POCTI/TRA/60585/2004 - ELOFRET
ELEMENTS FOR THE OPTIMIZATION OF INTERMODAL
CHAINS IN FREIGHT TRANSPORT

Scientific and Technical Coordination:
Professor Rosário Macário

Scientific team:
Eng Vasco Reis
Eng Luis Filipe

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1 INTRODUCTION

Globalization and other economic dynamics have put the logistics system under several recent structural changes. The main trends being the restructuring of logistic processes, the realignment of supply chains, the rescheduling of product flows, and changes in transport management and product design. At the same time, the transport sector has seen a move towards the concentration of transport in distribution hubs and therefore the development of hub and spoke systems, linked through transshipment, has been achieved. Along the years these trends fostered the growth of road transport volume (offering door to door mobility and high flexibility of solutions) threatening the sustainability of economic and social systems through the level of externalities produced. There is a growing awareness that to attain the overall objective of modal shift, logistic solutions need to consider an integrated approach to mobility taking into account the needs of the agents involved in the transportation process. However, evidence exists that too many hindrances appear to exist jeopardizing the potential for integrated solutions, that go beyond the well known problems of interoperability which are progressively solved by the technological development.

ELOFRET addresses the problems affecting the development of intermodalism and proposes a new concept to for assembling intermodal transport chain that takes in consideration each mode of transport’s capabilities of integration and potential to attract other modes of transport. Modes of transport with high potential of attraction fit better than those modes with lower potential of attraction. Consequently, by bringing together fitting modes, we would get tense intermodal transport chains. A tense transport chain has residual performance losses resulting from the interaction of transport agents, which means that it may reach higher performance (when comparing with non-tense transport chains). The assemblage of tense transport chain is dependent upon the depiction of each mode of transport’s profile. The profile is the characterisation of mode of transport along a set of key variables. By comparing the various variables, it is possible to understand which better fit.

This report is organised in four main chapters. Chapter 2 presents a state of the art in the freight transportation sector. Chapter 3 describes the sector along different topics. Chapter 4 describes and assess intermodal transport. In Chapter 5 presents the key concept of this
project: the attractiveness concept. Chapter 6 presents a case study from an intermodal transport chain from the port of Sines. And Chapter 7 concludes the report.

The attractiveness concept was developed within ELOFRET by the PhD student Eng Vasco Reis, who has been a main researcher in the project, having as scientific supervisor Prof Rosário Macário. Another student Eng Luís Filipe was engaged in the project as a grantholder with the mission of conducting desktop research, mainly concerning the modes of transport and agents’ information requirements which contributed to background knowledge in the development of his MSc Transport dissertation dedicated to information systems.

The project produced a total of five papers which were presented in the following conferences and seminars:


- Vasco Reis (2007) “Enhancing Intermodality”, 12th ELA Doctorate Workshop, 27th-29th June 2007, Grainau, Germany

2 STATE OF THE ART ON LOGISTICS AND TRANSPORTATION

2.1 Introduction

Transportation, as an economic activity, hardly arises spontaneously, instead, she is the result of the need of people and goods to move from one location to another. Therefore, transport activities are directly related with economic activity since when there is economic activity there is trade and both people and goods need to be transported between different locations. As a consequence, in times of economic upturn trade is more intense and people have more available income and transportation accompanies this rise, while in times of economic downturn economic activity decreases and people see their available income reduce with adverse consequence for the transportation activity. The fact of transportation to be closely linked with economic activity denotes the derived nature of the transportation sector, which means that an increase in industrial production and international trade will automatically lead to greater demand for transport services - of course, if no other measures were done.

The available statistics show precisely this kind of behaviour, Figure 1 presents the evolution of both GDP and Transport growth since 1970 within European Union (only concerns EU-15). As it is possible to see, freight transportation and GDP record continuous growth with the former closely following the latter.

However, since late 1980s, the behaviour freight transport changed, and freight transport activity began to growth above economic activity (Figure 2). This occurred because in the 1980s there has been the emergence of new management techniques of products’ production and distribution. Multiple new techniques have been (and still are being) developed: lean production, Just in Time production, etc., which generally are brought under the generic name of Supply Chain Management (SCM). SCM has changed the paradigm of production and distribution, and naturally, the role of transportation within firms. Consequently, transport has begun to be more dependent of the kind and nature if the SCM and less dependent of the economic environment. Moreover, these new management techniques are introducing important modifications in both nature and patterns of freight flows posing the transportation sector under a major stress to offer high quality and fully flexible solutions. Other important feature is that they are “transport
consuming” since are adding extra links to the Supply Chain generating extra transport volume (and this is the rationale for the results presented in Figure 2).

Due to the major relevance of SCM techniques on transportation organisation, pattern, and performance, and since it is fundamental to understand how transport activities have been evolving and how they will evolve, the origins and evolution until the emergence of SCM are presented in the next section, followed by the possible trends and the drivers that are
behind those trends. Acknowledge of the SCM trends is of paramount importance since the explain how transport activity is behaving and dictate how transport activity will develop in the following years.

Since SC has a major influence on transport services, policies regarding the future development of the freight transport systems can be done stimulating and driving the supply side of the freight transportation system - the SC. Therefore the study of the SC and Logistical trends is of paramount importance to understand and assess the development patterns of the freight transport systems. The understanding of the freight transport developments patterns is of major importance to policy makers both in the private and public sector. These developments patterns provide the basis for developing future strategies regarding the organisation of the freight transport system.

### 2.2 Evolution of Supply Chain Management

![Figure 3 – Evolution of management techniques (Hesse, M., et al. (2004), p 175)](image)

In the 1950s and 1960s, manufacturing companies used mass production aiming to minimise unit production cost; therefore, product tended to be equal with very little scope to product or process flexibility. New product development was slow and relied mostly on in-house technology and capacity. Customers were not taken into major consideration when new products had to be developed.
Production and distribution was based in large inventories that shielded companies against any fluctuation in supply or unpredictable bottlenecks. Naturally companies invested huge amounts in work in process (parts and subassemblies in the process of becoming completed assembly components; these items are no longer part of the raw materials inventory and are not yet part of the finished goods inventory) inventory. The various activities concerning production and distribution were managed independently not existing any kind of co-ordination and exchange of information between the various companies’ sectors. Furthermore, no kind of co-operation (share of expertise and technology) either with customers or suppliers existed. This was seen as a rather risky and unacceptable manoeuvre and companies avoid relationships.

In the 1970s, there was an intense global competition which has force companies to reduce costs, offer higher quality and reliable products. Manufacturing Resource Planning was introduce in manufacturing firms, with managers realising the major drawback (in terms of cost, quality a, new product delivery and delivery lead time) of having huge work in process inventory; moreover, they acknowledge the importance of new materials management concepts in the improvement of firm’s performance.

Just in Time and other similar techniques began to be used in order to improve manufacturing efficiency and cycle time. These techniques have reduced by large the necessary amount of products kept in inventory. It was with the reduction of the inventory levels, and thus, the reduction against unexpected changes in supplying and scheduling problems, that manufacturing companies began to realise the potential benefit and importance of strategic and cooperative buyer supplier relationship (Tan, K. C. (2001), p 41). This represented the emergence of the SCM concept – strategic partnership with their immediate suppliers. Soon, experts in transportation and logistic joined, carrying the concept of material management a little further by incorporating the physical distribution and transportation functions, which has resulted, later, in the integrated logistics concepts.

In the 1990s, there has been a continuous evolution with companies further extending their practices and including strategic suppliers’ products (this has had major benefits, for example, it was possible to end with product inspection, since suppliers certified their products’ quality). Furthermore, there as an exploitation of suppliers strengths and common efforts in the development of new products. Finally, in some supply chain
seamless integration of retailers’ physical distribution with transportation partners has been achieved. Meanwhile, the focus of supply chain has moved towards customers. It is the customers who driver all changes throughout firms’ internal and external linkages. In more recent years, the advent and development of electronics, has allowed a deeper and more efficient integration. There has been a complete electronic integration of the supply chain (the development of EDI as been a critical element of SCM).

Nowadays, the productive processes involve a multiplicity of firms located in different countries (and even continents), committed in the production of the final product. Goods are transported successively between those actors, from the source (raw material) towards the finished product, in each level value is added to the product. The establishment of these relationships among all partners of a logistics chain has led to the development of the concept of SCM (Figure 3). SC encompasses all firms within the values as a unified “virtual business” entity.

Among researchers the concept is not yet totally clear, being the literature full of definitions, however, it may be said that SCM concerns the management of all actors enrolled in a production of a certain product aiming benefits maximisation for the overall Supply Chain - even this meaning some actors do not maximise their benefits.

TRILOG defined supply chain management as being an extension of “the principles of logistics across enterprises boundaries” (TRILOG Europe Summary Report - ESR, pg 1).

By logistics, two OECD reports (TRILOG ESR, pg 41) defined as being “the concept of synchronising the activities of multiple organisations in the logistics chain and feeding back necessary information to organisations in production and and/or physical distribution.
sectors on a real time basis, by fully utilising information technology and digital communication networks”.

The European Founded project PROTRANS, defined as being “part of the process that plans, implements, and controls the efficient, effective flow and storage of goods, services, and related information from the point of origin to the point of consumption in order to meet customers’ requirements” (Deliverable 1, pg 20).

SULOGTRA (D4, p 28) defined supply chain management as being a rather broad system since it manages both the flow of materials and the relationships among channels intermediates, from the point of origin of raw materials to the final consumer.

Despite the lack existence of consensus, SCM is used in 3 different ways. 1st) to describe the purchasing and supply activities of manufacturers, 2nd) to describe transportation and logistics functions of the merchants and retailers, and 3rd) to describe all value adding activities (from the raw materials extractor to the end users including recycling). Supply chain management tend to include activities such as planning, product design and development, sourcing, manufacturing, fabrication, assembly, transportation, warehousing, distribution, and post delivery customer support (Tan, K. C. (2001), p40). Furthermore, in a supply chain, the final customers pull the inventory through the value chain instead of the manufacturer pushing the items to the end users.

2.3 Drivers and Trends in Logistics and Supply Chain Management

In this Section (Figure 5), an overall description of the main drivers and trends of Logistics and Supply Chain Management are presented aiming to explain the recent changes in the freight transportation sector.

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1 Driver is a force originating from the environment of a system which leads to changes in system configuration. Stated otherwise drivers are those forces that are shaping up the system in terms of its structure and organization. For the Supply Chain Management/Logistics System drivers are deriving from the socio-economic, political and technological environment and influence the development of SCM / Logistics system trends i.e. spatial concentration of inventory, etc.

2 Is the collective manifestation of the influence of the drivers on the configuration of the system. The extent to which a trend is widespread in a given SCM / Logistics system is determined by the intensity of the interaction between the system characteristics at a given time period and its environment.
2.3.1 Logistic and Supply Chain Management Drivers

Within Literature various drivers are identified as underlying changes in Logistics and SCM. These drivers are the basis for the identification of the causes of logistics and supply chain management trends. An European Union founded research project REDEFINE has considered the following drivers: Policies and Regulations: Economic policies, Environmental Policies, Social Policies, Transport Policies and RTD policies; Commercial Drivers: Profits, New Markets, Product Diversity; Technologies;

More recently, another project SULOGTRA has updated those projects and considered the following drivers. : Industrial and Management; Environmental; and Political; Social; Technological; Economic.

Economic, Industrial And Management Drivers

These are the most relevant drivers, they are the result of the fast changing economics and financial markets of the European Union. The European construction has been introducing important changes in the economic and market structure of the European Union countries. By deeply changing the rules companies were subjected, the European Union has introduced major changes in the companies’ productive and distributive processes. These changes have been produced at different levels, namely:

- **Changes in GDP** - As Figure 1 shows the European Union GDP continuously grew since 1970, which is a synonym of countries and, thus, people's wealth growth. By having more money, people can afford to buy more and expensive...
goods. Moreover, the pattern of economic activity is rather uneven both, within and between member countries. The most advanced areas of Europe are located within a region extending from the north west of London through Germany to northern Italy. Future areas for future possible growth include the axis from Paris to the Mediterranean, with a south western extension ranging from west since the major cities of Iberia to east to Prague and Vienna. This potential eastern shift of economical development in Europe might have strong implications for the location and management of logistics and supply chain practices (See Figure p 12, D1, SULOGTRA).

The recent enlargement of the European Union to east has deepened this potential, as the new European members present high levels of GDP’s growth.

- **Interest Rates** - Despite the continuous convergence of the interest rates, there are important differences between different areas of the EU having deep implications for the location of the industry. However, there are still important differences which might have some sort of influence over firms’ location.

- **Intra and Extra European trade levels** - The continuous deregulation of market activities within European Union has provoked major changes in companies’ way of doing business. Consequently, since late 1980s, the intra-European Union trade in comparative terms with the extra-European Union has been continuously growing causing an increase of intra-European transport.

- **Concentration of Industry and Services** - Globalisation is leading to the elimination of the barriers to production and trade allowing companies to take place within a wider geographic area. From late 1980s onwards, the European members’ nations experienced an increasing number of mergers, acquisitions, joint ventures and other forms of co operation in industry and services. Industrial and services concentration introduces relevant changes in companies management, with important consequence for their logistics and supply chains.

- **Globalisation of Industry and Services** - From the 1970s onwards, there has been at global level, a relaxation and elimination of most existing institutional barriers, easing the flow of people, goods, capital and information across countries. This phenomenon is usually known as Globalisation. Globalisation is a rather broad term...
used to describe the opening up and increasing internationalisation of markets, worldwide communication and mobility, the changing in the consumption patterns and lifestyles, the positioning in key position of multinational firms in world markets, a shifting of industrial activities (trade and transportation) all over the world, etc. Some driving forces behind this phenomenon were: first, the increasing liberalisation and deregulation of international trade, during the 1990s there were important developments in terms of international trade with many countries establishing free trade zones (or other similar agreements) and thus reducing the tariffs and quotas to international trade; second, the rise of new consumer markets; third, the technological developments in the field of telecommunications; and fourth a general decrease in the transportation costs.

With Globalisation, companies changed their supply chain management strategies (see below discussion), and competition moved from a national level into a global level; nowadays companies compete at a worldwide level. Finally, with the advent of Internet there was the emergence of e-commerce and e-business with people and firms being able to entail commercial relationships with others in any place, which has also contributed to the development of freight transportation growth. In Europe, owing to the ongoing European Construction that has been continuously both eliminating the existing institutional barriers between member states, and implementing a free and uniform market (in what concerns competition rules), the member states’ trade relations have deeply changed. The gradual reduction of the institutional barriers has led to a continuous growth in freight transport across member states.

- **Shift from Industrial to Service Sector** - In industrialised economies the service sector is always more relevant than the manufacturing sector in terms of GDP. So, the growing industrialisation of some European members might have introduced important changes in the logistics and supply chain of industries. The importance of this driver varies in relation to a country’s level of income. The service sector includes for example wholesale and retailing activities.

- **Proliferation of Product Types** - The number of new products on the market is increasing each year forcing improvement of logistic systems. In recent years, the
quantity of new products in the retail sector has suffered a major growth. The proliferation of such new products suggests increasing competition and the need to produce immediate results in order to keep running (slow sellers are rapidly eliminated in a matter of weeks and not months as in the past). The presence of such volatile changes in product manufacturing has had important implications for manufacturing and supply chain practices.

- **Organisational Re-structuring** - The recent changes in the global markets, like Globalisation, have put companies under a constant pressure (cost pressures, increase of competitiveness, world presence, new products, etc.) to re-arrange their organisational structure to match these market requirements. In order to run a business divided into processes the organisation has to be changed and the whole of the supply chain has to be included.

- **Supply Chain Integration** - Collaboration of companies along the supply chain is becoming a key factor for the competitive advantage of all companies enrolled. The growing integration and coordination of activities is leading to important changes in the manufacturing and distribution practices. With Globalisation, manufactory companies have abandoned their traditional behaviour, in which all business were planned at country level, and entailed on global business starting to embrace many partners in distinct countries. These changes have introduced major changes in the structure of firms’ logistics systems. Nowadays, the productive processes involve a multiplicity of firms located in different countries (and even continents), committed in the production of the final product. Goods are transported successively between those actors, from the source (raw material) towards the finished product, in each level value is added to the product. The establishment of these relationships among all partners of a logistics chain has led to the development of the concept of Supply Chain Management (SCM).

- **Mass Customisation and Customer Integration** - Customers are demanding more individualised services and products. In order to survive, companies have to integrate the needs of their customers into their concepts. Customer sophistication has been the major driving force in the development of the logistic and supply chain systems (SULOGTRA (2002), Deliverable 1, p 15). More and more,
customers are demanding greater product variety, more and tailored value added services, custom and tailored products, shorter responses time and greater accuracy and support throughout the product’s life cycle. Moreover, shipments are becoming smaller and unitised, since each customer demands a unique product. This is resulting in increasing flows of small parcel. These flows are not concentrated since customers are scattered across the countries (shipments are delivered at home and not in a selling location). These new needs go against the strategies of achieving economies of scale by mass production techniques, which are introducing important changes in the way companies manage the design, production and distribution phases (See figure pg16, D1, SULOGTRA).

• **Outsourcing of Non-Core Activities** - Sourcing out has been one of the dominant business trends during the 1980s and 1990s. Companies have been concentrating on their core activities contracting out all auxiliary functions. Logistics that is often regarded as a supporting function has been a common outsource activity. The way and extend in which logistics services are outsourced have influence on the overall quality and efficiency of a company’s logistics system. Outsourcing has led to the emergence of logistic service providers (that are usually called as Third Party Logistics) that are gaining more and more relevance in firms’ logistics. Nowadays, the relationship between them is of long term co operation. Reasons to source out: logistics cost reduction, service improvement, flexibility of response, wrong supply chain structure, large variations in volume, geography and service, small logistics activity and low operational efficiency. If the co-operation between company and the logistic service provider is being optimised, very good results can be obtained. The use of logistic providers has introduced important changes in the manufacturing factories.

• **Increased use of information and communication technology** - The growing use of ICT is reshaping the market. The major growth of Internet as new channel for marketing and as new infrastructure for order processing and distribution (in digital format) is changing the rules of the market (marketing is done in a different way, communication with the client is changing, new products are arising and others are put aside). In the next years, it is expected the continuation of this trends with more changes into the manufacturing companies and supply chain techniques.
Technological Drivers

Along with Economic this is the most important driver. During the past decades an impressive development of the Information and Communication Technologies (ICT) has happened - which is the main factor underlying this driver. Nonetheless, other technological developments have occurred in parallel.

- **Information Technology Advancement** - There have been enormous developments in hardware technologies (bottlenecks are no longer storage capacity or processing speed). The development of non-expensive personnel computers, the fast increase in the processing speed and the major developments in data storage capacity have enabled the widespread of cheap information technologies and the emergence of current IT solutions (like the real time systems).

- **ICT Integration and Development of Logistics Decisions Supporting Software** - Nowadays, companies not only need to manage their internal activities as well as the information flow they receive from the other partners in the supply chain. In order to be successful and fully reap the maximum benefits, firms along a supply chain have an integrate ICT system, which allow them to optimise the supply chain, and sustain competitive advantage. The integration of ICT systems results in far greater results that stand alone solutions. The first steps towards supply chain integration were given in the 1980s with the development of the Just in Time philosophy and lean production. Later during the 1990s, the Efficient Consumer Response (ECR) have been developed improving the cooperation between trade and consumer industries.

More recently, key elements to increase the flexibility of the value chain (instead of high utilisation and unitised product) have been a better communication between suppliers and customers, postponement and flexibility, which have only be possible with the development of software. The most important systems can be divided into: strategic SCM planning systems, tools for SCM optimisation, enlarged efficient resource planning systems, and Customer Relationship Management (SULOGTRA (2002), Deliverable 1, p 19). SCM planning systems optimise the processes of supply chains.
• **Evolution of Data Transmitting Technologies** - In the last decades major improvements have been done in the communication technologies (for example, development of GSM and UTMS), allowing firms to communicate faster, and exchange greater flows of information and with fewer failures.

• **Network Infrastructures** - The most relevant development has been the emergence of Internet that nowadays links hundreds of thousands computers worldwide, allowing a fast and secure exchange of information between them.

• **Data Interchange Standards** - The efficiency of supply chain depends on the utilisation of computer aided information system. Companies along a supply chain need to constantly exchange information in order to coordination the flow of goods and reduces errors. A seamless exchange of information requires compatible systems which means that information transmission has to be standardised. Nowadays, information exchange standardisation concerning transportation is based on EDITRANS (Electronic Data Interchange Transport) that is a subset of a large standardisation system called as EDIFACT. EDITRANS is especially suitable for the transmission particular forwarding orders, confirmation of orders and accounting. They are needed for an uncomplicated electronic data interchange.

• **Identification Systems** - They are speeding up the goods flow. By using standards, products do no have to be unpacked in order to identify them. They are used whenever the exact tracing of the identification objects (that can be either vehicles or shipments) is necessary (not being possible to use indirect tracing methods). The identification systems follows with the goods and are easily detected along the supply chain allowing companies to know in real time the location of the goods. Recently, there has been important technological developments with an increase of data storage and transmission capacity (the Radio Frequency Identification technology allows to exchange data into two directions with no need for direct contact).

• **Telematics** - Fundamental to cope with the constant expansion and grow of freight transport activities. Developments in terms of systems and services of telecommunication and informatics in the last decades has enabled companies to make use of track and tracing applications. For example, with the Global
Positioning System companies are able to know the exact location of a given shipment (error are inferior to 10 meters) allowing them to optimise the production patterns. Also they support traffic control systems to optimise the route planning.

- **Standardisation of Unit Loads** - Like what happens with Data Interchange, the standardisation of loading units for transport operations is rather important for transportation efficiency. It not only results in an acceleration of transshipping procedures (requiring less labour and less time), as well protects goods against weather and pilferage. Moreover, standards loading units are a key factor for the promotion of combined and intermodal transportation enabling a door to door transportation (and using other modes that exclusive than road).

It is in deep sea transportation that standardisation is most developed, nowadays almost all freight is transported in unitised loading units (as a consequence, nowadays the normal length of time for a port call for a modern container vessel is between 12 and 24 hours compared to one to two weeks in the past before containerisation (SULOGTRA (2002), Deliverable 1, p 23). Other important, standardisation moves have occurred in the other modes of transportation (for example, swap bodies in the road transportation and unit loading devices for air transportation). However, most of these standardisation has happened only within a given mode of transportation, which has conducted important problems of interoperability between modes reducing the scope for combined or intermodal transport. In the future, the continuous pressure towards standardisation is expected to continue compelling firms to adopt fully interoperable loading units between all modes of transportation.

- **Increase of capacities in Intercontinental Transportation** - There has been major improvements in the capacity of the transportation vehicles introducing important changes in the patterns of distribution. In the maritime transportation, since the development of the containerised transportation with the first generation vessels o the size of 730 TEU (twenty feet equivalent unit) capacities have increased up to 8000 TEU nowadays, having plans to build 10000 TEU ships. In the air transportation, the development of wide bodied aircrafts with a large belly space in comparison with the narrow bodied has also been a major achievement.
The impacts of these changes are reflected by the increase of the ratio of unit load transfers to the number of vehicle. Moreover, firms are being able to transport more cargo per shipment, forcing transfer points (port and airports) to handle with more cargo in shorter periods of time.

