politicians about the cost effectiveness, the environmental friendliness and social acceptance of platoon travel.

Limits of Human Productivity

Recently research has been performed into how *car drivers* adapt back to manual driving after automatically coupled journeys: These experiences cannot be transferred to the target group of *professional HGV drivers*. Consequently, research about the performance of professional HGV drivers should take place using simulators, along with the realisation of automatic control systems for trucks.

It can be assumed that distance adaptation is a general psychological phenomenon for all drivers. Therefore it is necessary that a system which gives feedback on the gap between the vehicles, is installed into the existing Organisational Assistant. It has been shown in other studies that feedback on several dimensions is most efficient. Here a signal designed like a beam is recommended. It can change size and colour according to the real distance of the

vehicle ahead. An audio warning in case of dangerously small distances should be added. The central display of the truck has to be equipped for colours and graphics. The feedback should be on the most visible area of the touch screen, and on the highest level of the menu.

Problems may occur if the driver changes from fully automatic system status to semi-automatic status. During the automatic journey the vehicle brakes completely automatically. So far Cruise Control systems which are already integrated in many trucks, have been designed as comfort systems. They brake only through engine braking. In platoons the input of the driver is needed to reduce speed decisively. The driver may have got accustomed to the fully automatic system during platooning, and the Cruise Control system may react similarly at first. Hence the driver might not react appropriately. Therefore it is recommended that after the fully automatic mode, at first the fully manual mode follows (i.e. without Cruise Control). Thus the driver will be completely integrated into the driving situation again and in terms of situational awareness, he is back “in the loop” again.

Social Acceptance

Continuous research using a truck platoon simulator is essential to gain knowledge about the social acceptance of such automatic truck platoons. Therefore an experimental simulation laboratory should be developed as subsequent project. Furthermore, targeted publicity campaigns by politicians are required when the automatic truck platoon journeys are introduced onto the motorways. The age and sex of the persons asked must be taken into account in order to be able to make use of such information in a targeted manner.

Economical Aspects within the Requirement Specifications

The following subcategories are comprised in the *Economical* aspects of the specifications (Norta, Schuckließ et al. 2005):

- Organisational and operational strategies
- The demand for information
- Integration into the existing traffic and infrastructure
- Cost effectiveness

They are discussed as follows.

Organisational and Operational Strategies

In the context of the research project EFAS, one particular scenario was chosen out of the three scenarios developed. This scenario includes the Organisational Assistant; hence, the way of organising the platoon is already narrowed down. In terms of medium-term realisation, the hardware and software components for the design of the Assistant should be made up of existing technologies wherever possible. A capable databank system must be initialized as basis for the planning and dispatching of the truck platoons. This system must be able to manage data quickly, accurately and safely. It should allow quick access to the data. Existing databanks, such as the ones used for internet services, can be used for the data management of the Organisational Assistant.

Different software components are necessary for operation management. Software for route planning and journey-time calculation is necessary. Procedures from rail industry software or route planning/navigation systems are usable here. The software has to include the following two components to support the efficient joining of vehicles: to suggest to the *searching* truck driver where a platoon-capable truck may be found to make up a new platoon, or where to find a platoon to be joined; for the truck driver *receiving* such an offer, to evaluate the offer of the searching vehicle. Criteria and conditions for evaluation and selection must be incorporated.

Demand for Information

The demand for information in the platoon system depends on the way of organising the platoon. The realisation of the system relies on the steady flow of information. The demand for information at the interface of *information technology* and *organisation* should be determined and described properly. The demand for information and the estimated amount of data are crucial regarding the selection of suitable technology.

Integration in the Existing Traffic and Infrastructure

With respect to the integration of truck platoons, e.g., into the existing German motorway network, the limiting values deduced here are classified as the first prerequisite for safety, and particularly in terms of traffic quality: the maximum traffic load to allow platooning.

In traffic simulations, it has so far not been possible to establish any negative influences caused by platoons on certain parts of motorways between junctions, neither on carriageways with two or three lanes. It is even possible to anticipate slightly positive influences of platooning on a dual carriageway. More critical to judge, however, are the junctions, particularly the joining points (however, only the single-lane type of joining points was considered here). There the limits of permissible traffic safety for a platoon were reached: maximum traffic load of 1550 vehicles per hour.

At bottlenecks such as construction sites, the required manoeuvres of the platoon were defined, e.g. changing lanes and disintegration of the platoon. The safeguarding measures were also defined, such as the maximum number of four trucks in a platoon. By the same token, tunnels were defined to require the decoupling manoeuvre for safety reasons to take place about 400 m or more ahead of the tunnel.

Cost Effectiveness (Profitability Estimation Focused on Benefits – PEFB) (Tool 9)

A positive economic balance sheet is essential for the introduction of HGV platoons. Even under consideration of the external costs, the economy of its use was verified. The figures used in the economic calculations are based on simulations and estimates and must be validated in real experiments (Table 5.4, Table 5.5, Table 5.6).

The specifications for minimization of costs and maximisation of benefits are suggested during the realisation as follows. The essential *internal* factors are

Table 5.4: List of platoon-related costs and benefits

Benefits	Costs
Fuel saving	Investments vehicle
Reduction of travel time	Increase of maintenance costs
Reduction of accidents and emissions	Noise and air pollution
Reduction of congestions	Trainings
Tax relief	Detouring
	Reduction of flexibility

Table 5.5: Costs for HGV platoons

	Probability that costs incur		
	high	middle	low
direct	Investments vehicle	Trainings	
relative	Increase of maintenance costs	Detouring	
difficult to ascertain	External costs, e.g. noise and air pollution	Reduction of flexibility	

Table 5.6: Benefits for HGV platoons

	Probability that benefits incur		
	high	middle	low
direct	Fuel saving		
relative	Reduction of travel time		Tax relief
difficult to ascertain	External benefits, e.g. reduction of accidents and emissions	External benefits, e.g. reduction of congestions	

the costs of investing in the vehicle, the costs due to additional organisational expenses, and the benefits of fuel and journey-time reduction. Concerning the *external* costs, reductions of insurance premiums and taxes are to be discussed because the introduction of HGV platoons contributes to increasing traffic safety and reducing pollution. However, this will not be included as a demand into the requirement specifications due to economic concerns.

Different cost types (internal, external) were already stated in Chap. 2. Here only platoon-related costs and benefits are listed. They are used according to the PEFB process described in Chap. 3 (Happe and Schmitz 2005). The estimation of the costs and benefits is based on literature references and statements of experts. Trucks and tractors with semi-trailers cause different costs. Hence they are stated separately (Table 5.7, Table 5.8, Table 5.9).

Table 5.7: Estimation of the costs and benefits regarding HGV platoons

Data		Source
Truck long distance freight transport	0.91 EUR/km	(Baum, Geißler et al. 2003; Selz 2003)
Truck as part of a platoon	0.81 EUR/km	
Tractor with semi-trailer as part of a platoon	0.86 EUR/km	
Percentage of travelling in platoon	30%	(According to Hipp, Jung et al. 2001): 70% Reduction related to the analyses during the project M F G
Investment for ADAS	2,500 EUR/piece; amortisation 5 years: 546 EUR/a	DaimlerChrysler; (Baum, Geißler et al. 2003)
Increase of maintenance costs	+ 50 EURO per year	experts
Training	One time 500 EURO per truck driver	experts
Detouring	Milage: 100,000 km/ a + 1% = 1,000 km => + 860 EUR/a	experts
Fuel saving	Minimum 6% Fuel saving truck: 10 ct/km, with 30% platooning of 100,000 km => 3,000 EUR/year Fuel saving tractor with semi-trailer: 5 ct/km, => 1,500 EUR/a	20% (Bonnet and Fritz 2002); 10% M F G scenario 1
Raise of average travel speed	From 70 km/h to 80 km/h => 2,750 EUR/a	(Baum, Geißler et al. 2003; Henning and Preuschoff 2003)
Cost reduction regarding accidents, emissions, congestions	500 EUR/a	(Jaeger 2003)
Tax relief (if granted!)	~ 500 EUR/a (~33%)	

Table 5.8: Estimated costs for HGV platoons

	Probability that cost incur									
	high			middle				low		
direct	546			500						
relative	50			860						
difficult to ascertain	7.900			500						
Risk stages	9	8	7	6	5	4	3	2	1	
Accumulated costs in EURO	10.356	10.356	10.356	9.856	9.856	9.856	1.096	596	546	

Table 5.9: Estimated benefits for HGV platoons (truck)

	Probability that benefits incur									
	high			middle				low		
direct	3,000			0				0		
relative	2,750			0				500		
difficult to ascertain	1,000			500				0		
Risk stages	1	2	3	4	5	6	7	8	9	
Accumulated costs in EURO	3,000	5,750	5,750	6,750	6,750	6,750	7,250	7,250	7,250	

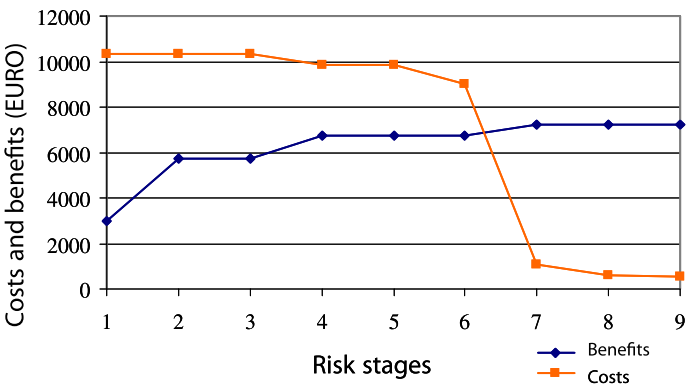


Fig. 5.8. Visualisation of costs and benefits according to risk stages for trucks (including external costs) (according to Happe and Schmitz 2005)

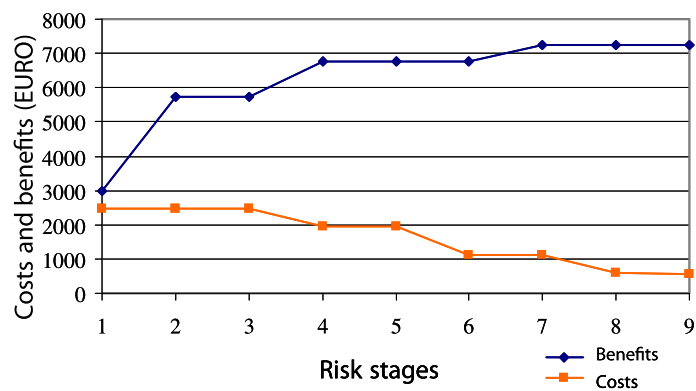


Fig. 5.9. Visualisation of costs and benefits according to risk stages for trucks (*excluding* external costs) (according to Happe and Schmitz 2005)

These tables show: concerning investment in new trucks, any investor would have to be *optimistic* to invest in platoon technology. But it has to be stressed, that external costs are integrated in this estimation. Looking at Fig. 5.8, however, it becomes obvious that the diagram differs and this investment would be fully advisable if those external costs are not included. In this case the benefits-graph is always located above the costs-graph (Fig. 5.9). This structure of the graph is particularly helpful for any safe investment, as has been explained in Chap. 4.

Tractors with semi-trailers achieve only fuel savings of 5 ct/km if participating in a platoon. Therefore the visualized costs and benefits estimation is less favourable as shown in Table 5.10 and Fig. 5.10.

Table 5.10: Estimated benefits for HGV platoons (tractor with semi-trailer)

	Probability that benefits incur								
	high			middle			low		
direct	1.500			0			0		
relative	2.750			0			500		
difficult to ascertain	1,000			500			0		
Risk stages	1	2	3	4	5	6	7	8	9
Accumulated costs in EURO	1,500	4,250	4,250	5,250	5,250	5,250	5,750	5,750	5,750

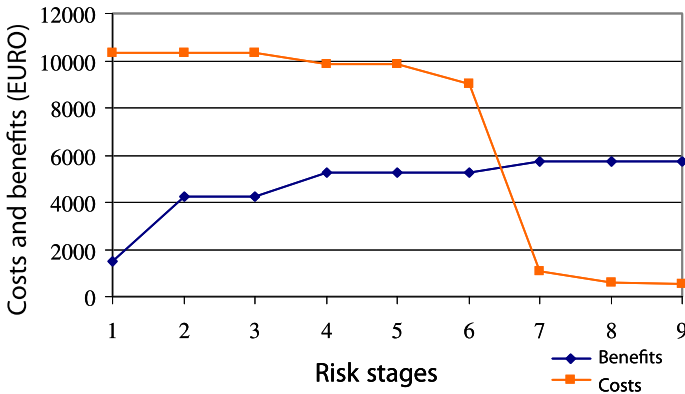


Fig. 5.10. Visualisation of costs and benefits according to risk stages for tractors with semi-trailer (*including external costs*) (according to Happe and Schmitz 2005)

Technological Aspects within the Requirement Specifications

The following subcategories are comprised in the *Technological* aspects (Zambou, Deutsche et al. 2005):

- Information technology
- Human-Machine Interface
- Vehicle and automation technology

They are discussed as follows.

Information Technology

From a technical point of view, all information technologies for platoon operation are available on the market. Recommendations can already be made for the choice of technology for individual methods of communication.

Communication technology for the project M F G will be based on a CAN-Bus, based on SAE J1939. Further bus structures used for observation reasons are, e.g., the so-called Private-CAN (radar or lidar sensors). They have to be connected by gateways. The same applies for image processing camera systems.

A final commitment for inter-vehicle communication technology seems to be difficult because standardisation throughout the whole automobile industry is required. Recommendation is needed for one of the two technologies mentioned here: the UTRA-TDD on UMTS basis, and the IEEE 802.11 on wireless LAN basis. It depends on the countries of the development and the development partners. In Europe the UTRA-TDD technology can be recommended because several car manufacturers have agreed on using this standard for the design of vehicle-vehicle communication.

Mobile networks can be used for the organisation-related communication between the vehicles and their drivers. This offers the advantage that the infrastructure in the car (antenna, connection terminal) is already available. The

range of channels is sufficient here since no real-time capability is required. The network coverage is ensured at least while using motorways. To this end, device adaptations might be necessary if certain standards are used (e.g. cellular phone network standards).

Human-Machine Interface

The ergonomic principles of Human-Machine Interfaces must be taken into account. The present prototype of the Human-Machine-Interface already fulfils all the specifications. It is in principle ready to be implemented (Wille and Debus 2005a). It is recommended to integrate the new devices into the existing technology of the truck panel in order to limit the number of additional devices in the cockpit. Further recommendations for successful integration have already been developed. However, an external device should be used during testing due to technical and economic reasons.

Automotive and Automation Technology

The specifications are dealing with automation technology, automotive technology, the fail-safe concept, and the simulation tool for platoon testing (Zambou, Preuschoff et al. 2004).

The automation systems have to be developed further compared to the present approaches in automation technology, e.g. as they were used in the previous project Promote Chauffeur. These solutions were based on developments in automation technology which are already available. They need close cooperation between the research institutes which have the suitable theoretical procedures available and experiences in their implementation, and those industries which possess more know-how in implementation and safety aspects.

In automation technology and control, the most important components are the actuators. It can be assumed that the most modern generation of commercial vehicles already possess suitable actuators in terms of longitudinal dynamics. For example, the power train is automated, and the gears/gear selector is activated via CAN. The latitudinal dynamics actuators of the vehicle are also available through extension of the existing actuators to automatic steering. Such systems are also already in tests.

Actuators and sensors which register information about the surrounding area are to be integrated. These sensors are divided for *close* and *far range*. For close range, all sensor concepts which are available today are to be taken into consideration (image processing, radar and laser). For observing the far range, radar or laser sensors seem to be most suitable. The necessary periphery sensors for the far range are already being tested (e.g. distance sensors for cruise control applications), while the sensors for close range will be introduced during this research project.

The following recommendations can be deduced on the topic of fail-safe which concerns the most important safety considerations of automatic platoon systems:

- The new system must be clearly defined in order to select the necessary components and to be able to judge their functionality at a later stage.

- The analysis of the system's safety can take place with the help of FMEA and FBA.
- Fallback solutions for the breakdown of components must be installed. They could be realised on individual component level through self-diagnosis, and the subsequent deactivation in case of error. Redundant components are recommended.
- Emergency strategies should be available if the system is crashing. For this purpose, the first task is recognising the mistakes in the system. Moreover, it should be ensured that the electronic components which are still functioning, can perform the corresponding driving manoeuvres.

Legal Aspects

It can be assumed that platoon vehicles must be treated with separate legal terms, different from normal road traffic (Frenz, Lingenberg et al. 2005). In this respect exemptions are to be made in particular from today's distance regulations.

Furthermore, the vehicles must be labelled. The existing regulations about the close association of vehicles are also to be applied to the platoon traffic. In this case new regulation will be supported which covers two or more platoon vehicles as being an association.

In contrast, the need for authorization of every individual case of platoon travel is not convincing. In this respect platoon travel is to be excluded from individual authorization. Therefore, a new regulation is needed for platoon travel. The same applies for the prohibition of overtaking on the right. Finally the attention of the drivers has to be ensured because of further different legal aspects.

Labeling the vehicles can easily take place. The attention of the drivers plays a legal role, especially concerning liability but it can be ensured through certain measures, and through the quality of the Human-Machine Interface. Thus, legal modifications in the liability context apply to platoon traffic (Frenz 2003).

To Come to a Decision

The projects EFAS and M F G were mainly research projects aiming at a substantiated feasibility study. Hence, three scenarios were designed while analysing the system coherences. The scenarios give an overview regarding the value proposition and different value chains. The requirement specifications focused on the feasibility regarding the *Social*, *Economical* and *Technological* aspects, and certain legal aspects. At this point of the project it had to be decided whether it would be reasonable to realize prototypes and prototypical transportations combined with new business procedures (Preuschoff and Happe 2003b). In the following paragraph, the different aspects are listed also concerning the Business Model.

Answering the Questions

Value Proposition: There are two main aspects to be mentioned: Increasing competitiveness of freight forwarding companies, and optimising road transportation.

Value chain: During the research projects EFAS and M F G, it was figured out by using traffic simulation tools⁵ that an increase of 14% traffic capacity can be realized. However, this depends on the number of road obstacles, e.g. construction sites, specific bridges, or changes between four or six lanes. The fuel consumption may be reduced by 10%⁶. The drivers' workload will be reduced due to the fact that the position of the leading vehicle can be switched. Surveys among other traffic participants and freight forwarders suggest high acceptance. It is expected that the technology of truck platoons will increase motorway safety.

Revenue-model: Money can be earned by the reduction of fuel consumption, the decrease of accident probability, and by using the driving hours of the following drivers to prepare, e.g., office work. Logistic concepts have to be adapted to this new technology. At this point it cannot be answered whether further savings are possible. The competitive system is the road-only transportation by individual trucks without platooning. In the PEFB process the reduced flexibility compared to road-only transportation was considered. The result has been favourable for freight forwarders using the platooning approach.

Considering the *Passive Variables*

The *passive* variables stress the *Social* partial-system. They offer the possibility to evaluate further the new technology (Henning, Preuschoff et al. 2003a). Those variables focus on: *acceptance*, *risk*, *workload*, *environmental effects*, *costs* and *savings*. The *acceptance* was shown to be high but it has to be analysed in more detail by using an advanced driving simulator which is especially adapted to truck platoons. No *increase* of risk may be assumed. But risk has to be further analysed using the special advanced driving simulator. The *workload* of the *leading driver* has to be analysed using also the special driving simulator adapted to truck platoons. The *workload* of the *following driver* will be reduced compared to conventional truck driving. But it has to be kept on an appropriate level, e.g., by conducting office work inside the truck. Considering the value chain the favourable *environmental effects*, *costs/savings* were already described. So far the optimum solution seems to be to have the platoons organised by the drivers themselves.

The results of the requirement specifications are summed-up in Fig. 5.11. On this basis it was decided to continue the development of HGV platoons.

⁵ Parallel Microscopic Simulation (PARAMICS).

⁶ Simulation tool: PELOPS.



Fig. 5.11. The main results of the requirement specifications

5.2.6 The Interfaces (Step 6)

System Specifications

The research project KONVOI was started in the year 2005. Objectives are to define the system specifications, to develop the prototypes, and to conduct first tests on German motorways. Certain aspects will be highlighted in the following paragraph.

So far the evaluation of the project has used the passive variables. It has stressed the need for further inquiries using a certain driving simulator adapted to HGV platoon testing. This simulator – InDriveS – will be described in the subsequent case study. The *Social* aspects are to be considered according to the requirement specifications. Hence, simulation procedures were designed and are being conducted. Those will offer a closer view on the workload of the *leading driver* and the *following drivers*. Furthermore acceptance and necessary IT support will be investigated. The electronic device Organisational Assistant

will be a main contribution in the project. The design of the Human-Machine Interface of this Organisational Assistant is presented in Fig. 5.12.

The integration of the different prototype components is shown in Fig. 5.13. It will be further explained in the following case study.

The software and hardware components are based on the requirement specifications. They are visualized in Fig. 5.14.

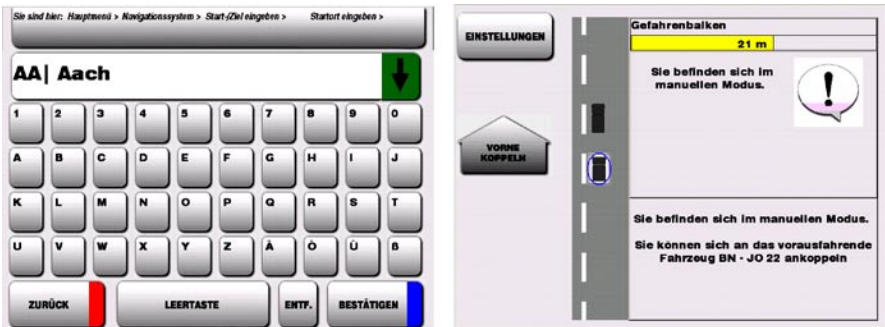


Fig. 5.12: The Human-Machine Interface of the Organisational Assistant (Wille 2006)

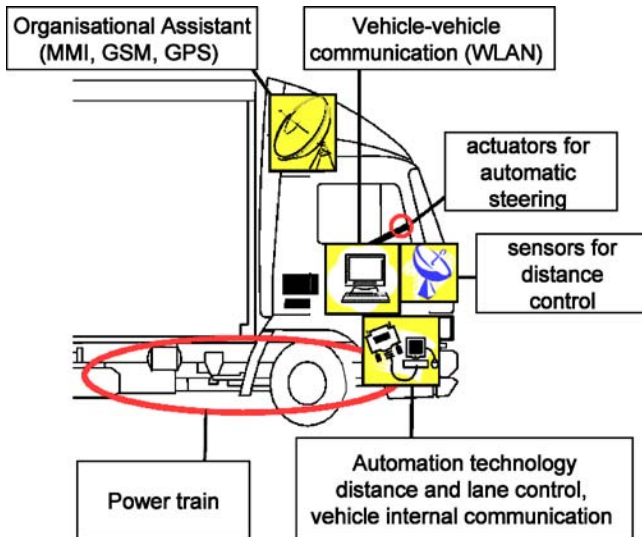


Fig. 5.13. The prototype design including add-ons for truck platoons (Friedrichs 2006)

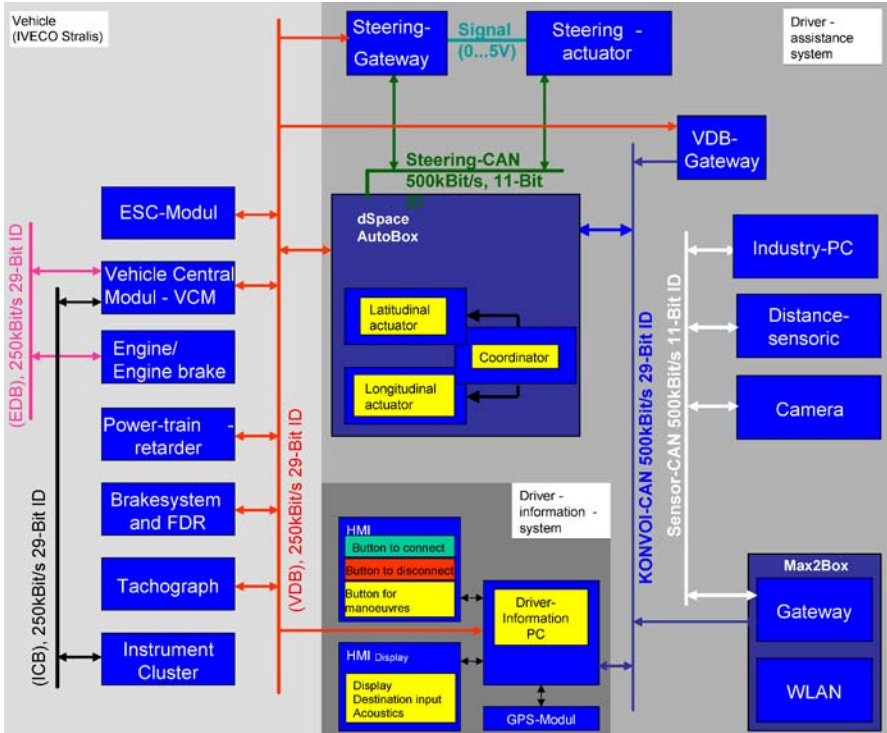


Fig. 5.14. Software and hardware components for truck platoons (according to Deutsche 2006)

5.2.7 Designing Prototypes, Efforts to Achieve Testing Accreditation (Step 7)

The prototypes of truck platoons will do first tests on German motorways in 2008. However the consortium is confronted with decisive problems regarding necessary permissions in order to test the prototypes under commercial conditions.

So far, the sequence of the three research projects EFAS, M F G, KONVOI has been described. These projects have led to a new understanding of the complex problems to be dealt with if industry goes ahead in putting truck platoons into practice. Such innovation would definitely need strong innovation management even far beyond first test runs of such platoons on any motorway. Hence the need has become obvious to test truck platoons in a special simulator laboratory under conditions close to reality on motorways. This task can be considered most challenging. It is described in the following chapter.

5.3 The Interactive Driving Simulator

5.3.1 The Need to Simulate Truck Platoons (Step 1)

Understanding the System

Objective of the Research Project

The setting-up of the Interactive Driving Simulator (InDriveS) was motivated by the findings gained in the research project considering the introduction of truck platoons on motorways. In those sequential projects it had become obvious that the complex technology of truck platoons would need to be thoroughly tested in this special simulation laboratory (Preuschoff and Friedrichs 2004).

For the design of this laboratory the *passive* variables – according to Vester (1995) – appeared helpful since they deal with the acceptance of platooning across society (Fig. 5.6), among other issues mentioned.

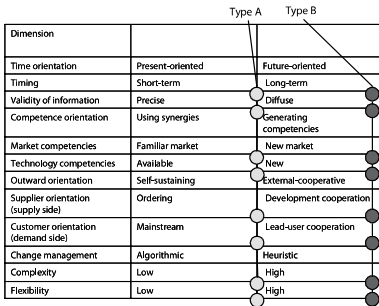
The *passive* variables had been ascertained in the previous research project as they are related to platooning. They were identified in order to evaluate the system KONVOI when it would be put into practice. Those *passive* variables stress the topics:

- acceptance by the other traffic participants,
- acceptance by truck drivers, acceptance by freight forwarders/shauliers,
- risks regarding the other traffic participants,
- workload of the leading driver,
- workload of the following driver.

The variables imply to investigate thoroughly the *Social partial-system* (e.g. workload, acceptance), the *Economical partial-system* (e.g. organisational and operational demands, effects on the surrounding traffic, provoked risks) as well as the *Technological partial-system* (e.g. information technology, Human-Machine Interface, as far as possible: automation technology).

Hence the driving simulator InDriveS should be realized as an innovative approach. Simulations of both the driving itself and the surrounding traffic should be combined. In this simulation, the drivers' behaviour would be influenced by the traffic conditions in real time. In parallel, the drivers' actions and reactions would have impact on the surrounding traffic (Preuschoff and Große-Kappenberg 2004a; Preuschoff and Große-Kappenberg 2004b). The author of this volume (Eva Savelsberg, maiden name Preuschoff) was responsible for the scientific concept, the development and the building of the simulation laboratory until the end of 2004.

Expected characteristics of the start-up situation of the innovation processes



The following list describes the expected characteristics of the start-up situation of the innovation processes according to the coordinate systems of Eversheim (2003). These characteristics are visualized in Fig. 5.15.

Time orientation – Square I

The objective is to develop a combined simulation laboratory in a ready-to-use version during the period of one-and-a-half year (Timing, *short-term*). Hence, the simulator can be used during the project KONVOI. It was obvious that after this development period decisive improvements would be gained.

One university institute, one vehicle engineering company and one HGV engineering company were considered to be involved. A new software system had to be developed and connected with an existing software system as well as with the vehicle cabin technology (Validity of information). At that time even most competent research communities did not know how to do it. Hence, the project started with an intensive period of inquiry and as a trial-and-error approach. The simulator should be used to test essential topics of the research project KONVOI. Those test scenarios were not listed in detail yet. They would be developed in parallel to the set-up of the simulator. Hence the validity of information of the start-up situation can be estimated as being *diffuse*.

Competence orientation – Square II

It was a major aim of the project to realize this system which would be attractive for a new market beyond its use for platoon testing (Market competencies). Otherwise the financing of further improvements and the general expenses would have been difficult. Demands had to be collected and customer clusters had to be described. Hence, the gain of market competencies was high.

At the project start an advanced simulation tool existed to simulate certain actions of drivers, aspects of the driver's environment, and the vehicle. But no experience existed regarding the following topics: how to visualize the results of the simulation process continuously; how to combine this existing simulation with the behaviour of a real driver sitting in a truck cabin; and how to feed back the results of the simulation into the truck cabin of the simulator (Technology competencies). Furthermore, requirements of the *Social* and the *Economical* partial-systems of the research project KONVOI had to be considered during the rapid-prototyping process. Additionally, a new market for the simulator was defined and would attract other customers. Thus, successful simulator applications would raise new demands. These would have to be answered by the

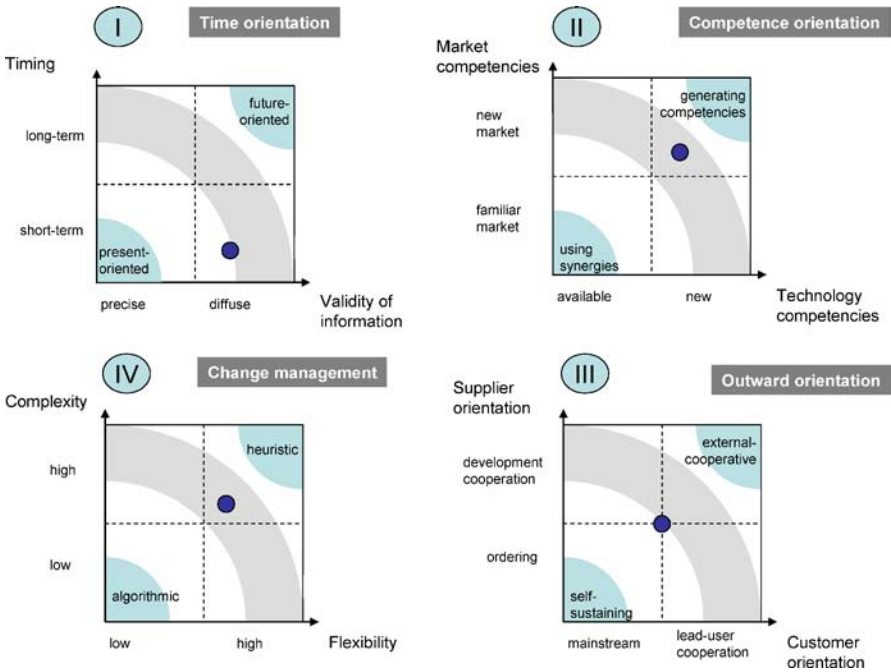


Fig. 5.15. Visualisation of the start-up situation of the innovation process (InDriveS)

development team at once if necessary. Although IT-competence was available, a proper truck simulator had to be realised ahead of the up-to-date technology. The gain of technology competencies was rated *high*.

Outward orientation – Square III

Only two suppliers worked together (Supplier orientation). But this cooperation was very intensive. Hence, the supplier orientation is rated to be a *moderate development cooperation*.

Two lead-users were involved: the HGV-engineering company and the consortium of the project KONVOI (Customer orientation). All research results were discussed in detail with the demand side of the project KONVOI. Hence, a strong *lead-user cooperation* was realised.

Change management – Square IV

The rapid prototyping approach to software development allows to handle complexity (Complexity). The technological innovation was demanding and the development cooperation and the lead-user cooperation were under high pressure. The simulator would have a decisive impact if it could be established on the market. Hence, the complexity can be rated *fairly high*.

Because of the challenging time table and the diverse contributions of the members of the consortium the strategy has to be adjusted flexibly to new results (Flexibility, *high*).

These different aspects are summarized in Fig. 5.15.

The four coordinate systems are merged in the way described in Chap. 3 (Fig. 5.16). The characteristics are at the inner positions of the concentric ring element as well as within this ring element. The characterisations based on the different dimensions suggest a *Moderate Innovator* (Type A Innovation). The simulation itself has no decisive effect on the traffic system. Only the products tested in this “virtual reality”, e.g. the truck platooning support systems, have impact on the traffic in reality. Hence, it was recommended to leave out Step 4 of the Innovation Management Method discussed here (Fig. 5.17). It was pointed out that during this technological innovation process, there had to be a strong focus on the *Social* and the *Economical* partial-systems. The software development process was based on rapid prototyping. Therefore the requirement specifications were in parallel transferred into system specifications and included in the continuous development process (Henning, Savelsberg et al. 2004; Große-Kappenberg 2006). In the following paragraph, the different steps to be performed are described as a first project overview.