- **Automation of Warehouses and of In-house Transportation** - These drivers follow the recent trend of more efficiency way of handling storage goods and products. Recent technological developments have enabled the introduction of operator devices, conveyors and commissioning robots which along with warehouse management control are responsible for the operations and control of the warehouse. These developments have fastened up the speed of handling and enhanced the management of the inventories (for example, it is now possible to know in real time the number and location of any item within the warehouse), allowing companies to better manage their stocks and patterns of distribution. This trend concerns the changes that have been happening in all technologies used to transport goods within a warehouse. In the last decades, due to technological developments there has been a relevant increase of the automation level of the transportation systems, introducing changes in the way micro logistics is conducted.

*Political Drivers*

The regulatory and political environment exert an important pressure on the logistics systems, since, it may completely change the market rules and, thus, the competitive environment.

- **Privatisation of tasks and financing** - With privatisation, tasks that were formerly performed by the governments are now accessible to privates. Which opens the door to companies enter into new markets, with all inherent changes. There is scope for partly or fully outsourcing of some activities, is special what concerns all logistic activities. On the other hand, the lack of financial capacity of many governments and the need of public investments is putting pressure on governments to form alliances with privates. The most attractive mechanism is the Public Private Partnerships.
• Harmonisation of regulation and laws - The European construction has been establishing a common regulatory field among all member countries. An important step was given in 1993 with the establishment of the European Union internal market. The gradual reduction of regulatory barriers is introducing major changes in the way companies manage their supply chains within Europe. One of the consequences of the legal harmonisation has been the change of the European economy from a “stock” economy to a “flow” economy, due to the relocation of some industries (in special, for goods with high labour input) in places where the production costs are lower.

• Transportation Industry deregulation - In Europe the various modes of transport are being consecutively deregulated, which is introducing important changes in market. Nowadays, companies have a greater flexibility and degree of freedom to choose, define and optimise the best mode of transportation.

Social Drivers

• Increase of European Union’s Total Population (EU15) - The total of population within EU has continuously increased in the last decades, and thus the total number of potential clients. If nothing is done, it is expected a decrease in near future.

• Changes of working hours and leisure time - The evolution of the Society in which working and opening times are dependent on the preferences of customers, employees and employers and led to the introduction of the 24 hours economy (prolonging the working hours and opening times). On the other hand, the working time has reduced continuously, and therefore led to the increase of the employees’ leisure time (different product needs and more time of consumption).

• Changes within and between Social Hierarchies - The growing attention for equality between individuals has levelled the various social classes (the lower classes are getting more consumption opportunities). This has introduced changes in the consumption patterns. Lower income classes are getting more opportunities. Moreover, along with mass customisation (and customer integration approaches) there has been a growing individualisation (the one person household as a percentage of the total of the private households have increased from 24.8% in
1981 to 28.2% in 1991 (SULOGTRA (2002), Deliverable 1, p 29)), introducing important changes in product consumption patterns;

- **Increase of ICT use in the Society** - Information and Communication are significantly affecting the people's habits of leisure, working and consumption. A rather relevant segment is the Internet Business to Customer commerce that has been changing and increasing rapidly, compelling industry to offer solutions to cope with the new demands.

*Environmental Drivers*

The increasing public awareness of the importance of environmental protection has increased in the fourth quarter of the last century. Nowadays, people and governments are pressing companies to offer more environmental friendly solutions and products.

- **Increasing number of vehicle kilometres** - The total number of freight vehicle kilometre, especially the road transportation, has continuously increased in the last decades (insert some sort of graphic), which is putting under pressure the scarce infrastructures (this is especially prominent in central Europe) and leading to increasing traffic and pollution problems. Population is demanding important changes in the way freight transportation is conducted.

- **Increased attention for re-using materials** - The European Union policies are stressing prevention of waste production and possibilities for re usage of waste (recycling). This situation may introduce new forces into the manufacturing and distribution firms.

### 2.3.2 Logistic and Supply Chain Management Trends

Concerning the phenomenon (that emerged during the 1990s) of freight transportation to growth above GDP; the reasons are related with the emergence of the Supply Chain concept and the changes Logistics suffered during the last decade. Owing to the drivers presented above, both, firms’ Logistics and Supply Chain have been undergoing important changes. These trends are introducing important modifications in both nature and patterns of freight flows posing the transportation sector under a major stress to offer high quality and fully flexible solutions. Other important feature of these trends is that they are “transport consuming” since are adding extra links to the Supply Chain generating extra
transport volume (and this is the explanation for the increase of freight transportation above GDP). The main trends are:

Restructuring of Logistics Systems

- **Spatial concentration of production** - Manufacturers have been concentrating production capacities in fewer locations, which has resulted in a reduction of the total number of factories and an increase of plant specialisation. The traditional national based production approach has been replaced by focused manufacturing where the entire production of a particular product for a continent or in some cases of the world market is based at a single location. This allows maximisation of economies of scale in the production operation but at the expense of making logistics system more transport intensive and lengthening the lead time to customers. Moreover, transportation has to be highly reliable and efficient. The TRILOG (1999) project found significant geographical concentration of production both, at a European and global level, which may indicate that concentration has already taken place (in many industries) and that now further economies of scale are only possible with concentration at supra-national level.

- **Spatial concentration of inventory** - The centralisation of inventory has been one of the most pronounced trends in Logistics over the past decades. The reduction of the stockholding points results in a diminution of the safety stocks necessary to provide a given level of customer service. The stock reduction can yield large financial results. Economies of scale in warehousing is another benefit. By concentrating all stock in a single (or few locations) companies are able to better respond to sudden demand changes, or to fluctuations in supply. On the other hand, transports costs rise since the distance between the warehouse and final product destination tends to increase. Yet, the benefits far exceed the costs. Within the Single European Market, companies are taking advantage of the removal of frontiers controls, the deregulation of international haulage and improvements in road and rail infrastructure, to concentrate their inventories (SULOGTRA (2002), Deliverable 1, p 32). Concentration in inventory is predicted to be greater than concentration in means of production.
• Development of break-bulk and transhipment techniques - Usually break bulk and stockholding were done at a same warehouse, nowadays, many companies are geographically separate them centralising warehousing while retaining a networks of break bulking facilities. The goal is to maintain the efficiency of firms’ transport operations. By keep break bulking decentralised, companies can minimise cost penalties associated with centralisation. By centralising inventory a network of non-stockholding, break bulk facilities is needed to maintain the efficiency of transport.

This separation is reflected in a general move toward smaller shipments at a national level and large shipments at a European or Global level particularly in the middle tiers of a supply chain. Highly efficient break bulk operation rely at great extend in efficient transhipment operations. As a consequence, there has been a pressure towards standardisation of loading units, in order to accelerate the transhipment process. The use of Internet and mass customisation have resulted in broad range of products that have to be delivered quickly to the final shipment in small shipments. The optimisation of break bulk operations may led, for example, to improvements in the transportation operations.

• Creation of hub satellite systems - This mostly concerns the express transportation (parcel and urgent mail). These companies have a large number of origin and destination locations scattered, nowadays, across the world; making the sorting operation much more complicated. In order to enjoy from important economies of scale, companies consolidate consignments into bigger loads, before dispatch them to a final common destination; this is specially important for the trunk movements. Consolidation enables company of maximise vehicles load factor, thus reducing transportation costs.

From an initial situation in which companies had multiple consolidation depots linked by direct trunk haul (which conducted to a rather complex network of transportation); companies have now adopted hub satellite systems. In this system, all (or most) routes are centralised at the hub or hubs (radial shape). Goods are transported from the origin points into the hub, sorted, consolidated and transported for other hub and for the final destinations. Such systems entails huge concentrated
flows of goods and, consequently, huge flows of information. Therefore, it is necessary warehouses with major handling capacity and high capacity IT solutions. The use of this system is a consequence of the increasing competition that is compelling companies to reduce costs; and a consequence of mass customisation and the use of Internet that has resulted in a broad range of products which have to be delivered quickly to the customer in small shipments.

Realignment of Supply Chains

- **Vertical disintegration of production** - The transformation of raw materials into the final product encompasses various processes and steps that may have been done by the same or different firms. In some cases, even basic assemblies are passed through the supply chain towards the final phases (see below discussion about ‘Postponement’). Nowadays, the growing use of outsourcing is increasing the number of partner enrolled in the production. This process of vertical disintegration is adding extra links to the supply chain and to some extend increasing the transport intensity of the production process. The restructuring of the value chain upstream and downstream of the main production activity is increasing the ration of logistics costs to net value added. The use of sourcing out might result in an increase of the number of transport links in the supply chain. The general management of outsourcing activities has been a major driver of the vertical disintegration.

Demand presents high differences between customers living in different regions; companies having a global presence need to effectively cope with these differences. Vertical disintegration allows a risk reduction to particular individual organisations. Other way, to deal with variable demand is the application of the postponement principles (see below discussion), which increases chain flexibility and can reduce wastage.

Vertical disintegration is only possible due to recent development in IT solutions that allows a real time control of all supply chain (vertical integration that happened some decades before, was due to the need of companies to control all productive process, nowadays, they can control without own all links of the supply chain due to all advances in IT). Vertical disintegration of production allows companies to reduce the risks of sector specific instabilities in demand. Its implementation into
the process of production is driven by supply chain integration and therefore re-organisation.

- **Rationalisation of the supply base** - Recently companies have steadily reduced the number of supplier used to provide a certain product or part. This allows reduction of the transition costs and strengthens the firm’s negotiating power with respect to the chosen supplier. On the other hand, firms become more vulnerable since if the supplier fails the delivery, the production will stop. The impact of this trend on transportation is very low.

- **Postponement and deferred customization** - It means to start as late as possible the order related production sequences that create an irreversible customised product. It is very important to achieve the necessary flexibility to cope with the fast changing demands of the market. The production line is no more done at the end of the production line but instead carried out by manufacturing sub contractors or at distribution centres. The customisation may include the configuration of items from standard modules. Companies hold these standard modules as long as possible and only when demand is know the final customised product is assembled. With postponement companies are able to enjoy from considerable economies of scale (due to the standard forms) while are able to continue to offer customised products (fundamental in nowadays markets) and achieve the flexibility they need to respond to the fast changing demands of the market. This strategy reduces the inventory costs, but adds an extra node into the supply chain. This results in an increase of the both, facilities and transportation costs. However, the effect on the transportation costs has only a minor effect (SULOGTRA (2002), Deliverable 1, p 38).

- **Increase in direct delivery** - It is the consequence of concentration of production and inventory, and the increase of direct marketing. There is a growing trend toward delivery from factory or warehouse directly to the final customer. This is the consequence of the growth on direct marketing (in special via electronic media). By directly deliver goods, firms are by passing conventional wholesalers and retail channels. This process has a major effect on the patterns of freight transportation since it is replacing the traditional echelon system with a hub and satellite parcel network (since now goods are packaged individually which results
in smaller flows). The increase of direct delivery favours the freight integrated carriers, since it entails the door to door transportation of multiple small parcels to different destinations. When companies decide to outsource transportation, the logistic service providers are also capable of offer such services.

- **Wider geographical sourcing of supplies and wider distribution of finished products** - Over the past decades, companies enjoying the growing freedoms have expanded the geographic scale of their sourcing and distribution operations. This resulted in the lengthened of the transportation links and, consequently, in the increase of the transportation costs. However, this has been reaped by the growing value of the goods to be transported (there has been the emergence of a new generation of high value manufactured products) in which the transportation costs are less important; by the location of manufacturing in low labour locations; and by the continuous decrease of the international transport costs due to overcapacities, relaxation of legal barriers and technological advances. Moreover, with Globalisation demand is universal and companies have to be able to deliver their product in any point as fast as possible. The development of improved supply chain management techniques has been a major achievement to companies to be able of to maintain efficient supply. Since the sourcing of goods and services from a wider geographic area increases the complexity of the supply chain.

- **Concentration of international trade on hub port and airports** - This trend is visible in USA and Asia, but not in Europe. Economies of scale and vehicle operations have led on a global level to the concentration of international trade through a smaller number of hub ports and airports. Globalisation of industries and outsourcing trends increase economic relations between countries and are therefore resulting in an increased transportation demand. On the other hand, deregulation and processes resulting from supply chain management integration have forced transportation companies to maximise their load factors in order to reduce transport costs. Finally, the global concentration of industries ha led to a concentration of trade and transport on hub ports and airports. Using concentration on hub results in a reduction of the transportation costs, since transportation is concentrated on main routes.
Rescheduling of product flows

- **Application of time compression principles in retailing and manufacturing** - The use of management principles and approaches such as Just in Time, quick response, lead time management, time compression, lean logistics, agile logistics, efficient consumer response, etc., is helping firms in accelerating their logistic operations. The purposes are to eliminate slack time and non-value adding activities along the supply chain. All these techniques make use at great extend of ICT capabilities. Only with the recent advancement in processing and storage capacities the development of standard and integrated IT solutions, the development of logistics decision supporting software, evolution of data emitting technologies, improvements to network infrastructure and to data exchange standards that has allowed information to be shared easily and quickly by different parts of the supply chain, is being possible to fully enjoy from the benefits of these management techniques.

Long transit times reduces the supply chain’s capacity of response to short term fluctuations in demand; beside compelling industries to increase their stocks (and, thus, inventory related costs). The increase of the speed by which products flow through the production and distribution systems results in several benefits: savings on inventory costs, reduction of the risk if dwindling, ability to rapidly respond to variations in demand. Moreover, the life cycle of many products is declining (most notably in the textiles and in the electronic and consumer electric sector), which compels firms to place product as fast as possible in market.

- **Growth of nominated day deliveries and timed deliveries** - By operating a nominated day delivery system firms can achieve higher levels of transport efficiency, since they force customers to adhere to an ordering and delivery timetable. Moreover, the concentration of deliveries in particular areas on particular days enable suppliers to achieve higher levels of load consolidation, drop density and vehicle utilisation, with significant reductions in traffic levels. Besides to nominated day delivery, the scheduling of freight movement has become more tightly disciplined owing to the introduction of timed delivery at factories, warehouses and shops.
• **Revere logistics** - Reverse logistics involves the return movement of product back along the supply chain (SULOGTRA (2002), Deliverable 1, p 47). In developed countries an increasing proportion of end of life products and packages is being returned for recycling and reuse, due to environmental considerations (increasing attention of society and governments to care about environment and the use of resources). Since, legal obligations oblige producers and distributors to take back the end of life product and packaging, they tend to use the existent distribution channels, therefore, not introducing major changes in the transportation patterns. Nevertheless, the effect of recycling on freight transportation levels at European level are not yet properly investigated. Waste usually tends to have low value with transportation representing a large proportion of the selling.

Changes in the management of transport resources

• **Changes in freight modal split** - Only trucks have been able to adapt quickly to new market demands. They present a set of characteristics that surpass all other modes, among other it is the ability of provide a door to door transportation and be highly flexible. The dominance of road transportation has increased during the last decade due to its competitive advantages. However, changes might occur in the near future. Within Europe, the railway sector is being deregulated, which anticipates changes in this sector. Moreover, the differences between member states are being eliminated allowing companies to have pan-European operations.

• **Reduction in international transport cost** - The real cost of international freight presents a decreasing trend as the carrying capacity has expanded and transport operators enjoyed larger economies of scale. Raising competition in the transportation industry has furthermore depressed rates. Furthermore, the application of telematics to improve and optimise sequence, planning and control of transportation and, thus, to improve the utilisation of vehicles should has also favoured the reduction of costs. The standardisation of loading units that has accelerated the transhipment procedures requiring less labour in much less time, has been another source of costs reduction. Moreover, more efficient vehicle technologies in combination with a more efficient usage of the increasing capacity have resulted in a decrease of transport cost. Finally, the deregulation in the
transport sector has led or should lead to more competition resulting in lower transport costs with the same quality level.

The sourcing out of logistics activities has been another source of transportation reduction, since the logistics service providers have the adequate organisation for transport in a more efficient way than the production companies. As a consequence, firms can increase transport intensity without significantly increase transportation costs. Moreover, transportation importance can continue to reduce in near future. Customers are demanding greater product variety and shorter response times; suppliers are responding by offering more value added services. These services are likely to increase the total value product reducing the weight of transportation costs.

Changes in product design

- **Modularity** - The growing demand for individualism of product in connection with short times of delivery and the difficulty to prognosticate the demand lead to an increasing importance of modularity. The creation of mass product that are flexible enough to be adjusted to the customer demand requires and promotes modularity. The use of postponement strengthens the importance of modularity. The impact of globalisation on modularity is rather enormous. The number of competitors increases as well as the number of products. Parts and complex components can be purchased world wide as national boundaries are no object. The procurement costs are decisive and determine the ordering. Modularity reduces the number of material flows and in this way cost for procurement.

2.4 The new role of transportation

Nowadays different companies align, combine and coordinate together all their activities in what is usually called as Supply Chain systems. On the other hand, transportation is just one of those many activities playing its role in the SC in function of the perceived importance, benefit and cost for the final products’ production. The depiction of the transport activities in the manufacturing companies and more widely in the Supply Chain systems is based on the fact that the Supply Chain is hierarchically structured and consists of four highly interrelated levels (Figure 6) (SULOGTRA (2002) Deliverable 4, p 23).
Each company has to manage and coordinate a set of different functions aiming to achieve the best overall results. From those functions one is the logistic function. Logistics activities cover various activities, for example; transportation, order processing, warehouse and inventory management, forwarding and customs activities, financial services, information technology, etc. So, transportation is just one of the many activities that occurs in a current productive activity. Consequently, it can not be expected transportation plays a major role when is just a function in many.

![Diagram: Hierarchical location of transport](source)

The maximisation of companies’ benefits may lead to over consumption of some activities if the gains in others surpass those costs; it is this situation that occurs with transportation. As transportation is one amongst many activities its costs and requirements have to be traded off against other activities’ costs and requirements. And transportation commonly is not a major variable in manufactory firms’ decisions, which has leading to an over consumption of transport (for example: Just in Time production that is used to reduce inventory costs, but leads to reduced vehicle load factors and increased number of trips; the use of roll cages that facilitates material handling but at the expense of vehicle fill; sales, for example, destabilise the flow of freight, making it more difficult to use the transport assts at a uniform high level). The no-efficient use of transport does not mean that companies are behaving irrationally. On the contrary, they are trading off different costs elements aiming to maximise overall profitability.

On the other hand in what concerns product and packaging design, it may be expected that a better design of products to fit in the pallets and loading units’ dimensions could lead to
higher transport efficient levels (being so, there is a greater potential to improve vehicle utilisation through the effective design of packaging). However, sales and marketing activities are still paramount (in special in consumer products). Furthermore, sales promotions can have a high transport and handling penalty that is rarely subject to a rigorous trade off against actual sales. In an opposite direction, recent trends towards the use of lighter materials and miniaturisation can indirectly contribute to an increase in transport efficiency (SULOGTRA (2002), Deliverable 2, p 43).

Therefore, a possible conclusion is that transportation only plays a minor role in firms’ decisions or that logistical costs trade offs attach insufficient weight to transport resulting in a systematic bias against the efficient use of the transport system. The minor role of transportation in firms’ decisions is ascribable to various factors:

Many firms do not explicitly modal trade off between logistical cost elements, as a consequence, decision making is based on a limited knowledge of the relevant cost functions. This situation is one of the main causes of market failure (SULOGTRA (22), Deliverable 2, p 4).

The transport costs that companies incur do not reflect the full environmental and social costs of freight transport. Different studies (which???) have showed the relevance of external costs in the transportation activities, notably, road transportation. The internalisation of those external costs would alter the economic importance of the transportation activity giving companies the incentives to use more effectively transport operations.

Transport management typically occupies a low position in the corporate hierarchy and yields much less bargaining power than function such as production, marketing or finance.

The transportation costs have been continuously shrinking since the beginning of the century, thus, the parcel correspondent to transportation costs has been reducing its importance and, as a consequence, transportation as an all. Nowadays, freight transport accounts for a small parcel of sales revenue, averaging around 2 - 3 per cent (SULOGTRA (2002) Deliverable 2, p4). There are several drivers underlying this decreasing trend, firstly, the continuous technologic developments; and secondly, the continuous increase of value of the goods conveyed and declined ration of weight to volume (this is directly related with the changes in the logistics systems that emerged with Globalisation).
There is the belief that transport is seldom a core competence or major source of competitive advantage. Being so, transportation is not regarded as an added value, but, instead, as another costs, and even as cost, it usually accounts for a small portion of manufactory companies’ total costs. Figure 7 presents the main five levels of decisions with impact over transportation: product market decisions, investment decisions, location decisions, logistics decisions, and transport decisions. The decisions with most relevance to transportation are those that do have only in minor consideration the transportation issues.

Transportation is placed at the lowest rank in firms’ decision factors. All other decision factors are more important; only, in extreme cases companies’ enter with transportation into consideration (for example, natural barriers). Moreover, there are a set of management decisions having a direct impact on the freight transport parameters, for instance: product development, order fulfilment, marketing planning, sales organisation, etc, and that ignore transportation factors.

There is a prevailing view of transport as a “derived demand” and hence having a subservient role to other activities.

In summary, transport management is therefore operating within a hierarchy of constrains, some of which are technical but many of organisational nature. These constrains are dependent on a wide variety of factors such as value density, product cube, position in the supply chain, geographical location with respect to markets, etc (SULOGTRA (2002), Deliverable 2, p 43).

Despite, the minor position of transportation in companies’ decision levels, the choice of mode of transport is often decided at strategic level (thus, it tends to be rather stable over
time). Moreover, studies found that the choice is not exclusively based in rational arguments (such as, costs and time) but also in managers’ perceptions about each mode; which naturally influences the type of transported chosen. Furthermore, there is in most cases some inertia to change, ascribable not only to the apprehension of the different and unknown, but also, because the change of mode of transport means the change of the entire system and process of transportation, for example, companies are obliged to entail new relationships with new partners (she has to rebuild her transportation network); all transport and handling material have to be changed or modified to the new mode of transport; and third, companies have to change all administrative procedures, etc.

### 2.5 Influence of Supply Change trends on transport systems

The relationship between the supply chain systems and the freight transportation systems is based on the assumption that the organisational and management of the SC system as a whole is decisive for the development of the freight transport system demand side; and that the (future) development patterns of the freight transport system are influenced by the organisation and managerial development of the SC system.

The Freight Transport System consists of: 1st) an institutional (regulatory) framework under which it performs its intended functions; 2nd) an infrastructure, 3rd) vehicles and transportation technologies, 4th) transportation services. And it is influenced and bounded by: 1st) external factor (such as: regional changes, deregulation, globalisation, etc.), 2nd) SC management system, 3rd) enterprise, 4th) logistic system (see figure 2.4, SULOGTRA, D4, p 30)

In order to understand the level of influence of the SC trends on the freight transport system, with the purpose of understanding the changes in the freight transport patterns, it is necessary to map between the SCM trends and the impacted freight transport system. Therefore, the freight transport system has to be characterised in terms of variables that will correlated with the trends. In this way, changes in the freight transport system variables will allow to draw conclusion concerning the changes in the freight transport patterns.
Since the main goal of this chapter is to get the general picture of the transport patterns’ changes and not to make a deep research about the influence of SCM on freight transport system; only the main impacts and relationships will be presented (further and deeper analysis can be found in the following European research Projects: SULOGTRA, REDEFINE, TRILOG, LOGIC).

It should be noticed, however, that the relationships between the SC trends and the freight transport system variables varies according to the individual sector under consideration (may be different or have different magnitude depending on the industrial sector. This is either due to characteristics of the products of the given sector or due to the level of development of the trends within the specific sector; the type of movement considered (the development of the freight transport system indicators may also vary within the same sector based on the type of movements it is referred to, i.e. national or international movements); and the transportation mode (substantial differences may also exist depending on the transportation mode the indicator is referred to each time). Therefore, the analysis should be carried out for different sectors (in the SOLUGTRA European project 7 sectors have been studied: food and beverage, waste, petrol, parcels, building materials, machinery, and chemicals and fertilizers).

Nonetheless, some overall conclusion may be drawn. The following table presents in the first column the SCM trends, in the second their impacts on the supply chain system and in the third the identification of the requirements for logistical services (the freight transport system is one of the various logistical services).

As already written the various SCM trends have different effects on the transportation system. Those having with a potential positive effect on transport intensity are the Vertical Disintegration of Production (since by adding extra links to the supply chain it might increase the transport intensity of the productive process), Postponement, Concentration of International Trade in Hub ports and Airports, application of Time Compression Principles in Retailing and Manufacturing, and Reverse Logistics. On the contrary, only one those trends has a potential negative effect on transport increase are Spatial Concentration of Production, since one of its impact is the increase of the transportation cost, which may influence company to reduce transport activities (however, as transportation costs, tend to
have a minor relevance, this impact most probably is not relevant). (explicar pq ajuda ou reduz a ntensidade do transporte)

Table 1 - Impacts of SCM trends on transportation sector

<table>
<thead>
<tr>
<th>SCM Trend</th>
<th>Impacts</th>
<th>Logistical Service Needs/Requirements</th>
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| Spatial Concentration of Production | - Plan Specialization  
- Reduction of the total number of Plants  
- Economies of scale in production  
- Increase of market coverage per plant  
- Increased Transportation Cost  
- Transport Intensive Logistical System  
- Relocation of Suppliers | - Large variation in volume, geography and services  
- Flexibility  
- Operational Efficiency  
- Specialized Services |
| Spatial Concentration of Inventory | - Reduction of the number of stockholding points  
- Economies of scale in warehousing  
- Cut of the amount for safety stock  
- Customer demand driven distribution System  
- Development of BB/TS and HSS  
- Increase transportation Cost | - Reduced amount of safety stock  
- Difficulties in coordination of centralized distribution operations with a sales function which remains nationally based  
- Fast and flexible delivery of goods  
- Large variation in geography, volume and services  
- Investment on assets |
| Development of Break Bulk Transshipment Systems | - Geographical separation of warehouses and break-bulk facilities  
- Development of a network of nonstockholding break-bulk facilities  
- Centralization of inventories  
- Economies of scale in vehicle use | - Demand for warehouse property around areas of interest  
- High cost-investment  
- Large variation in geography, volume and services  
- Coordination needs |
| Development of Hub Satellite Systems | - Development of highly mechanized handling systems  
- Economies of scale of handling systems and vehicle use | - Huge flow of single consignment, of information  
- Fast delivery to customers in small shipments  
- Optimization of transport vehicles  
- Optimization of packaging  
- High requirements for investment  
- Increased operational performance  
- Coordination |
<table>
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<tr>
<th>SCM Trend</th>
<th>Impacts</th>
<th>Logistical Service Needs/Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vertical Disintegration of Production</strong></td>
<td>Concentration on core activities, Sub-contracting non-core activities, Development of partnership networks, Development of virtual enterprises, Increase of transport intensity of the production process</td>
<td>Increase of logistic cost as compared to the net value added, Advances of the service control of the total supply chain, High investment on assets, Coordination needs</td>
</tr>
<tr>
<td><strong>Rationalization of the Supply Base</strong></td>
<td>Reduction of the number of suppliers for both logistical services and material goods</td>
<td>Coordination needs, Large variation in geography, volume and services, Increase of operational performance</td>
</tr>
<tr>
<td><strong>Postponement</strong></td>
<td>Movement downstream to the SC activities developed at the end of the production process, Outsource non-core activities, Centralization of inventory, Relocation of certain logistical services near to final customers, Reduced inventory stock, Shortening of lead Time</td>
<td>Transport Intensive Logistical System, Shortening of lead Time, Need for break bulk systems, Distribution centers and manufacturing sub-contractors provided a variety of logistical services, Reduced inventory stock, Coordination of logistical activities, High operational performance</td>
</tr>
<tr>
<td><strong>Direct Deliveries</strong></td>
<td>Direct distribution from manufacturers to end-users, Changes in the pattern of freight movements, Development of hub satellite systems and parcels networks, Personalized distribution of mass customized consumer goods, Logistics practices highly equipped</td>
<td>Intensive management and coordination effort, Specialized services, Investment on non-core activities, High operational performance</td>
</tr>
<tr>
<td><strong>Wider geographical Sourcing of Suppliers and Distribution of Finished Products</strong></td>
<td>Expansion of the geographical scale of sourcing and distribution operations, High value density products</td>
<td>Intensive coordination, Reduction of transportation cost, Transport intensive: large variation in geography, volume and services, Increased performance efficiency, High investment on assets</td>
</tr>
<tr>
<td><strong>Concentration of International Trade in Hub ports and Airports</strong></td>
<td>Economies of scale in terminal and vehicle operations, Development of hub and spoke concept</td>
<td>Facilities for handling and stowing goods, Transportation intensive, High investment on assets, Reduction of transportation/logistical cost, Large variation in geography, volume and services</td>
</tr>
<tr>
<td><strong>Application of Time Compression Principles in Retailing and Manufacturing</strong></td>
<td>Acceleration of logistical operations, Decrease of lead time, Decrease on safety stock, Fast response to variation in demand</td>
<td>Sophisticated logistical services, Coordination needs, Reduction of transportation/logistical cost, High investment requirements</td>
</tr>
</tbody>
</table>
Table 1 (cont.) - Impacts of SCM trends on transportation sector

<table>
<thead>
<tr>
<th>SCM Trend</th>
<th>Impacts</th>
<th>Logistical Service Needs/Requirements</th>
</tr>
</thead>
</table>
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3 UNDERSTANDING TRANSPORT SECTOR

3.1 Modes of Transportation

3.1.1 Technical Characterisation

Vehicles play a vital role, in freight transportation, as they have the mission to transport goods between the different places. On the one hand, they have to supply the necessary power for goods’ motion, as these can not move by themselves. On the other, they must provide all necessary conditions (in terms of space, capacity, and protection) for the safe and secure transport of goods. Furthermore, vehicles are created to both move on (or in) a specific environment (water, railway, road or air) with particular characteristic and properties, and operate within a regulatory framework that imposes restrictions in terms of size, shape, weight, strength, etc. As a result, each mode of transportation presents unique features and characteristics and rather different from the others.

Since, intermodal transportation entails the conveyance of goods between different various modes of transportation, the knowledge and understanding of each mode’s requirements and capabilities is of utmost important in order to ensure a frictionless transfer of goods.

Being so, the purpose of this paper is to provide an overview about the most relevant features of each means of transport. The features analysed individually for each mode of transport are: vehicles’ size and shape and the maximum allowed dimensions, vehicles’ current capacity in terms of weight and volume, vehicles’ speed, flexibility of the mode of transport to adapt to new demand patterns, the degree of risk involved in the transport of goods. Two extra features are also analysed simultaneously for all modes: costs and reliability. The paper is organised as follows, the next six chapters analyse each mode of transportation: road, rail, sea (deep sea and short sea shipping), inland and air. The paper ends with a summary of all conclusions drawn in the previous chapters, and a comparison concerning costs and reliability for the various modes of transport is conducted.

Bearing in mind that, first, intermodal transportation is the transportation segment under analysis and, second, cargo is transported within a loading unit; the analysis of the various modes of transportation is focussed on the transport of loading unit.
Road Transportation

The transportation of large quantities of goods by road is done mainly with either an articulated vehicle or a road train, commonly called as vehicle-combination. Both types have a power-driver vehicle - motor vehicle - which provides the vehicle with the necessary propulsion to travel on road by its own means. In case of a road train, the motor vehicle also has the additional capacity of to transport goods by itself. In an articulated vehicle the motor vehicle is coupled with a semi-trailer, while in a road train, the motor vehicle is coupled to a trailer. Both semi-trailer and trailer are non power-driven vehicles. In the former, weight (goods and vehicle’s weight) is borne by both the motor vehicle and the semi-trailer; while in the latter, all weight is borne by the trailer.

There is a large variety of vehicles operating in market, in function of the type of product they transport. For the transport of general dry cargo, usually intermodal loading units or fixed devices to the vehicle are used, while for bulk cargo (cereals, cements, etc.) or liquid (oils, fuels, etc.), special designed vehicles are used, whose security rules are laid down in national and European legislation in function of the type of product to be transported.

The dimensions of a road vehicle are laid down in the European Directive 96/53/EC, amended by European Directive 2002/7/EC. These directives define the maximum authorised dimensions in national and international traffic and the maximum authorised weights in international traffic for road vehicles. They were introduced in order to bring some harmonisation into the European Union market, which was a jigsaw of legal systems. Each country had designed its own road transportation regulatory system, regardless their neighbours; obviously, the outcome has been a large variety of legal systems. Such variety was introducing relevant frictions into the transportation market, either because road hauliers have had to either, own different types of vehicles to meet the different requirements, or use the vehicle below maximum capacity.

The following table gives the maximum dimensions and weight each member state has to ensure. Nonetheless, member states are free to adopt less restrictive rules for national transportation. The reasoning for the exemption given to the combined transport operations
has been, among other points, to balance the specific tare disadvantage\(^3\) of intermodal transport road vehicles and, in this way, to increase intermodal transportation competitiveness.

<table>
<thead>
<tr>
<th>Property</th>
<th>Vehicle</th>
<th>Maximum value allowed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>Motor vehicle other than a bus</td>
<td>12.00 m</td>
</tr>
<tr>
<td></td>
<td>12.00 m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Trailer</td>
<td>12.00 m</td>
</tr>
<tr>
<td></td>
<td>Articulated Vehicle</td>
<td>16.50 m</td>
</tr>
<tr>
<td></td>
<td>Road Train</td>
<td>18.75 m</td>
</tr>
<tr>
<td></td>
<td>Maximum distance between the axis</td>
<td>12.00 m</td>
</tr>
<tr>
<td></td>
<td>of the fifth-wheel king pin and</td>
<td></td>
</tr>
<tr>
<td></td>
<td>the rear of a semi-trailer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maximum distance between the axis</td>
<td>2.04 m</td>
</tr>
<tr>
<td></td>
<td>of the fifth-wheel king pin and</td>
<td></td>
</tr>
<tr>
<td></td>
<td>any point at the front of the</td>
<td></td>
</tr>
<tr>
<td></td>
<td>semi-trailer</td>
<td></td>
</tr>
<tr>
<td>Width</td>
<td>All vehicles</td>
<td>2.55 m</td>
</tr>
<tr>
<td></td>
<td>Superstructures of conditioned</td>
<td>2.60 m</td>
</tr>
<tr>
<td></td>
<td>vehicles ((^a))</td>
<td></td>
</tr>
<tr>
<td>Height</td>
<td>All vehicles</td>
<td>4.00 m</td>
</tr>
<tr>
<td></td>
<td>Road Train</td>
<td>40 tonnes</td>
</tr>
<tr>
<td></td>
<td>Articulated vehicle</td>
<td>40 tonnes</td>
</tr>
<tr>
<td></td>
<td>Articulated vehicle carrying 40</td>
<td>44 tonnes</td>
</tr>
<tr>
<td></td>
<td>ft ISO container as a combined</td>
<td></td>
</tr>
<tr>
<td></td>
<td>transport operation</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) vehicles to transport goods at controlled temperature


Within the current legal environment, road hauliers have some degree of freedom in choosing the type of loading units for their operations. Variety ranges from loading units separated from the chassis, like for example swap bodies, until loading units totally fixed to the chassis. The final configuration depends upon the scope and type of services. Commonly, road hauliers owning road trains use swap bodies Class C, since they offer multiple advantages compared to the traditional truck (see Loading Units_text.doc). Changing the length of the coupling device in order to not violate the maximum allowed length, multiple combinations of the swap bodies can be used: at maximum they can use two swap bodies Class C782 with a coupling device of 0.75 metres; on the other extreme, they can use two swap bodies Class C715 with a coupling device of 2.10 metres. On the other hand, most of the road hauliers owning articulated vehicles use semi-trailers (fixed loading unit) with the maximum allowed dimensions. Swap bodies Class A are not widely

\(^3\) As the loading unit and the chassis have to be designed as self supporting units a re-enforcement is needed, which creates an additional tare of approximately 2 tonnes. On the other hand, as in most road vehicles configuration a gross mass beyond 40 tonnes needs an additional axle to meet the maximum axle load regime, another 2 tonnes have to be added for the additional wheels and their suspension.
use in pure road transportation because they do not offer significant advantages when compared with semi-trailers. They are relevant only for those road hauliers enrolled in combined transport (road – rail), since these swap bodies because are more advantageous than the semi-trailers.

Concerning security, road transportation is rather prone to pilferage. First, road transportation is done side by side with any other vehicle that can be used to rob. Moreover, most vehicles do not offer major resistance to intrusion, since walls consist of textile easily cut (only the ISO containers are safer because they are made of corrugated steel). Finally, vigilance is usually done by the driver that cannot keep a permanent watch (he has to sleep, for example).

Road transportation is the paradigm of flexibility, this mode is able to reach any place within European Union. As road vehicles moves onto roads, they can link any two points that are connected with the road network; and, nowadays, the European road network is rather dense, connecting all existing factories, warehouses, selling points, ports, airports, rail terminals, etc. Furthermore, there are no major restrictions within the European Union, concerning both technical and regulatory aspects. Therefore, road vehicles have practically no restrictions to their mobility.

Finally, in what concerns speed, road hauliers are bounded by the legal limit of each country that is not yet harmonised legislation within European Union. However, nowadays, the legal limits are becoming increasingly less relevant, because other restrictive factors are growing importance, notably, congestion. The congestion levels within European Union are reaching very high values, influencing road vehicle’s speed. In central Europe, there are frequent reports of delays due to congestion. Moreover, some countries have banned road transportation on some days (weekends, holidays, etc.) or imposed restrictions on the maximum number of trucks, which further reduces the average speed of trucks. Nonetheless, in long distance services (to the European periphery), average speed is approximately 80 km per hour.

Rail Transportation

Currently, there is a jigsaw of railway transportation systems across European Union, even existing member states with different systems within bounds, like France or Italy. These differences cover all issues about railway operations, for example, line gauge, trains’
maximum dimensions, signalling, driver’s licence, break distance, etc, which, obviously, introduce many restrictions in the long distance transport operations. A European wide level harmonisation is almost impossible because it means massive investments (in new lines, renewable of equipments, changes in legislation, etc.), impossible to do at present time. The solution has been passing by developing interoperable rolling stock able to move in the various systems. Yet, even so, this tends to be a rather expansive solution and truly interoperability is almost impossible. Therefore, rail transportation within European is conducted with many restrictions and difficulties.

The transport of goods on rail is done onto platform railcars or into wagons. Once again, different types of vehicles have been built to transport the various kinds of goods: platform railcars are commonly used for the transportation of intermodal loading unit and vehicles (like semi-trailers); while specific wagons are used in the transportation of bulk, liquid or general cargo.

Due to the large variety of systems, the maximum allowed dimensions and weight vary considerably across European Union. In terms of width, there are no major problems concerning the transport of intermodal loading units, since the majority of the European railways support vehicles with a width of 2550 millimetres. Incompatibilities do appear in terms of maximum height, where there is a wide variety across Europe. The following table presents, for the main lines of some European countries, the maximum allowed height for: a complete train vehicle (platform railcar and container), a container (assuming a standard railcar\(^4\) height of 1175 mm) and a semi-trailer (assuming transport on a pocket platform railcar\(^5\) with a height of 330 mm). The analysis of the table reveals that the most relevant problems appear in the UK and in some lines in France and Italy, in which the transport of containers is only possible using low platform railcars. The remaining countries support the current standard boxes. To overcome height problems is necessary to lower the platform railcar, which can be achieved by either, using reduced height bogies with small wheels, or using low platform height between the normal bogies and wheels. The first solution keeps the original railcar’s length but reduces the maximum gross mass allowed because the reduced bogies and wheels are less resistance, for example, a

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reduction of 160 mm in the wheels’ diameter implies a reduction in the maximum gross mass allowed of 6.5 tonnes per axle (UTI-NORM, Final Report (1999) p 114). The second solution keeps the original resistance but implies longer railcars, the size could increase as much as 30 per cent (UTI-NORM, Final Report (1999) p 114). Longer railcars leads to a reduction of the maximum number of containers a train can transport, because train’s maximum length is limited in all countries (see discussion below).

Concerning the transport of semi-trailers, and bearing in mind that in road transportation height is limited to 4 metres, there are in all situations some restrictions, being necessary to use smaller semi-trailers.

Table 3 - Limits for rail transport

<table>
<thead>
<tr>
<th>Country</th>
<th>Maximum height</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Train Vehicle</td>
</tr>
<tr>
<td>Austria</td>
<td>4325 mm</td>
</tr>
<tr>
<td>Belgium</td>
<td></td>
</tr>
<tr>
<td>Denmark</td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td></td>
</tr>
<tr>
<td>Hungary</td>
<td></td>
</tr>
<tr>
<td>Netherlands</td>
<td></td>
</tr>
<tr>
<td>Luxemburg</td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>4075 mm</td>
</tr>
<tr>
<td>Switzerland</td>
<td>4225 mm</td>
</tr>
<tr>
<td>Italy</td>
<td>4125 mm</td>
</tr>
<tr>
<td></td>
<td>4075 mm</td>
</tr>
<tr>
<td></td>
<td>3945 mm</td>
</tr>
<tr>
<td></td>
<td>3845 mm</td>
</tr>
<tr>
<td>France</td>
<td>4075 mm</td>
</tr>
<tr>
<td></td>
<td>3945 mm</td>
</tr>
<tr>
<td>UK</td>
<td>3950 mm</td>
</tr>
</tbody>
</table>


In terms of maximum mass gross, there are also important variations within and between member states. However, the most important freight lines usually support a maximum of 22.5 tonnes per axles (or 8 tonnes per metre), which is more than enough to transport any existent intermodal loading unit or a semi-trailer.

Other relevant issue in rail transportation concerns the train’s maximum length. This parameters again show a wide variety, ranging 500 from 1000 metres within Europe, for example, in the Netherlands is of 650 metres, in France is of 750 metres and in Portugal is
of 500 metres. This parameter limits and defines the maximum number of wagons a train can transport each time, influencing in the competitiveness and profitability of the service. Problems appear in those lines with height restrictions in which is necessary to use low platform railcars with normal bogies, since the railcar’s length is increased, there is a reduction in the maximum number of allowed wagons. Moreover, in international transportation when there are lines with different restrictions important restrictions also appear, because train’s length is limited by the most restrictive line.

With so many restrictions and diversity in European railways, capacity setting is a rather difficult task. Nonetheless, with some assumptions some values can be found. Assuming a train’s length of 700 metres and a platform railcar’s length of 18.5 metres, able to transport 2 swap bodies Class C; each train would move about 74 swap bodies. A similar result was found by the European project CO-ACT that considered in their analyses that a complete freight train offered a capacity of 70 swap bodies Class C (CO-ACT, Deliverable 3 (2002) p 24). Performing a similar calculation for a platform railcar’s length of 16.5 meters, able to transport 1 swap body Class A or a semi-trailer; each train would move about 42 loading units. In terms of weight, considering that a Class C swap body and a Class A swap body have a gross weight of 16 tonnes and of 34 tonnes, respectively. A train is able to transport around 1450 tonnes.

In terms of risk, rail operations provide a good protection against pilferage acts. This transport is done in segregated channels, where no other vehicles (besides the authorised ones) are allowed to circulate, which reduces exposure to third parties. Furthermore, in rail transportation theoretically any service can be accomplished without stops, which further decreases the risk of pilferage. However, in practice there are stops, so this advantage is somehow undermined.

Concerning flexibility, rail transportation is rather inflexible, because trains can only move onto railways, and railways networks are very low dense, simply connecting the most important locations of a country. The construction and maintenance of a rail line is very high, so they are built only when there is an economic or social justification. Therefore,

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6 2 Swap Bodies Class C782 plus a buffer of around 3 metres.
7 74 Class C swap bodies X 16 tonnes per swap body = 1 200 tonnes
42 Class A swap bodies X 34 tonnes per swap body = 1 450 tonnes.
trains only serve those customers with direct access to the network, all the others are served by road transportation. Furthermore, within Europe there is a multiplicity of different systems, which combined with the lack of a truly liberalised market, further hinder companies’ mobility. Currently, international transport within Europe is done with many frictions, either, because railway systems are not compatible obliging a constant change of the rolling stock (or acquisition of very expensive interoperable technology); or because companies can not maximise trains capacity due to restrictions in some rail lines. Being so, the European railways’ flexibility is low.

Finally, in what concerns speed, rail transportation presents very poor results. The European Commission’s White Book\(^8\) indicates an average speed of 18 km per hour on the rail transportation services. However, there is example of much higher values: IKEA has achieved in central Europe an average speed of 60 km per hour. Nonetheless, bad results are record in almost every service. The current situation is the natural outcome of the large variety of systems that introduce important barriers to mobility and imply complex bureaucratic procedures.

**Sea Transportation**

In the context of this study, sea transportation was divided into two different markets: one concerning the transport of goods between European Union and other continents or regions - deep-sea transportation; other concerning, the transportation of intra-European of goods in the form of containers or trailers - Short Sea Shipping (SSS).

**Deep-see transportation**

In theory a ship can have any size or shape, as long as, it fulfils all security parameters. However, since ships are building to transport certain type of goods and to profitability operate on a given market, with ports and, eventually, channels that present some sort of restrictions in terms of width, length or depth; there are limits for the size of ships. Usually, deep sea ships are classified in function of the cargo they transport: bulk, general cargo, liquids or containers. Bulk cargo, like cereals or minerals, is transported in tailored made ships. These ships usually contain a set of cells which are mechanically loaded and unload, for example, through a conveyor

belt, directly from and to reservoirs existing in the ports. The transportation of general cargo is losing relevance, because most of this cargo is nowadays transported in containers. The handling these types of goods is difficult, demanding the intensive use of labour work and equipment, these were the reasons underlying the development of containers. In what concerns the transport of liquid cargo, like for example petroleum or oil, these ships are very similar to those that transport bulk cargo, only cells are replaced by impermeable tanks.

Finally, the transport of containers in deep sea is limited to the ISO containers (20 ft and 40 ft), since they have been developed precisely for this kind of transportation presenting all necessary features to perform well their task. Other, containers, like the swap bodies, are not used. Reflecting the freedom shipbuilders have, ships’ capacity ranges from some hundreds of TEUs\(^9\) until almost ten thousand TEUSs, yet the most common are those with a capacity of 4 to 6 thousand TEUs. Assuming that a 20 ft ISO container (1 TEU) has a gross weight of 24 tonnes and a net weight of 21.7 tonnes, a ship with 10 thousand TEUs of capacity has a gross weight around 240 000 tonnes and a net weight of 217 000 tonnes. Considering the most common ships with capacities ranging from 4 to 6 thousand TEUs, then the gross weights and net weights range from 96 000 to 144 000 tonnes and 86 800 to 130 200 tonnes, respectively.