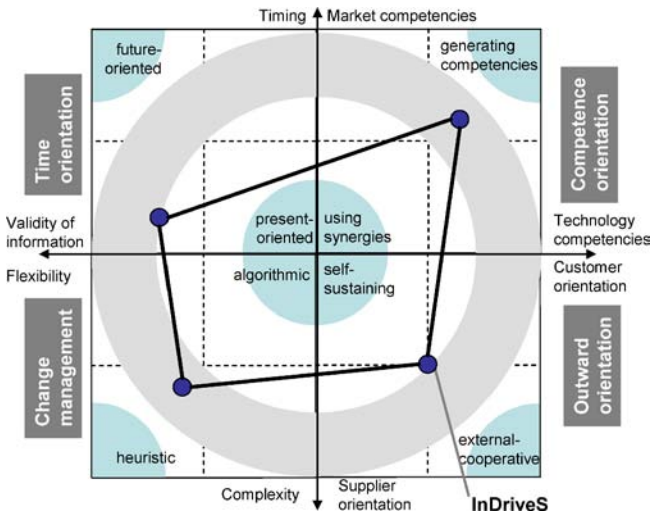


Fig. 5.16. Combined visualisation of the start-up situation of the innovation process (InDriveS)

Recommended Steps of the Method

Due to the characteristics of the *Type A Innovation*, moderate development cooperation and lead-user cooperation are recommended (Step 2) (Fig. 5.17). This project deals with developing a new technological product to be established on the market. Hence Step 3 is expected to be important. The development of the *Business Model* is started with Step 3. It will continue at least until Step 6 is finished.

A *Type A Innovation* has to be realized. As pointed out before, it is recommended to leave out Step 4. Due to the way of rapid-prototyping programming Steps 5 and 6 are combined. After one and a half years, first tests have to be conducted (Steps 7 and 8). The laboratory will be continuously improved over the following years. Some improvements will be decisive.

Here the development team has to focus on *migration* right from the beginning due to the fact that the financing of the laboratory has to be ensured.

After this overview, the description of the different steps in detail is continued as follows.

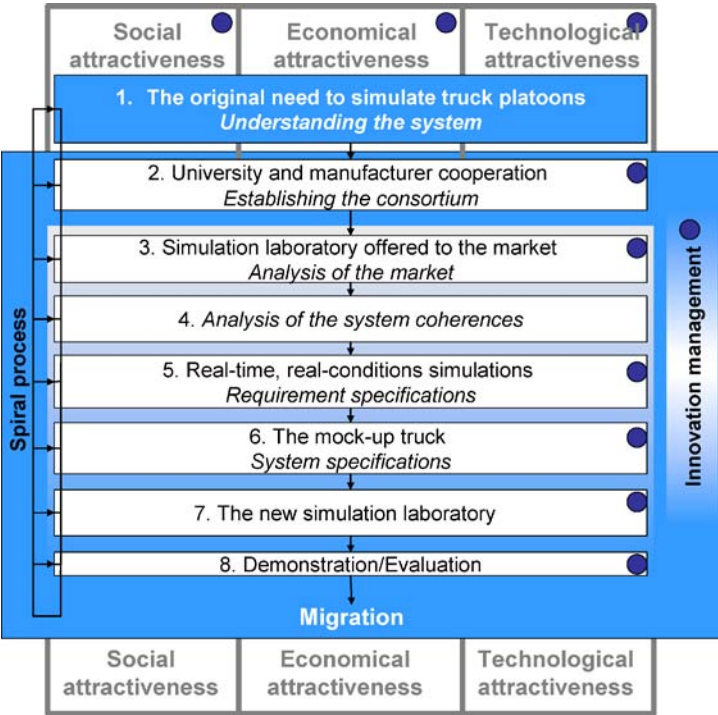


Fig. 5.17. Recommended steps to be accomplished in the research project InDriveS

5.3.2 University and Manufacturer Cooperation (Step 2)

Establishing the Consortium

The consortium included the *Department of Computer Science in Mechanical Engineering (ZLW/IMA)* as the university institute performing the research and development to establish this simulation laboratory. The *Forschungsgesellschaft Kraftfahrwesen Aachen mbH (fka)*⁷ and the truck producer *MAN Nutzfahrzeuge AG*. MAN donated a genuine truck cabin to be included in the simulation area. They also made available the necessary truck control knowledge to integrate the cabin technology into the simulation technology.

5.3.3 Simulation Laboratory Offered to the Market (Step 3)

Analysis of the Market

This system should offer the possibility to test a thoroughly innovative technology (KONVOI). The tests should be performed meticulously and in a save way (*value proposition*). In the beginning it was decided to realise a *static simulator* with the cabin not moving in parallel to the driving processes (*value chain*). By using this static simulator it would be possible to conduct all necessary tests. The economic risk to develop this kind of simulator was calculable. Later on, however, movement of the cabin is expected to be added in order to turn the simulator into a *dynamic tool*.

Furthermore it was considered to offer in the future various interesting applications beyond platoon testing. Hence a passenger car cabin as well as the truck cabin should be made available within the simulation laboratory. In parallel to the development process potential customer clusters were identified. Those were, e.g., truck driving schools, and insurance companies. For the latter, it should be possible to analyse accidents and to record all data by using the simulator (Preuschoff and Große-Kappenberg 2004a; Preuschoff and Große-Kappenberg 2004b). The main customer group would be producers of automation systems like ADAS (*revenue-model*). Those could test their own devices *in the loop* integrating real human drivers. Last but not least the simulator would be important for other university institutes. Benefits by offering different kinds of services were calculated as well as the costs, e.g. caused by the continuous technological development of the simulator, or the rent for the facilities.

⁷ Vehicle research and engineering.

5.3.4 *Real-Time, Real-Conditions Simulations (Step 5)*

Requirement Specifications

Here the requirements for the simulation laboratory are discussed. Computer-based simulations are especially used to test ADAS, sensors and actuators. Developments and testing based on such virtual driving offer the possibility to test software-in-the-loop (SIL) and hardware-in-the-loop (HIL) under stress conditions. This approach saves time and money. It improves safety since IT-systems are released only when obtaining a high degree of reliance.

In common driving simulators, however, those tests of SIL-tools and HIL-tools do not yet allow the IT-system to take sufficiently into account the vehicle itself, the surrounding traffic, furthermore the weather and the real drivers' behaviours (action/reaction). Therefore the requirements regarding the Interactive Driving Simulator (InDriveS) aim at the following aspects (Friedrichs, Savelsberg et al. 2005):

Integrating the Driver into the Simulation Process:

InDriveS will allow testing the driving behaviours of test persons in real time. Their reactions in specially designed events can be observed and reflected. Regarding the project KONVOI the simulator will support the analysis of burden and stress of both the *leading* and the *following* truck drivers, e.g. adaptation, time of reaction, danger of accidents. Furthermore the drivers' acceptance will be evaluated. The Organisational Assistant (Human-Machine-Interface) will be checked with respect to its design and ergonomics.

Possibility to Experience and Analyse the Simulation:

Visualisation based on interactive 3D video recording allows to integrate the following persons into the analysis and reflection of the tests: the test persons themselves, the scientists, the testing companies, operators of the simulator and the software developers. It will be possible to recall and analyse the driving process from every user-defined perspective.

Data Interpretation of the Impact and Effects on the Surrounding Traffic:

The impact of the truck platoon on its surrounding traffic can also be examined. The flow-rate of the traffic, traffic density as well as travel speed and duration can be changed and evaluated. Furthermore data concerning acceleration, fuel consumption and emission will be gained.

Testing under Different Weather Influences:

It is possible to simulate, e.g., rain, fog, snow and ice on the road.

Data Interpretation of the Vehicle and Automation Technology:

Variables of the simulation models can be examined. Those variables are, e.g., position of the brake pedal, throttle, engine speed, torque, and the gear rate.

These data are important for the design of the whole technological system, e.g. control algorithms and control units.

Software development should be based on specific human-oriented development processes (Henning and Kutscha 2003). Thus, the focus in the simulation laboratory is not only on how to develop the new software; but one emphasis is on how to realize software innovations for traffic applications which are ahead of the mainstream. Therefore this specific software development process is being used to reach the ambitious aims with the aid of InDriveS. The innovation coherences are explained correspondingly in the next paragraph as they are embedded into their broader context.

5.3.5 The Mock-Up Truck (Step 6)

System Specifications

For the simulation laboratory an already established simulation tool was used as the starting design. This traffic-flow simulation tool PELOPS offers a sub-microscopic model of vehicles in traffic, and a microscopic model of traffic-related data (Fig. 5.18). The tool focuses on the aspects route/environment, driver and vehicle (Fig. 5.19) (Wallentowitz, Debus et al. 2003). Different vehicles are modelled into PELOPS as parts of the environment. Thus, PELOPS is not designed for real-time applications, nor does it integrate real drivers into the simulation process while taking into account the microscopic traffic flow. To realise those aspects a special vehicle mock-up was created and extension of the software was developed.

Hence, the objective of the system specifications for InDriveS was to build the mock-up of the truck

- based on a real truck cabin,
- equipped with all controls and features of the real truck, and
- offering open view through the windscreen and the backward mirrors on the virtual motorway. This motorway was to be projected by several beamers and two PCs.

Furthermore the software was extended to allow real-time movements of all other cars and trucks on the motorway within the simulation. The traffic flow would also change in response to the actions of the test truck driver in his virtual (mock-up) truck. A first draft of the prototype was already presented in the preceding case study (Fig. 5.13).

In this InDriveS prototype, the interface between the truck cabin and the traffic-flow simulation PELOPS is realized by a CAN-bus through the first computer mentioned. Here data of every control unit and sensor are collected and utilized. Information like steering movements, acceleration, direction indicators etc., is collected by the CAN-bus of the vehicle mock-up. The data are

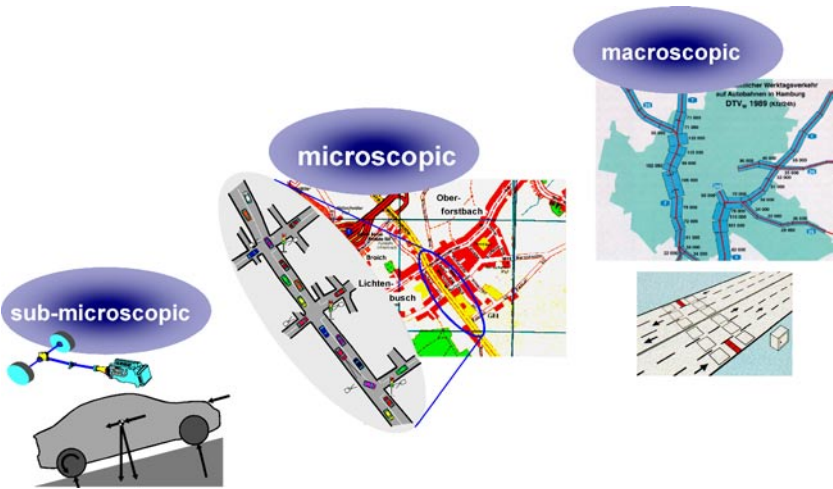


Fig. 5.18. Possible traffic-flow simulations (according to Deutsche 2006)

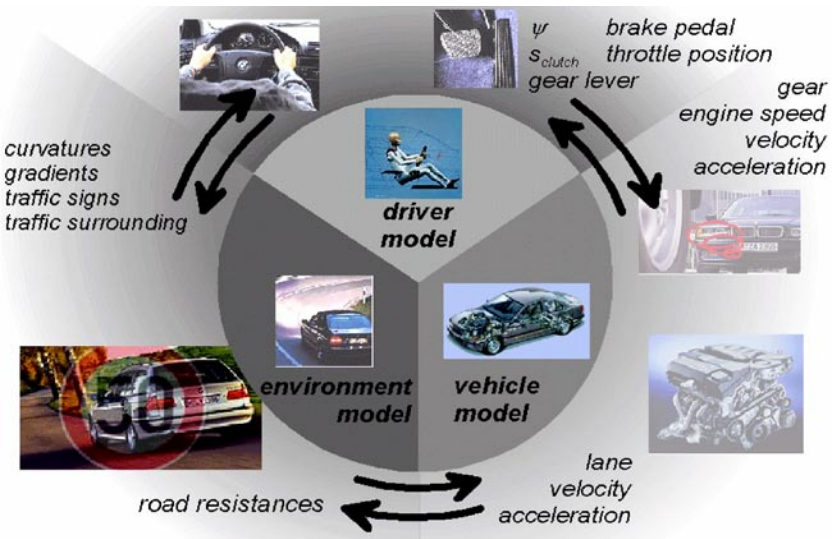


Fig. 5.19. Traffic-flow simulations PELOPS (according to Deutsche 2006)

delivered to the vehicle model of the traffic-flow simulation. Data used for the dashboard – like speed and torque – are transferred back by the CAN-bus to the truck mock-up.

A second connected computer realizes the visualisation. The driving-simulation software NIOBE offers the possibility to integrate the driver as a person (the human in the loop) into the simulation process.

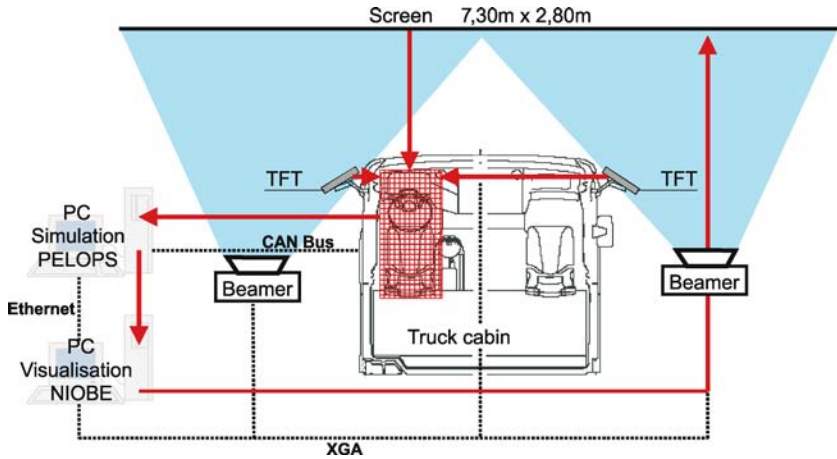


Fig. 5.20. The layout of InDriveS (Friedrichs 2006)

Summing up, InDriveS consists of the visualisation software NIOBE, and the integration of driving simulation and mock-up with the traffic-flow simulation PELOPS. Essential information like route/environment (profile of the landscape, curving) and different vehicles (position, speed etc.) are processed in real time. Two beamers allow the front view out of the vehicle. The backward traffic can be observed on two flat screens used as side mirrors (Fig. 5.20).

All features of this truck simulation can also be used for simulating the driving of a passenger car along the motorway in real time. For that purpose the mock-up of a passenger car has also been integrated into the InDriveS simulation laboratory.

5.3.6 The New Simulation Laboratory, Ongoing Improvement (Step 7 and 8)

Designing the Prototype, Demonstration and Evaluation

The new simulation laboratory InDriveS is characterized by ongoing improvement based on its high modularity. In the beginning it was already predictable that the demands would rise particularly regarding the motorway visualisation and the sound system. Therefore it is possible today to integrate further computers for such improvements. The hardware/software-in-the-loop tests can be conducted by using three different interfaces. The TCP/UDP-interface offers to test MATLAB/Simulink models of the vehicles, the sensors and control-units. The CAN-bus and RS422-interface make it possible to connect control units, actuators and dSpace-tools (Autobox). Hence, Rapid Prototyping models can be integrated into the simulation.

A view out of the front window of the truck cabin is shown in Fig. 5.21 and Fig. 5.22.

First of all, the Organisational Assistant (OA) used in the project KONVOI (Friedrichs 2006) needed to be tested. The tasks conducted by this device were already explained in the preceding case study. This development and testing of the OA has been the decisive evaluation of the quality of InDriveS. The software and hardware design will be explained in short in the following.

The main important element of the Organisational Assistant is the InCar-PC (Fig. 5.23) (1) (Friedrichs, Savelsberg et al. 2005). This PC comprises the software to develop the necessary algorithms for data management, truck navigation and the organisation of the platoons. Different components are connected by a wiring harness (2). Interfaces are, e.g., RS232, USB, energy supply, audio-in and audio-out. The GPS-module (3) for offering satellite navigation is connected via USB-interface. The communication between the vehicles is realized by GPRS-/GSM-modem (4). The communication towards the vehicle



Fig. 5.21. Virtual Reality of NIOBE – driving view (left) and top view (right)



Fig. 5.22. Simulation of different weather conditions

With these developments and tests, the simulator has shown its potential to support complex innovation processes. Thus it can be considered a substantial contribution to innovation management and migration of ambitious technical innovations.

The third research project of this Field of Action *Innovative Technologies* is the project FlexCargoRail which is described in the following section.

5.4 Individualized Single-Wagon Door-to-Door Rail Transport

5.4.1 The Decreasing Single-Wagon Business (Step 1)

Understanding the System

Objectives of the Research Project

The objective of *individualized single-wagon door-to-door rail transport* is to raise the attractiveness of the single-wagon transport business on rail. Therefore innovative, *partly automated wagons with an integrated power unit* will be developed. Those can serve the customers for door-to-door freight transport. This concept is based upon the research of Frederich (Blum 1993; Frederich 2001).

The project FlexCargoRail will improve the profitability of siding tracks (Fig. 2.4). The consortium of FlexCargoRail is convinced that this technology will have a decisive contribution to harmonisation of the modal split and therefore, to the stabilisation of the transportation system. The project FlexCargoRail is embedded in a large-scale project which evaluates possibilities of innovations regarding the single-wagon transport business.

The following statements reflect the convictions of the consortium participants (2005):

“I have said it for about 20 years now that we need to change over from freight wagon within a train, to the high-technology wagon”.

(Siegmann, TU Berlin)

“Already in 1987, we had the idea of individual freight wagons running 500 km across the country with about 40 km/h and with no stops or halts in-between”.

The research project is funded by the German Federal Government (BMWi). The Government is interested in the harmonisation and stabilisation of the modal split. Particularly the cutback of siding tracks taking place at present, endangers this ambition. This technology which raises especially the economic attractiveness of an area-wide rail service, would help to stop this development (Preuschhoff, Happe et al. 2003; Savelsberg 2006a). The author's role in the project was to submit the proposal and to suggest the project approach particularly regarding the economic evaluation of the project FlexCargoRail.

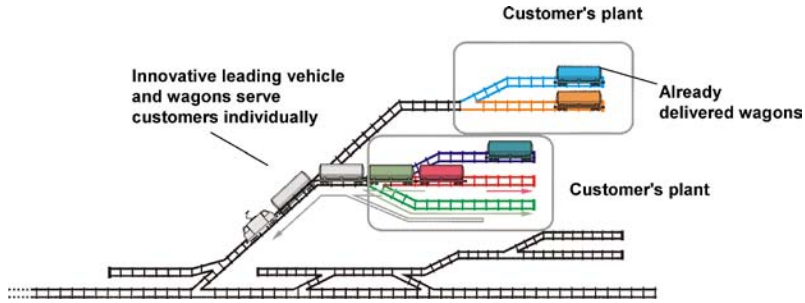


Fig. 5.25. Example of a railway siding track configuration (FlexCargoRail 2006)

Expected Characteristics of the Start-Up Situation of the Innovation Processes (Tool 1)

Dimension	Type A	Type B
Time orientation	Present-oriented	Future-oriented
Timing	Short-term	Long-term
Validity of information	Precise	Diffuse
Competence orientation	Using synergies	Generating competencies
Market competencies	Familiar market	New market
Technology competencies	Available	New
Outward orientation	Self-sustaining	External-cooperative
Supplier orientation (supply side)	Ordering	Development cooperation
Customer orientation (demand side)	Mainstream	Lead-user cooperation
Change management	Algorithmic	Heuristic
Complexity	Low	High
Flexibility	Low	High

The innovation process of FlexCargoRail will consist of two sequential research projects. In the following paragraphs, those are named FlexCargoRail I and II. The first sub-project is mainly a feasibility study. It will be finished in one year. The second sub-project will only be started if the results of the first one are promising. This succeeding project will probably need another three to four years.

The following list of issues describes the expected characteristics of the start-up situation of the innovation processes according to the coordinate systems of Eversheim (2003). The characteristics are visualized in Fig. 5.26.

Time Orientation – Square I

The objective is to develop a new technological solution. If approved, both sub-projects FlexCargoRail I and II will probably be conducted in the next *five* years (Timing, in between *short-term* and *long-term*).

The new technology will have *decisive impact* on the long-distance freight market (Validity of information). The *consortium* includes different institutes. They might see developments from different angles. Information has to be exchanged and discussed as a continuing process. Regarding the envisaged technology the solution space is narrowed down. Nevertheless, *surveys* and *meticulous analysis* have to be conducted for necessary further information. Hence the validity of information is rated *diffuse*.

Competence Orientation – Square II

The objective is to optimize rail transportation in order to regain German/European freight market shares. Everybody is familiar with the market (Market

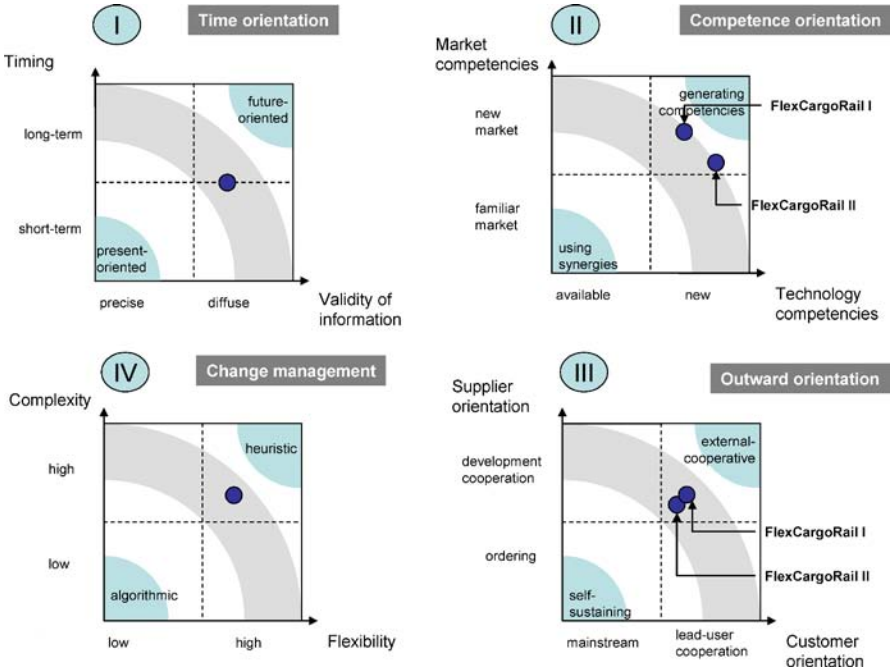


Fig. 5.26. Visualisation of the start-up situation of the innovation process (FlexCargoRail I and II)

competencies). Nevertheless, this technology will have *decisive impact* on the market. Hence, detailed information about the probable market response has to be gained. A *Business Model* will be one of the most decisive products of the first sub-project. *Customer clusters* have to be designed. Hence the *competitiveness* of the technology can be assessed. The further gain of market competencies is *high*. This applies especially to FlexCargoRail I.

The technological solution suggested is a challenging innovation (Technology competencies). Defined technology competencies are in principle available but it is necessary to find migration-oriented solutions. Hence *holistic knowledge* has to be established. Therefore, numerous companies have to be involved and new kinds of knowledge have to be gained and integrated. The partial-system *Technology* has to respond to the requirements of the *Social* and the *Economical* partial-systems. Hence, the gain of technology competencies will be *high*. This applies especially to FlexCargoRail II.

Outward Orientation – Square III

A strong and broad cooperation has to be realized (Supplier orientation). The first of the two sub-projects is rather research-oriented. All research results will be intensively discussed with suppliers who will be involved during the second project. Several representatives of the supply side will be part of the consor-

tium of the second sub-project. It will lead to stronger outward orientation (*development cooperation*).

All results will be discussed in detail with customers who will be involved during the second sub-project (Customer orientation). Several representatives of the demand side will be part of the consortium of the second project (*lead-user cooperation*).

Change Management – Square IV

The involvement of *numerous research institutes, administrative institutions and companies* increases complexity decisively (Complexity). A *challenging technology* is approached. The new technological system has *decisive impact on the market* and therefore on *business approaches*. The complexity can be rated *high*.

The strategy has to be adjusted flexibly to new results because of the challenging time table (Flexibility: *high*).

These aspects are shown in Fig. 5.26.

The four coordinate systems are merged in the way described in Chap. 3 (Fig. 5.27). The characteristics are within as well as at the outer area of the ring element. The characterisations based on the different dimensions suggest a *Thorough Innovator*. Hence, all steps of the method are recommended to be performed in conducting these two projects (Fig. 5.28).

In the following paragraphs, these different steps are described as a first project overview.

Recommended Steps of the Method

Due to the characteristics of the *Type B Innovation*, strong development cooperation and lead-user cooperation are recommended (Step 2). Step 3 aims at developing innovative, *partly automated wagons with integrated power unit*. Thus it should be achieved to conduct a substantial market share of transportation with those wagons. Hence, the project has to have a strong focus on the competitiveness of the technological solutions in comparison with road-only transport. The gaining of information and the design of the *Business Model* are made easier since lead-users should be part of the consortium.

The development of the Business Model is started with Step 3. It will continue until Step 8. The *partly automated wagons* will have decisive input on the market and on the processes of rail transportation. It means a *Type B Innovation* has to be realized. Hence, it is necessary to accomplish Step 4. There is no set solution space in the beginning. *Comprehensive knowledge of the system coherences* has to be achieved in order to establish the *shared view of the transportation system* among the different parties, to develop *appropriate solutions*, to *evaluate* those and finally, to *choose a technological design* which can successfully *migrate into the freight transportation system*.

The Business Model will be decisively elaborated within the requirement specifications (Step 5).

Each technological feature and the *partly automated technology* system in general, have to be checked on their effects considering the demand side of

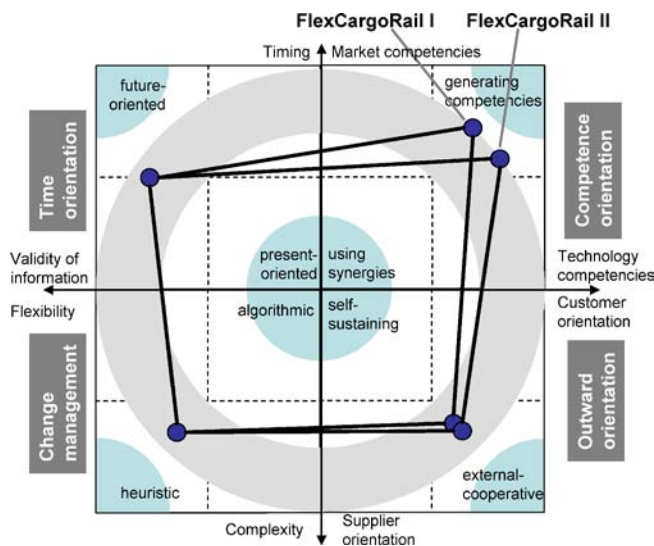


Fig. 5.27. Summarized visualisation (FlexCargoRail I and II)

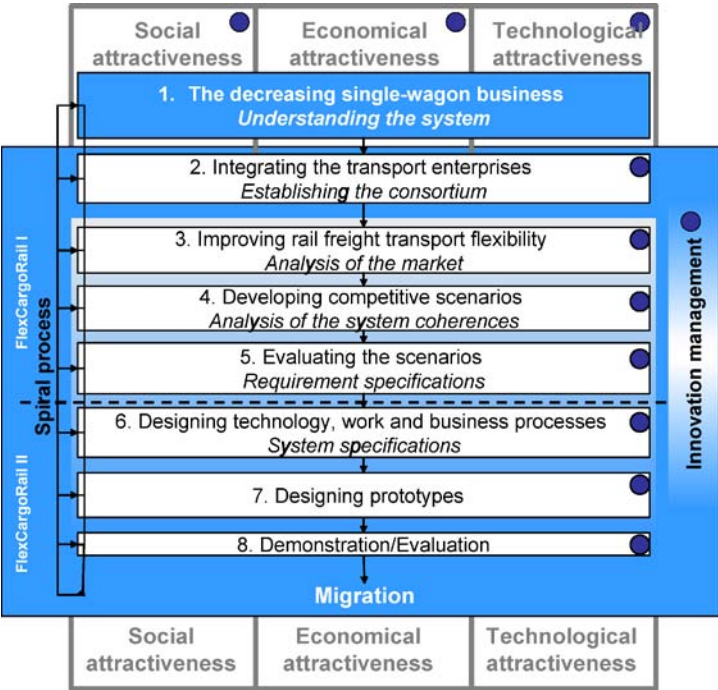


Fig. 5.28. Recommended steps to be accomplished during the research project (Flex-CargoRail I and II)

transportation products. The system specifications describe in detail how the requirement specifications will be realised (Step 6). It needs a subsequent project to be approved in order to have the prototypes being built (Step 7). Demonstration and evaluation are important for gaining information about the *Technological* and *Economical* attractiveness of the innovative technology (Step 8).

These steps are summarized in Fig. 5.28.

Specifically the sub-project FlexCargoRail I will be divided into the following four thematic parts:

- Scenarios (system coherences: Sensitivity Analysis – Tool 3, Scenarios – Tool 6),
- Operation specifications and simulations (requirement specifications),
- Realisation of the concept concerning the vehicle itself (requirement specifications), and
- Economic evaluation (collecting of data in parallel to the other project elements: PEFB process – Tool 9).

The institute IRT of the RWTH Aachen was chosen to organize the innovation management of these thematic parts of the sub-project FlexCargoRail I.

After this overview, the description of the different steps in detail is continued, as follows.

5.4.2 Integrating the Transport Enterprises (Step 2)

Establishing the Consortium

FlexCargoRail I is conducted mainly by four different university departments in cooperation with three companies and one administrative institution.

Universities:

- RWTH Aachen University (Rheinisch-Westfälische Technische Hochschule Aachen)
- Technische Universität Berlin
- Technische Universität Braunschweig
- Technische Universität Dresden

Companies:

- Siemens AG – Transportation Systems, Erlangen
- Railion Deutschland, Mainz
- Faiveley Transport, Remscheid

Administrative Institution:

- Association of German Transport Enterprises (VDV Verband Deutscher Verkehrsunternehmen)

5.4.3 Improving Rail Freight Transport Flexibility (Step 3)

Analysis of the Market

Questions to be Answered

Value Proposition: The research project FlexCargoRail will eliminate the operational disadvantages of the single-wagon business which exist up to today. The new technological system of *partly automated wagons with integrated power unit* will allow higher flexibility and improved efficiency regarding planning and conduction of logistic processes.

Value chain: Analyses of the value chain in transportation innovation are still strongly technology-oriented. During this particular project the *Social* and *Economical* aspects will be equally focused on. To give orientation of the status quo the technological considerations are presented in the following paragraphs (FlexCargoRail 2006).

First Considerations Regarding the Technological Aspects of the Value Chain

Any freight transport arrangement of FlexCargoRail will consist of two vehicle types: one *leading vehicle* and several *freight-carrying wagons* comparable to conventional wagons.

The *leading vehicle* can be compared with the conventional train engine. However, it offers only reduced traction. Hence, the leading vehicle can pull only a few conventional wagons. It comprises wheel-connected electric motors, acceleration/braking control devices, traction converter and the remote-control unit (Fig. 5.29).

The *freight-carrying wagon* is powered by electricity based on a battery (rechargeable units, here called *Akku*) (Fig. 5.30). On siding tracks this wagon can be steered individually by remote control. Besides the automated movement this control offers the possibility to use this wagon like a small train engine as commonly used for shunting procedures.

A full train of this innovative transportation system consists of one *leading vehicle* and a certain number of the innovative, partly automated *freight-carrying wagons* with integrated power units. While moving in a coupled convoy the leading vehicle controls the following freight-carrying wagons. The leading vehicle also powers these wagons. During stretches of the route which make peak power necessary the batteries of the innovative wagons will be activated additionally.

This technology offers the possibility to conduct the main haulage with coupled units similar to conventional trains. It is even possible to mix conventional wagons with these partly automated ones. However, on the siding tracks the new wagons can be moved automatically, and individually controlled by remote control. Furthermore they can even shunt conventional wagons. Hence, a door-to-door transport of those innovative wagons can be realized. Even conventional wagons can be brought along as individual transport units being pulled by these new wagons.

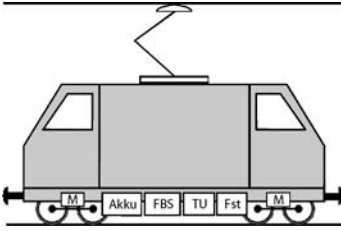


Fig. 5.29: Leading vehicle (M: motor, FBS: acceleration/brake unit, TU: traction converter, Fst: remote control)

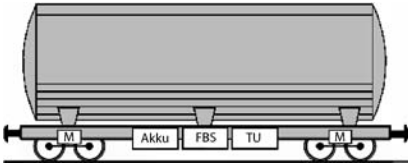


Fig. 5.30: Partly automated freight-carrying wagon (M: motor, FBS: acceleration/brake unit, TU: traction converter) (FlexCargoRail 2006)

5.4.4 Developing Competitive Scenarios (Step 4)

Analysis of the System Coherences

The next future step to be performed in this research project, is to develop a mutual view of the system coherences among the members of the consortium. Hence the Sensitivity Analysis (SA) will be conducted. Three different scenarios (ST) will be developed based on the information gained. Those might come from different customer clusters (e.g. large production plants, KEP services).

5.4.5 Evaluating the Scenarios (Step 5)

Requirement Specifications

The three scenarios will be evaluated by the PFEB process. Therefore further experts and potential users (demand side) of the new system will be invited. One scenario will be chosen for further research. The Business Model of this system will be completed for the most attractive scenario.

In the future, this Type B Innovation will have decisive impact on the structure of work places and working procedures as well as on business approaches. Therefore it is necessary to put a strong emphasis on each of the partial-systems.

5.4.6 *Designing Work and Business Processes* (Steps 6, 7 and 8)

System Specification => Demonstration

After finishing FlexCargoRail I and presenting promising results, the consortium will apply for the second research project FlexCargoRail II. It will focus on the realisation and migration of these partly automated wagons with integrated power units.

Three Levels of the Migration Concept – Focused on Technology (Enning and Berger 2006)

In general the planning of migration in freight transportation innovation is focused on resolving technological problems. In this specific research, this view has to be balanced by also considering the *Social* and *Economical* aspects during the two projects FlexCargoRail I and II.