Due to the dimensions of the ships, they have a very low top speeds (below 50 km per hour). However, since they do not need to stop, average speed tends to approximate of the maximum speed. Only, in case of bad weather conditions or to cross channels, boats are compelled to stop.

The transport of goods by sea (or inland waterways) is done between two ports, as ships need special infrastructures - ports - to load and unload cargo. On the other hand, ports’ density is very low, which means very few customers can be served directly by sea. All the others have to be connected either by road or rail (and eventually road). This denotes the very low flexibility of sea (and inland waterway) transportation.

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\(^9\) TEU - twenty foot equivalent unit. A 20 ft container represents 1 TEU, while a 40 ft container represents 2 TEUSs.
Finally in what concerns security, the transportation of goods by sea is extremely safe. Goods are transported in isolate vessels, in which access is rather different, thus, as pilferage is almost impossible. However, ships are at the mercy of weather conditions (a ship in open sea can not hide and protect himself against a storm), which makes this mode more somewhat prone to damage of goods. Furthermore, since speed is rather low, the risk to this kind of damage increases considerably.

**Short Sea Shipping**

Ships operating on SSS route can be broadly divided into two types: those that load and unload containers on trailers over ramps between quay and ship, called as RO-RO (or Roll On - Roll Off); and those that load and unload containers using cranes, called as LO-LO (Lift On - Lift Off).

Some of the cargo transported by the SSS carriers is cargo that otherwise would be moved by road, therefore, ships have to be prepared to transport the vehicles and load units used in land transportation - swap bodies and semi-trailers. On the other hand, feeding service of deep-sea routes is an important market for SSS operations, as in this market ISO containers are the dominant loading unit, SSS ships have also to be able to transport these containers. Being so, ships have to be as much flexible as possible in order to provide a universal service, and it is this need the basis of the large variety of vessels operating nowadays in the market.

RO-RO vessels are designed to carry cargo, which is loaded and unloaded on wheels. Loading and unloading operations are done through ramps that are located at the ship’s stern and/or bow. Typically, RO-RO vessels have more than one deck, usually three, which implies the existence of ramps inside the ship. Other relevant feature of these ships is their flexibility, they can carry any kind of trailers and semi-trailers; as well as, any selection of loading units, like ISO containers or swap bodies, as long as there is equipment to load and unload container onto the ship. Moreover, whenever deck has the necessary clearance, stack of two loading units is possible.

Furthermore, these ships are mostly larger and longer than SSS container ships, which in combination with more powerful engines leads to a higher speed of the ship. This however is at the expense of the capacity of the ship that is half of a container.
ship of the same size, this means that a RO-RO ship carries half of the number of loading units that a dedicated ship with container sin stacks.

LO-LO vessels, on the other hand, are designed to carry solely containers. Some ships, especially the bigger ones, are equipped with cell guides. Cell guides provide guidance during the loading and unloading operations reducing the operations’ time. However, they reduce ship’s flexibility as containers can only be positioned according to the cells arrangement; furthermore, cell guides are commonly designed to support ISO containers, and 20 and 40 ft pallet wide containers with ISO frameworks, which excludes other containers, like the swap bodies. On those ships without cell guides, containers can be positioned in any position, which provides higher flexibility. Regardless the presence or not of guide cells, these ships are commonly optimised for the transport of ISO containers, so the use of other containers may lead to capacity reduction.

Other feature of LO-LO vessels is the hatch cover, that isolates the containers placed below the main deck from those place on the main deck. The hatch provides an additional safety against bad weather and sea conditions for the containers below the main deck, promoting the goods’ preservation. However, it makes rather difficult the access to the containers below the main deck, which increases the loading and unloading operations time.

There are a large variety in terms of capacity, but usually the typical size ranges from 300 TEUs to 1000 TEUs, which in terms of tonnage\textsuperscript{10} represents an interval ranging from 7 200 to 24 000 tonnes (gross weight) and from 6 510 to 21 700 tonnes (net weight). In case of vessels with hatch, stack under deck is of 3 rows and on the deck can reach 4 rows. In case of hatchless ships, stacks can reach 6 layers.

In what concerns speed, flexibility and security, the conclusions drawn for the deep-sea transportation are the same as for the SSS operations.

\textit{Inland Transportation}

Inland waterway vessels are built in all sizes up to a length of 135 m. The design of these ships is simple and similar to the container ships used in SSS. The most relevant changes

\textsuperscript{10} 1 TEU has a gross weight of 24 tonnes and a net weight of 21.7 tonnes.
are in depth of the vessel and superstructure, which are smaller when compared with SSS ships. In this way, vessel can pass easily under bridges and sail with low water level. By far, the largest part of the inland waterway ships involved in the transport of containers on the Rhine have a beam of 11.40 to 11.45 metres and a length of 110 metres. However, due to the fact that 600 mm is needed on both sides of the vessels as a walkway from bow to stern, the holds of these ships will not be more than 10.20 m wide. Furthermore, these vessels are not equipped with cell guides.

Transport capacity of these vessels is up to 200 TEUs. A small number of ships have been built with larger beams up to 17 metres, which can carry stacks of 6 rows and has a transport capacity of up to 470 TEUs, which in terms of tonnage\textsuperscript{11} represents 11 300 tonnes (gross weight) and 10 200 tonnes (net weight). However, typically, on inland waterway ships units will be stacked to a maximum height of 5 units (4 on 1) on the larger vessels as bridges do not allow for higher stacks.

The speed of the ships is lower than the SSS ships, not only because they have less powerful engines but also, they have to face the river’s flow when moving upstream. For example, the Rhine river only allows a speed of 15 km per hour.

Concerning flexibility, the conclusions drawn for sea transportation are the same as for the inland waterway operations.

Finally in terms of safety, inland transportation is a rather secure mode of transportation even more than sea transportation, because, besides the reasons pointed out for sea transportation, the weather condition on a river are much better than on sea, therefore, the probability of damage is lower on inland transportation.

\textit{Air Transportation}

Aircrafts are the ships used in air transportation of people and goods (freight, mail and passenger’s luggage).

These vessels are used in a great variety of situations and for a large diversity of purposes. Nowadays, the most powerful ones are able to connect airports located as far as 16000 kilometres and carrying as much as 43.3 tonnes (Airbus A340-500). At the other end, there

\textsuperscript{11} 1 TEU has a gross weight of 24 tonnes and a net weight of 21.7 tonnes.
are planes transporting no more than 5 tonnes between places located within a range of 3000 kilometres (for example, the Embraer 145LR). Furthermore, aircrafts’ conception, design and construction is under the unique responsibility of aircraft builders. Of course, they have to follow the strict security rules laid down by IATA, ICAO and countries’ authority boards; but, even so aircraft builders have a great degree of freedom in terms of size and shape. As a result, a large variety of aircrafts are currently in operation, suitable for the most diverse purposes.

In commercial activity, planes are used to transport both passengers and cargo. Some of them transport exclusively cargo and designed as full-freights; while others transport mainly passengers along with some cargo on the plane’s belly - lower deck. There is an intermediate situation in which cargo is also transported in the upper deck along with passengers, these flights are called as combi-flights. Naturally, that the choice by a combi-flight relies entirely on the air company’s decision.

<table>
<thead>
<tr>
<th>Aircraft designation and Company</th>
<th>Freighter or Passenger</th>
<th>Freight Capacity (volume and weight)</th>
<th>Number and Type of ULDs and Pallets</th>
<th>Range [km]</th>
<th>Number of passengers</th>
</tr>
</thead>
<tbody>
<tr>
<td>B747 – 400F Asian Cargo</td>
<td>Freighter</td>
<td>117 tonnes</td>
<td>(30) PMC (11) LD3</td>
<td>13000</td>
<td>-</td>
</tr>
<tr>
<td>B 767 – 300F Asian Cargo</td>
<td>Freighter</td>
<td>54 tonnes</td>
<td>(7) PMC (30) LD2</td>
<td>10000</td>
<td>-</td>
</tr>
<tr>
<td>B747 – 400 Lufthansa</td>
<td>Passenger</td>
<td>14 tonnes</td>
<td>(30) LD3</td>
<td>13000</td>
<td>390</td>
</tr>
<tr>
<td>A340 – 300 Lufthansa</td>
<td>Passenger</td>
<td>20 tonnes</td>
<td>(10) PMW or (32) LD3</td>
<td>13300</td>
<td>275</td>
</tr>
<tr>
<td>A310-300 Lufthansa</td>
<td>Passenger</td>
<td>8 tonnes</td>
<td>(14) LD3</td>
<td>8000</td>
<td>225</td>
</tr>
<tr>
<td>A321 -200 TAP Portugal</td>
<td>Passenger</td>
<td>3.2 tonnes</td>
<td>4 PKC</td>
<td>4300</td>
<td>195</td>
</tr>
<tr>
<td>A319 -100 TAP Portugal</td>
<td>Passenger</td>
<td>1 ton</td>
<td>1 PKC</td>
<td>3300</td>
<td>130</td>
</tr>
</tbody>
</table>


Cargo within aircrafts is transported into ULDs or onto pallets, in some planes with smaller lower decks no loading unit can be used, so cargo is simply stored on the aircraft’s floor. ULDs have been specially designed to fit into the aircraft’s round shape. Some attempts to use other containers, notably 10 and 20 ft ISO containers, have been developed, but all
failed because these containers are two heavy and do not maximise aircraft’s capacity, making them completely unprofitable.

Due to the large variety of aircrafts, is not possible to present the capacity of all of them here. Being so, some planes have been chosen and are presented in the following table. Capacity is defined in terms of payload and volume. Besides the capacity, the table also presents: the number and type of ULDs or pallets, the number of passengers in case of a passenger plane and the aircraft’s range. It should be noted these values are merely indicative. As companies can personalise the aircraft’s interior, final exact available capacity changes from planes to plane.

In terms of speed, aircraft’s average speed is around 800 km per hour. Air transportation is the fastest mode of transportation. Only, high speed trains can compete for distances above 800 kilometres.

Flexibility of air transportation is rather similar to the flexibility of sea transportation. Planes only conduct point to point operations between two airports, where they can load and unload. Once again, very few customers are directly served with air transportation, relying on road or train (followed eventually by road) to access the rest of the market. Therefore, air transportation is very low flexible.

Finally in terms of security, air transportation is the safest mode of transport. Not only due to cargo be transported safely within plane’s fuselage, but mainly because transport times tend to be very short which reduces the goods’ exposure time reducing the probability of damage or pilferage.

Summary
As a consequence of the specific environment in which customers’ demands, freight’s specifications and regulations’ restrictions, the various modes of transport present unique characteristics and profound differences between them.

In terms of capacity, deep-sea ships are by far the ships with higher capacity, and planes, particularly the passengers ones, are those with lesser capacity. Considering the average capacity values of the various modes of transportation\(^\text{12}\), a 5 000 TEU deep-sea ship

\(^{12}\) Capacity of: deep-sea ship= 5 000 TEUs; plane= 20 tonnes; road vehicle= 40 tonnes; rail= 1 500 tonnes; inland ship= 4700 TEUs; and SSS ship= 700 TEUs.
transport as much as 6 000 planes, 3 000 road vehicles, 80 trains, 10 inland ships and 7 SSS ships.

On the other hand, when comparing the speed, planes are by far the fastest mode of transportation presenting an average speed around 800 km per hour. Road vehicle appears in second but far way with an average speed of about 80 km per hour. Furthermore, road vehicle’s speed is increasingly lower due to the increasing congestion problems around Europe. The remaining modes of transportation have rather low average speeds, in case of rail, this happens due to the jigsaw of rail systems that introduce many time losses; while, in case of sea and inland transportation this is the consequence of the technology of these modes, that in order to be economically viable have low speed.

In what concerns the assessment of the risks of damage or destruction involved in each mode, road is the one with higher risk, a consequence of moving in a non-segregate way and the low protection that swap bodies offer to intrusion. The other modes are safer, because they operate on exclusive routes. In special, air and water modes during transportation are completely inaccessible. The major problem of these modes is their sensible to the weather conditions that can provoke delays (and thus damage of goods) and, eventually, total loss.

Finally, concerning flexibility, road transportation is undoubtedly the most flexible mode of transportation. Using the dense European road network, road vehicles can reach virtually any place within European region. Being so, rode is the only mode able to do a truly door to door service; none of the others is able to provide such service. Rail network is far less dense than road network; therefore, rail transportation can reach a small part of the market, depending on road to reach the rest of the market. Finally, both air and water (sea and inland) transport modes are even less flexible, being only to provide a point to point service between special terminals: airports and ports. Since, there are very few of these terminals, they can reach directly a very small part of the mark. Once again, they depend entirely on road (and rail and then on road) to cover the rest of the market.

In the context of this paper, transportation costs refer solely to those costs clients have to pay to transport a unit of freight from one place to another. On the one hand, there are the direct costs, which are directly linked with mode’s capacity (in terms of weight and volume), higher capacity means lower costs per unit of freight (in terms of weight and
volume), due to the economies of scale. On the other hand, there are the indirect costs, namely the friction costs, which are those that arise due to inefficiencies within the transportation system.

Obviously, this is a rather simplified way to analyse costs; nonetheless, it is enough to draw some comparisons between the means of transportation, which is precisely the intention in this paper.

Waterways transportation (sea, SSS and Inland) is by far the most economic modes of transport, not only ships are the vehicles with most capacity, resulting in very low unitary costs; as well as congestion in sea is inexistend and ports strive to eliminate port congestion. In terms of direct costs, the following most economic mode of transportation is rail transportation, as it presents a considerable capacity, however, due to the inefficiency of the European railway systems, there are a lot of friction costs raising operation costs. In this way, albeit road has higher direct costs, since it has low friction costs, road transportation is more economic than rail transportation.

Finally, although having low friction costs, air transportation is the mode of transport with higher direct cost both, due to the aircrafts’ small cargo capacity, and due to the high energy consumption levels.

In terms of reliability, rail transportation is beyond any doubt the less reliable mode of transportation, mainly due to the lack of a harmonised railway system, which requires a constant change of both technologies (rolling stock) and drivers. Furthermore, as railways companies either own the rolling stock or employ the drivers, transportation companies are not able to planning in advance the rail leg services. The lack of reliability is the most severe problem on railway transportation. Inland transportation is also a non reliable mode of transportation, but, in this case, due to the environment on which she moves. Most rivers have a profound seasonality; during summer, due to drying, water depth may be not enough for the ships’ safe passenger, while during winter, due to floods and security reasons, transit on river can be forbidden.

Concerning the remaining modes of transport (road, sea and air), all of them show highly reliable services. This is particularly notable, taking into consideration that both sea and air transportation are highly sensible to the weather conditions. Road transportation’s reliability, on the other hand, is being jeopardised by the growing congestion problems and
legal restrictions that restrain and reduce road vehicles’ mobility; yet, even so, road is highly reliable.

3.1.2 Unit Loads

Transfer points are truly black spots of intermodal transportation. On the one hand, transfer of goods means waste of time spent, as goods are not moving along the chain towards the final destination. On the other hand, transfer facilities are prone to the damage and destruction of goods because handling and storage operations increase the probability of accident, robber and exposure to bad weather or harmful agents. Being so, the success of an intermodal transport chain relies at great extend on a frictionless transfer of the goods between the various modes of transport.

A seamless transfer entails that all technical features of vehicles, cargo compartments, handling devices and ancillary equipment fit into each other. In other words, frictionless transfer operations require the harmonisation of all equipment and techniques. This harmonisation should be extended to the entire market, in order to permit that all actors could take advantage of all existing benefits of such system.

Universal harmonisation is achieved through standardisation. Standardisation can be defined as an open process that allows all interested parties to join into the deliberations. In this way, results have global legitimacy and all parties have an opportunity to defend their interests.

From the various parts likely to be standardised, the movable parts – containers - are especially sensible, as they have to go through the entire chain. Commonly, equipment is designed after to fit into the containers’ specifications. Therefore, it is important to understand what the most relevant standardised containers are in operations within European market.

The purpose of this chapter is to describe the most relevant standard containers in use in European Union transportation market. After the presentation of the most relevant international standardisation bodies with relevance for the European Union market, a brief assessment about ISO pallets is made. Then different types of containers are presented: ISO containers, Swap Bodies, and Unit Loading Devices and Pallets. The chapter ends with a discussion about the European Union market of containers.
Standardisation bodies

The International Standardisation Organisation (ISO) and the European Committee for Standardization (CEN) are the two bodies with most influence on containers harmonisation in European Union. An exception exists with the air transport containers – Unit Loading Devices (ULD) – that due to their specificity and exclusive use in air transportation, the main standardisation work is done under the auspices of IATA (nonetheless, ISO organisation also has a standard: ISO 4128 Aircraft – air mode modular containers but with low penetration in the market).

<table>
<thead>
<tr>
<th>ISO standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO 668:1995</td>
<td>Series 1 freight containers - Classification, dimensions and ratings</td>
</tr>
<tr>
<td>ISO 830:1999</td>
<td>Freight containers - Vocabulary</td>
</tr>
<tr>
<td>ISO 1161:1984</td>
<td>Series 1 freight containers - Corner fittings - Specification</td>
</tr>
<tr>
<td>ISO 1496-1:1990</td>
<td>Series 1 freight containers - Specification and testing - Part 1: General cargo containers for general purposes</td>
</tr>
<tr>
<td>ISO 1496-3:1995</td>
<td>Series 1 freight containers - Specification and testing - Part 3: Tank containers for liquids, gases and pressurized dry bulk</td>
</tr>
<tr>
<td>ISO 1496-4:1991</td>
<td>Series 1 freight containers - Specification and testing - Part 4: Non-pressurized containers for dry bulk</td>
</tr>
<tr>
<td>ISO 2308:1972</td>
<td>Hooks for lifting of freight containers up to 30 tonnes capacity - Basic requirements</td>
</tr>
<tr>
<td>ISO 3874:1997</td>
<td>Series 1 freight containers - Handling and securing</td>
</tr>
<tr>
<td>ISO 6346:1995</td>
<td>Freight containers - Coding, identification and marking</td>
</tr>
<tr>
<td>ISO 9669:1990</td>
<td>Series 1 freight containers - Interface connections for tank containers</td>
</tr>
<tr>
<td>ISO 9711-1:1990</td>
<td>Freight containers - Information related to containers on board vessels - Part 1: Bay plan system</td>
</tr>
<tr>
<td>ISO 9711-2:1990</td>
<td>Freight containers - Information related to containers on board vessels - Part 2: Telex data transmission</td>
</tr>
<tr>
<td>ISO 9897:1997</td>
<td>Freight containers - Container equipment data exchange (CEDEX) - General communication codes</td>
</tr>
<tr>
<td>ISO 10368:1992</td>
<td>Freight thermal containers - Remote condition monitoring</td>
</tr>
<tr>
<td>ISO 10374:1991</td>
<td>Freight containers - Automatic identification</td>
</tr>
<tr>
<td>ISO 14829:2002</td>
<td>Freight containers - Straddle carriers for freight container handling - Calculation of stability</td>
</tr>
<tr>
<td>ISO/TR 15069:1997</td>
<td>Series 1 freight containers - Handling and securing - Rationale for ISO 3874 Annex A</td>
</tr>
<tr>
<td>ISO/TR 15070:1996</td>
<td>Series 1 freight containers - Rationale for structural test criteria</td>
</tr>
<tr>
<td>ISO/PAS 17712:2003</td>
<td>Freight containers - Mechanical seals</td>
</tr>
</tbody>
</table>

Source: ISO organisation website (http://www.iso.org accessed on 5 August 2005)

The ISO is an association with worldwide coverage. Its standards are voluntary in national application, which means the national associations enrolled in the ISO activities are free to adopt an ISO standard as it is or to standardise in a national standard different from an
agreed ISO standard. As a result, there are many products around a given standard, denoting that actors have adapted the ISO standard to their own needs.

The standardisation of freight containers is under the responsibility of the ISO technical committee: TC104 – “Freight Containers”, which has issued multiple standards. Those that form the basic standard of the containers transportation system are presented in Table 5.

<table>
<thead>
<tr>
<th>CEN Standard</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN 283:1991</td>
<td>Swap bodies - Testing</td>
</tr>
<tr>
<td>EN 284:1992</td>
<td>Swap bodies - Swap bodies of class C - Dimensions and general requirements</td>
</tr>
<tr>
<td>EN 452:1995</td>
<td>Swap bodies - Swap bodies of Class A - Dimensions and general requirements</td>
</tr>
<tr>
<td>EN 1432:1997</td>
<td>Swap bodies - Swap tanks - Dimensions, requirements, test methods, operation conditions</td>
</tr>
<tr>
<td>EN 12406:1999</td>
<td>Swap bodies - Thermal swap bodies of Class C - Dimensions and general requirements</td>
</tr>
<tr>
<td>EN 12410:1999</td>
<td>Swap bodies - Thermal swap bodies of Class A - Dimensions and general requirements</td>
</tr>
<tr>
<td>EN 12640:2000</td>
<td>Securing of cargo on road vehicles - Lashing points on commercial vehicles for goods transportation - Minimum requirements and testing</td>
</tr>
<tr>
<td>EN 12641-1:2005</td>
<td>Swap bodies and commercial vehicles - Tarpaulins - Part 1: Minimum requirements</td>
</tr>
<tr>
<td>EN 12642:2001</td>
<td>Securing of cargo on road vehicles - Body structure of commercial vehicles - Minimum requirements</td>
</tr>
<tr>
<td>EN 13044:2000</td>
<td>Swap bodies - Coding, identification and marking</td>
</tr>
<tr>
<td>CEN/TS 13853:2003</td>
<td>Swap bodies for combined transport - Stackable swap bodies type C 745-S16 - Dimensions, design requirements and testing</td>
</tr>
<tr>
<td>CEN/TS 14993:2005</td>
<td>Swap bodies for combined transport - Stackable swap bodies type A 1371 - Dimensions, design requirements and testing</td>
</tr>
</tbody>
</table>

Source: CEN organisation website (http://www.cenorm.be accessed on 5 August 2005)

The CEN in an organisation with European coverage: European Union plus Iceland, Liechtenstein, Norway and Switzerland, and is formed by the national members standardisation associations. CEN standards, in opposition to the voluntary nature of ISO standards, are compulsory. Once agreed by a majority of European standardisation associations, member states have to implement in their national standards collection the CEN standards and, if necessary, withdraw all national deviating standards. Furthermore, if CEN decides to start standardisation work on a given issue, all European national standardisation organisations have to interrupt their national standardisation work in that field and cooperate on European level.

The CEN technical committee in charge with the standardisation of freight containers is the CEN TC 119 – “Swap bodies for combined goods transport”, as the name shows to
CEN the standard freight containers are called as swap bodies. Like the ISO organisation, the CEN has been rather active in the standardisation process, Table 6 presents the work done by the CEN committee in this field.

ISO pallets
The pallets were introduced in European distribution market during the 1950s and soon became the universal means of movement of packages. Nowadays, many containers, especially those in intra-European movement, are transporting goods loaded onto pallets. Being so, the basic unit load to be considered in containers design and optimisation is no more the goods itself, but, instead the pallets on which they are stored. In this way, knowledge and understanding of the main pallets in use within European Union is vital for a complete and correct analysis of the European containers’ system.

Pallets’ unit cost is rather low, which along with a long life cycle and very low maintenance, make them rather attractive in terms of costs. Furthermore, pallets offer high economic benefits, since, first, they present a very low weight, although having a high capacity (pallets could transport from 300 to 1000 kilograms); and, second, in empty movement they fill less than ten percent of space they fill in laden movement. A final advantage concerns their versatility. Pallets are suitable to both human and automatic handling through pallet-trucks or forklift-trucks and suitable to be used in automatic guided and controlled belt or automatic vehicles system without the need of human guidance or surveillance. For all these reasons, pallets’ success has been tremendous in the distribution market, and, nowadays, they are used in almost all day-to-day operations, for example, within the production and warehousing flows, ramp activities, consolidation activities, intermodal transfer, etc.

The ISO organisation has intervened and brought forward the ISO 6780:2003 “Flat pallets for intercontinental materials handling - Principal dimensions and tolerances”, aiming to
harmonise the pallets’ market. ISO has defined various standard dimensions of which those with European relevance are the pallet with 800 by 1200 millimetres, commonly called as Europallet and the pallet with 1000 millimetres by 1200 millimetres, commonly called as Industry or UK pallet.

Since, pallets are transported nowadays within containers, those with bigger capacity are more advantageous. The following table compares the capacity of different containers. All of these containers are explained in detailed later in this text. The ISO CC and AA are ISO containers, the C745 and A13600 are swap bodies, and the EILU is a European Commission’s proposal for a future European loading unit.

<table>
<thead>
<tr>
<th>Container</th>
<th>Europallet (800 x 1200 mm)</th>
<th>UK pallet (1000 x 1200 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO CC</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>ISO AA</td>
<td>24</td>
<td>21</td>
</tr>
<tr>
<td>C 745</td>
<td>18</td>
<td>14</td>
</tr>
<tr>
<td>A 1360</td>
<td>32</td>
<td>26</td>
</tr>
<tr>
<td>EILU</td>
<td>33</td>
<td>26</td>
</tr>
</tbody>
</table>

The table reveals that swap bodies have a higher capacity than the ISO containers. As explained below, this happens because swap bodies were designed to fit into the European logistics, while ISO containers were born in the sea transportation where pallets had no relevance.

**ISO containers**

The ISO containers were first developed on the maritime transport operations and designed to fulfil the needs and specificities of such kind of transport. In the maritime services, containers have to support important dynamic and statics forces, resist to bad weather conditions (to be impermeable), be stackable (since vessels have a short available space but are able to carry much weight), and be easily manoeuvrable, in special, be suitable for lifting operations (since containers are usually loaded and unloaded using cranes). As a result of these needs, very robust, resistant to high stresses and stackable containers have been developed and standardised by ISO organisation.

Other relevant feature of ISO containers, which is a consequence of being stackable, is that all kind of forces are solely transmitted through their four corner posts. This is achieved through corner fittings that, on the bottom, protrude over the surface some millimetres, and, on the top, have a concavity of some millimetres. Therefore, when the container is lowered to the ground it rest mainly on the corner fittings; and, when in stacks, the four
lower corner fittings of the upper layer container sit exactly on the four top corner fittings of the lower layer container. This special design avoids the containers’ bottom to have intense contacts with the ground, reducing the damage effects. On the other hand, when in stacks the upper container only touches the lower container in four points preventing damage due to friction or concentrated stresses.

The access to ISO container’s interior is usually conditioned, since openings are important sources of strength reduction, for example, those designed for the general cargo only have a door on one of the container’s tops.

There are a large variety of ISO containers covering the different kinds of freight suitable for transport in loading units. They are able to store general cargo, bulk cargo (bulk containers), liquid cargo (tank containers), and, if necessary, at controlled temperature (reefer container).

The various ISO containers are laid down on standard ISO 668, the classification is done mainly according to their nominal length and height. The following table presents the various ISO containers, dimensions and the current maximum gross weight.

<table>
<thead>
<tr>
<th>Class</th>
<th>Length [mm]</th>
<th>Height [mm]</th>
<th>Width [mm]</th>
<th>Gross weight / Tare / Net [tonnes]</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>6058/5900</td>
<td>2438/2353</td>
<td>2438/2353</td>
<td>24.0/-/-</td>
</tr>
<tr>
<td>CC</td>
<td>6058/5900</td>
<td>2591/2390</td>
<td>2438/2353</td>
<td>24.0/2.3/21.7</td>
</tr>
<tr>
<td>A</td>
<td>12192/11963</td>
<td>2438/2356</td>
<td>2438/2356</td>
<td>30.5/-/-</td>
</tr>
<tr>
<td>AA</td>
<td>12192/11963</td>
<td>2591/2362</td>
<td>2438/2356</td>
<td>30.5/3.5/27.0</td>
</tr>
<tr>
<td>AAA</td>
<td>12192/12060</td>
<td>2892/2690</td>
<td>2438/2343</td>
<td>30.48/3/27.48</td>
</tr>
</tbody>
</table>
With time, a large variety of containers have been built around these measures, a consequence of the non compulsory nature of the ISO standards. Companies having specific needs might have felt the need to build containers with non standard dimensions.

**Swap Bodies**

Swap bodies are the standard loading unit of European Union transportation market. They were firstly designed and developed to fulfil road transport operations’ needs. The road transportation operations are far less demanding in terms of strength and resistance than the maritime transportation services. First, the forces and stresses during a journey are rather modest not being necessary highly resistant boxes; second only a stack of containers is transported each time; and third the goods can be either, loaded and unloaded directly from the container not being necessary to unload the container from the vehicle, or the container can be unloaded from the vehicle but is not required vertical movements as long as other techniques are available.

Consequently, the swap body has evolved rather differently from the ISO container. Swap bodies have, in general, light structure, movable curtains of heavy textile and four legs. The light structure maximises the available net weight, while the movable doors allow lateral access reducing the loading and unloading operations time (since goods can be more easily reached using pallet-trucks or forklift-trucks). However, due to these features, swap bodies are not stackable nor can be lifted by the top corners like the ISO containers. The legs are used to load and unload the container from the vehicle without further devices (basically, the legs are unfolded until they touch the ground, the road chassis is then lowered some centimetres releasing the container from the truck, the truck is then free and be pulled from under the container, leaving him standing in its legs).
Swap bodies are mainly used to transport general cargo, for the other types of cargo (bulk, liquid, etc.), specific containers have been designed.

The following table presents the standard dimensions of the various swap bodies. The most relevant classes of swap bodies are class A and class C, both with a width of 2550 millimetres.

<table>
<thead>
<tr>
<th>Classification Code</th>
<th>Length [mm]</th>
<th>Width [mm]</th>
<th>Height [mm]</th>
<th>Gross weight [tonnes]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ext. /Int.</td>
<td>Ext. /Int.</td>
<td>Ext. /Int.</td>
<td></td>
</tr>
<tr>
<td>C625</td>
<td>6250/6150</td>
<td>2500/&gt;2440</td>
<td>2670/2270</td>
<td>10</td>
</tr>
<tr>
<td>C715</td>
<td>7150/7050</td>
<td>2500/&gt;2440</td>
<td>2670/2270-2460</td>
<td>16</td>
</tr>
<tr>
<td>C745</td>
<td>7450/7350</td>
<td>2500/&gt;2440</td>
<td>2670/2270</td>
<td>16</td>
</tr>
<tr>
<td>C763</td>
<td>7635</td>
<td>2600</td>
<td>2670</td>
<td>16</td>
</tr>
<tr>
<td>C782</td>
<td>7820/7720</td>
<td>2500/&gt;2440</td>
<td>2670/2270</td>
<td>16</td>
</tr>
<tr>
<td>A1219</td>
<td>12190/12090</td>
<td>2500/&gt;2440</td>
<td>2670/2270</td>
<td>34</td>
</tr>
<tr>
<td>A1250</td>
<td>12500/12400</td>
<td>2500/&gt;2440</td>
<td>2670/2270</td>
<td>34</td>
</tr>
<tr>
<td>A1320</td>
<td>13200</td>
<td>&lt;2600</td>
<td>2670</td>
<td>34</td>
</tr>
<tr>
<td>A1360</td>
<td>13600/13500</td>
<td>2500/&gt;2440</td>
<td>2670/2270</td>
<td>34</td>
</tr>
<tr>
<td>A1404</td>
<td>14040</td>
<td>&lt;2600</td>
<td>2670</td>
<td>34</td>
</tr>
</tbody>
</table>

The Class C is specific for road trains\(^{13}\), since the maximum length of road trains allowed in European Union roads is of 18.75 meters which allows coupling of two Class C swap bodies: one on the truck and the other on the trailer. On the other hand, the Class A is intended for articulated vehicles\(^{14}\), since the European Union rules allow a maximum

\(^{13}\) Motor vehicle coupled to a trailer.
\(^{14}\) Motor vehicle coupled to a semi trailer.
length for articulated vehicles of 16.50 meters, which corresponds to a one class A swap body.

From the two classes the most successful one has been Class C. The majority of the road hauliers having trucks with the size of Class C use Swap bodies in their operations, because these swap bodies, besides offering the same conditions as an ordinary truck, are easily exchangeable and serve as self-warehouses. This properties offer important advantages, for example, in case of dead times or in longer loading and unloading operations, the road operator can leave the swap body at the ramp of the shipper freeing the driver and vehicle for another activities, or in case of downtown areas with no access to large road vehicles, the driver can uncouple the trailer with the second swap body at a freight station in the outside are of the town and deliver, this time as a single truck, the first swap body at its destination; afterwards he returns, picks up the second swap body, and drives again downtown for the second delivery. Class A swap bodies have not been so successful because it offers practically the same as the combination of a truck with a semi trailer. The major advantage of a swap body lays down in its easy separation from the truck (and driver), however, a truck with a semi trailer offers the same advantage (since, the semi trailer can be easily detached from the truck). Furthermore, the class A swap body can not be that easily exchange as class C swap body because the long and heavy unit cannot be set on standing legs for interchange. So, road haulier using articulated vehicles tend to use semi trailers instead of class A swap bodies.

Unit Loading Devices and Pallets
Air cargo transportation has particular features that hinder the widespread use of containers, and thus the intermodal transportation. First, planes have a round shape and the use of cubic containers lead to a suboptimal usage of the plane’s capacity (both in terms of space and volume). On the other hand, the use of round shapes containers on other modes is difficult since it implies the use of special technology to fix the container to the vehicle. Second, weight is a major concern and the ISO containers have a too heavy design for air cargo economics. In an air transportation service the stresses are much lower when compared with maritime transportation, thus the strength required for the ISO containers are not needed in air transportation operations. Third, aircrafts are loaded and discharged horizontally (since they can not be opened from the roof) by roller beds. However, ISO
containers have protruding corner fitting arrangements and can not be place and moved on roller beds.

Therefore, ISO containers (or other cubic container) are not suitable for air cargo transportation. In order to overcome the problem, the ISO organisation brought forward a new type of container under the standard ISO 8323 “Freight containers - Air/surface (intermodal) general purpose containers - specification and tests”. The container was design with an even bottom and lighter than the current ISO container (but, far less resistant). However, market has never accepted this container, and this technical line was closed and the standard not renewed.

As ISO containers and other box shaped containers failed the attempt of to be the air loading unit, air cargo operators, under the auspices of IATA, have decided to create a special container that would fulfil all requirements of air cargo operations. As a result, a new container has been developed and build called Unit Loading Device (ULD). These containers have a flat bottom and a round shape following the plane’s silhouette. Moreover, they met all security rules involved in air transportation operations. The flat bottom is a pre-requisite to containers be moved horizontally on the conveyor belts during the loading and unloading operations. Presenting a round shape, ULDs can maximise the plane’s space and capacity. Finally, meeting the air security rules, ULDs resulted in a lighter structure, releasing weight to cargo.

Besides ULDs, air companies have also built pallets that basically are the bottom of the ULDs. Cargo is simply loaded onto the pallet and then is secured by a net or igloo. Pallets have a lot of advantageous, as already explained in the Section concerning ISO Pallets.

Currently, in market there is an immense variety of ULDs each one presenting particular features to fit in a given plane or to particular goods. The following table presents some ULDs and pallets along with the plane they fit into and the basic dimensions.

<table>
<thead>
<tr>
<th>ULD or Pallet name</th>
<th>Compatible Aircraft</th>
<th>LD2</th>
<th>Compatible Aircraft</th>
<th>LD3</th>
</tr>
</thead>
<tbody>
<tr>
<td>LD2</td>
<td>B 767</td>
<td></td>
<td>B 747, B 767, B 777, B 757, A 300, A 310, A 330,</td>
<td></td>
</tr>
<tr>
<td>Basic Dimensions L - W- H [cm]</td>
<td>145 x 151 x 157</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gross Weight [kg]</td>
<td>1225</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Weight [kg]</td>
<td>1155</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tare Weight [kg]</td>
<td>70</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volume [m³]</td>
<td>3.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ULD or Pallet name</td>
<td>PMC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compatible Aircraft</td>
<td>Boeing, B747, B767, B777, MD11, Airbus, A300, A310, A330, A340</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic Dimensions L - W- H [cm]</td>
<td>192 x 155</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gross Weight [kg]</td>
<td>1588</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Weight [kg]</td>
<td>1516</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tare Weight [kg]</td>
<td>72</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volume [m³]</td>
<td>4.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ULD or Pallet name</td>
<td>PMW</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compatible Aircraft</td>
<td>Boeing, B747, B767, B777, MD11, Airbus, A300, A310, A330, A340</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Basic Dimensions L - W- H [cm] 307 x 232 x 157
Gross Weight [kg] 4626 - 5103
Net Weight [kg] 4496 - 4973
Tare Weight [kg] 130
Volume [m³] 12.7
ULD or Pallet name PKC
Compatible Aircraft B 747, MD11, A 300, A310, A 320, A321, A 330, A340

Basic Dimensions L - W- H [cm] 244 x 153 x 114
Gross Weight [kg] 1588
Net Weight [kg] 1518
Tare Weight [kg] 70
Volume [m³] 12.7

Source: Lufthansa Cargo (www.lhcargo.com 11-08-2005); BA Cargo (www.bacargo.com 11-08-2005)
European Market

The ISO containers have had a major success in the sea transportation simply because they were firstly designed to be used in that environment. Therefore, they fulfil all the necessary requirements to best perform their tasks in sea transportation. On the other hand, in land transportation, the ISO containers have not been successful. Only in rail transportation and only as a continental leg of sea operations, ISO containers have achieved some success, both, because there is some affinity between sea and rail operations (operators consider somehow natural transfer containers from sea to rail and, only afterwards to road), and the ISO containers’ excessive weight is not relevant.

Being so, ISO containers have failed to enter in the intra-European market because they do not fit into the needs of European logistics because. In first place, the ISO containers are not optimised to be used in road and rail operation. There are other more advantageous solutions, for example, swap bodies, trailers, or semi-trailers. Moreover, the standard pallets accommodation patterns of ISO containers are worst compared to those of similar size class road and rail vehicles (See ISO pallets table above).

Furthermore, some of the ISO containers’ properties (high resistance, to be stackable and impermeable, etc), necessary in sea transportation, represent an extra burden in road and rail transportation. For example, ISO container is heavier than other containers, which reduces available net weight; or ISO container only has a single door which reduces accessibility to the goods, while the swap bodies, for instance, allow lateral access. All these factors have contributed for the failure of the ISO containers to enter in the intra-European Market.

Identically, swap bodies were not able to enter into the sea transportation segment due to their characteristics. The swap bodies’ major problems are not being stackable and not be possible to lift them. Since, in road and rail transportation is not possible to transport containers in stacks, the swap bodies were developed without that functionality (it was this that, for example, allowed the introduction of movable curtains for lateral access). Being not possible to stack swap bodies, there was no need to introduce the ability of lifting (in special when that introduces important restriction in terms of resistance and strength). Other important problem is the low resistance to the weather conditions, swap bodies are not impermeable, which in deep sea transportation could mean goods’ damage and loss.
The ULDs have been developing especially to the air transportation and no other mean of transportation showed interest in adopt them.

As a result, nowadays, the European Union containerised transportation market is rather fragmented: intra-European movements are carried on trucks or in swap bodies, while the overseas import and export flows are moved in ISO containers. And the air cargo segment uses mainly ULDs.

This situation implies goods to be constantly transferred between containers (ISO, swap bodies, ULD, etc.), which creates important friction cost and reduces the efficiency of the overall European transportation market. With the purpose of clarifying which container is mostly used in each mode of transportation, the following was built.

<table>
<thead>
<tr>
<th>Most Common Loading Unit</th>
<th>Road</th>
<th>Rail</th>
<th>Sea</th>
<th>Inland</th>
<th>Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swap Bodies</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Semi-trailer</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>ISO containers</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>ULD</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>EILU</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Swap bodies are mainly used in intra-European transportation, which is conducted by road and rail. ISO containers are mainly connected with those modes that move on water: sea and inland transportation; having also some relevance in rail transportation. Semi-trailers, despite not being a traditional container, as it has wheels, it is widely used instead of swap bodies Class A. Thus, it is used by the same modes than the swap bodies and also in Short Sea Shipping transportation, in RO-RO operations. The ULD are solely used in air transportation. Finally, EILU stands for European Intermodal Loading Unit and is a new container that the European Commission expects to introduce in a near future. This loading unit has been though to fit in all modes accept air transportation.

Aware of the current situation of the European transportation market, the European Commission proposed, in 1999, the development of a new container expecting to end with such fragmentation. This proposal was one of fourteen proposals to promote the Short Sea Shipping\textsuperscript{15}. More recently, in 2003 and later in 2004, the European Commission submitted

\textsuperscript{15} COM(1999) 317 final
a proposal for a new European Directive on Intermodal Loading Units\textsuperscript{16} defining a new container: the European Intermodal Loading Unit (EILU). The rationale behind this proposal is that the current European Union freight transportation market is divided into closed but parallel segment, which reduces European competitiveness and goes directly against the idea of promotion of intermodal transportation, and in particularly the promotion of the Short Sea Shipping, as laid down in the European Commission’s White Paper on European Transport Policy for the year 2010\textsuperscript{17}. So, in order to promote intermodal transportation, a new truly interoperable container is necessary, this container should be suitable and economically viable to be transported by all means of transportation: road, rail, sea (in special Short Sea Shipping) and inland (air has been excluded).

The European Commission’s proposal does not define the container’s final dimensions, instead describes the main characteristics (capacity, resistance, purposes, etc.) the future container should fulfil. Above all, the EILU is solely to transport dry cargo, and must comply with the provisions of the European Directive 96/53/EC that stipulates the maximum authorized dimensions and weights for road vehicles circulating within the Community in national and international traffic.

The proposal includes two types of containers: a long one that should carry 11 units of 1200 millimetres plus space for manoeuvre (length around 13200 millimetres), and a short one that should carry 6 units of 1200 millimetres plus space for manoeuvre (length around 6600 millimetres). In what concerns width, the EILU should transport 2 Europallets or 2 UK pallets placed lengthways (i.e. 2 x 1200 mm) or 3 Europallets to be placed widthways (i.e. 3 x 800 mm) side by side, allowing sufficient margins for manoeuvre. In terms of external width, the container should allow a safe stowage inside and on deck of existing cellular container ships in accordance with applicable ISO standards. Finally, the proposal fixes the external height in 2900 millimetres.

In what concerns the resistance parameters, the proposal refers to the ISO 1496 series of standards as the reference document. Nonetheless, the long EILU should be stackable up to four units in sea conditions and the short EILU should match the ISO 20ft containers

\textsuperscript{17} COM(2001) 370 final
resistance. Furthermore, the EILU should have sufficient racking strength for carriage in the above height of stacks by inland waterway and short sea shipping and have top lifting capacities. Currently, the proposal is under analysis by the various European Union institutions.

3.2 Transport Agents

This chapter intends to provide a general overview of the various agents that usually participate on an intermodal transport service. The identification of the various groups is based on the role (or roles) each agent plays within the transport chain. Five main roles have been identified (Figure 11). The following picture depicts a simple intermodal transport chain, presenting the various roles and respective agents. The third leg crosses an external border where customs’ clearance is needed.

A transport service occurs from the need of conveying products between two agents - Shipper and Receiver - that are located apart. Through some sort of contract or commercial agreement the latter acquires products to the former, as they are located in different places transport is required. In the agreement is also established which of them - Shipper or Receiver - is responsible for arranging the transport of the goods. Regardless the case, the transport services are being increasingly outsourced to third specialised agents.

These specialised agents are the Freight Integrators. A Freight Integrator works in the best interest of a client - Shipper or Receiver - aiming to supply the intermodal transport solution that best fits the demands.

From the client’s point of view the only agent engaged in the transport operations is the Freight Integrator. As a consequence, she bears the full responsibility for transport service. This means that if goods suffer any kind of damage or loss, or if the transport service does not fulfil all the initially established conditions (like for example: in case of a delay in the delivery, or the delivery of the wrong goods or of an inadequate quantity), then the Freight Integrator is the only responsible.

A Freight Integrator’s mission can be divided in two main moments, one concerning the assembling of the intermodal transport service; and a second one concerning the management of the respective transport chain.
The assemblage of the transport service corresponds to the design of the transport chain, where the modes of transport and their positioning along the chain are defined; and to the choice of the transport companies for each positioning. The adequate accomplishment of this phase entails a deep knowledge about: firstly, the transport market, in order to know what is and what makes a transport service competitive; secondly, the operational characteristics of the various modes of transport, in order to chose those modes that best fit and yield higher performances; and thirdly, the transport companies, in order to chose the best qualified (most reliable and with high quality standards).

During the transport service, the Freight Integrator ensures that goods are being adequately conveyed within the conditions previously agreed (with the Client) and without suffering any damage or loss.

The Freight Integrator manages and coordinates the transport chain, taking the necessary steps to enforce agents performing their roles and duties in the best possible way, so that, goods could be adequately conveyed following the conditions previously agreed (with the Client) and without suffering any damage or loss. Moreover, the Freight Integrator intervenes to correct any deviation from what was initially planned (for example: if transport time increase, for any reason, the Freight Integrator may request terminal to reduce storage time or speed up their activities), or to solve any unforeseen event (like for example: accident, congestions, etc.).

In order to achieve her goals, a Freight Integrator to position herself above the transport chain (and consequently above the agents) so that she could get an holistic vision of the transport service.

In function of her roles, a Freight Integrator does not necessarily need to be engaged on field transport operations nor own any kind of assets (vehicles, buildings, etc).

The Freight Integrator is the cornerstone of any intermodal transport service, promoting the cohesion of chain and ensuring that all agents work in the direction.
The agents whom actually convey the goods are the Transport Companies. These agents are hired by the Freight Integrator, to transport goods between places: between the Shipper and a Terminal, between Terminals or between a Terminal and the Receiver. During the transport period, the Transport Companies is full liable for the goods. A Transport Company may operate more than one mode of transport: road, rail, air and shipping.

A Terminal is the agent that runs a transhipment terminal enabling goods’ modal transfer, where goods are unloaded from vehicles and, afterwards, loaded into (or onto) another ones. During the time goods are within the transhipment terminal, the Terminal is full liable for them. Increasingly, Terminals are supplying extra services, so that, during the period of time goods are within terminal valued could be added to the products and, in this
way, terminals do not being regarded as a simple cost (due to depreciation or damage). These services include, amongst others: deconsolidation and consolidation, stock management, labelling or repackaging. So, the time that goods spent within terminals are increasingly seen as another step in the production chain and not as a merely cost.