Here the migration concept will be preliminary discussed mainly considering technology aspects. This concept can be divided into three levels. Those are presented in the following paragraphs.

Level 1 – small-scale usage:

- Introduction of the partly automated wagons with integrated power units which can realize 80 km/h.
- During the main haulage the innovative freight-carrying wagons are part of conventional trains (charging of batteries).
- The customer can pick up the FlexCargoRail wagons at the connection point of the siding track and the main tracks and move them individually to their final destination.
- Additionally the FlexCargoRail wagons can conduct shunting of conventional wagons.

Revenue-model: Customers connected to main tracks can now be served separately and individually by the new individually powered wagons, after conducting the main haulage. Hence, the distribution time is reduced and more deliveries per day are possible.

Level 2 – substantial usage:

- Customers with a regular high amount of freight can use a certain number of FlexCargoRail wagons. Short distances can be accomplished by trains combining one of the innovative *leading vehicles* and several FlexCargoRail *freight-carrying wagons* plus a number of conventional wagons. For delivering trains on siding tracks, the *leading vehicle* can be used instead of expen-

sive shunting locomotives. Both the traction of the FlexCargoRail *leading vehicle* and the *wagons* can be used in parallel.

- The transportation and main haulage are conducted on main tracks as described in level 1.

Revenue-model: Expensive conventional shunting locomotives are exchanged for new FlexCargoRail leading vehicles. More deliveries per day are becoming possible.

Level 3 – full-scale usage:

- The main haulage is conducted on the main tracks by several FlexCargoRail leading vehicles connected with a substantial number of FlexCargoRail wagons. They make up trains similar to conventional freight trains.
- The traction is generated by the whole train. The energy is supplied by the leading vehicle. If necessary it is supported by the batteries of the FlexCargoRail wagons. Those are recharged during the usual main haulage.
- Deliveries regarding siding tracks are then conducted by further FlexCargoRail leading vehicles as described above.

Revenue-model: Besides the advantages of the levels 1 and 2, the traction of the new FlexCargoRail train system is in an optimum way adapted to the needs of medium to high business turnover.

5.5 Resume: Innovative Technologies in European Freight Transport

In this Part I of the Case Studies, the first Field of Action *Innovative Technologies* has been the main theme. It has been discussed by considering two different approaches to innovation in freight transport.

The first concept deals with *truck platoons* (or convoys) *on motorways*. It has been investigated by the sequence of research projects EFAS, M F G, KONVOI, and followed further by the simulation laboratory for truck platoons, InDriveS. Regarding such truck platoons it has been concluded that an increase of 14% traffic capacity can be realized by such platoons. The fuel consumption can be reduced by 10%. The drivers' workload will be reduced due to the fact that the position of the leading vehicle can be switched. Surveys among other traffic participants and freight forwarders suggest high acceptance. It is expected that the technology of truck platoons will increase safety. The economic evaluation points out that it might be necessary to support the implementation of this technology by Government incentives. Those can be of different kind, e.g., tax or insurance incentives. The simulation laboratory InDriveS has proved to be of tremendous support for testing and evaluating technological innovations.

The second concept of *individual freight-carrying engines and wagons on rail* has been represented by the project FlexCargo Rail. This technology of *partly automated wagons with integrated power units* is a very promising approach to raise the economic attractiveness of rail transportation. It might be advisable to adjust the simulation laboratory InDriveS in order to use it for testing certain aspects of this technology. To implement such a thorough innovation into the market it might also be necessary to offer government incentives.

The research projects within this particular Field of Action concerning the Innovative Technologies, offer the highest possible flexibility for the demand side of transportation with the exception of conventional road transportation.

In Part II of the Case Studies following here, the second Field of Action is considered. It deals with the intermodal freight transportation.

Chapter 6

Case studies – Part II: Innovations to Improve the Intermodal Transport Chain

6.1 Overview

In Chap. 6, the second of the three *Fields of Action* is considered (Fig. 6.1): *Innovations to improve the intermodal transport chain*. The two case studies presented here are listed below:

- Semi-trailers in Advanced European Intermodal Logistics: SAIL (Sect. 6.2), and
- European low-platform technologies for non-cranable semi-trailers: RoRo-Rail (Sect. 6.3).

In the following sections of this chapter, all recommended steps of the Systemic Innovation Management Method are performed. Finally the results of this Field of Action are matched with the objectives and requirements of the Impact Table.

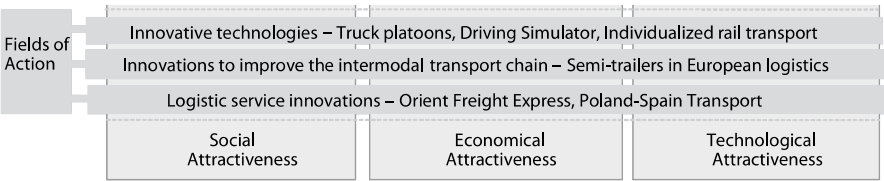


Fig. 6.1. Part of the Impact Table including the case studies

6.2 Semi-Trailers in Advanced European Intermodal Logistics (SAIL)

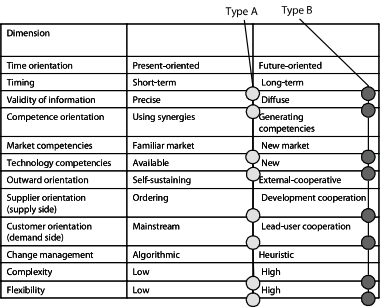
6.2.1 The Growing Numbers of Semi-Trailers (Step 1)

Understanding the System

Objective of the Research Project

Today semi-trailers are particularly favoured by freight forwarders. The numbers of semi-trailers have been constantly growing in *road transport*. In *intermodal transport*, however, the share of semi-trailers has been declining since 1990. Hence, in the future it is to be expected that rail transport will increasingly loose shares of the modal split considering this market segment (Henning, Preuschoff et al. 2003b). The goal of the project *Semi-trailer in Advanced Intermodal Logistics* (SAIL) was, therefore, to increase the numbers of semi-trailers involved in *intermodal transport*. The transport market regarding semi-trailers has been discussed in Chap. 2. On this background, the European Union supported the project which was conducted between 2000 and 2002. The overall financial volume was 4.5 Mio. EURO. The author Eva Savelsberg (maiden-name Preuschoff) was head of the consortium.

Expected Characteristics of the Start-Up Situation of the Innovation Processes



The following list describes the expected characteristics of the start-up situation of the innovation processes according to the coordinate systems of Eversheim (2003). The characteristics are visualized in Fig. 5.26.

Time Orientation – Square I

The objective is to develop new technological solutions during the next two years (Timing, *short-term*).

There is no set solution space. Surveys and meticulous analysis have to be conducted (Validity of information, *diffuse*).

Competence Orientation – Square II

Everybody is familiar with the market (Market competencies). Nevertheless the market potential regarding different technological solutions has to be analysed. The objective is to optimize intermodal transport devices in order to regain European market shares.

Defined technology competencies are in principle available but it is necessary to find migration-oriented solutions (Technology competencies). Thus holistic knowledge has to be established. Hence, numerous companies have to be involved and new kinds of knowledge have to be gained and integrated.

Outward Orientation – Square III

A strong and broad cooperation has to be realized (Supplier orientation). Several representatives of the supply side have to be involved (*development cooperation*). Those have to be from different European countries.

Lead-users of the developed technologies have to be part of the consortium (Customer orientation, *lead-user cooperation*).

Change Management – Square IV

The high number and different background of the companies to be involved (concerning the areas of operation and home countries) increase the complexity decisively (Complexity, *high*).

Because of the challenging time table the strategy has to be adjusted flexibly to new results (Flexibility, *high*).

These different aspects are shown in Fig. 6.2.

The four coordinate systems are merged in the way described in Chap. 3 (Fig. 6.3). The characteristics are within as well as at the outer positions of the

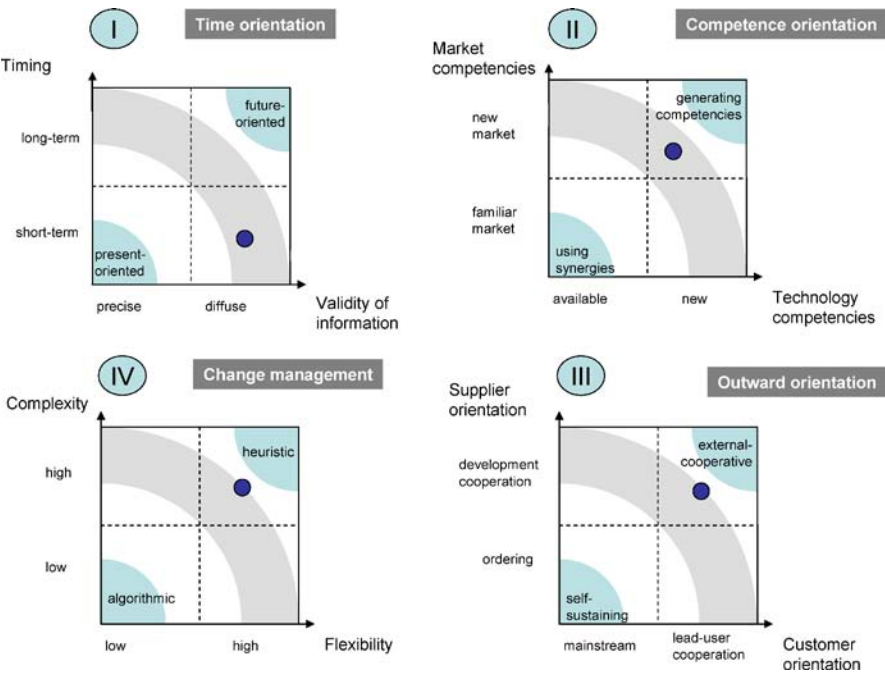


Fig. 6.2. Visualisation of the start-up situation of the innovation process (SAIL)

to accomplish Step 4. There is no set solution space in the beginning. *Comprehensive knowledge of the system coherences* has to be achieved in order to establish the *shared view of the transportation system* among the different parties, to gather *possible appropriate solutions*, to *evaluate* those and finally, to *choose technologies* which can successfully migrate into the freight transportation system. The Business Model will be decisively elaborated during the requirement specifications (Step 5).

Each technological feature has to be checked on its effects considering the demand side. The system specifications show in detail how the requirement specifications will be realised (Step 6). The prototypes have to be built and demonstrated during the set period of two years (Step 7). Demonstration and evaluation are important for gaining information about the technical and organisational attractiveness of the innovative technologies (Step 8).

After this overview, the description of the different steps in detail is continued as follows.

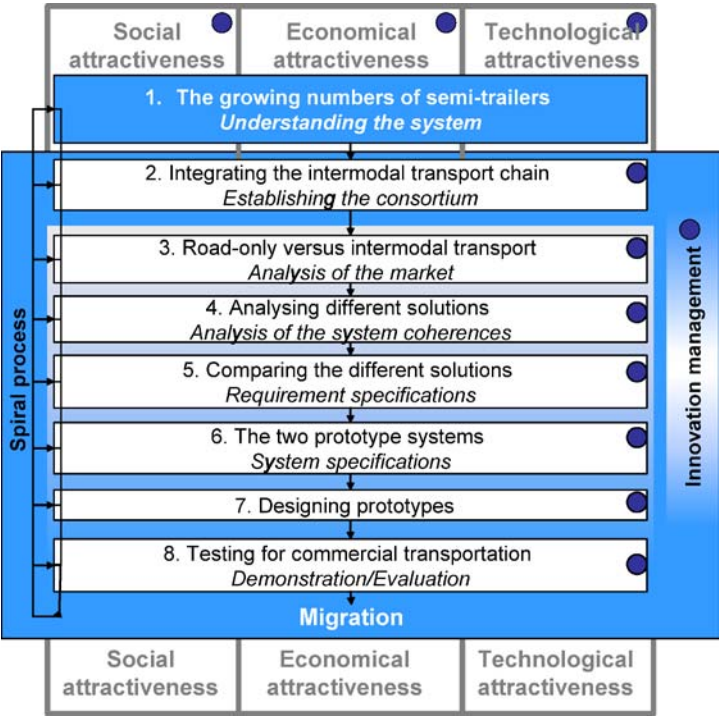


Fig. 6.4. Recommended steps of the suggested Method (SAIL)

6.2.2 Integrating the Intermodal Transport Chain (Step 2)

Establishing the Consortium

Representatives of the major interest groups have to be involved in order to realize the migration-oriented solution for the market with numerous players. The innovative technology and the accompanying logistic concept have to be attractive for the European market. Hence, it is necessary to include companies from different countries depending on the focused corridor. It might be necessary to add partners while developing the Business Model.

In the project described here, the following companies were chosen for co-operation:

- the Center for Learning and Knowledge Management and Department of Computer Science in mechanical Engineering (ZLW/IMA) – management of the innovation process, scientific tools,
- DUSS, CEMAT – terminal operators rail/road,
- Ewals Cargo Care – freight forwarder,
- TFK – consultant market analysis,
- Port of Trelleborg – terminal operator for road and rail/water,
- Ferriere Cattaneo – wagon design and production,
- Kögel – semi-trailer design and production,
- HUPAC, Kombiverkehr – intermodal operators and
- ICM – consultant intermodal transport.

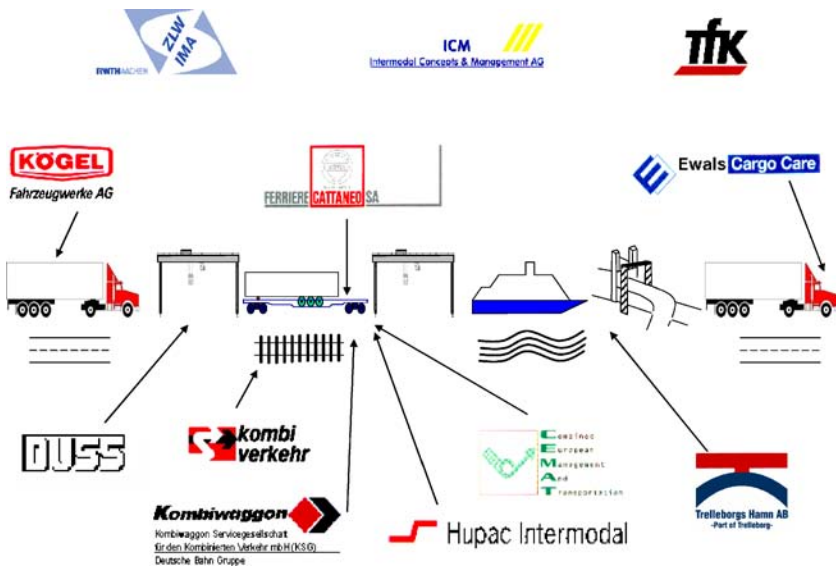


Fig. 6.5. Key-players involved in the intermodal transport chain

Fig. 6.5 presents which engineering companies are part of the consortium (see Fig. 2.11). Furthermore, the project has a thorough scientific claim and a strong research basis. Hence the project management methods, the tools used and the specific research activities are supported by several research institutes. Those are also shown in Fig. 6.15.

6.2.3 Road-Only Versus Intermodal Transport (Step 3)

Analysis of the Market

Questions to be Answered

Although all partners are experts concerning intermodal transport it was decided to conduct a market study regarding the *value proposition* and the *value chain*. Only this study would guarantee to gain sufficient knowledge about today's and future requests and developments of the demand side (Savelsberg 2006a). The market study was divided into quantitative and qualitative parts.

The Quantitative Analysis

The following facts were derived from intensive data analysis (Henning, Stumpe et al. 2000):

- The total number of semi-trailers in the EU has considerably increased during the eight years between 1990 and 1998.
- The numbers of semi-trailers is growing faster than the numbers of other road transport equipment which grows as well (in Germany most significantly).
- The large majority of all new semi-trailers have the maximum-permitted capacity in weight and/or volume.
- The largest group in each country are open semi-trailers either with or without curtain.
- There is overall growth of international road transport (measured in tonnes).
- In overall road transport the steady growth of the average length of haulage seems to come to a limit.
- The intermodal transport of semi-trailers in Europe is in its large majority the cross-alpine transport linking Northern Italy with Southern and Western Germany and Sweden.
- The intermodal transport from/to France and Spain is only marginally developed.
- Potential options for intermodal transport would include the following corridors: between the Netherlands, and Eastern Germany and Poland; domestic German intermodal transport; the corridor Denmark-Italy; intermodal supply to South-Western Europe (France, Spain) and South-Eastern Europe.

The Qualitative analysis

The following list presents the most obvious pre-requisites of competitive intermodal semi-trailer transport today (Henning, Stumpe et al. 2000):

- Semi-trailers would need to comply with at least the railway-profile of P384 if not P 400.
- Intermodal transport needs to improve efficiency in broken transport chains caused by natural barriers such as mountains or seas (e.g. Sweden-Germany-Italy or Italy-UK).
- Generally the reliability of intermodal transport supply needs to be improved.

The results of the qualitative analysis were collected separately for the *demand side* and the *supply side*.

Four different user profiles of forwarders/hauliers using semi-trailers (*demand side*) can be identified (Henning, Stumpe et al. 2000) (Tab. 6.1):

- *Pure road users* who optimise their semi-trailer equipment either in terms of maximum weight or maximum volume capacity, or both. For those road users intermodal transport is no viable option because the optimised semi-trailer equipment mostly does not fit to the technical requirements of intermodal transport, or because the future supply of intermodal transport is regarded as too questionable.
- *Regular intermodal users* who are focused on certain markets. They are actively involved into equipment that is most suitable for intermodal transport, e.g. semi-trailers. But this equipment is clearly less competitive if it is used on road only. These users are following long-term plans with a stable supply of intermodal transport using some definite corridors.
- *Regular intermodal users* with a strong swap-body fleet. For some markets they invest actively into intermodal equipment, but not into semi-trailers.
- *Occasional intermodal users* who deploy semi-trailers both in road-only and in intermodal transport for some of their target markets. For them intermodal transport could be one option among others, but not if it endangers their competitiveness on road.

One goal of further development may be to win the market of the first group mentioned, the pure road users.

The *supply side* analysis among intermodal operators, and wagon or terminal operators leads to the following results:

- On the corridors where semi-trailer transport is successfully operated, no innovation potential could be named today that would justify a completely new hardware solution.
- All operational and organisational problems named by the supply side are related to the system *semi-trailer* as such, its dimension, its total weight, and the corresponding requirements for equipment and personnel.
- The non-standardisation of both road and rail rolling equipment has been identified as a serious obstacle.

Table 6.1: Profiles of forwarders and hauliers using semi-trailers (demand side) (Henning, Stumpe et al. 2000)

Profile	share of semi-trailers used	share of jumbo-trailers used	share of swap-bodies	Country specific	share of balanced flows	Intermodal share	Intermodal future potential size
Pure road users	very high	small	close to zero	yes, mostly in NL, DE	small	close to zero	large
Regular intermodal users with semi-trailers	high	close to zero	medium	yes, on north-south axis SE-DE-IT	medium	medium to high	medium
Regular intermodal users with a strong swap-body fleet	small to zero	zero	high	yes, on north-south axis DK, , DE-IT	medium to high	high	small
Occasional intermodal users	high	close to zero	small	no	medium	small	medium

- On certain corridors which show no competitive intermodal semi-trailer transport, the major obstacle for increasing the intermodal split is the profile, e.g. tunnels etc.

Focusing of Features

After conducting the first part of the Business Model, the SAIL consortium agreed to focus on certain aspects and concepts regarding alternative solutions to the present intermodal concepts.

Firstly, one corridor has been focused on. This corridor stretches from Italy towards Sweden (Fig. 6.6). On the SAIL consortium, all necessary countries were represented.

- *Germany*: ZLW/IMA, DUSS, Kombiverkehr, Kombiwaggon and Kögel;
- *Netherlands*: Ewals Cargo Care;
- *Sweden*: TFK and Trelleborg Terminal;
- *Switzerland*: Ferriere Cattaneo and HUPAC;
- *Italy*: CEMAT.

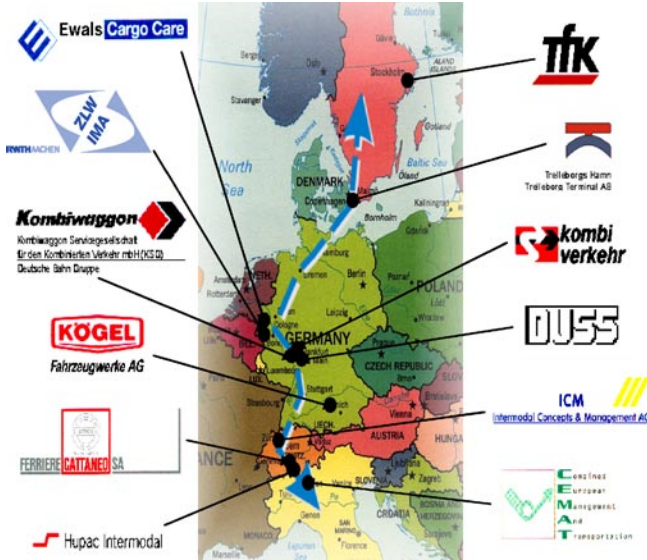


Fig. 6.6. Mapping of the partners considering the chosen corridor

Six different concepts for possible solutions were short-listed:

- RoRo-solution (low-platform solution)
- Pocket wagons
- Basket-carriage
- Swap-body standard
- EWALS/Argus-System
- ROADRAILER-System

These fundamentally different technological innovations were undergoing a thorough analysis and weighting procedure according to the Innovation Management Method suggested here (Savelsberg 2006a).

6.2.4 Analysing Different Solutions (Step 4)

Analysis of the System-Coherences

Sensitivity Analysis (SA) (Tool 2)

A description of the system *intermodal transport* was performed. It yielded 28 variables. According to the described procedure of the tool Sensitivity Analysis, the systemic role of each variable was specified. The resulting Impact Matrix is shown in Fig. 6.7. It demonstrates the following aspects:

The *active* variables are: international co-operation, technical instructions, political regulations, flexibility of the interfaces wagon/semi-trailer, and the loading method. These *active* variables should be used at present to influence

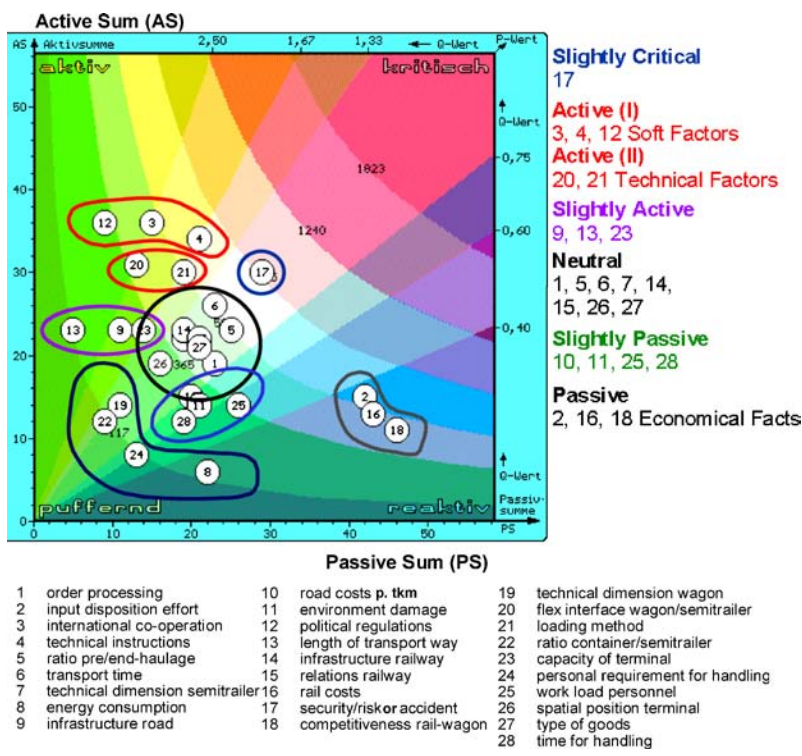


Fig. 6.7. The systemic roles of the focused variables (Savelsberg 2005a)

the system. *Security* is the most *critical* variable of the system. The *passive* variables are also important but not appropriate to influence the system as mentioned before.

Value Benefit Analysis (VBA) (Tool 4)

As described above, the Value Benefit Analysis (VBA) is the tool to compare different solutions considering their use and personal value. In this case, the tool was conducted separately for the demand side and the supply side. For each of the six focused solutions, the participants decided jointly and in agreement on the Degree of Performance. The assessment of fulfilment was also done on a scale between zero (not fulfilling the variable) and ten (absolutely fulfilling the variable).

The pros and contras were discussed by the consortium as follows (Fig. 6.8):

- RoRo-solution: **pro:** loading of every semi-trailer is possible; an older variant is already available; the new technology can offer the possibility to load faster.
- contra:** regarding this technology a sequential unloading is impossible; new infrastructure is necessary.

Pocket wagons:	pro: high potential for improvements which would still go along with standards. contra: no issues mentioned
Basket-carriage:	pro: loading of every kind of semi-trailer would be possible. contra: double-handling will be necessary; high dead load.
Swap-body “standard”:	pro: standardised interface (DIN EN 452). contra: smaller volume than the road alternative.
Swap-body EWALS:	pro: high volume loading would be possible (Argus-System). contra: new hanger and wagon would be necessary; it is incompatible with several other systems.
ROADRAILER-System:	pro: ambitious system to transport semi-trailers. contra: high dead load; design problems of stability.

The *supply side* gave the main emphasis on standardisation as suggested in the solution of Swap-body “standard”. The *demand side* was in favour of the EWALS system since high volume can be transported by this innovative technology approach (Fig. 6.8).

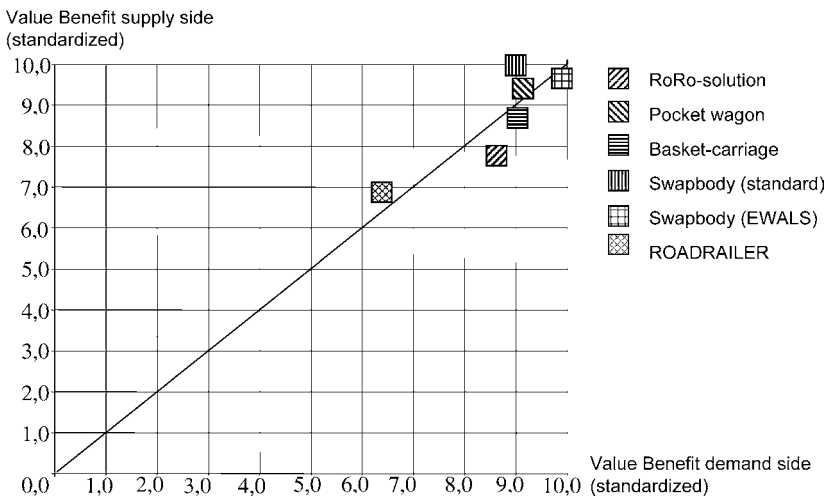


Fig. 6.8. Value Benefit of project SAIL, supply and demand side, for the six possible solutions

Technical Attractiveness (TA) (Tool 5)

Subsequently both tools, the *Sensitivity Analysis* and the estimation tool regarding *Technical Attractiveness*, were integrated into the further project strategy. The visualisation was discussed as follows (Fig. 6.9):

RoRo-solution:	The demand side did not believe in the realisation of this technology. These members voted against the realisation of the RoRo-solution due to the costs of building new terminals. Here, the focus on RoRo-solution did not offer the possibility of sequential loading and unloading. The solutions of offering sequential loading and unloading were excluded since security risks were expected, e.g., opening up of support beams during transportation. However with this kind of solution all semi-trailers can be loaded. Hence, the demand side was convinced by the supply side to build this solution as a model for further research possibilities.
Pocket wagons:	This solution was highly approved of by both sides. No obstacles seemed to block its realisation since in general this system has already been introduced into the market.
Basket-carriage:	The demand side did not believe in this solution since double handling is necessary and high dead loads have to be transported. The supply side, however, believed into realisation since all kinds of semi-trailers can be transported with this solution.
Swap-body "standard":	The high rank of this solution stressed the importance of standards for both sides.
Swap-body EWALS:	The supply side still worried whether the system could be implemented without difficulties concerning standards. The demand side stressed the positive feature of transporting higher volumes.
ROADRAILER-System:	This solution was assumed to be still exotic. Therefore the successful implementation into the market seemed to be questionable for both sides.

After the completion of all calculations and the integration of all relevant factors, the following decisions were made:

- The design and building of the prototypes will be initiated; the further development of one or more solutions should be decided on at a later stage.
- Solution 1 (RoRo, unaccompanied by special charger, similar to a Van-Carrier) will be developed to such an extent that it can be realised in a small-scale model.
- Solution 2 (pocket wagons) will be developed for semi-trailers with payload of 28 tonnes and loading volume of 100 m³. This wagon will be equipped

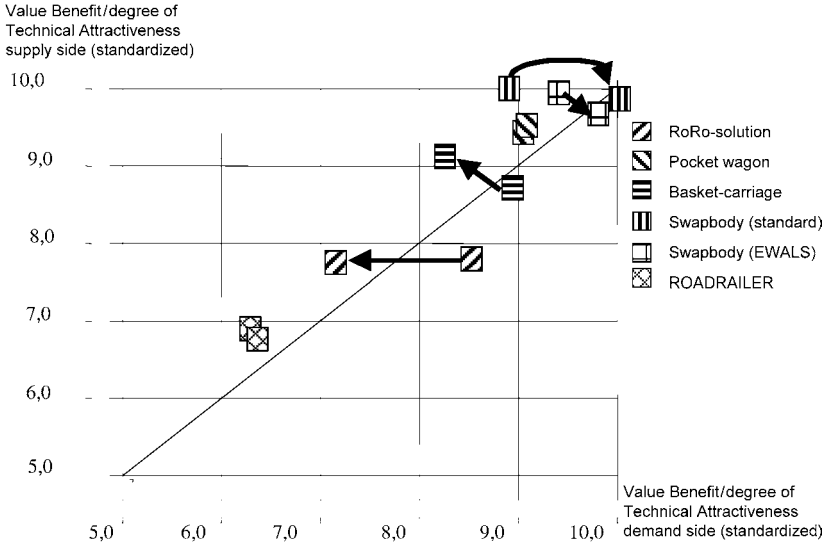


Fig. 6.9. Standardized visualisation of the Value Benefit and the degree of Technical Attractiveness of the six solutions focused on, in the project SAIL

with breakpoints for standardized swap containers. The prototype of this wagon will be built and demonstrated in full size.

- In accordance with the solution for the wagon, a chassis for semi-trailers with swap-body will be developed, which will have an approximate payload of 28 tonnes, and loading volume of 100 m³. The prototype of the wagon will be built and demonstrated in full size.

6.2.5 Comparing the Different Solutions (Step 5)

Requirement Specifications

The handling (shunting, loading, unloading, storage) in the terminal is the most critical period of intermodal transport. This procedure can be time-consuming and may cause damages to the freight. Therefore an analysis of critical points was conducted considering the *Social*, the *Economical* and the *Technological partial-systems*.

The operating personnel were taken into account (loading supervisor, crane driver, truck driver, terminal supervisor, train supervisor, wagon coordinator, train driver, maintenance personnel). The flow of action was visualized and effects of interferences and disturbances were pointed out (Fig. 6.10). Further areas of investigation were personnel qualifications and work safety.

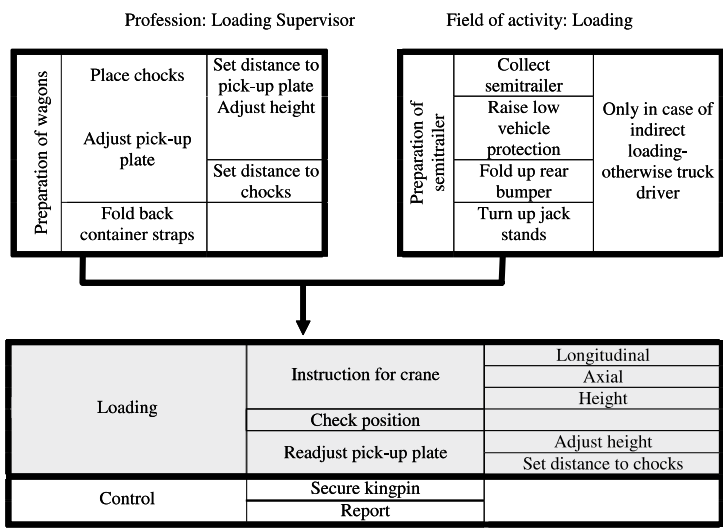


Fig. 6.10. Example of investigations on human factors (Henning, Stumpe et al. 2001)

Considering the work processes one finding will be described in more detail (Henning, Stumpe et al. 2001): The loading supervisor is subjected to great workload which should, wherever possible, be avoided. This work is carried out in the open air at all weather conditions. It is physically very strenuous as ergonomically unfavourable movements have to be carried out. Technical support would be possible in the case of strenuous muscular work, by means of hydraulic or pneumatic systems. But such systems are not being realised because of high costs. If possible SAIL should offer improvement in the working situation of the loading supervisor by means of variation of the loading techniques used.

The flow of data, information and communication was also analysed. Three findings will be described in more detail:

- Terminal performance strongly depends upon the timetable and the corresponding operating concept implemented in daily processes, e.g. loading the rail tracks may be performed only once per day. Hence it can have strong limiting effects on the transshipment capacity of the cranes. As an example, the transshipment capacity of a gantry crane is 30 loading units/hour. During one working day at a terminal with five gantry cranes, such as, for example, Köln-Eifeltor, a transshipment capacity of over 3000 units can be realized. However, according to the information supplied by the operator, Köln-Eifeltor transships only 1200 units per day.
- The types of freight trains to be handled have a major influence on terminal performance, e.g. there might be complete trains, trains with groups of wagons, scattered traffic, irregularly running train traffic etc. The trains often have to be regrouped and shunted. A new scheduling for the whole day must be conducted if trains are delayed. Collection and delivery of goods by customers may also have strong influence on the work of transshipment.

Customer delays, for example, lead towards setting-down again of freight containers by the crane and their intermediate storage. Hence, the actual number of movements by the cranes is increased without leading to train loading. At peak periods, however, the cranes are often operating at the limits of their capacity.