Finally, whenever goods are meant to be transported to or from a non European Union country, customs’ clearance is required. The agent that deals with the Customs Authorities conducting all necessary procedures to get clearance is the Freight Forwarder. This agent works on behalf of the Freight Integrator; acting as an intermediary between this agent and the Customs Authorities.

In most real case situations, the clear division or identification of these agents is not straightforward because more and more agents are playing more than one role within an intermodal transport chain. This is the outcome of market liberalisation, where companies to survive have to stay ahead of competition. A source of competitive advantage is through the supplying of customised bundle of services, in function of the customer’s needs. Therefore, companies have been adding new capabilities and services to their portfolios and nowadays many companies are in position of supplying a wide variety of services. For example: there are companies able to supply simultaneously the roles of Transport Companies and Terminal; while others have embraced all roles (Freight Integrator, Transport Company, Terminal and Freight Forwarder) offering an all-in-one service (are example of these companies the so-called Courriers: DHL, FEDEX, etc.).

Although, the division between these agents is not so clear nowadays, it is nevertheless a useful framework for all subsequent analysis carried out in this Thesis. Moreover, the attempt of describing all possible agents would be condemned to failure because the variety and range of possibilities is too much wide.

3.3 Understanding the market

After a long period of time of tight governmental regulation, the transport market has been undergoing major deregulation processes, on various regions world wide. The long tradition of governmental regulation on the transport market results from the early recognisance of the key role of this sector on regions and countries’ economic development, social cohesion and national defence. Governments have soon brought this sector under their direct control through either
national ownership, or private ownership but tight regulation. The regulation was felt at various levels, for example: admission to the occupation, access to the market, pricing policy, or aid and competitive policy. Usually, on the air and railway transport both infra-structures and companies were publicly owned, while on road and maritime transport infra-structures were publicly owned and companies privately owned. Naturally, within this environment, companies have no freedom and incentives to embrace on competitive and entrepreneurial strategies.

Recently, several countries have engaged on deregulation programs aimed to remove all governmental barriers (and laws) and, consequently, establish an open and free market. Most of these programs are ground on economic reasons, because transport market recorded continuous very low performance levels and most public companies relied on subsidies to keep on market. Deregulation was seen the solution to introduce competition into the market and compel companies to change their behaviour. On an initial stage most of these programs were conducted on a national basis, like for example on the United States or United Kingdom; yet with Globalisation and other similar phenomena groups of countries have been engaged on joint deregulation programmes, opening their markets to foreign competition. Nonetheless, there are regions and markets where governments keep a strong control, notably, most of them concern the international trade due to the afraid some governments have from foreign competition.

Within European Union, a similar process has been occurring, although other reason can be pointed out for its existence. In 1957, with the sign of the Treaty of Rome, the founders members of the European Union has decided to construct the Internal Market that envisaged free mobility of people, goods and capital amongst the members countries. Since, each member state’s laws and rules diverged; it was needed to bring into line the differences. Although, the Treaty dates of 1957, only in the eighties the liberalisation process of the transport market has in fact begun. Nowadays, the process is almost complete. Solely, the railway transport market is still in process of deregulation, the year 2007 is the year scheduled for the liberalisation of the freight transport and the 2010 for the passenger transport.

In an open and free market environment, business’s survival depends upon the capacity of securing demand for its products and services; otherwise no revenues are granted and withdrawal is inevitable. Demand is achieved by meeting and surpassing customers’ needs and tastes, while keeping costs as low as possible; in other words, through competitive advantage. If a company fails in fulfilling the customers’ needs, its products or products will not be sold. However, markets are rather heterogeneous with customers having different characteristics, needs and tastes. Such nature compels companies to identify various types of customers within market and produce customised
products or services for each one. This may lead companies to either, increase their portfolio of products and services, so that, they can meet the needs of the larger possible number of clients; or, by the contrary, narrow their portfolio and concentrate only a few customers. Regardless, the adopted strategy, only those companies able of identifying the specific needs of these groups of customers are in conditions of developing the best fitting solutions for one or more submarkets and, consequently, to obtain competitive advantage. Therefore understanding the market is of paramount importance for any business. This relevance is clearly stated by Hensher and Brewer when writing that “knowing want the market wants and being in a position to service these wants are the fundamental cornerstones of a successful marketing and advertising strategy” (Hensher et al, 1999, p 71). Understanding the market means, firstly, to know what customers want and, secondly, to define for which customers to compete.

3.4 Notion of Market Segment

The presence of group of customers with fairly similar characteristics and needs within market was first recognised by W. Smith in 1956. In his seminal paper, Smith identified the presence of group of customers with homogeneous demand within the market. So, the heterogeneity in the demand of products and services is the outcome of multiple different demands from homogeneous group of customers. Smith states that “market segmentation involves viewing a heterogeneous market as a number of smaller homogeneous markets, in response to differing preferences, attributable to the desires of consumers for more precise satisfaction of their varying wants”18. The concept of market segment has arisen from the conceptualization managers had of a structured and partitioned market. So, through market segmentation a company is able to divide the market into homogeneous submarkets which have customers that respond similarly. The process of segmenting the market requires the choice of variables that are used to identify the similarities amongst customers. Naturally, different variables lead to different segments to be revealed, so segmentation is not single but “a theoretical marketing concept involving artificial groupings of consumers constructed to help managers design and target their strategies”19. In this way, the choice of the variables depends directly from the purpose of the study, so that, the segments identified represent what is being studied. This leads to the conclusion that the appropriate choice of the variable is of utmost importance to the success of the study as to its usefulness to the company.

18 Citation from Wedel, M. & Kamakura, W. (1998, p 3).
19 Source: ibidem (p. 5)
The recognition of heterogeneity in a market implies the impossibility of representing market demand by a single curve. On the other hand, as market segment contains, by definition, customers with uniform tastes for a given variable, the demand of a market segment can be represented through a single demand curve. In this way, a market can be represented by multiple demand curves each one representing a market segment.

### 3.4.1 Demand for freight transport services

These entire projects have shed some light on the process of transport solution choice. Two main variables have been identified as decisive during the process of transport solution choice: cost and quality.

Cost of transport usually designates the out of pocket costs of a transport service, although other costs (like depreciation ratio or damage of goods) may be included. This variable tends to be the decisive one, because high transport costs may eliminate the customer’s profit margins. Yet, the relevance of the freight transport costs on the process of choice is directly related with the value of the freight. High valued freight is less affected by the costs of transport, because they account for a small share on the freight’s final costs; in these situations quality variables tend to be more relevant, such as: safety. On the other hand, in case of low valued freight the transport cost may account for an important share in freight’s final costs and, as such, demand diverts to the lower cost solution.

Quality of transport refers to the properties presented by the transport service. Its definition and measurement are rather complex because it is a concept that depends on each customer. Different customers comprehend different levels of quality, because they valorise different aspects (or attributes) of transport. As a way to reduce the complexity, these attributes have been identified. Naturally, different customers rank differently the various attributes. Although multiple attributed have been brought forward, four are considered the cornerstones of quality definition of a transport service: transit time, safety, reliability and flexibility.

The freight transport business is a timing consuming activity. During the production of the transport service the freight is conveyed in (or on) a vehicle and, as such, cannot be used. So, it can be considered as a stock, but instead of being stored in a warehouse is moving. Stocks are an important source of costs for companies, amongst other reasons, because of depreciation freight

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20 Just to mention some: transit time, safety, reliability, flexibility, responsiveness, equipment capacity, availability, capability, past performance and reputation of the service provider, density of the transport network, frequency, information feedback, or convenience. See McGinnes, M. A. (1990), Vernimmen, B. and F. Witlox (2003) or European Union funded project IQ (Inrets et al, 2000) for a detailed explanation of these and other quality variables.
suffer with time, some goods have very high depreciation ratios (like for example, perishable goods: fruit, flowers, newspapers, etc.) while others have very low depreciation ratios (for example: ores, cement, etc.). Customers obviously prefer shorter transit times.

Any transport service is prone to induce damage or loss on freight, because during transport freight is exposed to potentially harmful actions. On the one hand, freight is handled and stored several times before reaching her final destinations. Handling is an operation involving high stresses that may affect or destroy freight; during storage freight may suffer deterioration due to improper storage conditions or can be corrupted because it becomes easily accessible to third parties. On the other hand, transport is produced using a vehicle, which is not totally safe and can be a target of assaults or other intrusions. Therefore, any transport solution has always associated some degree of non-safety level. Moreover, safety is at some degree related transit time. In principle, shorter transit times result in safer transport service because freight is exposed to the risk for a smaller period of time. As cargo damage or loss represents costs, customers prefer those transport solutions that preserve their freight.

The two other factors recognised as playing a major influence on the demand of freight transport services are: reliability and flexibility of the transport solutions. If there were not uncertainties, the transit time of a transport solution would be fulfilled. Yet, the real world is crowded of unexpected events that may delay or failure a transport service. Events like congestion, accidents, bad management, lack of professionalism, etc. This uncertainty factor is not acceptable for most customers that want their cargo arrive on the scheduled time. Reliability is a concept used to describe the level of uncertainty in fulfilling the schedule of a transport solution; it is usually measured as probability of delays or failures per total number of services. In this way, services that have very low level of uncertainty attached and, therefore, most certainly will follow the schedule, are highly reliable. For certain customers, reliability is more important than transit times because a delay of a shipment may lead to a stop of those customers’ production. So, they prefer to have longer transit times, if that mean higher reliability, which is usually the case because with shorter transit time the slightest problem may result in delays. The final variable is also related with the uncertainty present in a transport service. When an unexpected event occurs, the transport solution should be able of dealing with in such a way that the service is even so accomplished and within the schedule.

Flexibility is a concept used to evaluate the ability of cope with unforeseen situations. Flexibility is at some extend related with reliability. A flexible solution should be able of dealing with a large variety of unexpected situations and, nonetheless, follow the schedule; so a flexible solution tends to be reliable. The term flexibility is often extended to include service provider. A flexible service
provider is a company able to provide within a short period of time solution for customer’s unexpected demands. It may happen a customer to need extra transport services, a flexible transport provider should be able to suppress that demand without problems.

This discussion allows a better understanding of the process of transport solution choice. Customers consider transport as a necessary problem, because they need to convey goods between places but, on the other hand, transport represents costs and may jeopardise the customer’s productive process. Therefore, during the process of decision customers define a threshold for the quality level and limit the maximum transport costs they can afford. The choice would naturally be that brings higher benefits for the customer with lower associated costs. Bearing in mind that quality usually represents higher costs of transport, the process of choice can be considered as an exercise where shipper trades off quality versus costs. Therefore, on the process of transport solution choice what really matters are the quality and costs of the solutions, whereas the quantity and types of modes and means of transport involved are totally irrelevant.

In this way, we believe the most relevant variables to segment the market are those that characterise the customers in function of their willingness to pay and quality attributes. This segmentation can yield several market segments depending on the definition and ranking given to each quality variable and costs. Nonetheless, it is possible to define the markets segments that lay at the extremes: on the one hand, there is the cost relevant market segment, which the only factor affecting process of decision is the transport costs. Usually the freight to be transport has very low unitary values and consequently, very low depreciation ratios. Under these circumstances quality factors such as safety is not relevant. Examples of products include: ores, natural products - like marble, oil products, etc. At the other extreme lay the quality relevant segment, where the decisive factors are quality related. For these customers, the transport costs represent a minor share on the freight’s value, so they are willing to pay for higher quality services. The freight’s value may arise either, from its intrinsic value (like for example: jewellery or high tech products), or from the characteristics of the freight that can not afford low quality transport (like for example: perishable products or paper documents). In between these extremes, one can define multiple segments, in function of the service providers’ ability in offering diversified or specific solutions.

3.4.2 The notion of Transport Logistic Cost

As way to clarify and introduce some rationality on the process of decision, and provide service providers with a tool to provide transport solution, in 1970 W. J. Baumol and H. D. Vinod presented the notion of Total Logistic Costs (TLC). The authors have drawn their model upon the inventory theoretic framework, modelling the process of transport solution choice as a trade off
between transport costs and inventory costs. The rationale is that transport solutions with higher quality (namely, shorter transit times and more reliability), albeit being more costly, can reduce the shipper’s inventory costs; turning out to be less expensive.

They considered a transport service setting with a single shipper and a single receiver, and a finite number of transport solutions to provide this service. The breakthrough on this solution is the assumption that a transport service corresponds to the period of time ranging from the moment freight leaves the shipper’s location until only when it is consumed at receiver’s location. Therefore the cargo stocked at the receiver’s location is considered as part of the transport service. This stock corresponds to the cargo delivered by each transport service, plus a safety stock to cope with any unexpected delay in the next deliver. The inclusion of this stock in the TLC model is justified by the fact that its level depend on the nature of the transport solution: more frequent delivers can result in lower stock at the shipper’s location, while higher reliable solutions can reduced the amount of safety stock.

Considering Q as the quantity of freight transported in each service, L the transit time and K the safety stock at the receiver’s location. The next figure sketches the variance of the stock level at receiver’s location.

![Figure 1 – Evolution of stock at receiver’s location](image)

Based on these assumptions, the authors identified four so-called “logistics characteristics”: transport costs, loading capacity, average lead time and variance of lead time. Each one of these characteristics is a potential source of costs. Thus, the TLC is compound by four parcels each one corresponding to a logistics characteristic: out of pocket costs, costs of cycle stock, cost of inventory in transit and cost of safety stock. The sum of these parcels corresponds to the TLC of the transport solution.
The variables not described so far are:

<table>
<thead>
<tr>
<th>Goods flow parameters</th>
<th>Transport Solution parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual volume (units)</td>
<td>R</td>
</tr>
<tr>
<td>Average daily demand (units/day)</td>
<td>D</td>
</tr>
<tr>
<td>Variance of daily demand (units²/day)</td>
<td>d</td>
</tr>
<tr>
<td>Value of the goods (€/unit)</td>
<td>v</td>
</tr>
<tr>
<td>Holding cost (% per year)</td>
<td>h</td>
</tr>
<tr>
<td>Safety factor</td>
<td>K</td>
</tr>
</tbody>
</table>

The parcel TC corresponds to the out of pocket cost of transport service. On the parcel costs of cycle stock, Q/2 corresponds to the average stock that is in cycle; multiplying this quantity with the value of the goods, v, and the holding costs, h, we get the annual costs of cycle stock; finally, dividing this quantity by the annual volume, R, we get the cost of cycle stock per unit. The parcel cost of inventory in transit corresponds to the cost of depreciation when freight is being conveyed, which depends on the average lead-time, L, the value of the goods and the holding costs. The final parcel refers to the costs of safety stock, which is dependent of the transport solution’s uncertainty represented by the variance of lead-time, l. The expression presented, only applies if there is independence both between lead-time and daily demand and between successive daily demands²¹.

Each solution yields a different value of TLC, the best one is in principle that minimises the TLC. This tool is rather simple of use, the data required is easily got and the calculations are

²¹ Further details on:
straightforward. Moreover, the understanding of the formula is intuitive, it is not required the great knowledge to understand what represents the parcels and how they should be computed. Other advantage is related with the fact of the output being a monetary value, which eases analyses of the solutions because most rationale are conducted in terms of costs. At last, the fact of the output being a cost, comparisons with other solutions or alternatives are straightforward. However, some drawbacks may be pointed out: firstly, not all quality variables are included in the formula, which reduces scope for use. Nonetheless, since a quality variable can be converted by some way in a monetary cost, new parcels can be included in the formula to include these variable, so this problem is only relative. The problem arises from the fact that some quality variable hardly can be converted into costs, because they depend upon each customer’s perception of value and importance of that variable. Usually this problem is by passed through market segmentation. For each segment a monetary cost is defined and assumed fixed.

Nevertheless, the TLC tool is a major reference for evaluating and comparing different transport solutions.

3.4.3 Supply of freight transport services

The freight transport market is highly heterogeneous due to the nature of this business. The transport business is a service rendered by a service provider (the transport company), whose output is the conveyance of goods between different places. In this way, an enormous variety of customers and goods can be identified. The customers range from a single person sending some goods to a relative, until large corporations that rely on transport services to forge competitive advantage. In the same line, the goods can appear in any shape, dimension, weight or state. This duality introduces a high degree of complexity on the analysis concerning the demand for freight transport services. As a way to reduce the inherent freight transport market’s complexity and allow the execution of analysis and studies the concept of market segment has been widely used. The variables used to segment the market depend upon the purpose of the study, so the diversity of segments identified are considerably high. Even considering only those studies aimed to understand the customers’ behaviour and the demand for intermodal transport services, the diversity is still high. For example, the European project IQ\(^2\)\(^\circ\) (Inrets et al, 2000) has identified 23 market segments, based on three variables: shippers’ characteristics, transport distance and commodity type; the European project LOGIC (Gruppo CLAS et al, 2000) has used four variables: shippers’ characteristics, transport actors’ characteristics, commodity type and characteristics of the

economic environment; the European project SULOGTRA\textsuperscript{23} (TUB et al, 2002) has identified 7 market segments based on the shippers’ characteristics; and the European projects INTERMODA (BIBA et al, 2002) and RECORDIT (Cranfield University et al, 2003) have used a geographically based variable.

As freight transport market opened, customers’ demand evolved and service transport providers embraced on a market oriented approach. Consequently, competition has steadily grown and service providers have recognised the only way to keep on the market was through supplying tailored services. However, there are limits to the variety of solutions a service provider can supply and, consequently, to the quantity of market segments where she can enter and compete. These limits arise from three different sources: transport market heterogeneity, modes of transport’s technological characteristics and service provider’s technological development.

As stated above, the freight transport market is rather heterogeneous with a large variety of customers and freight. Service providers have been compelled to identify the market segments where to compete and operate. Some have focussed on specific market segments, like the Express Operators that only transport urgent freight up to a fixed weight; while others have broadened encompassing multiple segments, like for example the road hauliers that convey any kind of cargo. Despite the market evolution, some service operators have remained faithful to the model business that went before deregulation, continuing supplying the same transport solutions; as a result, they have been losing market share keeping only the captive clients that have no alternatives whatsoever.

As a result of this evolution and diversification, there is nowadays a large variety of solutions covering the various market segments. The higher quality solutions, with lower transit times; and higher reliability, flexibility and security, tend to be the most expensive ones because, firstly, they require extra attention to assure customers’ criteria are met and, secondly, may lead to sub optimisation due to the shorter transit times. At the other extreme, the less expensive solutions tend to offer lower quality, essentially, longer transit times and lower flexibility; the other quality factors tend to remain equal because there is no demand for services non-reliable and that not assure the freight’s integrity, after all, no customer wants to lose its freight even the transport being cheap. Longer transit times give service provide the opportunity to better optimise their services, and less flexibility require lower dedicated personnel, the combination of these factors results in lower transport costs.

\textsuperscript{23} D1
Increasingly, service providers are adding other non-transport related services (such as: stock management, packaging, etc) to their portfolios of solutions. The goal is clear: add extra services in order to get the customers’ loyalty by doing non-core activities and increase revenues. Therefore, most service providers are no longer pure transport providers but supply a batch of services along with the traditional transport services.

Owing to historic reasons most service providers have developed towards modal specialisation, as a consequence, nowadays most portfolios are based on a single mode of transport. Since each mode of transport has specific technological characteristics, the transport solutions are bounded by those technological capacities and, consequently, the market segments on which the service provider can compete. The next table compares the performance of each mode of transport for the cost and quality variables presented above.

<table>
<thead>
<tr>
<th>Modes</th>
<th>Cost</th>
<th>Quality</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Reliability</td>
<td>Flexibility</td>
<td>Safety</td>
<td>Transit Time</td>
<td></td>
</tr>
<tr>
<td>Air</td>
<td>++++</td>
<td>++++</td>
<td>+</td>
<td>++++</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Road</td>
<td>+++</td>
<td>+++</td>
<td>++++</td>
<td>+</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Rail</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+++</td>
<td>+++</td>
<td></td>
</tr>
<tr>
<td>Sea</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>+++</td>
<td>++++</td>
<td></td>
</tr>
</tbody>
</table>

The modes of transport’s technological characteristics are detailed in Chapter 3.1. Air transport is the mode with the highest cost per unit volume and offers very low flexibility because it has to use dedicated infrastructure - airports. On the other hand, this mode of transport is the fastest one and presents a high reliability and safety levels because freight remains inaccessible within aircraft during transport. The dominance of road transport on land transport results from its high flexibility and reliability, and relatively reduced transit times. Yet, this mode is not as safe as others because it shares the mean of transport – roads – with other users, which can access freight during transport (in particular during driver’s resting or pausing times). In what concerns rail transport, this mode offers relatively lower reliability and longer transit times when compared with other modes, also it lacks flexibility. On the other hand, this mode tends to be safe because it uses a dedicated mean of transport - railroads, and has rather low transport costs. At last, the maritime transport is the cheapest mode; however, it has the longest transit times due to its very low speed. Flexibility of this mode of transport is low because, like air transport, maritime transport requires ports to load and unload freight. Although, freight being loaded onto the vessels remaining inaccessible during transport, it is exposed to weather conditions, so if bad weather occurs freight loss or damage may
happen. Moreover, bad weather condition can delay the transport service, affecting negatively the reliability.

The modes of transport’s technological characteristics determine the market segments on which a service provider can compete in two different ways. Firstly, technological characteristics bound upper quality of the transport service. Each mode presents limits for the various quality variable, therefore, the maximum attainable quality varies from mode to mode; for example, transit time is dependent on the mode’s maximum speed and flexibility on the mode’s ability of use different routes. Secondly, technological characteristics bound lower costs of the transport service. Recalling the notion of TLC, one of the parcel corresponds to the out of pocket costs of transport, which is directly related with the costs of the mode of transport (for example, the transport costs of a given transport service is naturally different if the mode chosen is maritime transport or air transport). As a result, certain service providers are not able of competing on certain market segments because the mode’ technological properties yield transport solutions that do not fit into the customers’ needs. As an example consider the market segment of very low valued products where the transport costs are fundamental, most probably, service providers using air transport can not compete on this market segment because costs are too high; at the other extreme, for the market segment of perishable goods time is vital, therefore, maritime transport service providers are not able of competing for this market segment because their transit time are most probably to long.

Finally, the service provider’s technological development influences the quality and costs that she can supply. Technological development is related with the level of useful technology a service provider applies on her solutions. Most of the technological can be used on all modes of transport, only depending on the service provider’s willingness. For example, the implementation of tracking & tracing systems increases transparency on the transport service improving reliability and safety.

3.4.4 Characterisation of the main products carried
Transportation is present in all situations goods need to be conveyed between two different locations, both, during the productive process in which value is added, and during distribution of the final product. As transports are conducted with some type of vehicle, whenever a transport service is required, a mode of transportation or several combined modes have to be selected. This selection is the result of multiple factors, however, in function of both, the characteristics of the goods to be transported, and the characteristics of the various modes of transport (in particular reliability, speed, and costs), each mode of
transportation has competitive advantage for certain segment of products. And statistics do confirm the competitive advantage of a mode in some product segments.