- It is planned to convert the internal information flow to an EDP-supported terminal-operating system. It would be implemented for the German Rail (DB) terminals and further private terminals, in the foreseeable future. But the conventional channels of information should not be done away with. They should be retained as redundant back-up measures. In addition, suitable building measures should be implemented, e.g. installation of video cameras and mirrors; combining the check-in and terminal scheduling. The mutual exchange of information between terminal scheduler, transport agency and wagon supervisor ensures constant quality control.

The project SAIL has been planned to increase the share of semi-trailers in intermodal transport. It aims at technological improvements. Those should meet the demands pointed out in Chap. 2: specifically improvements of the interfaces between the technical equipment of *transportation* and *transshipment*. It is required that those innovations are compatible to existing transport devices (Henning, Preuschoff et al. 2002a).

Focused Solutions

So far the Business Model, Sensitivity Analysis, Value Benefit Analysis and the combination of the latter two – the estimation of Technical Attractiveness – have been discussed concerning the six possible solutions. They lead towards three alternative approaches of intermodal transport technologies which appear particularly favoured by the SAIL consortium:

- ***the semi-trailer and the pocket wagon – PW*** (Fig. 6.11);
- ***the container/swap-body carrier vehicle & special wagon – CSW*** (Fig. 6.12);
- ***the low-level-wagon – LLW which will be used for RoRo-transportation*** (Fig. 6.13).

The first solution, the semi-trailer and the pocket wagon – *PW*, is oriented at today's semi-trailer technology in intermodal transport. New designs of the pocket wagons and semi-trailers enable potential transport capacities from 84m³ (25t) to 100m³ (28t).

The second solution, the container/swap-body carrier vehicle & special wagon – *CSW*, involves the use of swap-bodies. The volume of freight in this case is up to 100m³ (28t), but technical changes in the wagon and semi-trailer are necessary. The undercarriage remains with the vehicle (tractor); only the swap-body is loaded onto the wagon.

The third solution, the low-level-wagon – *LLW*, is based on current Roll-On-Roll-Off concepts. Modifications to the transfer device and the wagon allow all semi-trailers to be transported by rail. The semi-trailer is loaded onto

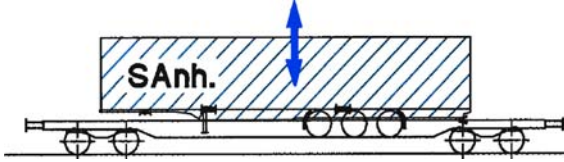


Fig. 6.11. Vertical loading (pocket wagon – PW)

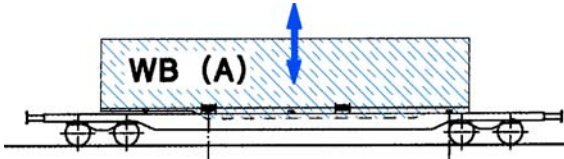


Fig. 6.12. Vertical loading of a swap-body (container carrier vehicle & special wagon – CSW)

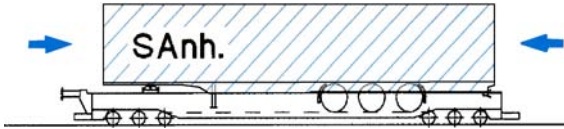


Fig. 6.13. Horizontal loading of a semi-trailer (low-level-wagon – LLW)

the wagon horizontally. This specific solution is focused on in the following sections. Hence the abbreviation LLW is used from here onwards instead of RoRo-solution as before.

These three alternatives will each be compared with the approach “Unimodal Transport on Road” which means the road-only transport. It would guarantee the comparability of the alternative approaches. Hence model calculations have been performed. Accordingly performance figures have been derived for the numbers of units transported per year, and the numbers of transport kilometres per year. The comparison in pairs, “Road-only Transport versus Intermodal Transport”, is the best way to compare the main existing approach (road-only) with those approaches which do not yet exist.

Performing the Traditional Economic Feasibility Analysis (TEFA: ROI, NPV) (Tools 7 and 8)

The different tools of the Economic Feasibility Analysis were presented in Fig. 4.9. In this paragraph, the Traditional Economic Feasibility Analysis TEFA approach is discussed for SAIL. The Extended Economic Feasibility Analysis EEFA is discussed in the subsequent paragraph.

Firstly it is important to determine how advantageous the alternative approaches may be. Therefore the market development (yearly growth in revenue) is assumed for both tools ROI and NPV at 4.5%. This development is based on

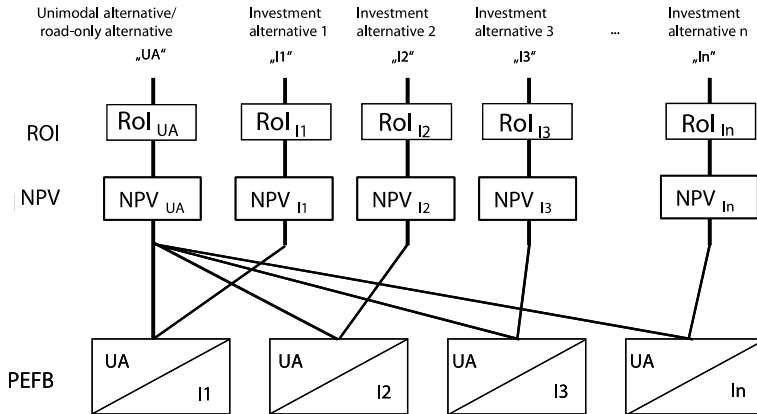


Fig. 6.14: Comparison in pairs (according to Stumpe 2003)

the recorded yearly growth of 4% of the market for freight transport during the last 20 years. An increase in activity in the next few years is expected due to political initiatives. Therefore an extra 0.5% are added (Henning, Preuschoff et al. 2001). It is assumed that financing is based on leasing. Hence the investment has a low average capital lockup. If the investment is financed by a loan (e.g. in 2002) the return on investment will be lower. All results are compared in pairs (Fig. 6.14).

The following setting is described to allow the comparison between the *unimodal (road-only) approach* and the three different *intermodal alternatives* (according to Henning, Preuschoff et al. 2001; Uribe 2001; Stumpe 2003):

- In the *road-only* (unimodal) transport, three truck drivers work 220 days per year and drive 800 kilometres per day. Thus, they deliver 660 charges while driving 528 000 kilometres per year. The average length of transport is assumed with 1000 kilometres (ECC 2001).
- Two truck drivers are involved in *intermodal* transport. The pre- and post-haulage is estimated with 100 kilometres. The drivers conduct three routes per day, hence, they manage on the average one-and-a-half cycles on 220 working days per year (ECC 2001; Henning, Preuschoff et al. 2001).
- There are three swap-bodies per trailer (one pre-haulage, one post-haulage, one storage or on train). The main haulage is estimated with 600 kilometres (Nolte 2001).
- The drivers perform 66,000 kilometres per year. During the main haulage the swap-bodies are transported 396 000 kilometres per year (together 528,000) and 660 deliveries are realized (WEKA 1999).

All those alternative approaches do not consider the costs of terminal buildings. Those are difficult to estimate and they are only needed for the RoRo-alternative (Uribe 2001).

Based on these assumptions, the pair-comparisons are described as follows (Table 6.2).

Unimodal Alternative (road-only)

- ROI: Estimated return on investment is 34.2%. The growth rate is assumed to stay between 4% and 7% according to the freight forwarder's current margins (viewed pessimistically). The different cost structure means lower operating costs.
- NPV: The NPV is the second lowest of all the alternative approaches (394,000 EURO) because of route-dependent costs, which are relatively high.

PW-Alternative (pocket wagon)

- ROI: This solution realizes a negative ROI (-20.9%). The very low levels of cash flows (in one year negative) are the cause of the poor result.
- NPV: This alternative is not profitable in comparison with the other alternatives. A reason for this could be the high level of investment necessary.

CSW-Alternative (container/swap-body)

- ROI: Due to changed cost structure for the period considered, this alternative has a return on investment of 0.6%. It shows the lowest necessary investment, but the other positions in the estimation (such as the rail journey) total more than 4.5%. As a result the discounted profits are very low in comparison with the other alternatives.
- NPV: This alternative has the highest NPV of all the solutions (504,000 EURO) due to the size of the deductions (e.g. depreciation, amortisation), which must be added to the profit or the loss.

LLW-Alternative (low-level-wagon)

- ROI: This alternative is estimated with ROI to be 67.9% because of high positive cash flows over the whole period considered.
- NPV: Regarding the NPV this alternative is the second best alternative (477,000 Euro). The deductions (e.g. depreciation, amortisation) in this case are not higher than those in the CSW alternative and the investment is more severe. But the LLW solution has the highest ROI value of all solutions. Hence the profitability of this alternative seems to be best guaranteed.

Table 6.2: Results of the TEFA (Henning, Preuschoff et al. 2001; Uribe 2001)

	Unimodal	PW	CSW	LLW
ROI (%)	34.2	-20.9	0.6	67.9
NPV (Euro)	394,501	185,791	504,110	477,760
Investment (Euro)	400,000	405,128	333,000	369,230
Revenue growth (%)	4.5	4.5	4.5	4.5

The tools of the TEFA and the comparison in pairs have shown that the alternatives CSW (*container/swap-body*) and LLW (*low-level-wagon*) are the most profitable approaches. Both require low level of investment to achieve the highest NPV results. However, considering the ROI value, the LLW alternative may be the best solution. But one has to take into account that the necessary modification or even new development of a terminal were not included into the calculation. If the benefit on a certain corridor would be assumed to be extremely high for society, the public investment into a new terminal should be considered. Then the LLW solution would be – regarding profit during any operation period – probably beneficial. When considering these results, it is important to realize that the original parameters may change. Therefore these results should only be interpreted as trend indicators.

Performing the Extended Economic Feasibility Analysis EEFA: *PEFB (Profitability Estimation Focused on Benefits) (Tool 9)*

The first phases of the *PEFB process* have already been accomplished during the previous steps of the innovation method. The next phase is *Evaluation/Quantifying and Visualisation of Measures* to be conducted as follows.

The important task to be performed here, is the distribution of the risk grades. The risk grades are distributed in the standard order according to Nagel (1990). The effects of the standard sequence are important. Some of the results are difficult to measure. They follow the direct or indirect factors with low probability of realisation. The following paragraph compares the three preferred solutions with the unimodal (road-only) approach, which is presented in relative values. The various parameters used already in the TEFA analysis, are incorporated into the cost-benefit matrix, according to *how easily* they can be evaluated (direct, indirect, and difficult to evaluate), and according to their *probability of realisation* (Henning, Preuschoff et al. 2001; Uribe 2001; Stumpe 2003).

PW-Alternative (pocket wagon)

This alternative appeared not profitable in the TEFA previously performed. During these PEFB calculations additional costs were added (Table 6.3). It clearly shows: similar cost and benefit factors were recorded for the CSE and LLW, but the values for the costs are significantly higher and the benefits lower.

CSW-Alternative (container/swap-body)

Regarding this alternative the factor “property remains in the hands of the owner” is extremely important (Table 6.4). It causes problems if the same vehicle is used by drivers of different transport companies. The factor “improvement in the human situation” is mentioned and is included in the benefit matrix, but it is evaluated as zero since no meaningful results are available. This part of the matrix is, however, still filled out in order to show that this alternative has further associated benefits which should be considered.

LLW-Alternative (low-level-wagon)

The problem that the “property passes through several hands” is evident. Investors are reluctant to allow their property to be used by others without its safety being guaranteed. A greater investment is necessary to achieve the same output (Table 6.5).

Table 6.3: Benefits-Costs-Matrix of the PW-Alternative (pocket wagon)

Benefits-Matrix		probability that benefits incur		
share of benefit	direct	* general administration costs * time-dependent costs * driver personnel costs * liquidation of assets		
	indirect	* transit dependent costs * repair costs * motorway tolls	* imputed individual risks * traffic-related additional personnel costs * sales	
	difficult to ascertain	* reduction in accidents on the road	* Improvement of the human situation	
Costs-Matrix		probability that costs incur		
share of costs	direct	* transfer costs * costs of train transport		
	indirect	* reduction of petrol tax		
	difficult to ascertain	* Investor has to give from the hand his investment (equipment)		

Benefits-Matrix		probability that benefits incur								
share of benefit	direct	536.778			0			0		
	indirect	759.234			179.778			0		
	difficult to ascertain	55.000			0			0		
		4			7			9		
risk stages		1	2	3	4	5	6	7	8	9
accumulated benefit in Euro		536.778	1.296.012	1.296.012	1.351.012	1.530.790	1.530.790	1.530.790	1.530.790	1.530.790
Costs-Matrix		probability that costs incur								
share of costs	direct	1.579.448			0			0		
	indirect	63.085			0			0		
	difficult to ascertain	175.000			0			0		
		4			7			9		
risk stages		9	8	7	6	5	4	3	2	1
accumulated costs in Euro		1.817.533	1.817.533	1.817.533	1.817.533	1.817.533	1.817.533	1.642.533	1.642.533	1.579.448

Table 6.4: Benefits-Costs-Matrix of the CSW-Alternative (container/swap-body)

Benefits-Matrix		probability that benefits incur								
		high		middle		low				
share of benefit	direct	* general administration costs * time-dependent costs * driver personnel costs * liquidation of assets								
	indirect	* transit dependent costs * repair costs * motorway tolls		* imputed individual risks * traffic-related additional personnel costs * sales						
	difficult to ascertain	* reduction in accidents on the road * Investor hasn't to give from the hand his investment (equipment)		* Improvement of the human situation						
Costs-Matrix		probability that costs incur								
		high		middle		low				
share of costs	direct	* transfer costs * costs of train transport								
	indirect	* reduction of petrol tax								
	difficult to ascertain			* Accident risk by loading at the platform						
Benefits-Matrix		probability that benefits incur								
		high			middle			low		
share of benefit	direct	470.254			0			0		
		1	3			6				
	indirect	626.096			493.040			0		
		2	5			8				
difficult to ascertain	230.000			0			0			
	4	7			9					
risk stages		1	2	3	4	5	6	7	8	9
accumulated benefit in Euro		470.254	1.096.350	1.096.350	1.326.350	1.819.390	1.819.390	1.819.390	1.819.390	1.819.390
Costs-Matrix		probability that costs incur								
		high			middle			low		
share of costs	direct	1.628.475			0			0		
		1	3			6				
	indirect	63.085			0			0		
		2	5			8				
difficult to ascertain	0			2.500			0			
	4	7			9					
risk stages		9	8	7	6	5	4	3	2	1
accumulated costs in Euro		1.694.059	1.694.059	1.694.059	1.691.559	1.691.559	1.691.559	1.691.559	1.691.559	1.628.475

Table 6.5: Benefits-Costs-Matrix of the LLW-Alternative (low-level-wagon)

Benefits-Matrix		probability that benefits incur					
		high		middle		low	
share of benefit	direct	* general administration costs * time-dependent costs * driver personnel costs * liquidation of assets					
	indirect	* transit dependent costs * repair costs * motorway tolls		* imputed individual risks * traffic-related additional personnel costs * sales			
	difficult to ascertain	* reduction in accidents on the road		* Improvement of the human situation			
Costs-Matrix		probability that costs incur					
		high		middle		low	
share of costs	direct	* transfer costs * costs of train transport					
	indirect	* reduction of petrol tax					
	difficult to ascertain	* Investor has to give from the Hand his investment (equipment)					

Benefits-Matrix		probability that benefits incur								
		high			middle			low		
share of benefit	direct	446.493			0			0		
		1	3			6				
	indirect	276.883			2.007.606			0		
		2	5			8				
	difficult to ascertain	55.000			0			0		
		4	7			9				
risk stages		1	2	3	4	5	6	7	8	9
accumulated benefit in Euro		446.493	723.376	723.376	778.376	2.785.982	2.785.982	2.785.982	2.785.982	2.785.982
Costs-Matrix		probability that costs incur								
		high			middle			low		
share of costs	direct	2.592.321			0			0		
		1	3			6				
	indirect	63.085			0			0		
		2	5			8				
	difficult to ascertain	175.000			0			0		
		4	7			9				
risk stages		9	8	7	6	5	4	3	2	1
accumulated costs in Euro		2.830.406	2.830.406	2.830.406	2.830.406	2.830.406	2.830.406	2.655.406	2.655.406	2.592.321

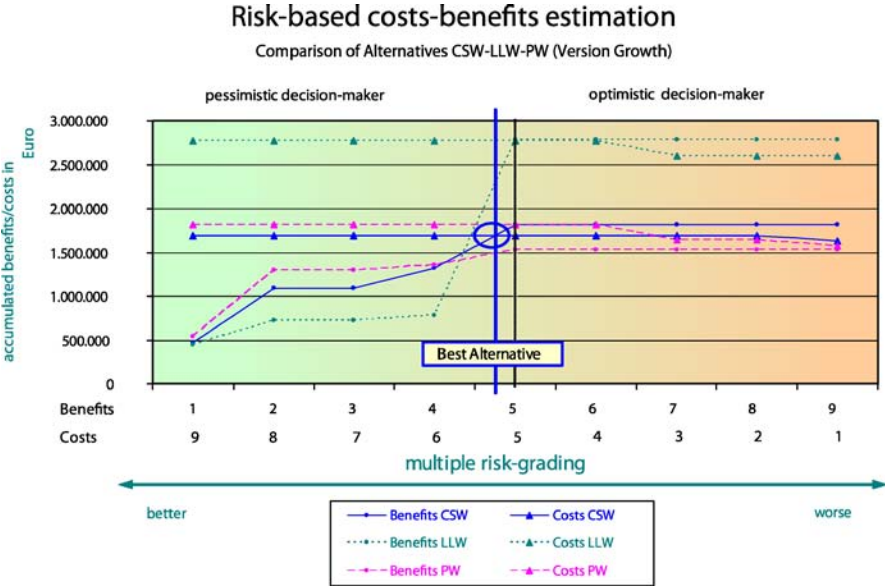


Fig. 6.15. Risk-based costs-benefits estimation comparing the alternative solutions PW, CSW, LLW

Results of the EEFA

The results of the Extended Economic Feasibility Analysis EEFA are in favour of the CSW-Alternative (container/swap-body). It is mirrored in this result that investors tend to favour alternatives where they do not have to pass on their own vehicles to another user. Fig. 6.15 shows the three alternative solutions according to their risk-based costs-benefits estimations.

The costs-graph (dashed line) of the *PW-Alternative* (pocket wagon) lies always above the benefits-graph. It follows that the *PW-Alternative* (pocket wagon) seems at present not to be very feasible. The costs-graph (dotted line) of the *LLW-Alternative* (low-level-wagon) lies particularly high, in comparison to the other alternative solutions. The intersection in the graph for this solution lies at risk grade 5 (the neutral level). Thus, as shown in the right-hand part of the diagram: only under very optimistic views, this solution may offer high benefits. Only the graphs (solid line) of the *CSW-Alternative* (container/swap-body) seem to show values for costs and benefits under risk conditions which appear generally acceptable.

To Come to a Decision

In this comprehensive research project SAIL, semi-trailers have been found to be particularly attractive regarding the project objectives to increase intermodal use of these semitrailers. The analysis described so far, has supported this view. Hence it should be possible to meet the expectations of the European Union to raise the competitiveness of the intermodal transport by modified or new intermodal technologies. Especially pure road users have been focused upon

since it should be possible to make them more interested in new approaches of intermodal transport. The corridor Italy–Sweden seemed to be best suited for this strategy. These project findings already contribute to the revenue-model required at this stage.

In the investigations of SAIL, several different tools were used to gain more insight into the system coherences concerning semi-trailers and intermodal transport. Based specifically on the Sensitivity Analysis, the following *active* variables to improve the *value chain* were identified:

- *international co-operation* – on a small scale supported by the composition of the consortium,
- *technical instructions (standards), flexibility of the interfaces wagon/semi-trailer, loading approaches* – the solutions 1 and 2 try to meet as many standards as possible; this will be described in more detail when presenting the system specifications in the subsequent paragraph (e.g. loading gauge, usability of different systems, accessibility to ferries etc.), and
- *political regulations* – several recommendations corresponding have already been published after finishing the project.

Further solutions of RoRo-technologies were not considered beyond the solutions suggested here. For other approaches than those described so far, specific security risks were pointed out during the project, e.g. the risk of support beams opening up during fast train transport. This observation would meet the *critical* status of the variable *security*.

In SAIL, the Value Benefit Analysis was performed in order to estimate how the different solutions suggested initially, contribute towards the *value chain* concerning semi-trailer and intermodal transport. The degree of the Technical Attractiveness gave some clue about the probability of realisation of any particular solution. These two tools narrowed down the solution space of the project

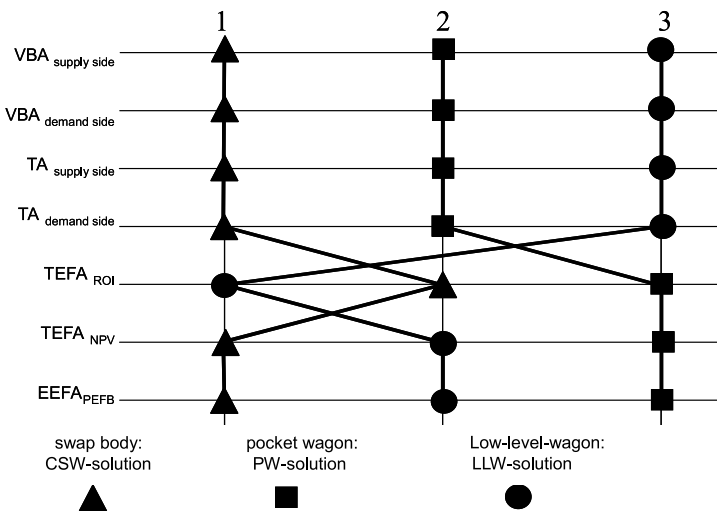


Fig. 6.16. Comparison of the results of the economic estimations of the three favoured solutions in SAIL: PW; CSW, LLW (RoRo) (according to Stumpe 2003)

SAIL. Subsequently several economic estimations were conducted. All these different evaluations have made it possible to rank the different solutions and to find the most favourable ones (Fig. 6.16). This ranking is explained as follows.

The *swap-body solution (CSW)* seems to be most advantageous regarding the Value Benefit and therefore, the *value chain*. The degree of the Technical Attractiveness is assumed to be the highest. Regarding the ROI, it is second place because of high investments needed for new road vehicles. The Extended Economic Feasibility Analysis estimations, however, stress the first place of this solution.

The *semi-trailer/pocket wagon solution (PW)* is ranked on second place by means of the tools Value Benefit Analysis and Technical Attractiveness estimation. It has gained low marks in the economic estimations, however. This observation highlights the necessity of different tools to analyse *system coherences* and *economic estimations*.

The *low-level-wagon solution (LLW)* is rated very differently. *Economically* it is rated first and second place by means of the more traditional tools of TEFA. Regarding the *system coherences*, however, it is estimated not to fit well as has become visible already in the diagram Fig. 6.15. This negative ranking is mainly based on the results of the Extended Economic Feasibility Analysis.

All economic estimations were performed by comparing these innovative technical solutions with the unimodal alternative of road-only transport. This is the main competitor to all new or modified intermodal approaches. The *revenue-model* was discussed in the consortium between demand side and supply side; the estimations are the results of those investigations. In general the more pessimistic viewpoint was taken when using the tools ROI and NPV. This means that under different conditions, positive viewpoints might be feasible. Thus these alternatives would then appear more profitable.

6.2.6 Designing Two Prototype Systems (Steps 6 and 7)

System Specifications and Designing Prototypes

On the basis of the evaluation described so far, it was decided to put the following alternative solutions into testing and practice (Fig. 6.17):

- prototype of solution 1, comprising a semi-trailer and a pocket wagon (*PW-Alternative*)

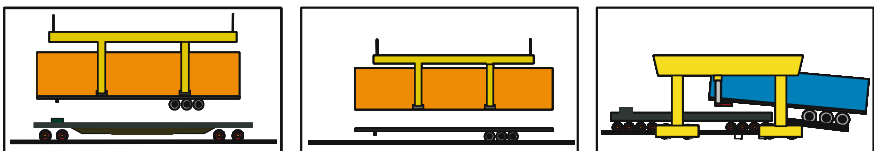


Fig. 6.17. Solution 1: the cranable semi-trailer/pocket wagon (*PW*); solution 2: the swap-body/wagon (*CSW*); solution 3: the low-level-wagon (*LLW*)

- prototype of solution 2, comprising a swap-body and a wagon (*CSW-Alternative*), and
- working model of solution 3, comprising a semi-trailer, a low-level-wagon, a straddle carrier and parts of a new terminal (*LLW-Alternative*).

Thus the research project SAIL took charge to realise two solutions as prototypes, and one as a working model. In the following paragraph, design sketches are presented and main features are listed for the two solutions PW and CSW (Henning, Preuschoff et al. 2002b). Pictures of the prototypes will be shown.

Solution 1: Cranable Semi-Trailer (PW)

This new generation of cranable semi-trailers was developed as a prototype (Fig. 6.18 and Fig. 6.19). A special road vehicle was built with minimum restrictions and modifications. In particular new grab edges were attached for crane handling. This new semi-trailer corresponds completely to the non-intermodal semi-trailers commonly in use today. It has interior headroom of 3 m, total length of 13.7 m and a resulting load volume of 100 m³. The entire height of 3 m interior can be used. During loading the trailer roof is raised in order to position the load. Thus approx. 28 t loading mass can be carried. The rear under-run bumper with the rear lights is equipped in a way to improve the freight processing at the terminal.

In the rear part of the semi-trailer an additional cylinder is mounted (apart from the control unit of the pneumatic spring and the air parking brake). This

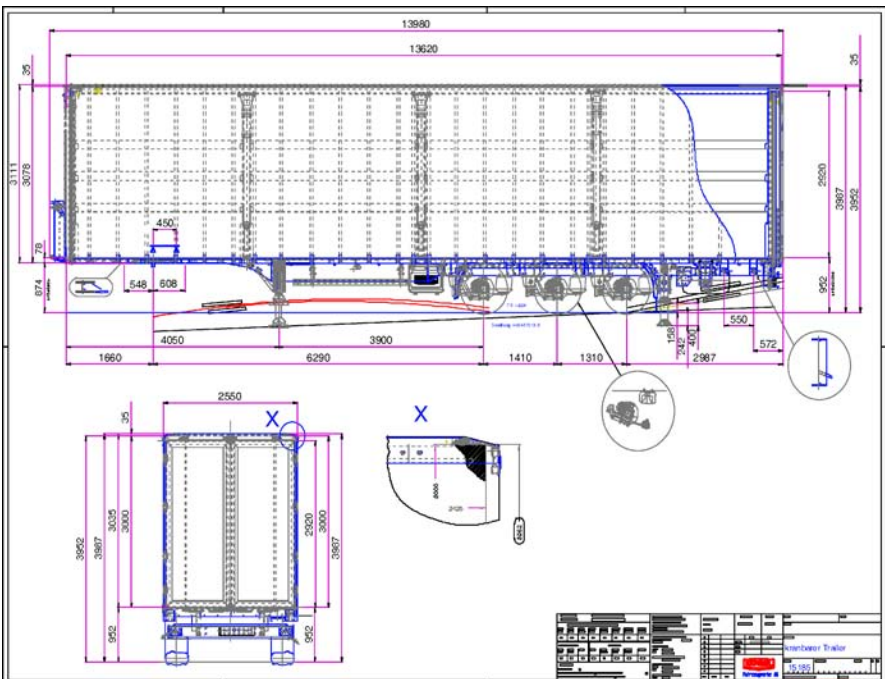


Fig. 6.18. Design sketch of the solution 1: cranable semi-trailer (PW)



Fig. 6.19. Prototype of solution 1: crunable semi-trailer and wagon (PW)

cylinder can be driven out during loading and unloading for support of the vehicle. The axle system consists of three axles. The springs are air-operated. The pneumatic springs are accordingly equipped for vertical loading. This avoids sagging while rising. All three axles are equipped with tires of the size 44 5/45 R19.5. The forward part of the semi-trailer carries the lateral under-run bumper. Due to the supports the semi-trailer can be stored on ground without tractor. Finally the king pin is mounted within the foremost area, in a distance of approx. 1.70 m from the front. The grab edges for the cargo handling gear of the crane are mounted in standard distance under the information plate of the semi-trailer. Hence, the unit load device can be fastened from the inside to the logistic steel base plate.

Thus, this crunable semi-trailer is fully equipped for intermodal transport. Its use on the road, however, does not differ from the use of other road vehicles. The semi-trailer is equipped with a ramp starting assistance which brakes if necessary, through the left and right half of the vehicle's axles to back up to the ramp safely. A navigation-tool is connected with the truck by a specific interface. It enables constant information for scheduling, the position and the status of the vehicle.

So far the description of the road vehicle. For this prototype, a new pocket-wagon generation was developed. It realizes optimum loading gauge. The rail-mounted vehicle has a length over buffers of 19.7 m and a pivot distance of 14.2 m. The bogie has an axle-base of 1.8 m and wheel diameter of 840 mm. On the base position (front cross beam) the support is attached in a distance of approx. 2200 mm. This support is hinged if containers must be transported, and it is adjustable accordingly for the support height of 980 mm and, with respect to newer generations, for 850 mm standing height. The old standing height of approx. 1100 mm can still be integrated if desired. For this fixed sup-

port position a base position is defined in a distance of 7700 mm. This base position defines the middle axle of the semi-trailer. Around this base position a pocket was built, which has a standing height of 270 mm. This pocket is arranged in such a way that semi-trailers of different lengths and different axle positions can be shipped. The innovation in this rail-mounted vehicle is that no wheel-rugs are necessary. The save locking-in of the semi-trailer can be done through the king pin and the locked air brake of the axles. Additionally in the new railway loading gauge of this pocket-wagon, the turn-up of the semi-trailer bumper for shipping is not necessary any more.

Containers of the classes “20 foot to 24 foot” as well as containers of the classes 30/31 and 40/42/44 and 45 foot can be shipped on this new pocket-wagon. The wagon has to be codified on P400/P70 due to the possibility to take up the new semi-trailers with a corner height of four meters.

Solution 2: Swap-Body Concept (CSW)

This swap-body has the same loading mass (28 t, 100 m³) and the same external and internal dimensions (3 m interior headroom, 13.6 m interior length) as the cranable semi-trailer (Fig. 6.21). In contrast to the cranable semi-trailer, however, the loading box can be separated completely from the wheels and the wheel set of the road vehicle, and it can be shipped separately on an adapted wagon. Thus the carriage remains on the road, and proceeds with the truck/tractor. It means that the road wheel sets remain with the haulier locally. The swap-body corresponds to the new types of modern semi-trailers. This self-supporting swap-body has cross bars within the lower area with a submergence depth of approx. 270 mm. Furthermore it has grab edges in the standardised distance of approx. 5 m. For this swap-body, a rail-mounted vehicle was developed which can be used with a coding of C70 in the rail traffic. The rail-mounted vehicle has a total length over buffers of 19.74 m and, like the rail-mounted vehicle for the semi-trailer (solution 1), has a pivot distance from 14.2 m. The assigned



Fig. 6.20. Design sketch of solution 2: swap-body and bogie (CSW)

(solution 1). In the project SAIL these two types of wagons are offered as a joint vehicle. Thus it is possible, apart from saving one bogie, that one rail-mounted wagon is available that can carry the old swap-bodies, additionally about all container configurations, and both these innovative developments: the new semi-trailers (PW) and the new swap-bodies (CSW). By the integration into one vehicle, the operating expenses for the scheduler are reduced by the factor four. Such an arranged rail-mounted vehicle has total length of 33.68 m over buffers, pivot distance of 13.95 m from the outside bogie of the carrying wagon section to the central bogie, and pivot distance of 14.2 m from the outside bogie of the pocket-wagon to the central bogie. The joint vehicle has double coding which corresponds to C70 for the swap-body section, and P400 for the pocket-wagon section. This coding is only used by loading a new swap-body or a new semi-trailer.

6.2.7 Testing for Commercial Transportation (Step 8)

These different prototypes of the new semi-trailer/wagon combination (PW) and the swap-body/wagon combination (CSW) were designed and built within SAIL. Ewals Cargo Care took the role of testing the new equipment for commercial transports under real circumstances. During the commercial trial period the new trailer went a distance of 47,757 km. In total 56 transports were conducted. The payweights of the goods were between 9400 kg and 24500 kg. The total achievement was 750,000 tkm. In detail, the following observations have been recorded (Table 6.6 and Fig. 6.23).

The homologation procedure of the SAIL wagon was started early. Unfortunately it was finished after the end of the project. Hence, the wagon could not be included in the commercial tests. Anyway wagon technology based on the SAIL concept was later successfully introduced into the market.

Semi-Trailer (PW-Alternative)

The trailer was exclusively used for road transports – mainly full truck loads – between Germany and Italy. The major part of the transports door-to-door was for

Table 6.6: Examples of actual routes

FROM	TO	KM	COMMODITY
IT-NOGARA	DE-LÖHNE	1.073	WHITE GOODS
DE-BREMEN	IT-MANTOVA	1.203	FORKLIFT TRUCKS
IT-ASTI	DE-WOLFSBURG	1.108	AUTOMOTIVE PARTS
DE-BOCHUM	IT-PERUGIA	1.339	TEXTILES
IT-BELVEDERE	DE-OHRDRUF	1.122	FURNITURE
D-BOETZINGEN	SF-UUSIKAUPUNKI	1.798	AUTOMOTIVE PARTS



Fig. 6.23. The routes of the prototype tests

distances of more than 1000 km, and a quite large variety of commodities were moved during the trial. The Alps were crossed for all transports, and this was done via the St. Bernhard and the Brenner connection (Table 6.6, Fig. 6.23).

Unfortunately the wagon for railway transport of the SAIL equipment could not be made available on time. Therefore, the trailer could not yet get tested under intermodal conditions road-rail-road.

Ewals Cargo Care decided to have only one individual driver on one tractor unit moving the trailer throughout the entire trial period in order to keep continuity and to record more easily experiences with the new equipment. At the end of the trial period the driver was interviewed about his experiences and his observations, and also a questionnaire was filled in. As an overall result, it can be said that the SAIL trailer showed very good performance under road conditions. The general comment by the driver was: "Between February and May 2002 we drove 47757 km with this trailer – without any problems".

When looking at the competitiveness of these innovative transport means, the most important feature was the 3 m internal height in combination with the high payload. Also the sliding roof made it possible to do transports which cannot be done with conventional equipment.

Concerning the craning of the new equipment, the trailer was handled at the Cologne-Niehl terminal of Ewals Cargo Care on 19th March 2002. It was dealt with by standard intermodal handling equipment and regular handling staff (crane drivers). There were no technical problems detected, neither when using

a gantry crane, nor when using a mobile crane. The result of this trial was that the equipment can be used beneficially in daily intermodal handling business.

Swap-Bodies (CSW-Alternative)

These units were tested for short distance road transports. Ewals Cargo Care detected some minor technical issues which need further attention and will be resolved for the production of a larger series of units. It has been concluded that general design characteristics will not need to be changed.

So far, the project SAIL has been described. It has become obvious that innovations towards increasing the market share of intermodal freight transport in Europe might be possible because such innovations as described would in principle be acceptable to freight forwarders on a large scale. There are, however, fundamental problems to be taken into account if European politics were developing in this direction of acting. In the following paragraph, it is briefly discussed how some of these problems may be overcome.

6.2.8 Challenging Innovation Oriented Politics

As discussed by Stumpe (2003), recent research was performed in the USA to measure the damage caused on motorways by heavy trucks. It has been shown that these trucks are the main cause for motorway damages. In comparison, cars do not cause any significant damage. Hence one of the main expenses for the European countries in transportation, is to repair these damages continuously. These aspects have been followed further by the research project SAIL.

Calculations have been performed within SAIL to estimate the numbers of heavy trucks and their load per km across Europe, for the period until 2010. These calculations are based on the figures comprised in the Whitebook of the European Commission (European Commission 2001). There the figures are given for the years 1990-1998. They show roughly a linear relationship of truck numbers and years. Hence the linear extrapolation performed in SAIL, starts with these data from 1998 to be extended until 2010. Two additional scenarios have been considered by Stumpe (2003) which describe the Best Case and the Worst Case. They lead to extrapolated data which are located below and above the Whitebook data. They are also fully sensible and acceptable as options for future development of the freight transport system. Here, however, the Whitebook data extrapolation will merely be followed further.

According to the linear extrapolation, the figure for overall European freight transportation for the year 2010 is

1711×10^9 tkm.

It refers mainly to road-only transport. This figure, however, can only be achieved if all motorway damages are being continuously repaired. Additionally the existing motorways need to be extended and enlarged. Here a linear

relationship of transportation figures and overall road investment in Europe can be assumed. This extrapolation would need to be based on the existing data of the Whitebook. Hence the total cost estimation for the year 2010 leads to the figure

900×10^9 EURO.

These expenses have been added up for the years 1998–2010 in order to make the estimations more easily usable for comparisons.

The main aim of the research project SAIL was to investigate the options to shift significant portions of freight transport from road to rail. Corresponding to the results of SAIL, one particular strategy for such shift would be as follows: to equip all semitrailers with grab edges to allow easy crane handling at the intermodal terminals. Thus it would become possible to transport semi-trailers on rail for long-distance haulage, without any further difficulties. This innovative technology may migrate into semi-trailer production gradually if all new semi-trailers are equipped with these grab edges as they are being built.

The additional costs for the producer to mount these grab edges onto the new semi-trailers, would be about 2000 EURO per trailer. This amount could be offered to the truck producers by the national Governments or the EU, free of any other burden. It would be paid out of the expenses saved from road repairs if an increasing number of semi-trailers are transported by rail. The figures corresponding have been estimated by SAIL as follows.

The percentage of semi-trailers compared to all heavy-good vehicles (HGV), is at present calculated to be about 17%. Within SAIL it has been extrapolated that it may increase up to about 20%, by the year 2010. Accordingly the overall figure of semi-trailers in use by 2020 has been calculated for this case, following a polynomial extrapolation. This figure is about 1.7×10^6 semi-trailers. Thus the expenses for the new grab edges would come to about

10×10^9 EURO.

These expenses have been added up again for the time period corresponding.

Now the road damages are to be considered again as they are caused by these semi-trailers. It can be sensibly assumed that at maximum 70% of all long-distance haulage may be shifted from road to rail by utilising the newly equipped semi-trailers for rail transport. These figures lead to certain estimations of the savings on motorway repairs etc. which amount to

54×10^9 EURO.

This figure is again added up for the time period considered.

In comparison, the two additional scenarios mentioned above, lead to the following figures:

- Best Case: 76×10^9 EURO
- Worst Case 30×10^9 EURO

Hence it follows that the savings on road repairs appear to be much higher than the expenses paid to the truck producers as their main incentive to equip future semi-trailers for rail transport. The remaining savings are considerable. They could be used to improve and develop further the road-rail infrastructure. It refers particularly to building new intermodal terminals, rebuilding and extending the rail system for freight transportation etc.

In this way the EU and the European countries may contribute to higher efficiency and a more significant role, of intermodal transport within the European freight transport system.

It may be worth mentioning here that the project SAIL was awarded to be one of the Reference Projects of the European Union.

6.3 European Low-Platform Technologies for Non-Cranable Semi-Trailers

6.3.1 Analysing Four Low-Platform Technologies (Step 1)

Understanding the System

Objectives of the Project

In this section the European research project RoRo-Rail is described which deals with low-platform technologies for non-cranable semi-trailers. The consortium of this research project was given the task to perform specific research concerning certain aspects of European freight transportation. The objective was a Feasibility Study to consider these low-platform technologies for non-cranable semi-trailers with particular emphasis on the hinterland of the ports of Lübeck¹. The project was funded by the German Federal Government (Ministry of Education and Research – BMBF)².

This case study focused on innovative technologies which more or less existed already. Hence, several specific low-platform technologies were chosen from these existing technologies. This choice was based on the following criteria:

- Applicability for all semi-trailers of EU-Directive 95/53,
- No limits for dimensions and weight of licensed semi-trailers,
- No modifications of the design of semi-trailers to be needed,
- No additional equipment to be required,
- Only horizontal handling systems of semi-trailers to be considered,
- No need of transportation of tractor and driver,
- Costs for maintenance not to be increased, hence, no small wheels of the wagons (<600 mm).

¹ Chosen as an exemplary area.

² Up to 2006 the transport sector was part of the Federal Ministry of Education and Research (BMBF). Today it is part of the Federal Ministry of Economics and Technology (BMWi).

On this background, four technologies were selected for this research:

- CargoBeamer, Germany: this approach is the most innovative approach in terms of intermodal efficiency but so far, it only exists as engineering drawings and simulations.
- CargoSpeed, Great Britain: this prototype has been built which made the demonstration of operation possible.
- Flexiwaggon, Sweden: this prototype has also been built but the presentation of its complete operation was not yet possible.
- Modalohr, France: this company is operating a specific RoRo-system financially supported by the French Government.

None of these four technologies have so far been successfully implemented into the market nor have they been running as financially independent business. Official institutions wanted to know if those technologies can be conducive to the harmonization of the freight traffic growth. In addition – and even more important – it has to be estimated whether those technologies will be accepted by the market in the long run. Hence, it had to be answered whether their successful migration is probable (Savelsberg 2005a). The author (Eva Savelsberg, maiden name Preuschoff) was head of the economic evaluation team.

Expected Characteristics of the Start-Up Situation of the Innovation Processes

Dimension	Type A	Type B
Time orientation	Present-oriented	Future-oriented
Timing	Short-term	Long-term
Validity of information	Precise	Diffuse
Competence orientation	Using synergies	Generating competencies
Market competencies	Familiar market	New market
Technology competencies	Available	New
Outward orientation	Self-sustaining	External-cooperative
Supplier orientation (supply side)	Ordering	Development cooperation
Customer orientation (demand side)	Mainstream	Lead-user cooperation
Change management	Algorithmic	Heuristic
Complexity	Low	High
Flexibility	Low	High

The Feasibility Study described here, was an innovation process in itself. It was to evaluate certain technological innovations in freight transportation. Hence, the feasibility study would influence the innovation processes of each of the considered technologies. There were five consortiums involved: four consortiums at that time putting the technologies to be investigated into practice, and one consortium conducting the feasibility study.

Hence many different persons were involved. The feasibility study can be assumed to be an innovation process conducted on a meta-level.

The following list describes the expected characteristics of the start-up situation of the innovation processes – the feasibility study – according to the coordinate systems of Eversheim (2003). The characteristics are visualized in Fig. 6.24.

Time Orientation – Square I

The feasibility study had to be conducted during one year (Timing, *short-term*).

The evaluated innovative technologies would have *decisive impact* on the long-distance freight market. The information was gained based on different sources (Validity of information). Data concerning those four evaluated tech-

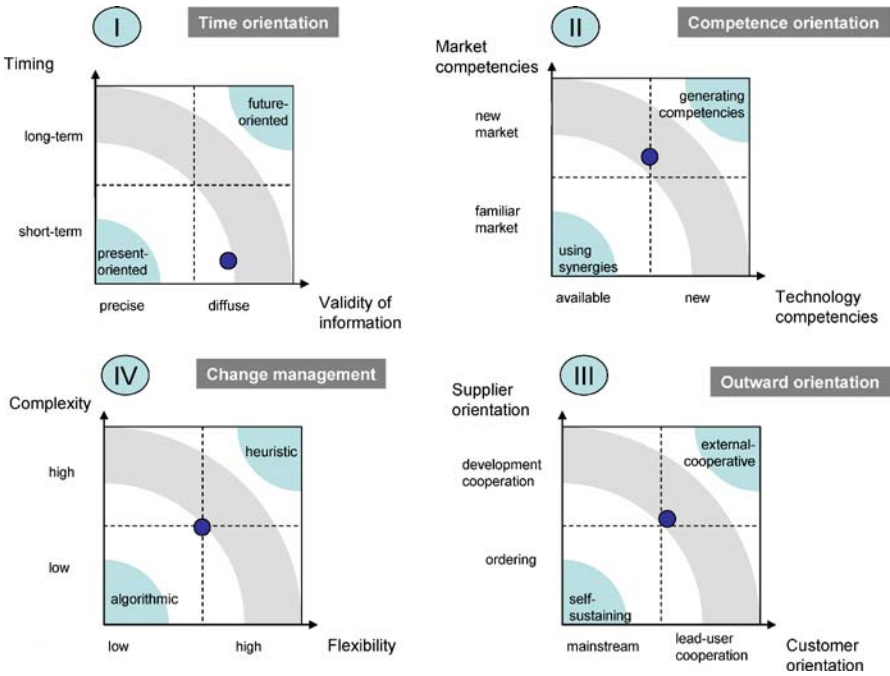


Fig. 6.24. Visualisation of the start-up situation of the Feasibility Study (RoRo-Rail)

nologies had to be checked. It was necessary to conduct *surveys* for further information. The evaluating *consortium* included different institutes and companies. Information had to be exchanged and discussed. Hence the validity of information is rated *diffuse*.

Competence Orientation – Square II

The feasibility study was focused on the competitiveness of the evaluated technologies. In general everybody was familiar with the market (Market competencies). The applicability of new technologies with their decisive input on the market should be evaluated. Hence, detailed information about the probable market response had to be gathered. The evaluation of special aspects of a *Business Model* would be one of the most decisive products of the project. The further gain of market competencies is *high*.

It was important to evaluate the technological performance of the different RoRo-solutions (Technology competencies). Different simulations were conducted. The gain of technology competencies can be rated between *low* and *high*.

Outward Orientation – Square III

The cooperation among researchers and representatives of the supply side was established (Supplier orientation, *development cooperation*).

The cooperation among researchers and representatives of the demand side was also established (Customer orientation, *lead-user cooperation*).

Change Management – Square IV

The involvement of *research institutes*, *administrative institutions* and *companies* constituted a certain complexity. The Complexity could be rated between *low* and *high*.

The members of the consortium had to consult with each other and with representatives of the different technologies. Strategies had to be based on mutual agreement and if necessary, adapted to new information. The Flexibility was rated between *low* and *high*.

These aspects are shown in Fig. 6.24.

The four coordinate systems are merged in the way described in Chap. 3 (Fig. 6.25). The characteristics are mostly within the concentric ring area. Competencies have to be generated. The evaluation process itself can be characterized to be a *Moderate Innovator* contributing towards *Thorough Innovators* (evaluated technologies). The feasibility study can be described as being rather present-oriented, generating competencies and outward-oriented. A moderate heuristic approach is recommended but no major obstacles are expected.

The evaluated technologies are assumed to be *Thorough Innovators*. During their development process it would have been advisable to accomplish all steps of the systemic innovation management method. Considering the evaluation process, which is a *Moderate Innovator* itself, specific steps of the method should be conducted (Fig. 6.26). They are described as a first project overview, as follows.

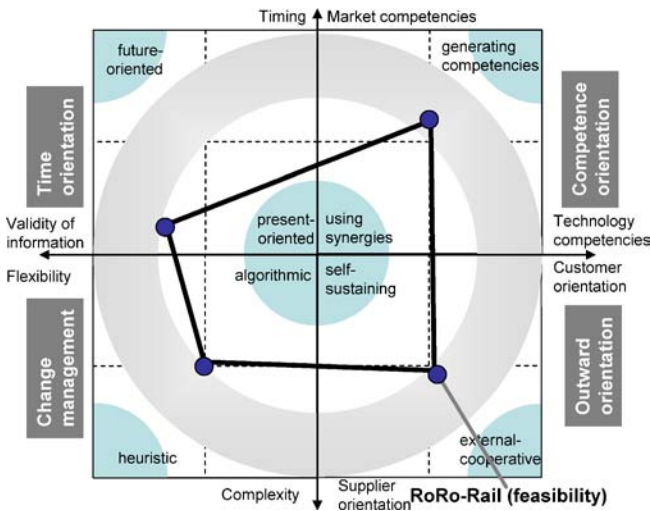


Fig. 6.25. Summary of the Feasibility Study (RoRo-Rail)

Recommended Steps of the Method

Due to the characteristics of the Moderate Innovation, development cooperation and lead-user cooperation are recommended (Step 2). The probability of migration of those technologies is called into question. Hence, this Step 3 is supposed to be the most important. Lead-users are part of the consortium, hence the gaining of information is made easier. The project deals with the evaluation of already more or less existing technologies. Hence it is not necessary to perform Step 4. The requirement specifications are combined with the system specification (Steps 5 and 6). Information is processed and checked considering the questions: what has been intended to be realized and how has it been realized. The results of the Business Model which started with Step 3, are used. At the same time the requirement specifications and the system specifications contribute to the Business Model. The prototypes do already exist (Step 7). The demonstration and evaluation are mostly based on simulations and surveys of the prototypes (Step 8).

The probability of *migration* of the technologies is to be evaluated. Because of the moderate character of this innovation, *accompanying* innovation management is sufficient. The *Social, Economical* and *Technological partial-systems* should be taken into consideration since technologies as *Thorough Innovators* are considered. The main focus will be on the *Economical partial-system*.

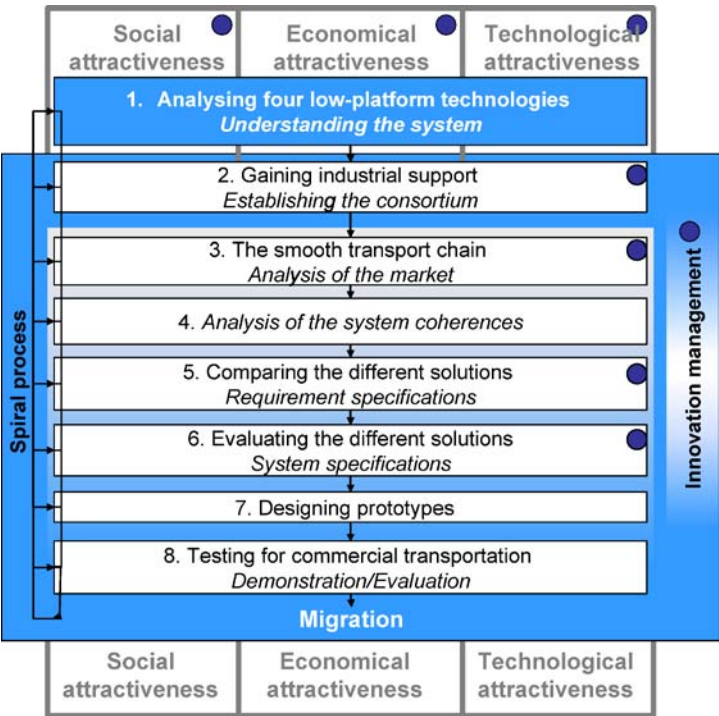


Fig. 6.26. Recommended steps to be performed in the Feasibility Study (RoRo-Rail)

6.3.2 Gaining Industrial Support (Step 2)

Establishing the Consortium

The consortium included universities, administrative institutions as well as companies.

Universities:

- Institute of Track and Railway Operations, Technical University of Berlin
- Institute for Conveying Technology and Logistics, University Karlsruhe (TH)
- Department of Computer Science in Mechanical Engineering, RWTH Aachen

Administrative Institutions:

- Promotion Centre for Intermodal Traffic (SGKV), Frankfurt
- ASG European Road Transport GmbH, Lübeck

Companies:

- TT-Line GmbH & Co. – privately-owned group of shipping lines/ferries
- Lübecker Hafen-Gesellschaft mbH – Port of Lübeck

6.3.3 The Smooth Transport Chain (Step 3)

Analysis of the Market

Questions to be Answered

Value Proposition: The need of the customer Government is already described in Step 1. The demand side in the project RoRo-Rail is represented by the two companies included in the consortium (shipping lines/port). The products of the supply side are evaluated (development teams of the low-platform technologies).

The need of the demand side is a smooth transport chain from the hinterland of the port Lübeck towards destinations in Sweden.

6.3.4 Comparing and Evaluating the Different Technologies (Steps 5 and 6)

Requirement/System Specifications

The chosen technologies will be presented and analysed in the subsequent chapter (*value chain*). The following aspects are to be considered:

- Terminal logistics: Aspects of terminal handling processes (*value chain*) (TH Karlsruhe),
- Technology and operation: Aspects of railway environment (*value chain*) (TU Berlin),
- Economic efficiency³: Return on Investment (ROI) and Net Present Value (NPV) which are tools of the Traditional Economic Feasibility Analysis (TEFA), and Profitability Estimation Focused on Benefits (PEFB) which is the tool of the Extended Economic Feasibility Analysis (EEFA) (*revenue-model*).

In the following paragraphs, the four evaluated technologies are briefly described. Subsequently they are compared to each other in terms of the value chain concerning terminal logistics and operations.

The Four Evaluated Technologies (value chain)

The pictures presented in the following are kindly provided by the different companies. Most of those are enclosed in the final documentation of the project RoRoRail (2005) or were used during the final presentation of the project.

CargoBeamer, Germany

The technology CargoBeamer operates with a kind of basket system. Those baskets are stored at the terminal next to the tracks. The tractor drives over the basket, uncouples and leaves the trailer behind inside the basket. The baskets can be loaded or unloaded with their trailers in advance of train arrival or after its departure (Fig. 6.27, Fig. 6.28, Fig. 6.29). The basket is carried by a train-wagon. In the terminal a lifting device can move the basket upwards. A horizontal movement of the basket follows. Then a tractor or a tugmaster can be coupled with the semi-trailer and unload the trailer. As soon as the train arrives, 30 trailers may already be positioned on the baskets. They can be loaded in about 10 minutes – according to the statements of the developing consortium.

CargoSpeed, Great Britain

CargoSpeed – Cargo Rail-Road Interchange at Speed – is a development of one British engineer. The prototype was presented in 2004. A large T-like device between the tracks at the terminal can be moved upwards, and subsequently turned horizontally around a vertical pivot. Thus it lifts upwards the platform of a specially designed wagon (Fig. 6.30). After turning this platform in the horizontal plane, the truck with semi-trailer can cross it and the semi-trailer can be uncoupled and left behind on this platform. This technology would allow “bus stop” operations along the route. The main objective of this technology has been to reduce the distance of intermodal transport in terms of economy, from today 600 km to 300 km.

³ Under the direction of the author.

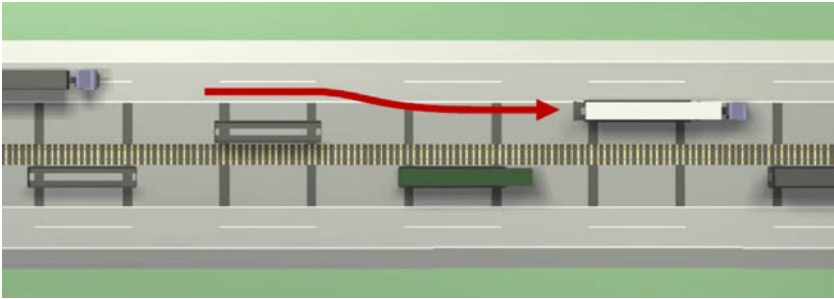


Fig. 6.27. Loading platforms/baskets, CargoBeamer, D

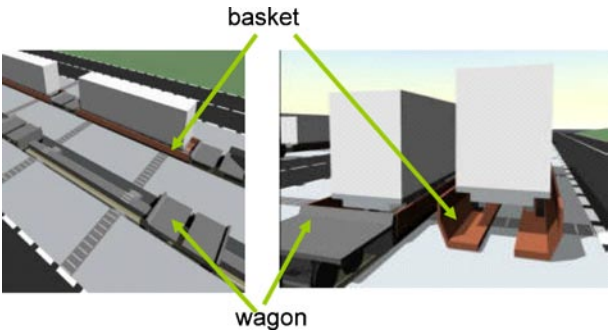


Fig. 6.28. Wagon and basket, CargoBeamer, D

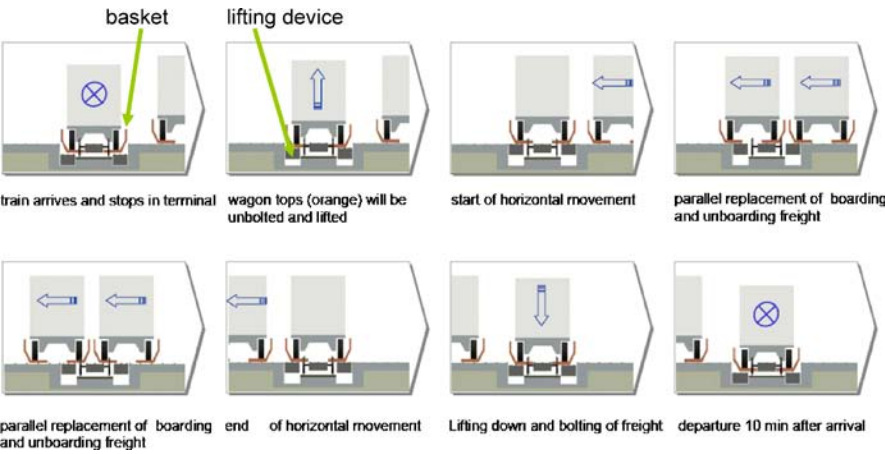


Fig. 6.29. Loading process, CargoBeamer, D



Fig. 6.30. Technology CargoSpeed, GB

Flexiwaggon, Sweden

The technology Flexiwaggon is adapted to the specific needs of Swedish transport. The specific wagon can carry both tractor and semi-trailer. A ramp can be swivelled out hydraulically (Fig. 6.31). The handling process will be fully automated. The truck driver has only to push a button. No special equipment – not even a terminal – is necessary for loading or unloading.

Modalohr, France

Modalohr is a development of the French company Lohr. This technology offers the possibility of sequential loading. The loading platform rotates around the middle of the wagon. The truck can be driven forward onto the ramp (Fig. 6.32). In the terminal a certain area has to be designed for this swivelling. The wagon is constructed as a two-part vehicle. Three wagons can carry either six semi-trailers or four tractors⁴ with trailers⁵. The bogies⁶ have wheels of either 920 mm or 840 mm. Transportation is already conducted on the following corridor: Atiton/Bourneuf (France) towards Orbasso (Italy). Further transportation is planned on the corridor Regensburg towards Vienna.

⁴ German: Zugmaschine.

⁵ German: Anhänger.

⁶ German: Drehgestell – the word *bogie* is as well common for light trailer device without swap-body as presented in the case study SAIL.

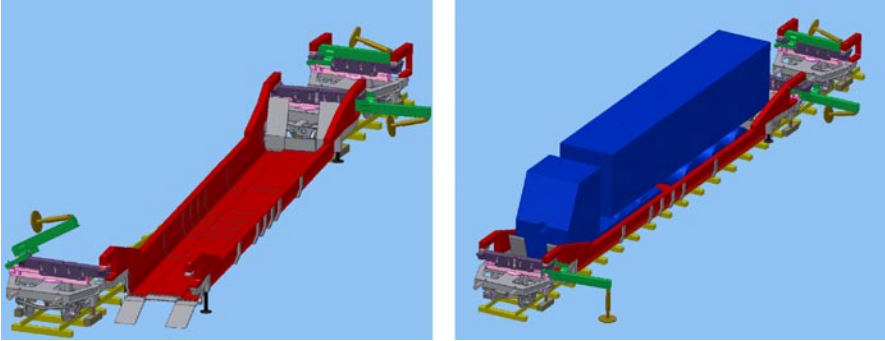


Fig. 6.31. Technology Flexiwaggon, SE



Fig. 6.32. Technology Modalohr, FR

Terminal Logistics: Aspects of Handling Processes (Value Chain)

These four different technological approaches were investigated in the Feasibility Study, in terms of the value chain for terminal handling. Hence a specific terminal concept for horizontal handling was developed. Several different simulations were conducted to test these four concepts under varying conditions.

Two exemplary simulation results are presented in the following paragraph. Fig. 6.33 shows the minimum amount of time which the train has to stop to be unloaded and loaded. The simulation was based on the following assumptions:

- 50% loading to be performed by the truck drivers, 50% by the tugmasters,
- 75% unloading by the truck drivers, 25% by the tugmasters,
- considering one specific stop or terminal of the freight train, 67% of the freight is loaded and unloaded by different trucks, 33% of the freight is loaded and unloaded by the same truck, i.e. the truck arrives, unloads its freight, and picks up new freight.

The number of tugmasters involved was raised during the simulation.

Fig. 6.33 shows that the CargoBeamer technology has a decisive advantage: the actual loading and unloading processes are largely decoupled from the processes taking place when the train arrives to be unloaded and loaded. Regard-

ing the CargoBeamer technology the necessary train stop duration is very low, and independent from the number of tugmasters involved or the percentage of truck drivers delivering or picking up freight.

Fig. 6.34 does not focus on the duration of the train stops but on the *handling times* of the load units. Here, the handling times were estimated. Hence, it has no impact that for the CargoBeamer, loading/unloading has been uncoupled from the train stop duration. Fig. 6.34 shows that under these conditions, the handling performance depends mainly on the organisation of the loading and unloading process and less on the technology. The simulation was based on the same assumptions as the one presented before.

Further simulations considering different terminal concepts were conducted. It was observed during the simulations that the number of tugmasters, the arrangement and positioning of buffer areas, the positioning of the trucks and the information management are the most critical factors.

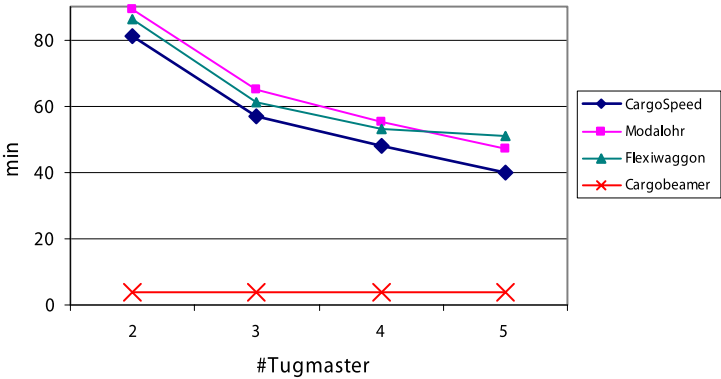


Fig. 6.33. Necessary *minimum duration of time of train stops* for loading and unloading depending on the number of tugmaster (according to University of Karlsruhe 2005)

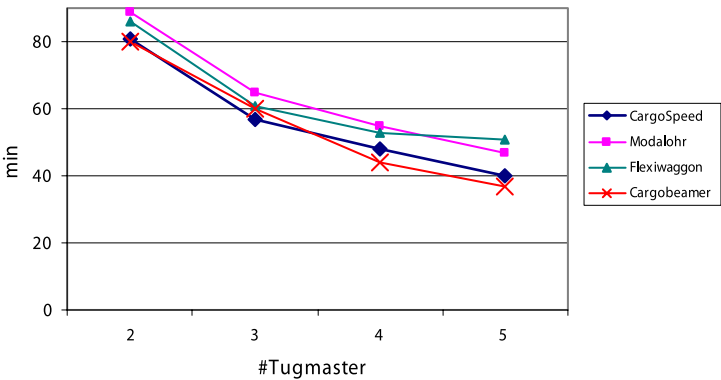


Fig. 6.34. Necessary *minimum period of handling time* for unloading and loading the platforms/baskets depending on the number of tugmaster (University of Karlsruhe 2005)

Technology and Operation: Aspects of the Railway Environment (Value Chain)

A further simulation (Open Track) was adapted to test different operation strategies of these future technologies in comparison.

The *travel time* of the *freight train* was optimized for the first simulation by the following steps: (*separating* the loading and unloading procedure for train and semi-trailer (e.g. CargoBeamer technology), *optimizing* the *terminal structure* and the *organisational procedures*. An A-B-C relation was chosen with one stopover for loading and unloading at B.

A second simulation investigated the *transportation time* of a *semi-trailer* comparing *optimized* and *not-optimized terminal structures* and *operation procedures*. An A-B relation of 500 km was chosen (Fig. 6.35, Fig. 6.36). The loading and unloading procedure was calculated with 60 min each.

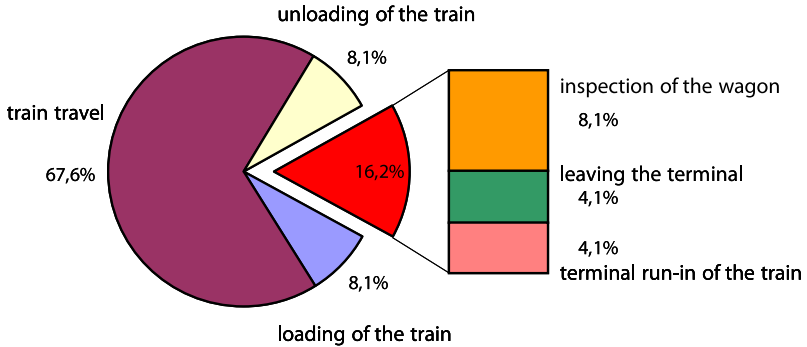


Fig. 6.35. Transportation times of a semi-trailer, A-B relation, 500 km, loading and unloading 60 min each; terminal structure and operation strategies not optimized (according to University of Berlin 2005)

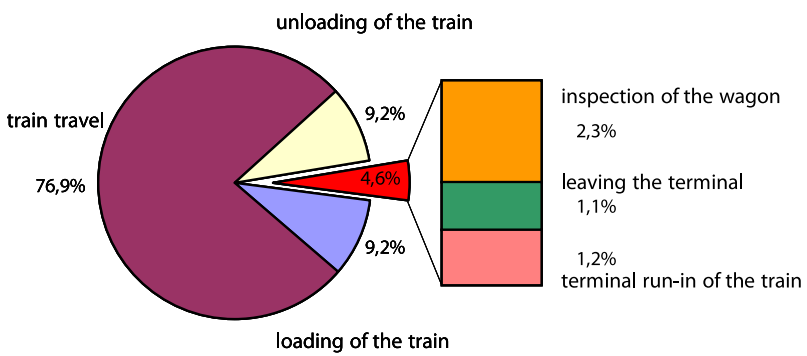


Fig. 6.36. Transportation times of a semi-trailer, A-B relation, 500 km, loading and unloading 60 min each; terminal structure and operation strategies optimized (according to University of Berlin 2005)

It was derived from these simulations that *optimized terminal structures* and *operational procedures* reduce the transportation times of semi-trailers and the travel times of the train by up to 14%. The *separation* of the *loading* and *unloading procedure* (e.g. CargoBeamer technology) is only an advantage if a stopover (A-B-C relation) exists.

Hence it needs to optimize the following structures and procedures: enough possibilities for train overtaking, possibilities of direct run-in and departure of the train, automation of, e.g., wagon coupling etc.

Economic Efficiency (ROI, NPV, PEFB – Tools 7, 8 and 9) (Revenue-Model)

In the following paragraph, the crucial question is: *Would it be beneficial to invest in those technologies* (Savelsberg and Friedrichs 2005)? The approach for estimating economic efficiency is described in Chap. 4. To gain the corresponding data, cooperation between representatives of the *demand side* (here: shipping line, port and in addition, freight forwarders) and the *supply side* (here: intermodal transport operator, terminal operator, wagon owners) was necessary.

Considering the technologies, the main expenditures are: operating costs, costs of investment and capital costs. Those *costs* are shown in Table 6.7. Money can be earned by handling and transport of the semi-trailers. This revenue is considered the *benefit* of those technologies.

In the following tables the necessary data are listed regarding the economic evaluations. Those data were gained during joint surveys of the prototypes and the operating system, furthermore through visits of representatives of the development consortiums, and utilising the cooperation patterns mentioned above.

Two routes were considered: Point-to-point relation (A-B) to realize a shuttle train, and a cyclic relation⁷ for coverage of an area (A-B-C-D-A) (Fig. 6.37). The consortium had to agree upon estimations and assumptions. Those are listed in Table 6.8.

Table 6.7: Costs and benefits in intermodal transport considering the supply side (terminal and technology purchase and operation)

Costs		
Investment	Operating costs (annual)	Cost of capital (annual)
– Rolling stock, wagons	– Route & traction	– Pay-back of credits
– Rolling stock, train engines	– Costs of maintenance, wagon	– Interests for credits
– New terminals	– Overhead	– Amortisation
	– Terminals	
Benefits		
– Revenue: handling and transportation of semi-trailers		

⁷ Possible relation: Lübeck–Ruhrgebiet–centre of Germany–Niedersachsen–Lübeck.