Since intermodal transportation entails the conveyance of goods between different modes, the knowledge and understanding of the segments in which the various modes are more competitive is vital to assure a competitive transport.

Being so, the purpose of this chapter is to present a brief overview about the most relevant products transported by each mode of transport and the justification for that situation.

Road Transport

Road haulage is responsible for more than half of the total transport of goods within European Union. The high reliability and flexibility, combined with acceptable average speeds and costs, are the main underlying factors for its success.

Road transportation is nowadays a competitive industry in multiple segments of products. On the one hand, road haulage is highly reliable and flexible being able to successfully cope with both, customers’ demands (e.g. nowadays many companies manufactures work following stockless principles - Just in Time or Lean production - which impose strict demands - constant flow of goods and arrival within short windows time) and unexpected situations during transport (e.g. in case of heavy congestion or bad weather new paths can be chosen any time during the journey). On the other hand, despite the growing congestion in many roads of central Europe and the resting times imposed at both diver and vehicle, road haulage’s average speed fits into the demands of manufacturing companies. Moreover, costs of road operations are perfectly bearable by the manufacturing companies, in special, when transportation’s cost commonly represents a minor fraction in companies’ total costs. Therefore, road transportation fulfils the demands of most manufacturing and retail industries.

Furthermore, road transportation ensures the initial and final legs of all other modes (rail, sea, air and inland), as these modes can not provide a truly door-to-door service, which further enlarges the scope of goods road transportation is moving.

Finally, rail transport that is (at least potentially) the road transport’s direct competitor in the intra European transport is not being able to cope with nowadays demands, meaning the intra-European transportation market is served by road haulage.
As a result, road haulage transports a wide spectrum of goods; nonetheless, it is possible to identify several types of goods with special relevance for this mode of transport. The following figure presents the relative importance (in terms of tonnes-kilometres) of 24 segments of products, as defined by the Eurostat, for road transportation conducted within European Union, for the year 2004.

**Eurostat Product Groups**

<table>
<thead>
<tr>
<th>Group</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Cereals;</td>
</tr>
<tr>
<td>02</td>
<td>Potatoes, other fresh or frozen fruits and vegetables;</td>
</tr>
<tr>
<td>03</td>
<td>Live animals, sugar beet;</td>
</tr>
<tr>
<td>04</td>
<td>Wood and cork;</td>
</tr>
<tr>
<td>05</td>
<td>Textiles, textile articles and man-made fibres, other raw animal and vegetable materials;</td>
</tr>
<tr>
<td>06</td>
<td>Foodstuff and animal fodder;</td>
</tr>
<tr>
<td>07</td>
<td>Oil seeds and oleaginous fruits and fats;</td>
</tr>
<tr>
<td>08</td>
<td>Solid minerals fuels;</td>
</tr>
<tr>
<td>09</td>
<td>Crude petroleum;</td>
</tr>
<tr>
<td>10</td>
<td>Petroleum products;</td>
</tr>
<tr>
<td>11</td>
<td>Iron ore, iron and steel waste and blast furnace dust;</td>
</tr>
<tr>
<td>12</td>
<td>Non-ferrous ores and waste;</td>
</tr>
<tr>
<td>13</td>
<td>Metal products;</td>
</tr>
<tr>
<td>14</td>
<td>Cement, lime, manufactured building materials;</td>
</tr>
<tr>
<td>15</td>
<td>Crude and manufactured minerals;</td>
</tr>
<tr>
<td>16</td>
<td>Natural and chemical fertilizers;</td>
</tr>
<tr>
<td>17</td>
<td>Coal chemicals, tar;</td>
</tr>
<tr>
<td>18</td>
<td>Chemicals other than coal chemicals and tar;</td>
</tr>
<tr>
<td>19</td>
<td>Paper pulp and waste paper;</td>
</tr>
<tr>
<td>20</td>
<td>Transport equipment, machinery, apparatus, engines, whether or not assembled, and parts thereof;</td>
</tr>
<tr>
<td>21</td>
<td>Manufactures of metal;</td>
</tr>
<tr>
<td>22</td>
<td>Glass, glassware, ceramic products;</td>
</tr>
<tr>
<td>23</td>
<td>Leather, textile, clothing, other manufactured articles;</td>
</tr>
<tr>
<td>24</td>
<td>Miscellaneous articles</td>
</tr>
</tbody>
</table>

*Source: Eurostat*

**Figure 12 - Products groups’ relative importance in road transportation, year 2004**

The products most relevant in road transportation are: foodstuff and animal fodder (Group 6), crude and manufactured minerals (Group 14), and leather, textile, clothing and other manufactured articles (Group 23). These products are dispatched mainly by the manufacturing and retail industries.

The miscellaneous group (Group 24), that embodies all remaining products, is ranked second, denoting the large variety of products transported by road.

**Rail Transportation**

Rail transport is the only mode with potential to compete against road transport in intra-European transportation; however, European Union railways are, and always were, a jigsaw of systems introducing major friction costs into the rail transportation services,
particularly the international ones. As a consequence, rail transportation has not been able to cope with current customers’ demands, like road transportation has been doing, which is the cause of the continuous rail transportation’s market loss in the last decades.

Products prone to be transported by railways, within the current environment, are those with a low unitary value (low value per unit weight or volume) and in which time is not relevant. By other words, only products that transportation represents a high proportion of total cost and that do not lose commercial value with time\textsuperscript{24} are possible to be transported by rail. This means that products susceptible to be transported by rail are products like raw or bulk materials or semi-finished products (e.g.: cereals, cement, mineral, metals, etc) because commonly these products have low intrinsic value and time is not relevant as they are not in their final form. Of course, that nowadays with the increasing pressure to be used more sustainable modes of transportation, substantial efforts have been done to revitalise rail transportation. However, most of them were still trial tests and few commercial operations are currently in operations.

The following figure presents the relative importance (in terms of tonnes-kilometres) for the same 24 segments of products, as presented above in road transportation, for rail transportation conducted within European Union, for the year 2004.

![Figure 13 - Products groups’ relative importance in rail transportation, year 2004](image)

Products with more relevance in rail transportation are: solid mineral fuels, petroleum products and metal products, with the miscellaneous group being the most relevant one. As expected, those groups fit into the characteristics written above: low unitary value and low

\textsuperscript{24} Either, because they rapidly get damaged or destroyed (e.g.: foodstuff), or because they become obsolete (e.g.: high tech product).
elasticity to time. The high relevance of the miscellaneous could represent that rail is still nowadays used to move a large diversity of other non-classified products.

*Waterway Transportation (sea and inland)*

Deep sea transportation is responsible for the transport of the vast majority of goods between European Union and overseas. Due to ships’ large capacity, deep sea transportation presents important economies of scale being a rather economic mode of transportation. Naturally, that only on routes with large flow of goods, deep sea transport can be profitably used, by fully exploiting all economies. Therefore, this mode of transport is especially attractive to transport large quantities of products at once, like what happens in intercontinental flows. Moreover, being average speed rather low, only products with relative long life cycles can be transported by sea. The transport of short life cycle products is only viable by expanding their life cycle, for example, using refrigerated ships (or containers) to transport foodstuff, or postponing final production to the final products.

When analysing deep sea transportation statistics, a further analysis has to be carried out, as cargo is divided into four segments in function of its nature: general cargo, containers, dry cargo in bulk, liquid cargo in bulk. General cargo represents all cargo that has to be handled individually, like for instance, unshaped masses of stone. In the transport of containers cargo is loaded into the loading unit and this is the unit to be handled; only ISO containers are transported by sea. Cargo in bulk is transported in tailored ships that are loaded and unloaded using especially techniques, examples of dry cargo are cereals or fertilisers and of liquid cargo are petroleum or oil.

No statistical data has been found at European Union level concerning the relevance of each segment; only data for Portugal has been collected. The following figure presents the relevance of each segment in the Portuguese market.

25 The direct competitor is air transportation but its high costs and low capacity hinders him to gain quota in intercontinental transport.
In terms of type of cargo, once again, no information has been found at European Union level. The following figures present the international freight transport by type of goods for Portugal (year 2004) and Spain (year 2001).

Figures reveal that almost half of the freight is of petroleum products, which is natural paying attention that both Portugal and Spain have no natural crude fields. Furthermore, these products are transported in large quantities and have a very low value, not being feasible transport them by air from overseas. Other products include mineral fuels, fertilisers, metal products, which are also low valuable goods.

It should be noticed that these statistics do not take into account goods transported within containers; therefore, for a significant and growing part of the market no data exists. Nevertheless, within containers, products such as leather, textile, and clothing; glass, glassware and ceramic products; fresh and frozen fruits and vegetables; and diverse manufactured articles, should represent and important part of this segment.
In what concerns, Short Sea Shipping (SSS) again no data has been found. On the one hand, because, cargo is only transported within loading units (such as: containers, semi-trailers, swap bodies, etc), and statistical data about the type of products is lacking. On the other hand, SSS services are both, used as feeding (and distribution) services of deep sea services, and used as substitutes for intra-European transport, mainly road haulage; thus, making even more difficult statistical analysis.

Finally, in what concerns inland transportation, besides the assumptions already made for sea transportation, this mode is able to be a good substitute for certain types of goods in intra-European transportation. For all those products with low unitary products and long life cycles, inland proves to be a profitable means of transportation. The following figure presents the relevance (in terms of tonnes-kilometre) of the same 24 products as presented previously for the Europe Union inland transportation in the year 2004.

The most relevant products with almost a third of the market are crude and manufactured minerals; they are followed by the petroleum products and far behind by iron ore, iron and steel waste and blast furnace dust. All these products fit perfectly within the characteristics of inland transportation characteristics: very low unitary value and do not value with time.

Once again, it should be noticed that these statistics do not concern the transport of containers, which in certain river is a relevant segment. Mainly, along the Rhine river where feeding and distribution services from and to the Rotterdam port represent an important part of the market.
Air Transportation

In terms of statistical data, none has been found; thus, only some considerations are drawn concerning the most likely products to be transported by air. There is a large variety of products (in terms of type, size and density) that are, nowadays, transported by air. Despite the wide diversity, all of them have in common the fact of being high-valued products or/and perishable goods, in which time is very important and cost of transportation only plays a minor role in product’s final price. Therefore, bulk goods (or low valued goods) rarely are transported by air, since for these products costs of transportation are very important. Even so, in special situations like congestion or disruption of surface communications, in which severe losses may happen if transport is cancelled, air transportation can be used as a substitute.

Two categories of freight that are always transported by air are the ultra-high valued products and what can be called as emergency goods. The former category included products like: gold, jewellery, diamonds, valuable metals or rare furniture; while the latter includes medical products (vaccines, etc.), spare parts for machinery, documents (business contracts, medical records, financial papers, articles and reports, etc.), art (films, paintings, etc.) or high-tech products (software and hardware). Although, the demand for these kinds of products tends to be irregular, intermittent and unpredictable in volume and in size of individual consignments; they form a relevant market segment as they are highly profitable (since transportation costs are irrelevant when compared with the goods’ value).

Other category of freight refers to the perishable products. These products have a very short life cycle and shippers can not risk sending goods by other mode than air without risking to lose all cargo. In this case, time is far more relevant than cost transportation. Examples of these products are: food (e.g.: fish, out of season vegetables or fruit), commodities (e.g.: high fashion textiles, newspapers, films or flowers), or high technology products (e.g.: personal computers, laptops or software).

A final category concerns the non-perishable goods, this category embodies a large variety of products ranging from raw materials and agricultural product to manufactured products. Despite the variety of products, all of them have in common the fact of to have a high value to weight ratio. Furthermore, they tend to be also fragile and liable to damage or loss if subject to excessive handling. Examples of these products are: manufactured products
3.5 Liability

In professional transportation market, stakeholders’ liability arises from delivering third party goods for a fee.

By the fact of conveying third party goods, all actors enrolled in a transport operation assume the legal responsibility for those goods. This means that if something goes wrong during the journey, and one or more conditions set between shippers and actors are not correctly fulfilled, then these have to indemnify those for any damage and/or loss.

The conditions or liability principles define the stakeholders’ liability with respect to loss and damage and, for certain modes, delay of goods moved. As these principles are used to define conditions transportation companies have met, they can also be used to excuse them from their duties.

As, on the one hand, the knowing and understanding of the liability principles are important in the professional freight transportation and, on the other, intermodal transport is facing problems within the current legal framework; this paper describes the current liability regime both, for each mode of transportation, and for intermodal transportation. The main problems intermodal transportation is currently facing are also presented.

3.5.1 Current Liability Regime

Freight transportation services have always been based on a single mode basis; only, more recently, intermodal transportation has gained some relevance. As a result, carriers’ liability has been developed on a unimodal basis. Through time, each country has defined its own national legal framework regulating the carriers’ liability engaged in national transportation of goods. As in international transportation, country’s national laws have no legal right, countries felt the need for a global and universal liable regime ruling these services. Being so, through several international conferences, countries have successively defined the liability principles for each mode of transportation. The following table presents the main current liability regimes in force for each mode. It should be noticed
some of these agreements are volunteer by nature, therefore, countries only accept them if they want.

<table>
<thead>
<tr>
<th>Table 13 - Liability regime</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modes</strong></td>
</tr>
<tr>
<td>Maritime</td>
</tr>
<tr>
<td>Air</td>
</tr>
<tr>
<td>Road</td>
</tr>
<tr>
<td>Rail</td>
</tr>
<tr>
<td>Inland</td>
</tr>
</tbody>
</table>

Source: IM Technologies Ltd (2001), p. 6

Under the current liability regime, whenever an international transportation service is set, multiple contracts have to be signed between the various actors\(^{26}\) enrolled in the transportation service. These contracts define the extension of each actor’s liability. Moreover, as contracts tend to be specific only covering few legal issues, stakeholders have to commonly sign more than one contract, the goal is to cover all issues and casualties that may arise or happen during the transportation, and in this way, avoid bearing unexpected costs. As a result, the current liability regime proves to be somehow complex, particularly, in case of intermodal transportation. The following picture (Figure 1) shows the relationships and liability contracts\(^{27}\) signed between the stakeholders in a transportation service, as it is possible to see the current legal regime lead to a dense web of relationships. As complexity is synonymous of friction and lack of transparency, the natural conclusion is that the current system is prone to introduce costs within the transportation system.

\(^{26}\) Despite the large variety of actors, the most common are the following: shipper, freight forwarder, transportation company (or companies) and insurer. The shipper is the client that sends the goods expecting their arrival within a certain time and without any damage or destruction. The freight forwarder acts on the behalf of the shipper when dealing with the transportation companies. Its purpose it to get the most favourable transportation arrangements and ensure that shipper’s conditions are all correctly met. The transportation company is in charge to convey goods between two or more locations. The insurer company takes and assumes other companies’ responsibilities, as these may not have the necessary amount of money to pay for what they are legally responsible.

\(^{27}\) It should be noticed that in this picture only the international conventions are presented. There are other possible contracts suitable for the various situations.
In what concerns the contracts, nowadays, stakeholders have at their disposal a great variety covering all issues of a transportation service. These contracts can be divided into three levels (Figure 2), each level is more specific but covers less issues.

Contracts are primarily based on the international conventions rules that are like an umbrella defining and establishing the minimum legal responsibilities of each stakeholder. Yet, for those situations requiring higher level of detail or when some particular issues are not covered, other legal texts have to be used. Countries’ national laws may be a solution. As each country has its own legal framework establishing rules for national freight transport, stakeholders can make use of such legal texts on their contracts. Finally, if even so, international and national legal texts do not provide the adequate contract conditions that stakeholders expect, they can make use of a large variety of standard term contracts specifically designed by the international association bodies (e.g.: FIATA bill of lading or the Multidoc 95).
Being so, the current legal framework consists of a confused maze of international conventions designed to regulate unimodal haulage, diverse national laws and standard term contracts. The presence of these three echelons that facilitates the proliferation of different types of contracts and liability principles introducing confusion and, consequently, reducing transparency, further contributes for the complexity presented above.

Finally a note reminding that these laws only concern the modes of transportation. So, liability principles concerning warehouses, ports, terminals and infrastructure operators are defined by the respective countries’ national laws and regimes.
Table 14 - Comparison of the Liability Regimes

<table>
<thead>
<tr>
<th>Period of application</th>
<th>ROAD TRANSPORTATION</th>
<th>AIR TRANSPORTATION</th>
<th>RAIL TRANSPORTATION</th>
<th>MARITIME TRANSPORTATION</th>
<th>INLAND TRANSPORTATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>From taking over to delivery</td>
<td>• From acceptance through delivery or release during carriage by air</td>
<td>• From acceptance through delivery or release during carriage by air</td>
<td>• From time of acceptance for carriage over the entire route up to delivery</td>
<td>• From loading of goods until discharge from vessel</td>
<td>• From taking over until delivery</td>
</tr>
<tr>
<td>Confirmation of consignment note</td>
<td>• Air waybill - 12 minimum particulars</td>
<td>• Air waybill - 4 essential particulars</td>
<td>• Acceptance of the goods with consignment note</td>
<td>• Acceptance of the goods with consignment note</td>
<td>• Bill of lading</td>
</tr>
<tr>
<td>Presumed fault of carrier for loss, damage, delay</td>
<td>• Presumed fault of carrier for loss, damage, delay. If carriage by land, sea or river performed outside an aerodrome for the purpose of loading, delivery or transhipment then damage is presumed, subject to proof to the contrary.</td>
<td>• Strict liability for loss or damage resulting from the loss or damage and from the transit period being exceeded</td>
<td>• Liability for wastage in transit only if wastage exceeds specific allowances</td>
<td>• Restricted liability for wastage in transit only if wastage exceeds specific allowances</td>
<td>• Liability for loss, damage and delay</td>
</tr>
<tr>
<td>Air waybill - 12 minimum particulars</td>
<td>• Air waybill - 4 essential particulars</td>
<td>• Acceptance of the goods with consignment note</td>
<td>• For loss, non-use or misuse of documents</td>
<td>• For any consequences arising from the loss or misuse of the documents referred to in the consignment note and accompanying it or deposited with the carrier</td>
<td>• For loss or damage</td>
</tr>
<tr>
<td>• From acceptance through delivery or release during carriage by air</td>
<td>• From time of acceptance for carriage over the entire route up to delivery</td>
<td>• Liability in case of nuclear incidents</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Liability for indirect or consequential loss**

<table>
<thead>
<tr>
<th>Carriage charges</th>
<th>Customs duties</th>
<th>No restriction on damage occasioned by delay in carriage</th>
<th>Consignee liable for any loss or damage arising from absence, insufficiency of or irregularity in documents.</th>
<th>In case of interest in delivery</th>
<th>Cost for evaluating damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 8.33 SDR/kg</td>
<td>• For delay 1 value of freight</td>
<td>• 17 SDR/kg</td>
<td>• By the international tariffs applicable; not within transit periods agreed by the railways participating in the carriage. If no indication: transit period must not exceed that which would result from the application of 27 § 2 which determines the maximum transit periods</td>
<td>• Delay excluded</td>
<td>• Delivery period as agreed period</td>
</tr>
<tr>
<td>Notice of claim</td>
<td>• Against payment of surcharge</td>
<td>• Consentir must make a specific declaration of interest, subject to payment of a supplementary sum</td>
<td>• By special declaration of interest</td>
<td>• Further reduction of limitation of liability under certain tariffs in the case of exceeding the transport period</td>
<td>• By agreement increase or reduction shall be embodied in the bill of lading</td>
</tr>
<tr>
<td>• Damage: within 7 days not including weekends</td>
<td>• Damage: Within 7 days from receipt of the goods; Delay: within 14 days after the date on which goods have been placed at his disposal</td>
<td>• Damage: Within 14 days from receipt of the goods; Delay: within 21 days after the date on which goods have been placed at his disposal</td>
<td>• Acceptance according to Art. 52 before acceptance; if not: extinction of right of action</td>
<td>• Liability in case of nuclear incidents</td>
<td></td>
</tr>
<tr>
<td>• Delay: within 21 after goods placed at consignee’s disposal</td>
<td>• Extending the period of responsibility - higher limits of liability</td>
<td>• Extending the period of responsibility - higher limits of liability</td>
<td>• No apparent loss: 7 days after acceptance</td>
<td>• Liability in respect of rail-sea traffic if carrier proves that loss occurred in course of the sea journey between loading on board and unloading from ship he has more exception clauses (e.g.: fire; saving life or property at sea)</td>
<td>• Liability in respect of rail-sea traffic if carrier proves that loss occurred in course of the sea journey between loading on board and unloading from ship he has more exception clauses (e.g.: fire; saving life or property at sea)</td>
</tr>
<tr>
<td>Other provisions</td>
<td>• Applicable to the whole of the carriage unless proved that loss was not caused by carrier by road (Goods not unpacked from container)</td>
<td>• In the case of combined transport performed partly by air, these rules apply only to carriage by air</td>
<td>• Liability in respect of rail-sea traffic if carrier proves that loss occurred in course of the sea journey between loading on board and unloading from ship he has more exception clauses (e.g.: fire; saving life or property at sea)</td>
<td>• Responsibility for loading and unloading carrier for packages, consignor for full wagon loads, consignee for unloading after delivery</td>
<td>• Liability in case of nuclear incidents</td>
</tr>
<tr>
<td>• In the case of combined transport performed partly by air, these rules apply only to carriage by air</td>
<td>• Liability in respect of rail-sea traffic if carrier proves that loss occurred in course of the sea journey between loading on board and unloading from ship he has more exception clauses (e.g.: fire; saving life or property at sea)</td>
<td>• Liability in respect of rail-sea traffic if carrier proves that loss occurred in course of the sea journey between loading on board and unloading from ship he has more exception clauses (e.g.: fire; saving life or property at sea)</td>
<td>• Liability in respect of rail-sea traffic if carrier proves that loss occurred in course of the sea journey between loading on board and unloading from ship he has more exception clauses (e.g.: fire; saving life or property at sea)</td>
<td>• Compensation is computed by reference to the value of the goods at the place and time they are discharged from the vessel</td>
<td>• Liability in case of nuclear incidents</td>
</tr>
</tbody>
</table>
3.5.2 *The International Conventions’ provisions*

As already written, the liability systems for international unimodal transportation services are defined by a set of International Conventions. The table in the previous page summarises the main issues of each convention, providing a picture of each mode of transportation’s liability regime. The main issues covered by the international conventions are: period of application, contract of carriage, basis of liability, delay in delivery, liability for indirect or consequential loss, extension of the responsibility - higher limits of liability, and notice of claim. An extra field (‘other provisions’) was added to describe other relevant information. It should be noticed that some conventions do not cover one or more of these issues, which means that there are gaps in the liability regimes (this is a reasons for stakeholder use other regulations and contracts - Figure 2).

The liability regime relevant for international transportation by road transportation was defined in the CMR Convention (1956). The CMR regime is mandatory for international transport.

In what concerns the Air Transportation, the liability system was firstly defined in the Warsaw Convention (1929), and more recently amended in the Montreal Convention (1999). This regime is not mandatory but has had a large support, and nowadays most countries are signatories.

One situation that arises on a regular basis in intra-European traffic is air trucking, that means the carriage of air freight by truck or rail. In this case the liability regime of the transport mode is applicable (CMR or COTOF/CIM), even though the accompanying document is the airway bill. The only exception occurs when shipments have a declared value exceeding the liability limits according to the applicable liability regime; in these cases shipments are carried under the terms and conditions of the Warsaw Convention (but only if this part of the transport is arranged by the air cargo carrier and the shipment is accompanied only by an airway bill on this part of the journey).