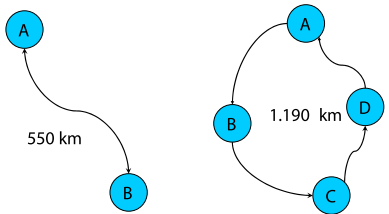


Fig. 6.37. Point-to-point relation (left) and cyclic relation (right)

Table 6.8: Collected data considering the point-to-point relation and the cyclic relation

Data	Value
Utilisation of trains	80%
Number of train-sets	3
Number of storing positions per train	27 up to 36 semi-trailers – max. length of train 620 m
Number of tugmaster at the terminal	3
Train-travels per year	Point-to point: 280; cyclic 230 - 320 depending on the transportation system
Distance between terminals	Point-to-point: 550 km; cyclic: 180 - 460 km (all together 1190 km)
Number of shifts at the terminal	3
Number of employees at the terminal	5
Internal interest rate of return (German: interner Zinsfluss)	8%
Tax rate (corporate income tax and trade income tax)	37.5%
Annual interest rate for credit	8%
Equity ratio of the investment	30%
Price for transportation	0.9 EURO per km

In Table 6.9, the data for the economic evaluation are listed taking into consideration the four different technologies. The main obstacle throughout the whole project was the following: the technology Modalohr is the only one operating. Therefore reliable data only existed of this technology. Data regarding the other technologies were based on the statements of the developing consortiums/companies. Before the year 2005, however, the costs (traction) rose decisively if the weight of the train was above 1600 t. Although this restriction does not exist any longer those data are still considered because strategy changes might occur again in a similar way, in the future.

Table 6.9: Necessary data for economic evaluation ([1] inclusive two loading platforms) (Savelsberg and Friedrichs 2005)

	CargoBeamer	CargoSpeed	Flexiwaggon	Modalohr
Max. number of semi-trailers (train weight max. 1.599 t)	29	27	27	28
Max. number of semi-trailers (max. train length 620 m)	31	33	27	36
Costs per wagon	105,000 EUR	120,000 EUR	175,000 EUR	355,000 EUR
Period of amortisation per wagon	20 years	20 years	20 years	20 years
Running costs per wagon	0.063 EUR/km (developer)	0.06 EUR/km (approx.)	0.06 EUR/km (approx.)	0.053 EUR/km (developer)
Width of handling area in terminal	38 m	60 m	25 m	50 m
Length of terminal	660 m	660 m	660 m	660 m
Extend of handling area	25,080 m ²	32,000 m ²	16,500 m ²	31,000 m ²
Area Check-In /-Out	2,000 m ²	2,000 m ²	2,000 m ²	2,000 m ²
Buffer area	10,000 m ²	10,000 m ²	10,000 m ²	10,000 m ²
Terminal investments – for the new intermodal techniques	1.2 Mio. EUR	2.3 Mio. EUR	non	3 Mio. EUR
Time of circulation for cyclic relation	21 hours	29 hours	29 hours	30 hours
Transported semi-trailer per year (80% utilisation of the trains)	41,644	44,352	36,288	48,384

Here, the calculations of the two tools Return on Investment (ROI) and the Net Present Value (NPV) were combined.

Return on Investment (ROI):

$$ROI = \frac{P}{C_{Inv.}} \times 100$$

- ROI: Return on investment
- P: Profit at present value (cash value during investment period)
- C_{Inv.}: Invested capital in the beginning of the investment period (EURO)

The *profit at present value* P considers the cash value of the expected revenue during the investment period. The invested capital C_{Inv} considers the invested capital in the beginning of the investment period. Thus, the disadvantage of this tool – the short period considered – is avoided.

The NPV tool considers the cash flow instead of the accounting revenue. This discounted-cash-flow approach “focuses on cash inflows and outflows while taking into account the time value of the money” (Horngren, Sundem et al. 1999). Hence, investing companies can base their decisions on more realistic estimations.

Net Present Value (NPV):

$$NPV = \sum_{t=0}^n \frac{EVA_t}{(1+i)^t}$$

NPV: Net Present Value based on yearly EVAs

EVA: Economic value added = Cash flow (CF)

EVA_t : Cash inflows and outflows at the end of the period t (EURO)

i: Discount rate⁸ (minimum desired rate of return, based on the company's cost of capital) (%)

t: Period (t=1,2, ... , n)

n: Useful life of the investment object (years)

To offer a visualised overview of the findings the tools ROI and NPV were combined.

$$ROI = \frac{NPV}{C_{Inv}} \times 100$$

Results of the Traditional Economic Feasibility Analysis (TEFA)

The cost structures considering both the point-to-point relation, and the cyclic relation are presented in Table 6.10 and Table 6.11. The average costs considering each type of relation are visualized in Fig. 6.38 and Fig. 6.39.

Fig. 6.38 shows that the investment costs account for one-quarter (24%), the operating costs for two-thirds (67%), and the capital costs round about one-tenth (9%) of the average costs.

Fig. 6.39 shows that the investment costs account for one-quarter (23%), the operating costs 58%, and the capital costs round about one-fifth (19%) of the average costs. The raise of the capital costs is due to the high investment for four terminals. This makes long-term credits necessary.

In the following paragraph, the correlation of the Net Present Value, possible charges for transportation, and the utilisation of the trains are visualised. The correlations are quite similar considering both the point-to-point relation, and the cyclic relation. Hence, only the visualisation of the correlation between Net Present Value and utilisation is pointed out.

⁸ Kalkulationszinsfluss.

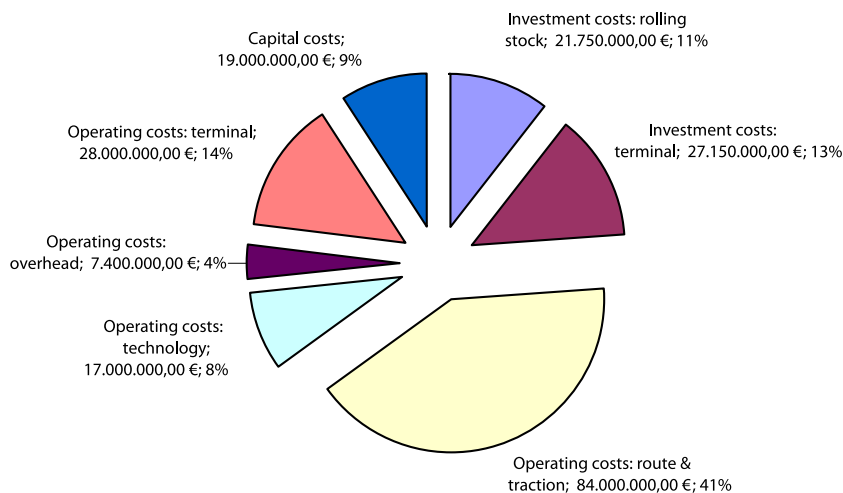


Fig. 6.38. Average costs considering the point-to-point relation (A-B)

Table 6.10: Cost structure considering the point-to-point relation with two terminals (A-B)

Period of 20 years	minimum	maximum
Investment costs rolling stock	18.5 million EUR	25 million EUR
Investment costs terminal	20.7 million EUR	33.6 million EUR
Operating costs route & traction	84 million EUR	84 million EUR
Operating costs technology	15 million EUR	19 million EUR
Operating costs overhead	7.4 million EUR	7.4 million EUR
Operating costs terminal	26 million EUR	30 million EUR
Capital costs	17 million EUR	21 million EUR

Table 6.11: Cost structure considering the cyclic relation with four terminals (A-B-C-D-A)

Period of 20 years	minimum	maximum
Investment costs rolling stock	19.1 million EUR	29.2 million EUR
Investment costs terminal	42.1 million EUR	64.3 million EUR
Operating costs route & traction	104.3 million EUR	104.3 million EUR
Operating costs technology	15.9 million EUR	24.4 million EUR
Operating costs overhead	9.5 million EUR	9.5 million EUR
Operating costs terminal	48.9 million EUR	58.9 million EUR
Capital costs	52.4 million EUR	74.8 million EUR

The Modalohr system needs only an utilisation above 60% in order to realize a positive Net Present Value after a period of 20 years (Fig. 6.40). It is due to the fact that a Modalohr train of 620 m can transport 36 semi-trailers which are more than the other technologies (Table 6.9). The CargoSpeed system and the CargoBeamer system need 70% utilisation and Flexiwaggon ~ 78%. A charge for transportation of 0.90 EURO per km can be realized with most of the systems if the utilisation is above 70% (Fig. 6.41).

Fig. 6.42 shows the correlation of the Net Present Value and the utilisation of trains realising a cyclic relation. A cyclic relation implies to build four terminals (A-B-C-D-A) instead of two (A-B). The systems CargoSpeed and Modalohr can realize a ROI if the utilisation of the trains is above 95% after

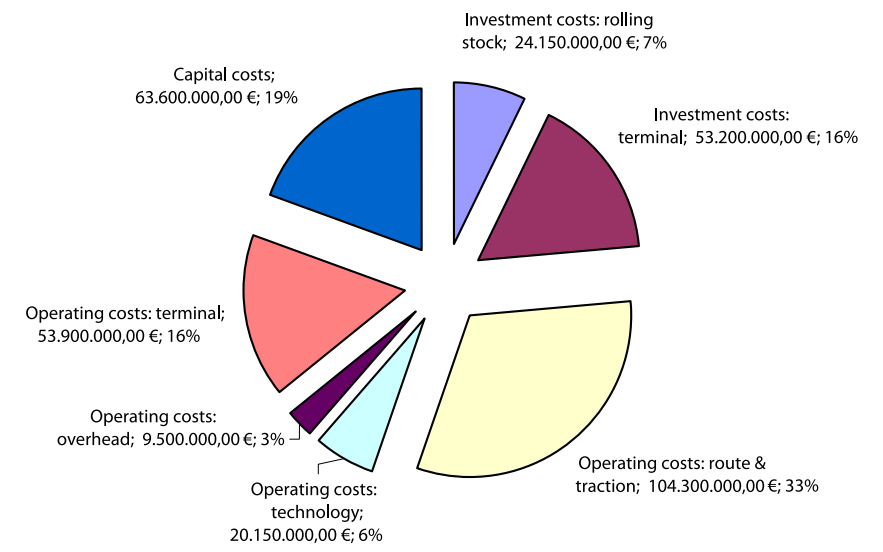


Fig. 6.39. Average costs considering the cyclic relation (A-B-C-D-A)

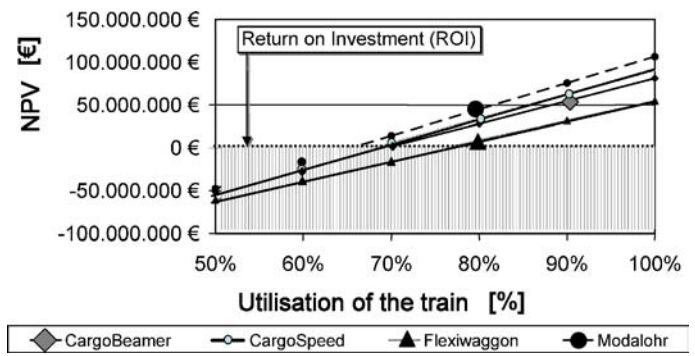


Fig. 6.40. Correlation of changing utilisation of the trains and the Net Present Value – time period considered: 20 years (point-to-point relation A-B)

a period of 20 years. Flexiwaggon would need more than 20 years to realize a ROI. Due to the four train stops the separation of the loading and unloading of the trains and the semi-trailers is a decisive advantage. The CargoBeamer system can realize short train stop durations in the terminal. Its overall travel time is shorter than the travel times of the other systems. Hence, a higher transportation performance (t/km) can be accomplished with the CargoBeamer system. A positive ROI can be realized if the utilization is above 79%.

Results of the Extended Economic Feasibility Analysis (EEFA)

So far, several case studies have been described above in which the specific approach of the Profitability Estimation Focused on Benefits (PEFB) has been used. Hence it may suffice here to merely visualise the results of applying this tool to the RoRo-Rail technologies investigated. The main results are described in the following paragraphs.

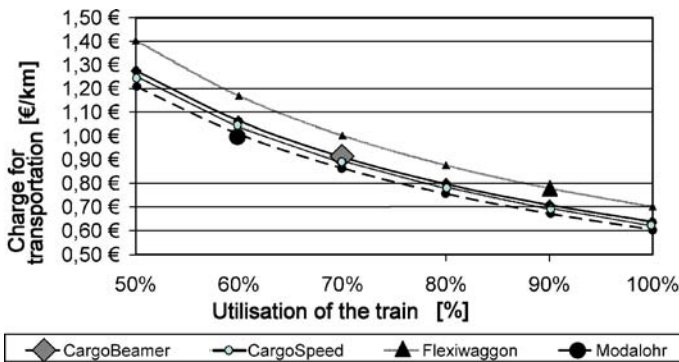


Fig. 6.41. Correlation of changing utilisation of the trains and the possible charges for transportation – time period considered: 20 years (*point-to-point relation A-B*)

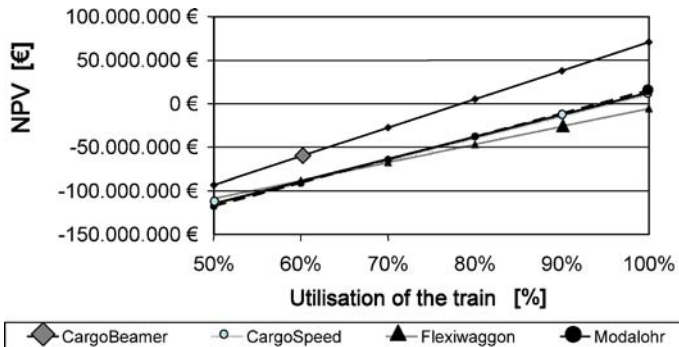


Fig. 6.42. Correlation of changing utilisation of the trains and the costs for transportation – considered period 20 years (*cyclic relation (A-B-C-D-A)*)

Table 6.12 and Table 6.13 list possible costs and benefits. Those are divided into *direct* and *indirect* costs and benefits, and such costs and benefits which are *difficult to ascertain*. The probability that these different types of costs and benefits occur can be *high*, *middle* or *low*. Costs which are difficult to ascertain are, for example, operational obstacles at a terminal. Hence a specific workshop was conducted to derive the definitions of these terms as inter-subjective agreements among the consortium members. During this workshop the costs and benefits were estimated with approximately 50,000 EURO for each terminal. Loss of income due to different reasons was estimated with approximately 5% for each stage of probability.

The expenditures for a new terminal as well as the cost price for each wagon are very diverse and these data were assumed not to be reliable. Hence, those costs were not included in the following estimations. For the calculations following here, the data were utilized as they were agreed upon by the project consortium after performing the estimations and assumptions corresponding.

The data of Table 6.8 were considered as stated. Additionally the restriction of the train length to 620 m was taken into account. Hence, the numbers of storing positions per train and the transportation performance per year will account for differences among the systems. In order to estimate the competitiveness of those transportation systems all data were accumulated, and separated in *costs* and *benefits*. As a result, each diagram shows the graph of these costs and benefits. The estimated competitiveness is reflected by the *point of crossing* of those two graphs showing separately the *costs* and the *benefits estimations*. The benefit-graph specifically shows three stages. Those are due to the probability of utilisation of 60% (risk stage 1 and 2), 80% (risk stage 3, 4 and 5) or 100% (risk stage 6, 7, 8 and 9). These results are briefly discussed in the following paragraph.

Table 6.12: Costs matrix considering the RoRo-Rail transportation chain

Probability that costs incur			
costs	high	middle	low
direct	Investment rolling stock Investment terminal Operating costs of route Operating costs technology Operating costs terminal Capital costs		
indirect	Improvement of system Employee training Operating costs administration Repairing „Schleuderspuren“	Costs for reparations	Reserve of rolling stock
difficult to ascertain	Operating imponderableness Failure (5%)	Failure (5%)	Failure (5%)

Table 6.13: Benefits matrix considering the RoRo-Rail transportation chain

Probability that benefit incur			
benefits	high	middle	low
direct	Profit (60% utilisation)	Profit (+ 20% utilisation)	Profit (+ 20% utilisation)

Point-To-Point Relation

In comparison of the four technologies, Flexiwaggon would need the most optimistic decision maker to risk the investment needed (Fig. 6.43, Fig. 6.44, Fig. 6.45, Fig. 6.46). For this technology, the utilisation of the train length is the lowest. It has to be pointed out, however, that this system is very appropriate for a very specific surrounding.

Cyclic Relation

The CargoBeamer system performs best in the following estimations concerning the cyclic relation (Fig. 6.47, Fig. 6.48, Fig. 6.49, Fig. 6.50). This is due to good utilisation of the train length, and high transportation performance per year. The other systems would be only recommended to be implemented if the decision maker is quite optimistic. Thus the Profitability Estimation may be concluded as far as it has been performed within the feasibility study RoRo-Rail. It follows a short analysis of the findings summarising the main points of this research project.

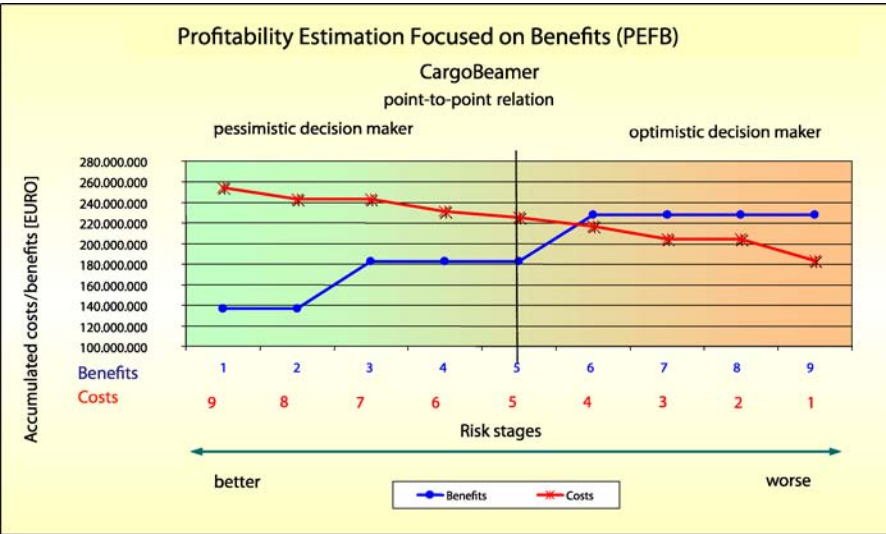


Fig. 6.43. Profitability Estimation Focused on Benefits (PEFB) – point-to-point relation – CargoBeamer

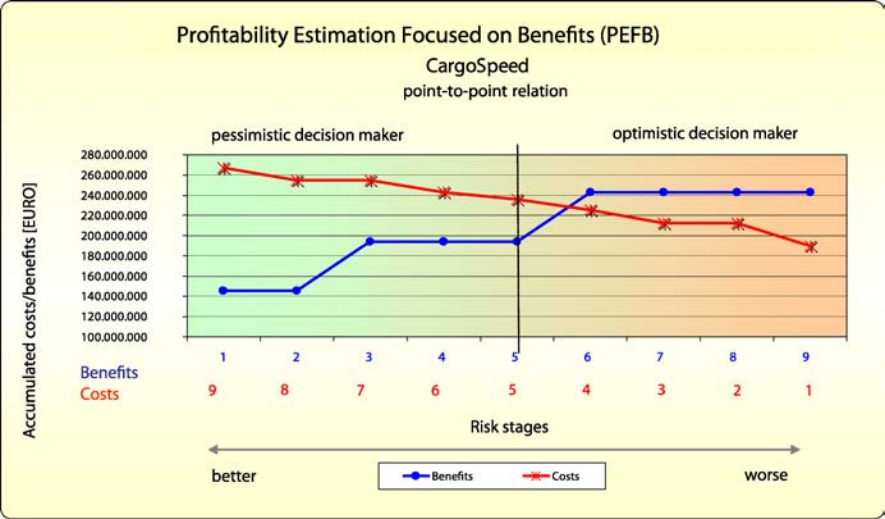


Fig. 6.44. Profitability Estimation Focused on Benefits (PEFB) – point-to-point relation – CargoSpeed

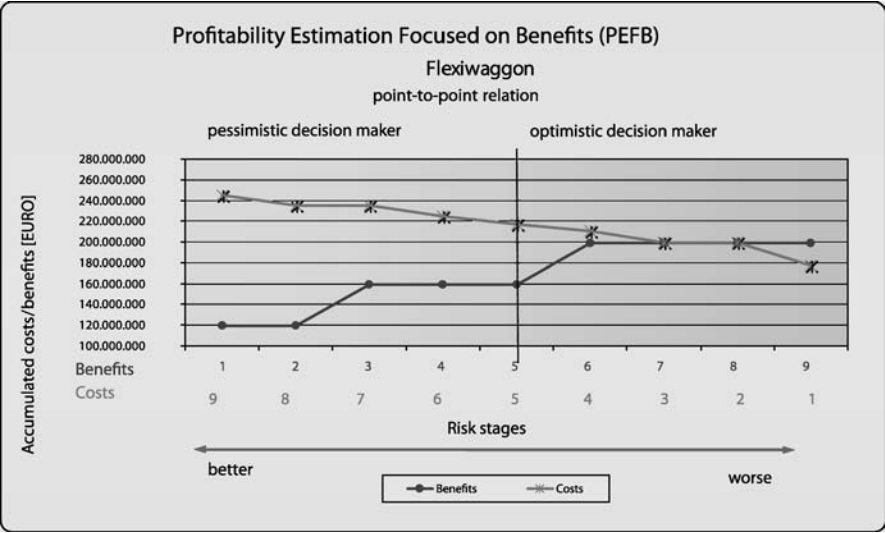


Fig. 6.45. Profitability Estimation Focused on Benefits (PEFB) – point-to-point relation – Flexiwaggon

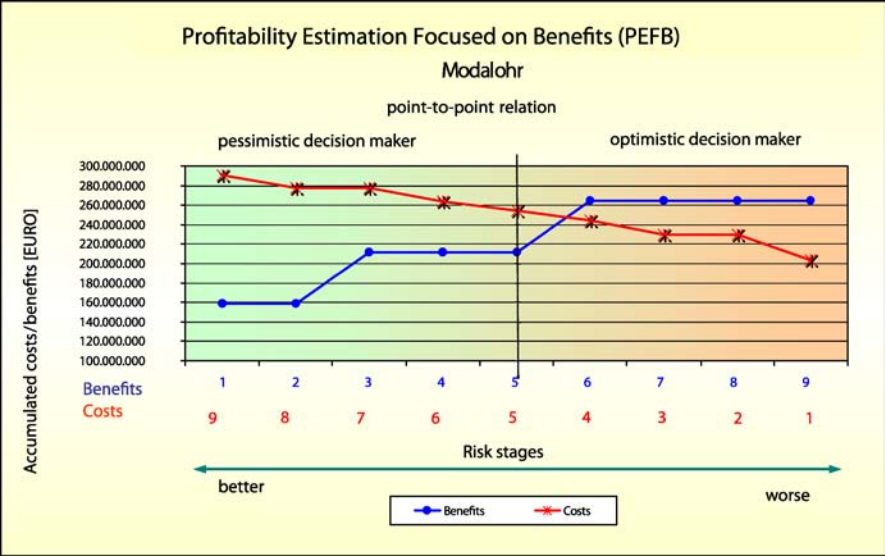


Fig. 6.46. Profitability Estimation Focused on Benefits (PEFB) – point-to-point-relation – Modalohr

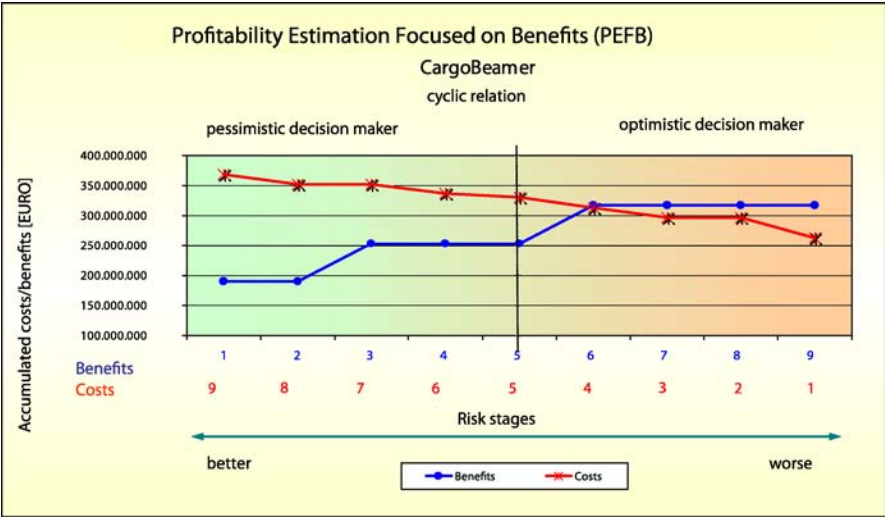


Fig. 6.47. Profitability Estimation Focused on Benefits (PEFB) – cyclic relation – Cargo-Beamer

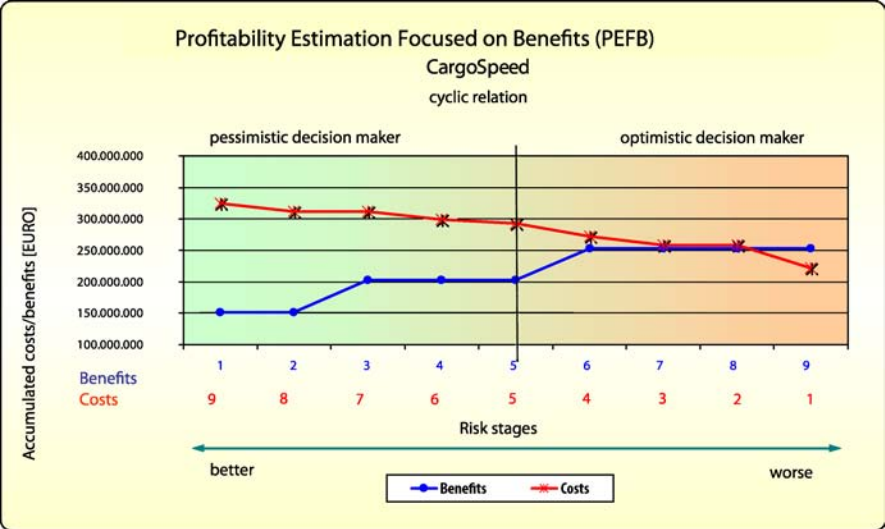


Fig. 6.48. Profitability Estimation Focused on Benefits (PEFB) – cyclic relation – CargoSpeed

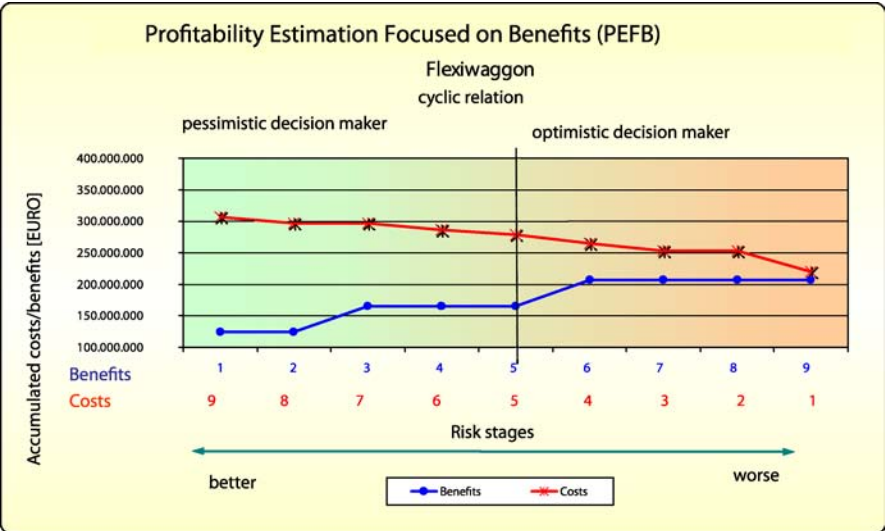


Fig. 6.49. Profitability Estimation Focused on Benefits (PEFB) – cyclic relation – Flexiwaggon

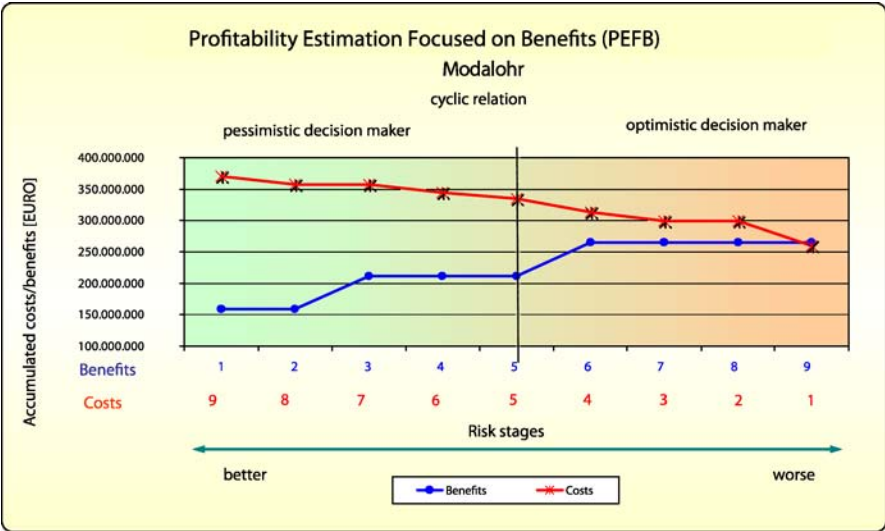


Fig. 6.50. Profitability Estimation Focused on Benefits (PEFB) – cyclic relation – Modalohr

6.3.5 Summarising the Findings of the Research Project

The findings are clustered as follows:

- Feasibility (general, infrastructural, organisational)
- Realisation/migration

Feasibility (General, Infrastructural, Organisational) (RoRo-Rail 2005)

- All four systems investigated seem to be technically and logistically feasible.
- The possibility of separating loading and unloading of the trains and the semi-trailer can support innovative operation strategies (cyclic relations).
- The separation of handling and transportation (CargoBeamer) reduces the travel time of the train. It has minor influence on the transportation time of the semi-trailer.
- The investment in new innovative terminals is only recommendable if a high amount of freight can be expected in the long run.
- The handling time in the terminal mainly depends on the lay-out of the terminal, and the operation or logistic processes in the terminal.

Realisation/Migration

- Specific corridors have to be chosen which are appropriate considering high demand and high performance.
- The logistics needs and business processes of freight forwarders have to be further evaluated.
- None of the four technologies can be advantageously integrated in existing infrastructures. Hence, probably a partial initial funding is necessary to reduce the economic risk of implementing any of these innovative technologies across Europe.

6.4 Resume: Innovations to Improve the Intermodal Transport Chain

In this chapter, the second Field of Action has been discussed: Innovations to improve the intermodal transport chain. The two research projects *SAIL* and *RoRo-Rail* focus on such a decisive improvement of intermodal transportation. *SAIL* has proven to be rather appropriate for single-wagon business, and the *RoRo-Rail* technologies may be applied to full-train business based on a shuttle concept (A-B relation).

Both case studies stress the importance of choosing appropriate corridors. Both case studies also stress the need to make use of government incentives in order to support migration of innovations for the intermodal transport chain. Political developments suggest that in the future, intermodal solutions might be promoted and more strongly supported across Europe. Hence relevant political measures and corresponding economic developments may come into force. Thus the unimodal alternative (road-only) may become more expensive for freight forwarders than today. Subsequently some of the approaches investigated in *SAIL* and *RoRo-Rail* may become feasible and they may be put into practice.

In the following chapter, the third Field of Action will be discussed: Logistic service innovations. It has been investigated by two different research projects: Orient Freight Express, and Poland-Spain Transport.

Chapter 7

Case studies – Part III:

Logistic Service Innovations

7.1 Overview

In Chap. 7, the third of the three *Fields of Action* is considered (Fig. 7.1): *Logistic service innovations*. The case studies presented are:

- the research project *Orient Freight Express* (Sect. 7.2) and
- the prospective research project *Poland-Spain Transport* (Sect. 7.3).

In the following sections the recommended steps of the Systemic Migration – Oriented Innovation Management Method are performed. Finally the results of this Field of Action are matched with the objectives and requirements of the Impact Table.

Fields of Action	Innovative technologies – EFAS/MFG/KONVOI, InDriveS, FlexCargoRail		
	Innovations to improve the intermodal transport chain – SAIL, RoRo-Rail		
	Logistic service innovations – Orient Freight Express, Poland-Spain Transport		
	Economical Attractiveness	Social Attractiveness	Technological Attractiveness

Fig. 7.1. Part of the Impact Table including the case studies

7.2 Orient Freight Express

7.2.1 The Transport Corridor Great Britain-Turkey (Step 1)

Understanding the System

Objective of the Research Project

Objective of the project *Orient Freight Express* is the modal shift of 400 million tkm from road to rail. The project *Orient Freight Express* is focused on the transport corridor Great Britain-Turkey. This corridor is one of the most important corridors. Business will even intensify if Turkey and the European Union decide on terms of closer economic and political relationship (Fig. 7.2). Then the modal shift has to be prepared to be realized between Germany and Turkey on a larger scale than today. This preparation and implementation will happen over the next three years by deploying intermodal block trains between Germany and Turkey as the main part of this corridor Great Britain-Turkey.

The modal shift from road to rail is one of the main priorities listed in the White Paper of the European Union (European Union 2004). The programme *Marco Polo* is designed correspondingly. It is funded by the European Union to support the development and realisation of new customized transportation. These services have to shift a certain minimum amount of tkm from road to rail (or to water-bound) transport. A pilot service is supposed to be tested and supported by *Marco Polo* during a period of three years. The companies involved are to conduct a decisive part of the service on their own account. Hence, a strong interest can be assumed to establish continuing successful service if the consortium is being established for such a project (Savelsberg 2006b).

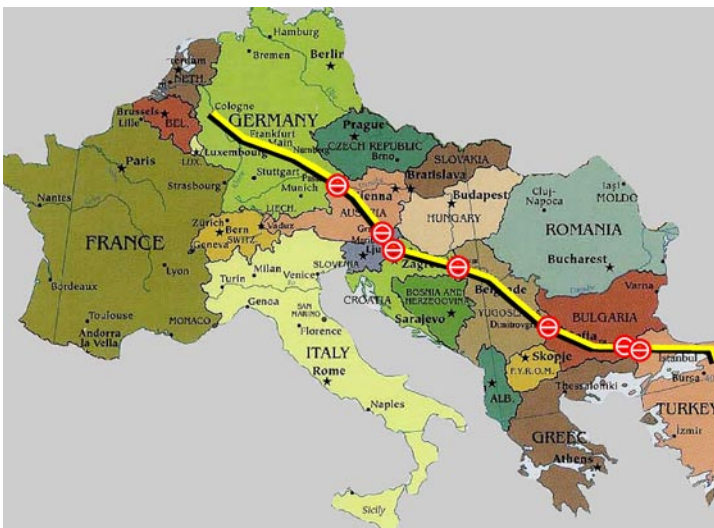


Fig. 7.2. The route used as road – only transport route Cologne – Izmit/Istanbul up to today

The actual business concerning this corridor is described in the following paragraph.

Presently approximately 507000 tons/year of goods would have to be transported within the scope of this project (automotive components, textiles, chemicals, ceramics and electronic goods): They are being transported mainly by road between Turkey and Germany, UK, Netherlands and Belgium. The particular goods relevant for the shift are presently transported by road mainly on the route between Cologne (Germany) and Izmit near Istanbul (Turkey). Austria, Hungary, Bulgaria, Greece and Romania or Serbia are passed (Fig. 7.2). For some countries special transit permissions are needed which in some cases are difficult to obtain. The “road”-route between these two terminals (Cologne-Niehl & Izmit-Köseköy) amounts to 2489 km, with 1.040 km on the territory of the European Union (Germany, Austria and Greece).

Expected Characteristics of the Start-Up Situation of the Innovation Processes

Dimension	Type A	Type B
Time orientation	Present-oriented	Future-oriented
Timing	Short-term	Long-term
Validity of information	Precise	Diffuse
Competence orientation	Using synergies	Generating competencies
Market competencies	Familiar market	New market
Technology competencies	Available	New
Outward orientation	Self-sustaining	External-cooperative
Supplier orientation (supply side)	Ordering	Development cooperation
Customer orientation (demand side)	Mainstream	Lead-user cooperation
Change management	Algorithmic	Heuristic
Complexity	Low	High
Flexibility	Low	High

The following list describes the expected characteristics of the start-up situation of the innovation processes according to the coordinate systems of Eversheim (2003). The characteristics are visualized in Fig. 7.3. The achievement of service competencies is included in the dimension *technology competencies* (Chap. 3).

Time Orientation – Square I

The objective is to establish the new service successfully during the period of three years (Timing, *short-term*).

The partners agree in advance on the outlines of the service (Validity of information, *precise*).

Competence Orientation – Square II

Everybody is familiar with the market although this specific service regarding this specific corridor, had not yet been conducted (Market competencies).

Special technical equipment will be used (Technology/service competencies). 200 new double-platform wagons are to be purchased. Furthermore 450 high-volume swap-bodies are to be used which are especially adapted to automobile logistics¹. Both measures enable an optimum usage of train capacity.

The whole service is monitored by the IT-system TOIS (Transfesa Online Information System). It offers comprehensive tracking and tracing of freight.

¹ Again, the migration of the SAIL swap-body concept is shown. Likewise these swap-bodies offer the possibility to staple two transport devices of 1.50 m.

Due to general insecurities, obstacles are to be expected. The new service creates new problems due to the complexity of the transportation market. Several countries have to be crossed by rail which are supposed to be somewhat complicated in terms of infrastructure and bureaucracy (e.g. Romania, Bulgaria etc.). Hence, the logistic service innovation is ranked regarding this dimension, between *available* and *new*.

Outward Orientation – Square III

The main cooperation would be among two logistic service providers and one lead-user (Supplier orientation). Due to the structure of the freight transport market further companies will probably be involved on a different business level. In transportation, collaboration of different companies is essential but needs continuous care and re-negotiations.

Regarding the Customer orientation the argumentation of the previous paragraph applies as well.

Change Management – Square IV

Different companies would have to work together and adjust their business processes to the new service. The new transport implies the crossing of several borders (Complexity).

Problems of very different origin would possibly occur. The new transport implies the crossing of several borders. Geographically it would not easily be possible to solve problems in the countries involved (Flexibility).

These aspects are shown in Fig. 7.3.

The four coordinate systems are merged in the way described in Chap. 3 (Fig. 7.4). All system characteristics are located within the concentric ring element. They reflect a *Type A Innovation: the Moderate Innovator*. This *Type A Innovation* – as mentioned in Chap. 3 – can be justly described by *short-term timing, precise validity of information, and familiar market*. The *technology/service competencies* are *new* rather than *available*. *Development cooperation* and *lead-user cooperation* have to be established due to the necessities of the transportation market. The *complexity* and *flexibility* are high, as expected. Hence, a *heuristic change management* approach has to be realized. The corresponding steps to be performed are described here as a first project overview.

Recommended Steps of the Method

Due to the characteristics of the *Type A Innovation*, development cooperation and lead-user cooperation are recommended (Step 2) (Fig. 7.5). Due to the objective to establish a new rail-based service during three years, this step is supposed to be the most important activity. The gaining of information and the design of the Business Model are made easier since the lead-user should be part of the consortium. The logistic service providers have to work closely together with other parties contributing to the value chain.

The development of the Business Model is started with Step 3. It will continue at least until Step 6 is finished. A *Type A Innovation* has to be realized. Hence, it is not considered to be necessary to accomplish Step 4. Regarding the

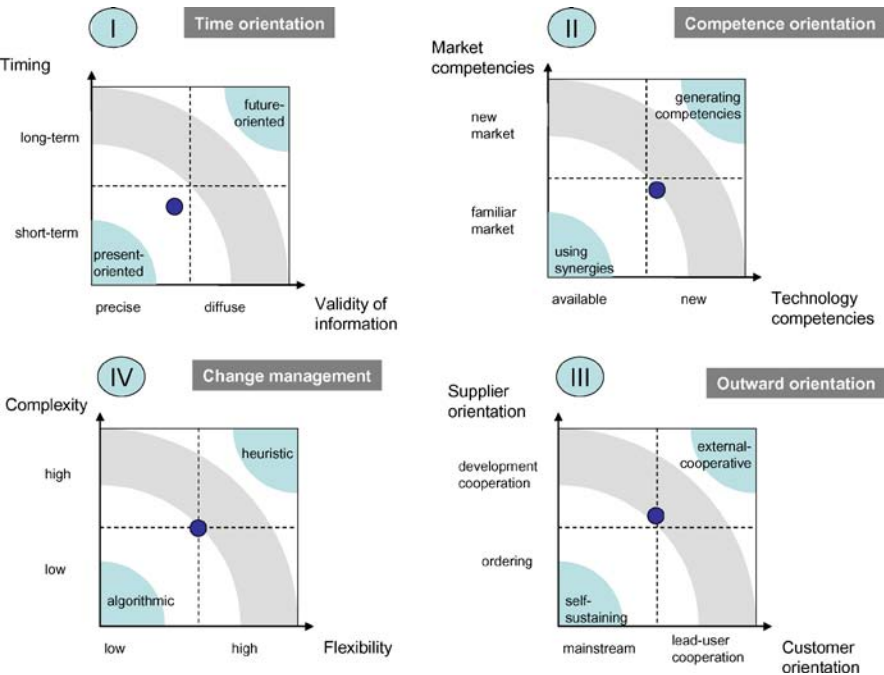


Fig. 7.3. Visualisation of the start-up situation (Orient Freight Express)

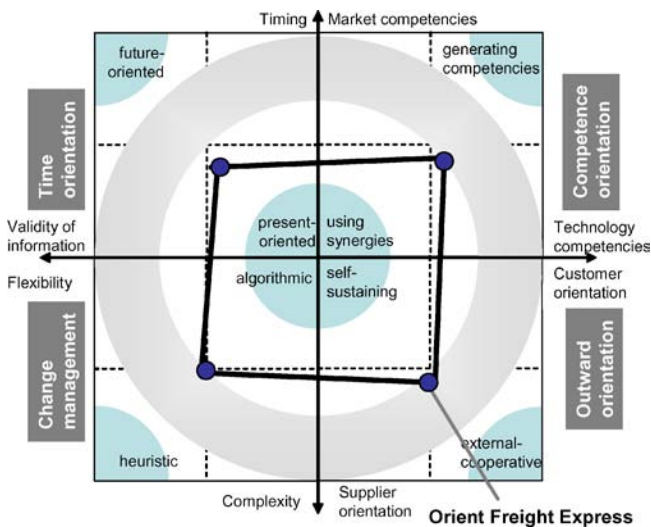


Fig. 7.4. Combined visualisation of the start-up situation (Orient Freight Express)

system *freight market*, only one defined sub-system – *logistic service considering a specific corridor* – is affected. Nevertheless complexity and flexibility have to be managed. From an economic point of view this reduced approach makes sense. Steps 5 and 6 can be combined during the development process of a moderate logistic service innovation. Hence, it has to be answered *what is to be realized* and *how it is to be realized*. The results of the Business Model which started with Step 3, are used. At the same time the requirement and the system specifications contribute to the Business Model. Hence, a rather economic approach is combined with an engineering approach. The service would start almost right away. Hence, the prototype would be already the demonstration (Steps 7 and 8).

The *migration* of this service has to be successfully accomplished during the following three years. Because of the moderate character of this innovation the *accompanying strategy* is sufficient. The *Social, Economical* and *Technological partial-systems* should be taken into consideration. The main focus will be on the *Economical partial-system Organisation*.

After this overview, the description of the different steps in detail is continued as follows.

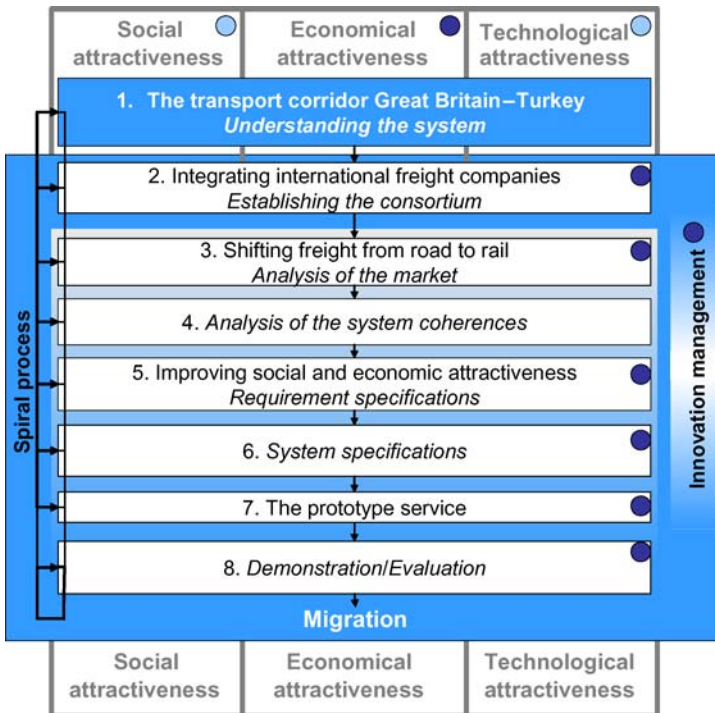


Fig. 7.5. Recommended steps of the Systemic Innovation Method (Orient Freight Express)

7.2.2 Integrating International Freight Companies (Step 2)

Establishing the Consortium

Partners of the consortium are the Spanish freight forwarder/logistic service provider Transfesa, and the Turkish logistic service provider OMSAN Lojistik. Lead-user is the Ford Motor Company in Turkey. Goods from various component suppliers have to be delivered (Fig. 2.11).

Since Transfesa's foundation, the main objective of the company has been to create an intermodal transport network across Europe. In order to promote this intermodality, the operator owns a major fleet of crunable swap-bodies of different types as well as trucks and semi-trailers for road consignments. The main operating activity is the motor manufacturing sector but also chemical products, furthermore white-goods, ceramics, machinery and construction materials. Transfesa is a pan-European player and has the resources and organisation to offer the integrated management of the customer's supply chain.

OMSAN started international land transportation with a fleet of 15 vehicles in 1982. The scope of services and business volume expanded rapidly in line with emerging concepts such as "integrated logistic services" and "supply chain management".

The car manufacturing company Ford Motor Company supports the project. It is involved in the process of developing the new service. The car manufacturer is the main customer of the innovative logistic service.

7.2.3 Shifting Freight from Road to Rail (Step 3)

Analysis of the Market

Questions to be Answered

Considerations regarding the *value proposition* and the *revenue-model* are stated as follows. The Ford Motor Company decided on shifting this specific transport from road to rail. To be competitive the new service had to offer at least the same quality as the road bound service (in-time service, flexible, undamaged delivery etc ...). The need of the customer European Union is already described in Step 1.

Furthermore, the analysis of the market is part of the *revenue-model*. The market potential of the corridor: United Kingdom (UK) – Benelux (B, NL, L) – Germany (DE) to Turkey (TR) is described in the following paragraph (Fig. 7.6).

In 2000, the amount of goods imported from the named countries to Turkey was approx. 15.2 billion U.S. dollars. Most of those goods are suitable for intermodal transport with swap-body technology. Some examples are automotive parts (for OEM's and suppliers), textiles, plastic products, machinery

etc. Potential customer within Europe is the automotive industry. In Germany, for example, 11 automotive manufacturers are among the 60 most important companies. In the year 2001, the average of 767 340 people were working in the automotive industry. This industry is one of the most important industrial activities in Germany. Its share in the gross domestic product is 20%. The automotive industry holds 1/6 in the overall turnover of the German industry. Every 7th place of employment depends on business connected with cars. A lot of German suppliers for the automotive industry and automotive manufacturers already have plants in Eastern Europe. These figures show the importance of this project in terms of the revenue model.

The market potential of the corridor: Turkey (TR) – Germany (DE) – Benelux (B, NL, L) – United Kingdom (UK) is described in the following paragraph.

The corridor Turkey to UK, Benelux, France and Germany is characterised by increasing trade activities. Turkey exported 5.9 billion U.S. dollars of goods to Germany in 2002. In the same period, Turkey exported 3.9 billion U.S. dollars of goods to Britain and 2.2 billion dollars of goods to France. Compared to 2001, the exports to Germany increased by 9.8%, to Britain climbed by 41.1% and to France increased by 13.6%. Meanwhile, Turkey exports 1.5 billion U.S. dollars of goods to the Netherlands and 715 million U.S. dollars of goods to Belgium and Luxembourg. The market segment is mainly white-goods, household appliances, textiles, ceramics and food. Again these figures show the importance of the freight transport corridor considered here.



Fig. 7.6. The future route for the modal-shift corridor Germany-Turkey

7.2.4 Improving Social and Economic Attractiveness (Steps 516)

Requirement and System Specifications

In the following paragraphs, aspects of the *Social*, the *Economical* and the *Technological* attractiveness are taken into account.

Social Attractiveness (here Focus on Ecological Attractiveness)

To achieve funding the partners have to point out the ecologically and socially favourable effects of the project. It is a decisive contribution towards the social/ecological and economical attractiveness to relieve congested traffic areas in Europe. Firstly, those are the cities Cologne, Frankfurt, Graz, Zagreb, Belgrade, Sofia and Istanbul. Secondly, the region north of the river Dava is a nature protection area. It will be substantially relieved from freight transport by trucks through this project.

Economical and Technological Attractiveness

The organisation of the *value chain* is described in the following paragraphs. The main focus is on the corridors Germany–Turkey and Turkey–Germany since those offer the possibility of a modal shift. Between Germany and Turkey, an average of 155 674 tons per annum (467 024 tons in three years) will be shifted to rail (door-to-door-connection). Hence a direct intermodal train shuttle service will be circulating between Cologne (terminal Cologne-Niehl) and Izmit near Istanbul (terminal Köseköy) (Fig. 7.7). The transit time between the two terminals is six days (single trip). The same amount of time has to be calculated for road transport. As a backup-solution, trains can be diverted to the terminal in Halkali/Istanbul. The frequency will rise from 2 to 4 trains/week within the three years of funding. There will be no shunting and re-grouping on the route. The train will circulate on a fixed and regular schedule. A full train consists of 17 double-platform wagons carrying 34 swap-bodies. The train parameters are: 550 m length and 1100 metric tons mass, the rail profile is C45. Hicube swap-bodies (“Mega Combis” of 13.6 m length) being the means for door-to-door transport, are handled by mobile or gantry cranes from road to rail and vice versa in the terminals at both ends of the intermodal train route. For road transport, the swap-bodies are put on skeletal trailers (chassis) being towed by tractor units. For rail transport, special double-platform wagons are used. Specific swap-bodies and wagons are dedicated to this project and circulate in a closed circle.

The highest investment into the infrastructure necessary is caused by the planned extension of the terminal in Köseköy (TR). It is to be made by the consortium. Shipment monitoring and tracing tools will also be installed which allow global positioning even in unaccompanied combined transport. No further survey and research activities are necessary due to the long experience of the two project partners on the corridors corresponding.

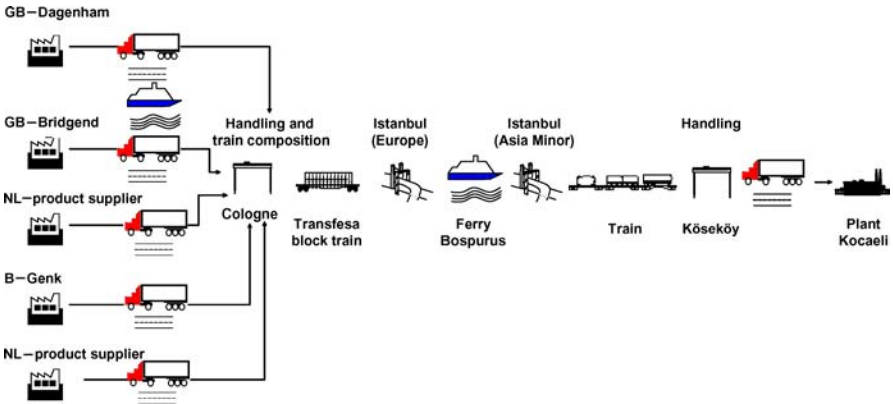


Fig. 7.7. New intermodal transport chain (according to Transfesa)

The new intermodal transport chain is presented in Fig. 7.7.

The *value chain* regarding the corridors Germany–Turkey (south-bound SB) and Turkey–Germany (north-bound NB) are explained in the following paragraphs.

The origins of freight are in the UK (50%) and in BeNeLux, N-France and Germany (50%). UK volumes arrive in Vlissingen (NL) by ferry and are forwarded by road to Cologne. Some 30% of the volumes are planned to be loaded/delivered directly via rail link, the remaining volumes will be road collections/deliveries. On the main route Germany–Turkey the block train passes through the EU-member states Germany and Austria (length of “rail”-route, single trip: 1053 km). The south-bound traffic amounts to 100% in automotive components.

On the main route Turkey–Germany the shuttle transport uses the same route as on the main route Germany–Turkey. Here the commodities are 50% empty transportation racks, and car parts of Turkish origin. Approx. 40% capacity is taken by other commodities (textiles, chemicals, ceramics, electronic goods). The remaining approx. 10% capacity has to be repositioned empty.

Regarding technological aspects, 200 double-platform wagons and 450 high-volume swap-bodies of the type “Mega Combi”² have been purchased. No major investment in infrastructure is necessary.

Within the project about 450,000,000 tkm will be shifted from road to rail during the three years of EU subsidy. The shuttle trains with four-axle double-platform wagons commute between Cologne and Köseköy (empty weight 26.6 t for two swap-bodies). They have a capacity of 34 swap-bodies (empty weight

² The project SAIL was finished in 2002. The project Orient Freight Express was started in 2004. During the time in-between, the new technology of standardized high-volume swap-bodies, adjusted for intermodal transport, became state of the art. The migration was especially supported by the feature of 3 m inside loading height. This allows to staple two standard transport devices of 1.50 m each.

of 6.35 t). The swap-bodies carry in average of 16 t pay weight. The length of the old “road”-route within the European territory (Germany, Austria and Greece) is 1040 km in single trip (ST). This allows the modal shift of 16640 tkm ($16 \text{ t} \times 1040 \text{ km}$) per loading unit. The total amount of loading units p.a. arises from the amount of trains/year and loading units/train, as well as from some percentage of empty repositioning. The transport volumes will permanently increase over the three years. The departure frequency and thus, the number of shuttle trains is going to double within project duration. In the year 2007 the action will be continued without the subsidy of the EU.

7.2.5 The Prototype Service (Steps 7/18)

The new service is already running very well. The maximum travel speed of 120 km/h allows accomplishing the distance of 2800 km within six days. Handling on each side has to be calculated with half a day. The IT- system Transfesa Online Information System (TOIS) allows tracking and tracing. By the end of 2005 five to ten pairs of trains each loaded with 32 swap-bodies, were running every week.

The intention of the European Union has been fully met to shift considerable amounts of freight from road to rail and thus, to relieve congested traffic areas.

This new service was awarded financial support because of its contribution to reducing social and economic hardships connected with road-based freight transportation, and because of its high quality. The *Association of Train Hauliers* (“Interessengemeinschaft der Bahnspediteure” –IBS e.V.) awarded Transfesa the special award “IBS-Förderpreis Rail Logistic” 2005 (DVZ 2005)

7.3 Poland-Spain Transport

7.3.1 The Transport Corridor Poland-Spain (Step 1)

Understanding the System

Objective of the Project

Objective of the project *Poland-Spain Transport* (PST) is the modal shift of over 300 million tkm of freight from road to rail across Europe. The research project focuses specifically on the transport corridor Poland-Spain. This project is not realized yet. Hence in the following paragraphs and sections, only the perspectives are presented. The road transport conducted up to now is described in the following paragraph. It is mainly concerned with transportation of white goods produced by one certain company.

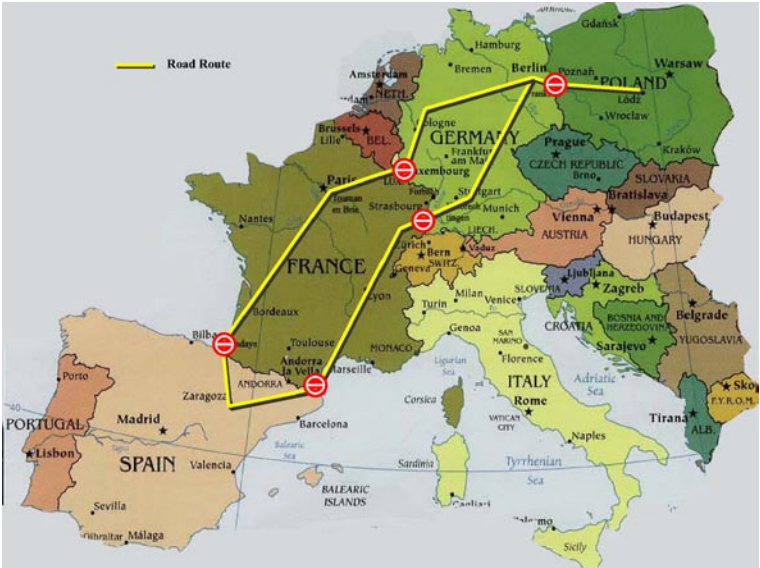


Fig. 7.8. Actual route

The focused on white-goods³ producer manages up to now the internal logistics between the subsidiaries in Spain, France, Germany and Poland (production plants and warehouses) (Fig. 7.8). All of the subsidiaries are located in only one corridor which spans from Zaragoza (Spain) via France and Germany to Lodz (Poland). This route coincides with one of the most frequented high-performance corridors in Europe. At present, this door-to-door service is run 100% on road by various transportation suppliers. Transported goods are household appliances and white goods; e.g. washing machines are transported from the production plant in Spain to warehouses in France, Germany and Poland. In return, other products of the white-goods producer are delivered back to Spain. The actual service on road covers almost 7.500 km – single trip.

Expected Characteristics of the Start-Up Situation of the Innovation Processes

Dimension	Type A	Type B
	Present-oriented	Future-oriented
Time orientation	Short-term	Long-term
Timing	Precise	Diffuse
Validity of information	Precise	Diffuse
Competence orientation	Using synergies	Generating competencies
Market competencies	Familiar market	New market
Technology competencies	Available	New
Outward orientation	Self-sustaining	External-cooperative
Supplier orientation (supply side)	Ordering	Development cooperation
Customer orientation (demand side)	Mainstream	Lead-user cooperation
Change management	Algorithmic	Heuristic
Complexity	Low	High
Flexibility	Low	High

The following list describes the expected characteristics of the start-up situation of the innovation processes according to the coordinate systems of Eversheim (2003). The characteristics are visualized in Fig. 7.9. The achievement of service competencies is included in the dimension *technology competencies*.

³ E.g. refrigerator, stoves, washing machines

Time Orientation – Square I

The objective is to establish the service successfully during a period of three years (Timing, *short-term*).

The partners agree in advance on the outlines of the service (Validity of information, *precise*).

Competence Orientation – Square II

Everyone is familiar with the market although this specific service regarding this specific corridor has not been conducted yet (Market competencies).

Special technical equipment should be used (Technology/service competencies). Due to general insecurities obstacles would have to be expected. The new service creates new problems due to the complexity of the transportation market. The service can be considered to be *moderately innovative*. Hence it is ranked regarding this dimension, between *available* and *new*.

Outward Orientation – Square III

The main cooperation would be among one logistic service provider and one lead-user (Supplier orientation). Due to the structure of the freight transport market further companies will be probably involved on a different business level. In transportation, collaboration of different companies is essential but needs continuous care and re-negotiations.

Regarding Customer orientation the argumentation of the previous paragraph applies as well.

Change Management – Square IV

Different companies will have to work together and adjust their business processes to the new service (Complexity). The new transport implies the crossing of several borders.

Problems of very different origin would possibly occur (Flexibility). The new transport implies the crossing of several borders. Geographically it would not be easily possible to solve problems in the countries involved.

These aspects are shown in Fig. 7.9.

The four coordinate systems are merged in the way described in Chap. 3 (Fig. 7.10). The characteristics are within the concentric ring element. Thus they reflect a *Type A Innovation: the Moderate Innovator*. A *Type A Innovation* – as mentioned in Chap. 3 – can be described by *short term timing, precise validity of information, familiar market and available technology/service competencies*. *Development cooperation* and *lead-user cooperation* have to be established due to the necessities of the transportation market. The *complexity* and *flexibility* are high, as to be expected. Hence, a *heuristic change management* approach has to be realized.

The corresponding steps to be performed are described here as a first project overview.

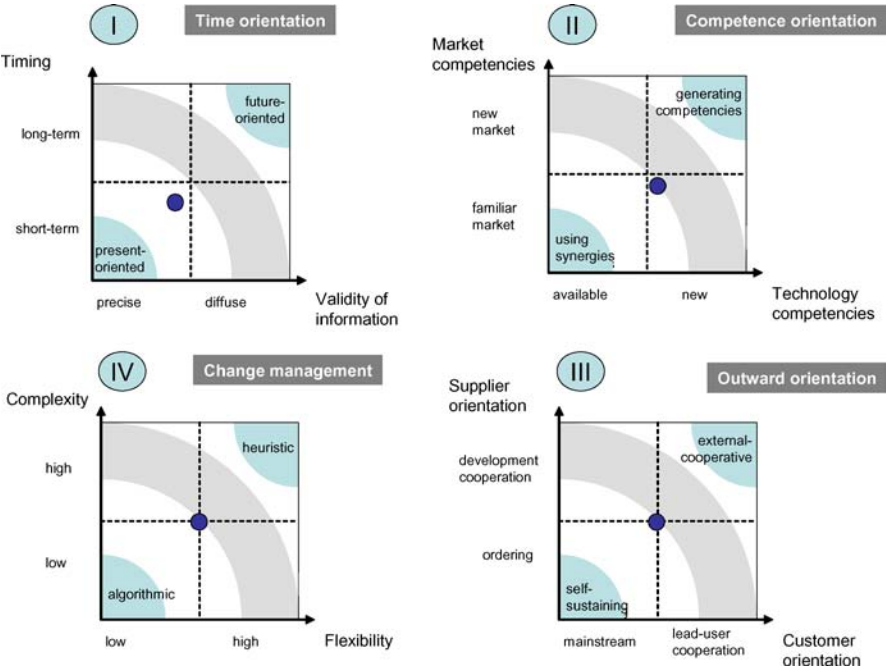


Fig. 7.9. Visualisation of the start-up situation of the research project *Poland-Spain Transport*

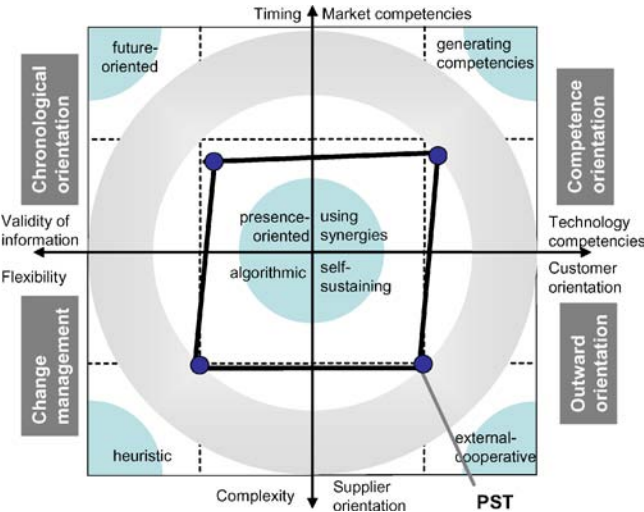


Fig. 7.10. Combined visualisation of the start-up situation (Poland-Spain Transport)

Recommended Steps of the Method

Due to the characteristics of the *Type A Innovation*, development cooperation and lead-user cooperation are recommended (Step 2) (Fig. 7.11). Due to the objective to establish a new rail-based service during three years, this step is supposed to be the most important activity. The gaining of information and the design of the Business Model are made easier since the lead-user should be part of the consortium. The logistic service provider has to work closely together with other parties contributing to the value chain.

The development of the Business Model is started with Step 3. It will continue at least until Step 6 is finished. A *Type A Innovation* has to be realized. Hence, it is not considered to be necessary to accomplish Step 4. Regarding the system *freight market*, only one defined sub-system – *logistic service considering a specific corridor* – is affected. Nevertheless complexity and flexibility have to be managed. From an economic point of view the reduced approach makes sense.

Steps 5 and 6 can be combined during the development process of this *moderate* logistic service innovation. Hence, it has to be answered *what is to be realized* and *how it should be realized*. The results of the Business Model which started with Step 3, are to be used. At the same time the requirement and the system specifications contribute to the Business Model. Hence, a rather economy-oriented approach is combined with an engineering approach. The service

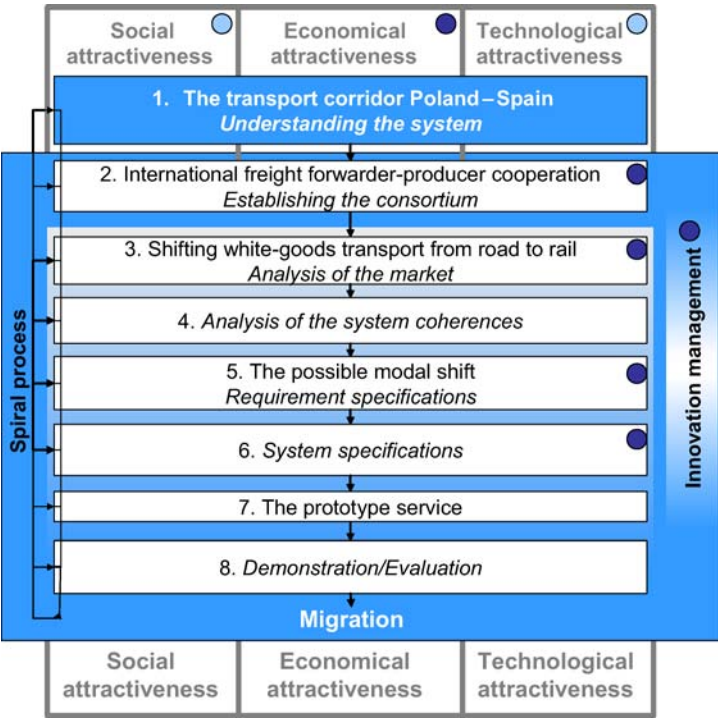


Fig. 7.11. Recommended steps of the suggested Method (Poland-Spain Transport – PST)

would start almost right away. Hence, the prototype would be already the demonstration (Steps 7 and 8).

The *migration* of this service has to be successfully accomplished during the following three years. Because of the moderate character of this innovation *accompanying* research is sufficient. The *Social*, *Economical* and *Technological partial-systems* should be taken into consideration. The main focus will be on the *Economical partial-system*. The focus on those partial-systems implies already to contribute towards the *Social*, *Economical* and *Technological* attractiveness.

After this overview, the description of the different steps in detail is continued as follows

7.3.2 *International Freight Forwarder-Producer Cooperation (Step 2)*

Establishing the Consortium

The potential consortium would be characterized by cooperation between one logistic service provider and the white-goods producer (Fig. 2.11). This pan-European logistics operator has the resources and organisation to handle the integrated management of the customer's supply chain. The operator is forwarding motor manufacturing products, chemical products, white-goods, ceramics and machinery as well as construction materials.

The lead-user involved produces mainly white-goods. The volume of goods transported in Europe has been increasing steadily for years while at the same time the requirements of the customers have become more and more stringent. The lead-users company has to conduct different transport tasks: transport of production material from the suppliers to the plants, and finished goods from the plants to the customers and warehouses. Therefore a fast and smooth process of national and international delivery is necessary. These requirements can only be accomplished with the support of reliable and flexible transport service providers.

7.3.3 *Shifting White-Goods Transport from Road to Rail (Step 3)*

Analysis of the Market

Questions to be Answered

Considerations regarding the *value proposition* and the *revenue-model* are stated as follows. The white-goods producer plans to shift this specific transport from

road to rail. To be competitive the new service had to offer at least the same quality as the road bound service (being on time, flexible, undamaged delivery etc.).

The market potential regarding further customers has already been estimated. The research project PST aims primarily at white goods. A cross-docking platform in Zaragoza would be offered. In the future this can be used as an open platform for other customers who want to shift their freight transport to rail. The service is suitable for all companies which have traffic between Northern Spain (Aragon) and almost all other European regions. It would allow an environmentally compatible and sustainable door-to-door transport on rail. This service can be used for interplant logistics as well as for the supply of customers of the companies in the European urban areas. This service can be implemented with minimum investment in infrastructure. No new railway tracks will be necessary. The existing routes are spanned widely across Europe to meet the logistics requirements of today's transportation market. More and more companies within the EU are planning to reactivate or build anew, their own railway sidings as it is one of the major goals of the EU. Zaragoza and Hendaye are the most important junctions of the Spanish railway network because the alternative route over the Pyrenees via Cerbere (Mediterranean Sea) is already working at full capacity. A specially adapted wagon can be used on these routes. It is capable of loading high volume and/or heavy goods. This boxcar offers high quality standard for goods transport, whether for white-goods or for other capable freight within the door-to-door transport segment, e.g. washing machines, dish-washers or heating systems.

7.3.4 The Possible Modal Shift (Steps 5/6)

Requirement and System Specifications

In the following paragraphs aspects of the *Social*, the *Economical* and the *Technological* attractiveness are taken into account.

Social Attractiveness (here Focus on Ecological Attractiveness)

The project supports one of the main priorities of the EU *White Book*: to develop easier freight passage through the Pyrenees. The main transport routes Spain-France are going in the directions across the Pyrenees. Half of the long-distance transports from the Iberian Peninsula go to France and beyond and thus, they have to pass the bottleneck of the Pyrenees (Fig.7.12). The consequences are congestion, high levels of pollution (noise, CO₂) and time loss in this area. In the project PST, the bottleneck is to be avoided by the combination of the new cross-docking platform in Zaragoza, together with the automated gauge-changing station at the Spanish-French border. The gauge-changing station is necessary since one of the main obstacles of European East-West

corridors into Spain is the change of track width between France and Spain. Furthermore the planned modal shift aims to reduce the detrimental impact of freight transportation especially in and around Paris; in the German State Saarland; furthermore in and around the German cities Stuttgart, Berlin; and in Poland around Lodz. After the implementation of the rail-service for the lead-user, the new door-to-door concept of PST will also draw in new customers in the Eastern European countries. They will get new possibilities to perform sustainable economic and ecological freight transportation through the European Union.

Economical and Technological Attractiveness

The organisation of the *value chain* is described in the following paragraphs. The project PST may finally allow the modal shift of over 300 million tkm from road to rail across the European Union. Therefore a competitive door-to-door transport between different subsidiaries of the lead-user, located in Spain, France, Germany and Poland, is to be established. Especially for the Spanish market, the cross-docking rail-based platform at Zaragoza will be constructed as mentioned above. The cross-docking platform will be used as the logistics centre in North-Spain, where the goods are directly transferred between road trucks and rail wagons and vice versa, with a minimum of road haulage. It supports the cross-border transport on rail towards France and the other European countries primarily for the lead-user. Later on other customers may want to participate in similar door-to-door service concepts.

Regarding the *value chain* the following considerations were conducted. So far no railway sidings exist for the production plants and warehouses of the lead-user in Zaragoza. Therefore this specific cross-docking platform in Zaragoza is to be built in order to give access to the railway net and to link it up to the European factories and warehouses. The pre- and post-haulage between the lead-user sites in Zaragoza and this platform will be by road. The distance is approximately 10 km. In other countries the lead-user has already railway sidings at all production plants and warehouses. Generally, the platform will meet the customers' needs within the Aragon region.

The white-goods producer together with the logistic service provider aim at shifting 80% of the total transport capacity of 80 000 t/year from road to rail during the three years, with exception of the local pre- and post-haulage in Zaragoza (Fig. 7.13). This railway transport will be established on already existing routes between the lead-user's factories and warehouses located in Spain, France, Germany and Poland (Fig. 7.12). On Spanish territory, dedicated trains (30 wagons per train) will run on the segment between Zaragoza and Hendaye. In Hendaye the axles of the wagons will be changed automatically to fit the gauge of Central European railways and vice versa. The trains at Hendaye will be separated according to their destinations France and Germany. On the routes to France, Germany and Poland the wagons will be combined with wagons from other clients.

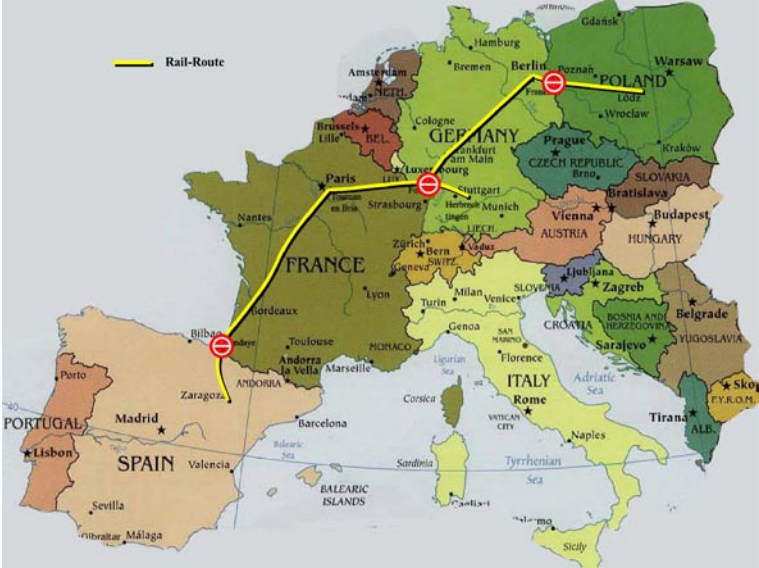


Fig. 7.12. Possible future route of the project Poland-Spain Transport

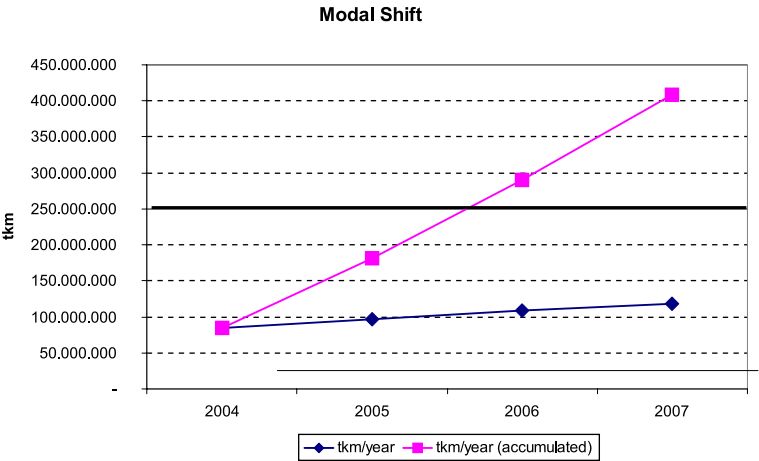


Fig. 7.13. Possible modal shift of the project Poland-Spain Transport

7.4 Resume: Logistic Service Innovations

This chapter has dealt with the third Field of Action discussed in this volume: how to implement *logistic service innovations*. Two projects have been in the centre of this chapter: The project *Orient Freight Express* presently running, and the prospective project *Poland-Spain Transport*. These projects have shown the advantages of a well designed innovation and business approach. Again the need of incentives was stressed to be offered by national governments or the European Union.

There may be developments taking place in European politics which can strongly encourage freight forwarders and goods producers to strengthen their rail transport activities rather than continuing to increase road-only freight transport across Europe. These aspects will be taken up again in the final chapters of this volume.

Chapter 8

Conclusions and Perspectives

8.1 Overview

The main aim of this research has been to suggest a specific and comprehensive *Systemic Migration-Oriented Innovation Management Method*. The Method includes the supporting tools related to innovative technologies and logistic service innovations. The innovations discussed here deal with the land-based long-distance European freight transport. Seven different case studies have recently been performed which put such innovations into practice. They visualise the outcomes of different innovation processes. These case studies particularly demonstrate how implementations of innovations may be supported by the use of the *Systemic Migration-Oriented Innovation Management Method* suggested in this research. By means of the seven case studies, this research may contribute to making certain recent research on land-based long-distance freight transport more visible for interested European researchers and practitioners.

8.2 The Strategic Questions

The following four *Strategic Questions* have been the starting points of the research reported here:

1. Which political objectives and innovation-related requirements have to be considered concerning the land-based long-distance freight market, separately for each carrier? (compare Chap. 2, the Impact Table)
2. Which Fields of Action should be focused on in order to contribute towards continuous development and improvement of the European freight sector? (compare Chap. 2, the Impact Table)

3. Which are the basic principles of the Systemic Migration-Oriented Innovation Management Method and which steps have to be conducted within this Method? (compare Chap. 3, the two Hypotheses of Innovation)
4. Which tools can be used to support the steps of this Method? (compare Chap. 4)

These Strategic Questions have been transferred onto the land-based long-distance freight market so that the most significant aspects have been leading to the Impact Table (Fig. 8.1). This Impact Table summarizes political objectives and innovation-related requirements taking into account the most recent freight market development (Strategic Question 1).

According to *Strategic Question 1*, the political objectives in the European context can be summarized as follows.

As discussed in Chap. 2 of this volume, Europe needs efficient and reliable freight transportation particularly under the challenges of globalisation, and in consideration of the recent developments in the Eastern European countries. These challenges need both *moderate innovations* as well as *thorough innovations* because they will be determining the economic future of Europe to a large extent during the next decades. The innovations, however, are not easily implemented into the European freight market as a socio-technical system. Hence in this research, the following aspects have been taken into consideration.

Innovative transportation technology has to be *socially* and *environmentally attractive* to reduce the external costs of present transportation. Furthermore innovative transportation technology has to be *economically attractive* to improve the development of European economy. Finally the new *technology* itself has to be *attractive* in order to be competitive in comparison to other transportation systems which are already existing and widely used. These aspects have been integrated in the **Impact Table** (Fig. 8.1) in the top and bottom rows of the table. They serve as a means to structure the different political objectives which are particularly significant for the research reported here.

Within the Impact Table, 13 different **Innovation-related Requirements** have been introduced. They are structured according to the different carriers and the different business approaches, specifically road transport, intermodal transport, single-wagon business and full-train business. Based on those structuring elements, the Requirements have been focused on the most urgent aspects concerning innovations: e.g. external costs, infrastructure, demands of the market, different corridors, and education and training.

Furthermore three **Fields of Action** have been derived for innovations in European freight transport in order to take care of the political objectives and the Innovation-related Requirements mentioned. These *Fields of Action* have also been integrated into the Impact Table corresponding to *Strategic Question 2*. They are comprised in the lower part of the Impact Table. The Fields of Action focus on the following aspects:

- *Innovative technologies* in European freight transport to compensate the inherent disadvantages of the different carriers and business approaches (Field of Action I).

Political objectives	Social/environmental attractiveness	Economical attractiveness	Technological attractiveness	
	• Reduce external costs	• Ensure the competitiveness of the European economy Measures to enforce the economical attractiveness of innovative technologies and services: => stronger consultation with stakeholders and industries as well as stronger economic analyses and impact assessments	▪ Improved transport efficiency & logistics throughout the supply chain (reduction of congestions on road and rail, develop intermodality and comodality), ▪ Harmonization of the modal split (increase of the attractiveness of rail and intermodal transport) and ▪ Reduction of the external costs (especially safety and emissions), ▪ Competitive to already existing transportation systems	
Innovation-related requirements	Road	Intermodal	Single-wagon	Full-train
	External costs	R2– Reduction of external costs.		
	Infra-structure	R9– Avoid additional demands for new infrastructure.		
		R3– Better use of road capacity.	R5 – Improve/support terminal processes.	R1 – Improve the profitability of single-wagon business.
	Demands of the market	R4– Increase usage of semi-trailers. R6– Innovative transport units with competitive capacity. R8 – Service possibilities closer to the actors of road transport.		
		R7 – Cooperation between road and rail actors.		
		R10 – Attractiveness to upcoming markets.		
		R11 – Consideration of the criteria: quality, time, cost, being agile, high ability to respond to changes and lean processes		
	Corridors	R12 – Optimum use of the strengths of each carrier and technology.		
	Education/training	R13 – Get innovations in freight transport closer to users, organisations and society.		
Fields of Action	Innovative technologies – Truck platoons, Driving Simulator, Individualized rail transport			
	Innovations to improve the intermodal transport chain – Semi-trailers in European logistics			
	Logistic service innovations – Orient Freight Express, Poland-Spain Transport			
	Social attractiveness	Economical attractiveness	Technological attractiveness	

Fig. 8.1: The Impact Table

- Innovations to improve the *intermodal transport chain*, particularly the competitiveness of this business approach (Field of Action II).
- *Logistic service innovations* to increase the efficiency of European freight transport (Field of Action III).

This Impact Table is the basis for the **Systemic Migration-Oriented Innovation Management Method** which has been mentioned in *Strategic Question 3*. For

this Method, certain relevant aspects of System Theory and Innovation Management approaches have been merged into two *Hypotheses of Innovation*.

According to **Hypothesis 1**, the innovation processes concerning land-based long-distance freight transport technologies and logistic services, are understood to be a special kind of *socio-technical system* in themselves because they concern *humans* within certain *organisations*. These humans are dealing with complex technologies under market conditions. This socio-technical system of the *innovation processes* is embedded within the socio-technical system of the land-based, long-distance *freight market*. The interaction between the two systems aims at changing the system of the freight market through the innovation processes. Hence first of all, it is recommended to take the *Social, Economical and Technological Partial-Systems* into account in order to successfully influence this freight market system. Thus the fundamental knowledge and deep understanding of the system and its coherences are necessary as mentioned above.

According to **Hypothesis 2**, *innovative technologies* and *new logistic services* can be considered as the main components of the *innovation processes* required today within the freight market system. The business processes will be changed if any *moderate* or even *thorough* technological or service innovation is being introduced successfully. This fact has to be taken into account since it is a major obstacle for migration processes. Accordingly the innovation processes have to be designed *differently* compared to *continuous product modifications* and improvements as usually considered in production engineering. Thus a *heuristic approach* is necessary here including continuous focus on the migration process, and on the embedded acceptance process within the freight market. Such *migration* processes always imply fundamental *change* processes which require specific *management* strategies. Therefore experienced and strong *innovation management* has to be established.

These two Hypotheses have been the basic principles for the **Systemic Migration-Oriented Innovation Management Method**.

Furthermore nine **Tools** have been recommended corresponding to *Strategic Question 4*. They support the performance of this Method and can be characterised in the following way:

- Tool 1 to analyse the characteristics of the planned technological innovation and to choose the appropriate steps of the Method.
- Tool 2 to establish migration-orientation considering the whole innovation process.
- Tools 3–6 to analyse the system coherences and to choose competitive solutions.
- Tools 7–9 to evaluate the economic feasibility of the selected technological solutions.

The following seven **Case Studies** have been chosen to meet the Fields of Action:

Field of Action I:

- Introducing truck platoons on motorways (EFAS, M F G, KONVOI)

- The Interactive Driving Simulator (InDriveS)
- Individualized single-wagon door-to-door rail transport (FlexCargoRail I/II)

Field of Action II:

- Semi-trailers in Advanced European Intermodal Logistics (SAIL)
- European low-platform technologies for non-cranable semi-trailers (RoRo-Rail)

Field of Action III:

- Orient Freight Express
- Poland-Spain Transport

The results of these Case Studies are briefly presented in the following paragraphs, within the structures of the three *Fields of Action*.

8.3 Results of the Seven Case Studies

Here the seven Case Studies are briefly described and characterized, within the structures of the three *Fields of Action*.

Field of Action I: Innovative Technologies in European Freight Transport

- Introducing truck platoons on motorways: the sequential research projects EFAS, M F G, KONVOI,
- The Interactive Driving Simulator: InDriveS,
- Individualized single-wagon door-to-door rail transport: FlexCargoRail I/II.

The research projects *EFAS*, *M F G*, *KONVOI* supported by the simulation laboratory *InDriveS* and the research project *FlexCargoRail I/II*, focus on new ways of European freight transportation by utilising *innovative technologies*. Those technologies would bring trains onto the road and trucks onto the rail. Hence, they would add flexibility to rail transportation but they would slightly reduce the flexibility of road transportation. Both technologies have to migrate into the market in combination with decisive adjustment or further development of specific business procedures.

The different kinds of tools support the necessary comprehensive knowledge of technology and market throughout the consortium (Tool 1, Tools 3–6). Considering *KONVOI* and *FlexCargoRail* it is fundamental to achieve outward orientation. Hence, lead-users and different developers have to be involved. Migration-orientation has to be established from the beginning of the innovation process (Tool 2). It has proved to be an advantage to raise trust capital among

researchers and practitioners. Hence a sequential approach has been chosen for both approaches, truck platoons and individualized single-wagon transport. After conducting specific steps of the Systemic Migration-Oriented Innovation Management Method, it was/will be decided whether these technologies are promising (Tools 3, 4, 6). Finally the economic risk of implementing those technologies into the market was/will be evaluated (Tool 9).

The research projects within this particular Field of Action concerning the *innovative technologies*, offer the highest possible flexibility for the demand side of transportation with the exception of conventional road transportation. Truck platoons and individualized single-wagon rail transport offer the possibility to compensate the inherent disadvantages of the different carriers and business approaches. The external costs of road transportation can be reduced and the profitability and competitiveness of rail transport can be increased. Those technologies are very advanced and cause decisive changes in work and business processes. They will have a substantial input on the freight market.

It is strongly recommended to accompany the innovation and migration process by extended simulations. Hence, the simulation laboratory *InDriveS* developed as one of the seven Case Studies, would need to be upgraded to become a combined rail-and-road simulator. This is a decisive measure to raise acceptance at an early stage of those innovations presented, and future innovations of similar kind.

A major obstacle of these projects is the topic of homologation. To achieve experiences by using the prototypes it is necessary to test those prototypes in commercial transport. To reduce the risk of investment in such innovations there must be a realistic chance to complete the final homologation during an appropriate period of time.

Field of Action II: Innovations to Improve the Intermodal Transport Chain

- Semi-trailers in Advanced European Intermodal Logistics: SAIL, and
- European low-platform technologies for non-cranable semi-trailers: RoRo-Rail.

The development of the modal split means *innovations to improve the intermodal transport chain*. Such aim would already be achieved if pure road users could be convinced to make increasing use of *intermodal transport*. Due to the increase of semi-trailers in long-distance freight transportation it makes sense to have intermodal transport more accessible for this kind of vehicles. In this research, two approaches have been focused on:

- Firstly, the project SAIL offers possibilities to adjust semi-trailers, swap-bodies and wagons for intermodal transport considering competitive loading volumes and technical interfaces.
- Secondly, the feasibility study RoRo-Rail evaluates technologies which may offer options of intermodal transport to all semi-trailers without the need of any technical adjustment.

Both case studies stress the importance of choosing appropriate corridors. Both case studies also stress the need to make use of government incentives in order to support migration of the innovations to improve the intermodal transport chain.

The research project SAIL and the feasibility study RoRo-Rail focus on rather short-term improvement of the intermodal transport chain. This reflects the urgent need of the European transportation system to offer attractive technologies besides conventional road-only transport (Tool 2). Several freight transportation experts were made members of the consortiums. Competencies had to be shared and gained because of the complexity of the changes envisaged (Tools 3–6). Specifically both projects demanded economic risk evaluation of introducing the new technologies (Tools 7–9).

SAIL was based on strong and broad cooperation of both lead-users (demand side) and developers (supply side) of transportation. This arrangement supported the successful development of the innovations. The suggested *Method* was necessary due to the following aspects: the challenging objectives of the project, the complexity of the freight system, the effected changes of business procedures, and the internationality of the partners. A major obstacle considering the migration of the technologies developed in the project SAIL, has been the homologation process.

In comparison, *RoRo-Rail* estimated the feasibility of different intermodal innovations considering the demand side of transportation – freight forwarders, hauliers etc. Hence the problem of transfer of experience into practice has not yet come up.

Field of Action III: Logistic Service Innovations

- the research project *Orient Freight Express*, and
- the prospective research project *Poland-Spain Transport*.

The research projects *Orient Freight Express* and *Poland-Spain Transport* aim at *logistic service innovations*. They specifically focus on transferring certain volumes of freight from road to rail considering specific European corridors and business cases. This approach seems to have been very successful concerning invested resources and outcome. All involved parties have been focused on economic improvements (Tool 2). At the same time certain social and environmental problems have been and may still further be resolved in the course of these projects.

Both projects, *Orient Freight Express* and *Poland-Spain Transport*, may be considered moderate innovations. They show rather *present-oriented time orientation* and *moderate competence orientation*. Nevertheless, outward orientation has to be established and adequate change management has to be applied because of the characteristics of the freight market. Hence, certain steps of the *Method* have specifically been recommended (Steps 1–3, 5–8), and the Tools 1 and 2 have been applied in particular.

The two different Types of Innovation have been mentioned above – the *Moderate Innovator* and the *Thorough Innovator*. According to the *Moderate Innovator* it can be concluded that in general, those seven research projects show mostly short-term up to moderate long-term *time orientation*. This is due to the fact that problems of the transportation system have to be resolved as soon as possible, which means: in the near future. Nevertheless the impact of these projects on the freight transport system will have strong *future orientation* which corresponds rather to the *Thorough Innovator*. The transport innovations described here should start to migrate into the market as soon as possible because of the time pressure reported in the second chapter of this report. Furthermore the Case Studies presented here cover different degrees of *outward orientation* but they impose different demands on *change management*. Thus they all have to be performed following a *heuristic approach* rather than an algorithmic approach.

It follows: both kinds *moderate innovation* and *thorough innovation*, have to be developed and implemented in parallel in order to realise decisive changes in this particular market. Those changes need the involvement and comprehensive development of different competencies considering all stakeholder groups. The experiences of the case studies point out that technological and logistic service innovations of very different characteristics are required in order to innovate the freight transport system in practice.

These aspects correspond closely to the 13 *Innovation-related Requirements* which are to be recommended for innovation projects. They would facilitate to achieve both the *moderate innovations* and the *thorough innovations* as needed within the freight market. These requirements have been derived in the course of this research, and they are summarized in the Impact Table (Fig. 8.1). They are discussed here as follows.

8.4 Responding to the Innovation-Related Requirements

In a certain way, the seven Case Studies are the response of the research and development teams in the different projects to the 13 *Innovation-related Requirements* as shown here:

- R1:** *It is important to develop innovative technologies and services to improve the profitability of single-wagon business* – this requirement has been particularly taken care of in the project ***Individualized single-wagon rail transport***.
- R2:** *Reduction of the external costs is especially necessary in road transport* – this requirement corresponds to the projects ***Introducing truck platoons on motorways*** and ***The Interactive Driving Simulator***.

- R3:** *Those technological and logistic approaches are favourable which make better use of the existing road capacity – the projects **Introducing truck platoons on motorways** and **The Interactive Driving Simulator** have been specifically designed to respond to this requirement.*
- R4:** *It is recommended to support the usage of semi-trailers in intermodal transport. This can be based on load on/load off or roll on/roll off techniques – the projects **Semi-trailers in Advanced European Intermodal Logistic** and **European low-platform technologies** are, first of all, experiments in intermodal transport.*
- R5:** *Innovative intermodal technologies should fundamentally improve terminal processes – the projects **Individualized single-wagon rail transport**, **Semi-trailers in Advanced European Intermodal Logistics**, **European low-platform technologies** can be considered contributions to this requirement.*
- R6:** *Innovative intermodal transport units should realise the same capacities as units for road transport only – as realised in the projects **Individualized single-wagon rail transport** and **Semi-trailers in Advanced European Intermodal Logistics**.*
- R7:** *It is strongly recommended to support and develop cooperation between road and rail actors – the project **Individualized single-wagon rail transport** has put particular emphasis on this requirement.*
- R8:** *Educational measures are needed in order to get intermodal service options closer to the road transport managers – such measures have been developing specifically out of the projects **Individualized single-wagon rail transport**, **Semi-trailers in Advanced European Intermodal Logistics**, **European low-platform technologies**, **Orient Freight Express**, **Poland-Spain Transport**.*
- R9:** *It is recommended to primarily develop technological innovations which are not creating new infrastructure demands – this requirement has been taken care of, in the projects **Introducing truck platoons on motorways**, **The Interactive Driving Simulator**, **Individualized single-wagon rail transport**, **Semi-trailers in Advanced European Intermodal Logistics**, **Orient Freight Express**, **Poland-Spain Transport**.*
- R10:** *Rail transport has to become attractive to the upcoming markets of regional retail goods and furthermore, for prospering commodities – as considered in **Individualized single-wagon rail transport**, **Semi-trailers in Advanced European Intermodal Logistics**, **European low-platform technologies**, **Orient Freight Express**, **Poland-Spain Transport**.*

- R11:** Innovative technologies and logistic service innovations have to consider the following criteria: quality, time, cost, being agile and being able to respond quickly to changing demands, and to realise lean processes – *all seven Cases*.
- R12:** It will be decisive for future freight transport to make optimum use of the strengths of each carrier and each technology regarding the problems and challenges of each corridor, and regarding the demands of the transported commodities – *all seven Cases*.
- R13:** It is necessary to introduce innovations in freight transport at an earlier stage to users, organisations and society. Educational and training measures can support this demand. – *all seven Cases*.

In this brief description of the case studies, it becomes obvious in which way the projects have been responding to the Innovation-related Requirements of the socio-technical system *freight market*.

All seven case studies stress the necessity to perceive as socio-technical systems both the system *freight market*, and the *innovation system*. Therefore especially the innovation type of the *Thorough Innovator* has been required here to take into consideration the system coherences and the *Social, Economical and Technological Partial-Systems*.

All innovative technologies and logistic services presented in the case studies have been designed to correspond to the all-European political objectives. The case studies explicitly support sustainable development of the European freight transportation market. Actually two main approaches have been considered: firstly, to realise truck platoons on motorways and secondly, to transfer significant amounts of freight from road to rail. Both approaches would contribute to reducing external costs of freight transportation. The efficiency and competitiveness of the different innovations have been analysed from the viewpoint of the demand side which includes the freight forwarders, hauliers, etc. This analysis has shown how difficult it is at present for these innovations to offer the same advantages as *road-only* transportation. The *Systemic Migration-Oriented Innovation Management Method*, however, represents one optimum strategy for migration of these innovations into the market. This *Method* has proved to be supportive to achieve these aims, which has been shown by conducting and evaluating the seven different case studies. This Method is simultaneously the response of the research to the overall political objectives which have been the starting point of this all-European research.

8.5 Future Research Demands

As pointed out, the innovations described will be finally successful only if the pressure to improve the transportation system will be kept up, or even *increase*. If in the future, this pressure may *decrease* rather than increase the demand side

of freight transportation – the freight forwarders etc. – will probably continue to choose the most competitive transport strategy which still is the conventional *road-only* transport.

There might be quite different developments taking place across Europe which will bring different change and innovation requirements into view. Here it may suffice to mention a few examples:

- The European Commission may strongly increase pressure to improve fundamentally the freight transport system according to the political aims mentioned before.
- Environmental pressure may become another innovation force on a larger scale than up to today.
- The future may bring about some steep increase of distance-dependent Traffic Tax on motorways for trucks on long-distance haulage.
- Europe might experience a steep increase of petrol prices because of crude-oil shortages. It might be caused by international political tensions, depletion of resources, or continuous exponential growth of global petrol use taking into account, e.g., India and China.

Thus the system *freight market* may yield to such innovation pressures in the directions which have already been envisaged by the European Commission and other powers, during the past years. Opposite developments may take place if the *decrease of population* in Europe continues because the need for transportation of goods across Europe may decrease¹.

These aspects are scope for discussions of experts on different levels. Accordingly, five specific *perspectives* for future research will be listed here as follows:

- The **first perspective** concerns *increasing efficiency* of utilizing existing infrastructure and capacities in freight transportation, and enlarging those capacities in the future as needed.
- The **second perspective** is closely linked to the first perspective. It concerns the development of new *automation concepts* in freight transportation. It would include developing further the advanced interactive driving simulation laboratory considering rail, road and even air transport technologies.
- The **third perspective** concerns the research to improve *acceptance of innovations* in freight transportation, which may comprise the acceptance of both technical or organizational innovations.
- The **fourth perspective** concerns interdisciplinary research on strengthening the *migration of technological innovations*. Here strategies need to be investigated which may lead to improved politics of implementing innovations despite legal difficulties or complex regulations in European transport business.
- The **fifth perspective** concerns the *automation of container terminals* which needs to be followed further for improved transport performance. This theme has not been discussed in this report.

¹ (Prof. Klaus interviewed by Helmke 2005b).

The many different aspects mentioned in this research, show the need for communication in order to find the optimum path to innovation success. Through communication, acceptance for innovation has to be raised among executives, politicians, and society. This has to be done by information campaigns, educational and training measures as well as simulation laboratories etc. Thus innovations require technological know-how but also communication and educational measures to be finally successful. Some such measures will be briefly presented in the final section. In particular two new *Educational and Training Measures* are presented in the following paragraphs which may be considered *accompanying measures* of the seven innovation projects described in this research.

8.6 Educational and Training Measures

Educational and Training Measure I: *The Intermodal Masterclass*

The European Intermodal Association (EIA) promotes and develops intermodal freight transportation systems in Europe. This Association has started an ambitious project together with six European universities: the annual *Intermodal Masterclass* (Savelsberg 2006c). The first cycle of the Masterclass was started in Winter 2005, the next will follow 2006/07. The goal of this Masterclass is to get closer to the market, the concept of European intermodal transport and its opportunities, and thus, to come closer to the executives within the system.

The universities of Venlo, St. Gallen, Aachen, Rome, Duisburg and Rotterdam, and the EIA in Brussels have come together to ensure the high quality of this Masterclass. Executives from all over Europe are invited to participate in the seven sessions of this Masterclass. Thus the executives learn about market structures, networks, and legal as well as technical aspects concerning intermodal transport.

The Masterclass is being offered in cooperation with lecturers from transport and logistics industries who give first-hand insights on processes combining and integrating freight transportation by rail, road, inland or maritime waterways. After finishing the Masterclass the participants are expected to implement their new knowledge on how to improve logistic chains in their own enterprises and businesses making best use of intermodal approaches.

Educational and Training Measure II: *The Colloquium Advanced Driver Assistance Systems in Freight Transport*

The Colloquium *Advanced Driver Assistance Systems in Freight Transport* has been designed to increase the interdisciplinary knowledge and awareness of young scientists regarding this upcoming technology. Furthermore the participants are expected to gain experiences regarding interdisciplinary cooperation, and the assessment of technological impact.

In 2004 twenty scientists from seven German universities joined with practitioners from the freight industry (freight forwarders, truck drivers and their instructors) to develop requirement specifications during a two-day workshop. The specifications should be applicable to truck-platoons in long-distance freight transport, based on Advanced Driver Assistance Systems (ADAS). Different lectures were given by experts on ADAS, freight transport and methods of technology assessment. The lectures were accompanied by extensive workshops in mixed groups taking into consideration the different disciplines and background of the participants.

It is to be expected that through such measures of communication, education and training the willingness will be raised to come to terms with the fundamental innovation processes needed in the near future within the freight transport system across Europe.

Summary

Serious problems and risks can be observed in European transportation development. Major difficulties are the imbalance of growth of the different freight transportation modes, the congestion on the main overland routes and furthermore, the major impact of transportation on the environment and on citizens' health. The research presented here, has stressed the following points.

In European freight transport, fundamental innovations are needed to cope with the problems and risks mentioned. *Innovative Technologies* and *Logistic Services* can be considered the main components of the *innovation processes* required. However, the transport and logistic sector shows a lack of tradition in utilising systematic *innovation management*.

Thus, this investigation aims at the following innovation requirements. Due to the complexity of the freight market, *migration-oriented systemic development of technological innovations* appears to be required to gain very early the support of all stakeholders for successful migration of such innovations. Furthermore, the technological transportation innovations have to be *socially* and *environmentally attractive* to reduce the external costs. They have to be *economically attractive* to improve the development of European economy. Finally the new *technology* itself has to be *attractive* in order to be competitive to other already existing transportation systems.

Hence, this research aims at suggesting a specific and comprehensive *Systemic Migration-Oriented Innovation Management Method*. The *Method* includes the supporting tools for *Innovative Technologies and Logistic Service Innovations*.

Within this research, seven case studies of European freight transport innovations have been conducted according to this *Method*. They offer a broad and comprehensive up-to-date view concerning the European *land-based long-distance freight transportation*. They deal with the following themes:

- different carriers (rail, road, intermodal),
- different degrees of automation, and
- different corridors across Europe (north-south, east-west, or any other corridor).

These case studies demonstrate how implementations of innovations may be performed successfully by using the suggested *Method*. Additionally this volume may contribute to making certain recent research on land-based long-distance freight transport more visible for interested European researchers and practitioners.

All technologies and logistic services presented in the case studies have been designed to support sustainable development of the European freight transportation market. The following seven approaches have been considered within the case studies:

- the introduction of truck platoons on motorways,
- the development of the *Interactive Driving Simulator*,
- Individualized single-wagon door-to-door rail transport,
- Semi-trailers in Advanced European Intermodal Logistics,
- European low-platform technologies for non-cranable semi-trailers,
- the logistic service innovation *Orient Freight Express*, and
- the prospective logistic service innovation *Poland-Spain Transport*.

All approaches contribute to the reduction of external costs of European freight transport.

The efficiency and competitiveness of these different innovations have been analysed from the viewpoint of the demand side which includes the freight forwarders, hauliers, etc. This analysis has shown how difficult it is at present for such innovations to offer the same advantages as road-only transportation. The *Systemic Migration-Oriented Innovation Management Method*, however, represents one optimum strategy for migration of these innovations into the market. But the pressure to improve the transportation system will need to be kept up, or even to be *increased* in order for those innovations to be finally successful. If in the future, this pressure *decreases* rather than increases the demand side of freight transportation – the freight forwarders etc. – will probably continue to choose the still most competitive transport strategy, which is the conventional *road-only transport*.

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