Concerning Railways Transportation, the liability regime relevant for international transportation is defined in the Appendix B, under the name of CIM, of the convention on international rail transport (COTIF) of 1980. More recently, in 1990 a Protocol made some amendments. The COTIF/CIM regime is mandatory for international movements.
The liability regime relevant for international transportation by Maritime Transportation was defined in the Hague Rules (1924) that were more recently amended by the Brussels Protocol (Hague-Visby, 1968).

For Inland waterways Transportation the liability regime relevant was defined in the CMNI Convention (1999).

### 3.5.3 Intermodal Transportation

If until recently the unimodal based liability regimes have never been a problem, as most cargo was moved in a single mode; nowadays, with the growing of intermodality, the present legal framework poses relevant problems (see below discussion). Intermodal transportation by principle is far more complex than unimodal transportation, as besides entailing the use of least two different modes, there is always one or more transfer points in which cargo is handled and stored. Therefore, the one-mode based liability regimes are not adequate in these situations, since they only define liability of one mode and do not take into account the possibility of other modes’ influence.

Aiming to overcoming this situation, the United Nations in 1980 promoted the Multimodal Transport Convention in which a uniform system for claims arising out of multimodal contracts was designed and defined. However, it has failed to attract sufficient signatures and ratifications to enter into force. One of the reasons for this failure is that the convention is largely based on another convention (the 1978 United Convention on the Carriage of Goods by Sea), which has not been yet ratified by any major shipping nations. Furthermore, the convention does not provide a truly uniform system, since, first, the need to establish the stage where a loss occurs and to determine which mandatory international and national law applies remains; second, knowing the location of the loss, the convention gives precedence to applicable international and national law providing for a higher limit of liability; and third, convention provides for a different financial limit if a contract does not include carriage of goods by sea or inland waterway.

Failed the attempt of the 1980 Multimodal Transport Convention to define a global and uniform liability regime for intermodal transportation, the existent legal void remained. Feeling the need to find a more suitable liability regime, twelve years late another attempt was brought forward with the 1992 UNCTAD/ICC Rules. These rules are not mandatory and are intended to be signed between the freight’s sender - shipper - and the chain’s
manager - freight forwarder. Although, not being mandatory, they may be incorporated into a contract if stakeholders agree (like for example the 1996 FIATA FBL) giving in this situation precedence to mandatory law. Furthermore, they are based on the so called “network principle”, which means that “providing that the unimodal stage of the transport where the loss occurred can be established, then the liability limit that applies is that which corresponds to the national or international law that world have applied for that stage under a unimodal contract”; however, “these Rules shall only take effect to the extent that they are not contrary to the mandatory provisions of international conventions or national law applicable to the multimodal transport contract” (IM Technologies Ltd (2001), pp. 34-35).

The following table presents the main features of the UNCTAD/ICC Rules.

<table>
<thead>
<tr>
<th>Issue</th>
<th>UNCTAD/ICC (1992)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period of application</td>
<td>From taking the goods in charge until delivery</td>
</tr>
<tr>
<td>Contract of carriage</td>
<td>Multimodal Transport (MT) document evidences MT contract</td>
</tr>
<tr>
<td>Basis of liability</td>
<td>Presumed liability for loss, damage and delay (if declaration of interest of timely delivery has been accepted by Multimodal Transport Operator (MTO))</td>
</tr>
<tr>
<td>Delay in delivery</td>
<td>In no event liable for loss following from delay unless expressly agreed in writing</td>
</tr>
<tr>
<td>Liability for indirect or consequential loss</td>
<td>Consequential loss or damage other than loss of or damage to the goods</td>
</tr>
<tr>
<td>Limitations of liability</td>
<td>2 SDR((^a))/kg or 666.67 SDR/package</td>
</tr>
<tr>
<td></td>
<td>8.33 SDR/kg if no carriage by sea/water</td>
</tr>
<tr>
<td></td>
<td>Delay, consequential loss 1x amount of freight</td>
</tr>
<tr>
<td></td>
<td>Limit of unimodal Convention if loss/damage localised</td>
</tr>
<tr>
<td>Extension of the responsibility - higher limits of liability</td>
<td>By agreement fixed in the MTO document</td>
</tr>
<tr>
<td>Notice of claim</td>
<td>Non apparent loss or damage - 6 consecutive days after handing over</td>
</tr>
<tr>
<td></td>
<td>9 months after (supposed) delivery or after 90 days (treatment of the goods as lost)</td>
</tr>
<tr>
<td>Other provisions</td>
<td>MTO has to add clauses on: routing, freight and charges, liens, both-to-blame collision, general average, jurisdiction, arbitration and applicable law</td>
</tr>
</tbody>
</table>

\(^a\) SDR - Special Drawing Rights  

For shippers these rules came to reduce both uncertainty and some (friction) costs of intermodal transportation, since they are always secured regardless the condition of losses or damages. If loss or damage is localised then the limits of unimodal conventions are applied making no difference to the sum that is recovered; if loss or damage is not localised then shippers receive the minimum fixed on the Rules rather than nothing. As a
proof of these benefits a recent survey\textsuperscript{28} found that within European Union contracts based on these rules are quite successful.

However, in fact, the UNCTAD/ICC and other similar rules do not reduce overall complexity or uncertainty, instead, they pass the problems into the freight forwarders’ hands. First, the need of the existing regimes is not eliminated, as the limit of liability continues to be based on them. So, now it is the freight forwarder that has to deal with all the different contracts. Second, the limit of liability is not pre-determined, continuing to depend on where and whether the damage or loss is identified. Thus, freight forwarder faces the same uncertainty as before.

Being so, nowadays, the liability regime of an intermodal transportation entails that, first, unique contracts have to be signed between chain’s manager and every stakeholder present on an intermodal chain: both modes of transportation and actors enrolled in ancillary tasks; and second, a single contract has to be signed between the chain’s manager and the freight forwarder, when he exist (commonly, this contract is based on the UNCTAD/ICC Rules) (Figure 1). Therefore, on an intermodal transportation chain multiple contracts with different liability principles may co-exist. This situation increases the complexity and bureaucracy, which ultimately leads to the increase of the transportation costs.

In what concerns the chain’s manager, he can be either the shipper or the freight forwarder. In the former situation, the presence of the freight forwarder is only as an intermediary, since shipper is in charge to define, arrange and manage all contracts concerning transportation. The cargo is moved under the shipper’s name and contracts are addressed also in shipper’s name. In this situation, all complexity inherent to intermodal transportation liability regime is managed by the shipper itself, which may represent a substantial burden as transportation is commonly considered as a non-core sector and, thus, (manufacturing) companies do not devoted significant efforts or attention. This situation may led (manufacturing) companies to prefer unimodal transportation.

In the other case, which is the most usual nowadays, the freight forwarder is the responsible for the management of the transportation chain. The current trends in Logistics and Supply Chain consider transportation a non-core activity of (manufacturing) companies.

\textsuperscript{28} IM Technologies Ltd (2001), p. 37
companies regarding outsourcing as the most advantageous outcome. Therefore, shippers are more and more outsourcing transportation activities, only imposing the conditions (in terms of time and conditions) freight forwarders have to meet. In these cases, freight forwarders are the chains’ managers and all cargo is transported under their name (despite cargo belongs to third parties). Moreover, only a general contract is signed between the shipper and the freight forwarder that can embody the UNCTAD/ICC rules.

Under the current liability regime, claiming for losses or delays entail a clear identification of the stage where the problem occurs, as the liability regimes have a unimodal scope. Although, shippers have an additional security in case of following the UNCTAD/ICC Rules, freight forwarders have always to know where the problem occurred to define the liability of each mode.

This reality rises diverse problems.

First, the fact of existing different contracts for each mode of transport means that the same goods of a shipment are subjected to different liability regimes while moving along the transportation chain. As the various conventions have different liability principles, on the same chain goods can be either ‘over protected’ or ‘under protected’ in function of the mode on which they are.

Second, the identification of the location where the loss or damage occurred is not always straightforward, either because it may happen gradually along transport chain, or in the course of ancillary services to transportation (e.g.: warehouse). When is not possible to identify the location where loss or damage happened, than international conventions can not be applied. If for the shipper this may not pose a major problem as he may be shielded (for example, through a contract following the UNCTAD/ICC Rules), for the freight forwarder this situation represents an extra burden - higher loss and greater complexity - as he has no one to whom he can claim for the losses or damages. Furthermore, even knowing on which mode there was the problem, it is necessary to know the causes of the loss, in other words, it is necessary to prove carrier’s fault, which is not always easy (as time and money is required to track down the actual carrier responsible for loss and damage, and evidences may be hard to obtain or the suit may be time barred). Finally, it may happen that the regime mandatory regime is a national law that shipper does not fully understand. Therefore, both the applicable liability rules and the degree and extend of carrier’s liability
vary great from case to case and are unpredictable. And uncertainty raises costs and discourages trade.

Third, there is substantive uncertainty as to the applicable legal regime. Not only there is overlapping of the various (international and national) unimodal liability regimes29, as well as, provisions in standard term documents are often difficult to understand. Furthermore, these standard documents give precedence to mandatory national and international law without providing further guidance as to which regime should be applicable. As a result, many times in situations of claim the various stakeholders do not agree on the terms and litigation is the common end. Yet, even with courts decisions are far for simple or easy as often they have different readings of the law (some may consider that a certain regime is mandatory while others may judge in another direction). Therefore, the same case may have different sentences depending upon the court. Naturally, this situation further increases uncertainty and consumes time representing extra costs for the stakeholders and ultimately for intermodal transportation.

Fourth, liability for delayed delivery is not always covered by the same rules as liability for losses or damage of goods. So, new contracts have to be agreed between stakeholders, further increasing system’s complexity and costs.

Therefore, nowadays, carriers engaged in intermodal transportation face a major uncertainty and complexity with regard to the liability regime. Uncertainty over the location where the loss happens, concerning the contract and the identity of the carrier, and concerning the applicable legal regime and its effects. Complexity concerning the great variety of contracts, concerning the multiple contracts that have to be signed, and concerning the contracts’ different levels of precedence. This means that there is neither a uniform regime governing liability for loss, damage or delay, nor a uniform regime providing one standard of liability for all stages of the intermodal transportation. All this uncertainty surrounding intermodal transportation is regarded as one of the most important sources of friction costs, with a strong influence on its competitiveness. Naturally, transport companies and clients are not willing to use a transport that in case of damage,

29 Aiming to provide a full coverage of the mode they represent, the international conventions have extended their scope a little beyond the strict limits of a mode of transportation (it is precisely at the ‘frontiers’, they overlap).
loss or delay does not assure a simple and transparent liability regime, when there are others modes that have it.

Moreover, the dimension and relevance of this problem has been recently acknowledged by the European Commission\textsuperscript{30}. On that document she stated that the current regime leads to some uncertainties that are sources of friction and costs, and that the lack of uniform carriers’ liability regime hinders the intermodal transport development. Currently, efforts are being made to reduce the level of fragmentation of current situation.

Finally, in terms of costs, the following table presents the actual losses and administrative costs arising from the current liability system, as a percentage of transport costs and for three typical journeys.

<table>
<thead>
<tr>
<th>Friction Costs</th>
<th>Journeys</th>
<th>National</th>
<th>Intra-European</th>
<th>Extra-European</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual Losses</td>
<td></td>
<td>3.83</td>
<td>2.17</td>
<td>1.33</td>
</tr>
<tr>
<td>of which</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shipper</td>
<td></td>
<td>1.21</td>
<td>0.31</td>
<td>0.09</td>
</tr>
<tr>
<td>Carrier</td>
<td></td>
<td>0.17</td>
<td>0.20</td>
<td>0.15</td>
</tr>
<tr>
<td>Cargo Insurer</td>
<td></td>
<td>2.07</td>
<td>1.21</td>
<td>0.74</td>
</tr>
<tr>
<td>Carrier Insurer</td>
<td></td>
<td>0.39</td>
<td>0.45</td>
<td>0.34</td>
</tr>
<tr>
<td>Administrative costs</td>
<td></td>
<td>2.46</td>
<td>1.71</td>
<td>1.09</td>
</tr>
<tr>
<td>of which</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shipper</td>
<td></td>
<td>0.81</td>
<td>0.49</td>
<td>0.27</td>
</tr>
<tr>
<td>Carrier</td>
<td></td>
<td>0.11</td>
<td>0.13</td>
<td>0.10</td>
</tr>
<tr>
<td>Cargo Insurer</td>
<td></td>
<td>1.38</td>
<td>0.88</td>
<td>0.54</td>
</tr>
<tr>
<td>Carrier Insurer</td>
<td></td>
<td>0.17</td>
<td>0.21</td>
<td>0.17</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>6.29</td>
<td>3.88</td>
<td>2.42</td>
</tr>
</tbody>
</table>


As it is possible to understand friction costs due to failures of the liability system represent a minor cost in the transportation operations, ranging from 2.42 percent on extra-European journeys until 6.29 percentage on national journeys. Even cargo insurance, a common solution and extra cost that nowadays customers use to reduce the uncertainty inherent to intermodal transportation\textsuperscript{31}, does not represent a major percentage on final costs. Therefore, following these figures, the costs arising from the current situation are non-

\textsuperscript{30} COM(97)243

\textsuperscript{31} Insurance is also widely used on unimodal transportation. Insurance is used not only to cover any eventual problem as well as to cover the actual value of goods, since some international conventions have low limits of liability. Furthermore, insurance represents a minor costs in total transportation costs.
relevant, and, so, the current liability system, although imperfect and fragmented, does not introduce major costs.

However, it should be notice that regarding friction costs as merely a percentage of goods value may be a misconception since the real costs arising from loss, damage or delay, may be felt in many other activities of the manufacturing companies. Just an example, factories employing Just in Time techniques can stop if cargo delays in arriving just some hours. And the close down of an entire production line provokes immensely higher costs than the value of the delayed cargo. Being so, the friction costs introduced by the current liability system into the intermodal operations, most likely represent major sums and, therefore, should not be ignored, as they can lead to the abandonment of this type of solution.

3.5.4 Summary
Reflecting the long historic tradition of unimodal based transportation, the liability regimes have been developed on the same base. As a result, multiple liability systems, each one mandatory for a certain mode of transportations, have been designed. Furthermore, regimes with different precedence co-exist nowadays, namely, international conventions, national laws and standard term contracts. This situation is the outcome of the result of how liability regimes have been defined. In a first phase they have been developed at a national basis and later in face of the growing importance of international transportation countries have developed international regimes. Recently, with new needs and conditions, stakeholders have defined standard contracts.

Being so, nowadays the liability system consists of a maze of unimodal based liability regimes.

This situation poses substantial problems in case of intermodal transportation, as they do not correctly cope with the specificities of this kind of transportation. Some attempts to introduce a harmonised regulatory framework have been done, yet all have failed. Therefore, nowadays, stakeholders are obliged to sign multiple modal-based contracts with all stakeholders, which naturally leads to a sub-optimal solution. As a result, nowadays, the legal system used in intermodal transportation is fragmented, complex and uncertain, introducing substantial costs. These costs albeit representing a minor percentage of transportation total costs, can introduce relevant costs at other levels of (manufacturing) companies. Being so, the need of a uniform and harmonised liability regime for intermodal
transportation is real and may lead to an important increase in the competitiveness of this kind of transportation.

### 3.6 Regulatory Environment

The transportation sector has always been at the cornerstone of countries’ development. On the one hand, transports are the lubricant of a country’s economic system by enabling and promoting both people and goods mobility; on the other hand, transportation has since its earlier developments played an important social, in special in large countries, by easing the central government’s task of promote and keep the national cohesion. Moreover, transports are the central key in every country defence, not only by a mean as itself (like for example war ships or war aircrafts) but also by facilitating the fast movement of troops.

Therefore, it is somehow natural that multiple countries always kept and continuing to keep a close control over their national transportation systems. Even in more liberal regions, like in the United States or in the European Union, there are still relevant restrictions (for example, the international aviation sector continues to be heavily regulated is most countries). The regulation is evident at various levels, for example: admission to the occupation, access to the market, technical regulation, social legislation, pricing policy, or aid and competitive policy. Naturally, that within such controlled and restricted environment diverse segments of the transportation sector began to present clear signs of stagnation, rather poor financial results, and needing heavy subsidies to maintain activities (for example, the air and railway transportation are chronic segments that survive only with state aid). The poor situation of the transportation system has reached an extreme situation and some governments understood that the transportation sector might have been jeopardising the country’s development. As a consequence, some (notably, the United States) engaged in liberalising its national transportation system.

In the European Union, when several countries engaged in the European construction have decided to create a single, free, liberalised region in which people, goods and capital could move freely free of governmental regulation barriers. However, by that time, each European country presented its own regulations often distinct from neighbour countries, which were important sources of market distortion simply because a country’s regulation could be far less restrictive than others (for example, in what concerns taxation, environmental restrictions, labour conditions, etc.). This means a company could have had
a better performance than others not because it was better but due the regulatory framework. Naturally, this situation went against the principles of underlying the European constructions - free and open market - and there has been a continuous effort to bring into line the member states’ regulation with European ruling. As a result in the last decades a wide diversity of directives and regulations relating to transport (by road, rail, inland waterway, sea and air) have been dictated aiming the harmonisation of European practice. However, due to both the member states’ perception about their national transportation system and the relevant of some segments, the liberalisation process and not been neither even nor complete with the various segments presenting nowadays different levels of liberalisation.

The goals of this chapter are to describe the current regulatory framework of each mode of transportation (road, air, rail, sea and inland), and provide a brief explanation of the past or on-going liberalisation process. The structure of the rest of the chapter is as follows: next section reviews the most relevant acts concerning the European Common Transport Policy, then for each mode of transportation: road, air, rail, sea and inland, a short description of the initial regulatory environment and the major liberalisation steps is presented, along with a detailed description of several regulatory issues of the current regulatory framework: admission to the occupation, access to the market, competition rules, pricing policy, and technical and social regulation.

3.6.1 The European Common Transport Policy

The European construction has started almost fifty years ago, when in 1957 six countries signed the Treaty of Rome establishing the foundations of the European Community. The Treaty envisaged free mobility of people, goods and capital within Europe Union, however, for more than thirty years, the transportation sector was kept apart and only in the late 1980s market was released from those governmental regulation bounds. Ending the governmental market distortions, market has been developing towards a competitive open system, enjoying from its inherent welfares.

The Treaty represents the beginning of the European Community instituting the rules for a Common Market, and Economic and Monetary Union. Moreover, the freedoms foreseen in the Treaty called for the elimination of all protective barriers and obstacles. In its context, all regulatory distortions should also be removed. The importance of transportation, for
European Community development and cohesion, was foreseen in the Treaty. The European transportation policies were defined from articles 70 to 80 under the Title V - “Transportation” in Part Three - “Community Policies”, establishing the European Common Transportation Policy. Article 70 binds member states to follow a common transport policy - “the objectives of this Treaty shall, in matters governed by this title, be pursued by Member States within the framework of a Common Transportation Policy”, and Article 71 lays down the principles of free competition, non-discrimination and free movement of goods and services across the border of member states. Later, in the Maastricht Treaty, the emphasis is on the removal of discrimination arising from differential tariffs on moving freight originating in different countries (Article 75). Moreover, all national freight transport regulations which are aimed at protecting national companies are forbidden under Article 76.

Under the Treaty’s philosophy, the existing system of transportation regulation was unsustainable, as the current system of regulation was anti-competitive and in opposition with the competitive spirit of the Treaty, furthermore, market access or price fixing restrictions were against the idea of freedom to supply services. The European Commission was charged with the implementation of the Treaty. However, at the outset, the mission was quite complicated as the forces favoured the existing regulatory system. Three main reasons can be pointed out. First, transports have had a different position, under the Treaty, than the other services. Title V (Articles 71 and 80) relinquishes to the Council of the European Union the decision to rule and to legislate about the Common Transportation Policy. Second, the air and maritime transportation were not initially included in the Common Transportation Policy (Article 80). Third, countries and companies were also favourable to the existing system and the status quo. The reasons for this included that: the incumbent firms were operating under little economic risk because of the limited access to the market, transaction and information costs were low because of the fixed tariff system, and under the umbrella of regulation there was some flexibility to compete by providing better services (for example, transport related services that fell outside the regulations). These features have reduced the European Commission’s authority and albeit all initiatives the market has remained heavily regulated for more several years. Changes have arrived slowly and in different ways.
In face of a continuous absence of change in the European policies, some countries have engaged in liberalise their own domestic markets and promote (bilateral) agreements with other member states. For example: at air transportation level, the United Kingdom was the most active one, and from 1984 until 1987 has relaxed its bilateral agreements with the Netherlands, Luxemburg, France, Belgium, and Federal Republic of Germany; at road transportation, again the United Kingdom, in 1968 with the Transport Act introduced a fair liberalised system in what concerns licensing; or at inland navigation, due to the importance of the Rhine river, the neighbour countries have always been engaged in the promotion of liberalised services.

A very important change occurred in 1979, when for the first time the European Parliament was directly elected rather than being representatives of national parliament. This has enhanced its authority and soon it has put forward a far reaching draft Treaty of Europe Union. This has led to an intergovernmental conference and although, member states have not entirely agreed with Parliament’s proposal, they have recognize the importance of an open and closer economic union (Button et al., 2002).

The European Court of Justice has also taken an important role in the change of the European transportation policy. In 1974, with the French Merchant Seamen case declaring that rules governing competition in the Rome Treaty should be applied to transports. On 2 May 1985 the European Court of Justice decided in favour of the European Parliament (that decided in 1983 to take the European Council of Ministers to the European Court of Justice over the absence of action to implement the transport policies in the Rome Treaty), stating that the Treaty provisions concerning the single market formation (free movement of people, goods, capital ad services which would be free of discrimination and national protectionism policy) were also applicable to the transport sector despite difficulties with national regulations and the complex relationships between the states and their companies. And in 1986, with the Nouvelles Frontieres declaring that national rules should be in conformity with the European laws. Its deliberations, against the Council and the existing regulatory system, have strengthened the voice of the European Commission. Although the European Court of Justice did not fix a timetable for the completion of the single market, the member states set a clear deadline of 1 January 1993 at there summit meeting on 30 June 1985 in Milan. The official compromise was done in 1987, when the European Single Act entered into forced in which the member states engaged in establish until 31 December
1992 the European Internal Market. Other important step was done in 1985 by the European Commission that brought forward the White Book about the European Internal Market. The main goal was the creation until 31 December 1992 of a truly European Internal Market. The final step occurred in 1992 with the sign of the Treaty of Maastricht implementing the European Community. The Treaty devotes a special attention to the transportation sector (articles 70º to 80º), which was another major contributor for the liberalisation of the transportation sector.

Before the fully establishment of an uniform and truly open market, the conditions of competition among transport modes or among transport companies of different members states had to be harmonised, in order to avoid major distresses in the transportation and other markets. Therefore, besides the decision of the creation of a free market without quantity restrictions by the end of 1992, the Council of Transport Ministers decided on 14 November 1985 to define a step-by-step adjustment of bilateral quotas to minimise national discrimination and an extension of a common international quota, and to reduce the existing distortions in the transport market aiming the promotion of Europe wide competition. The harmonisation took different steps and procedures concerning the mode of transport, since each one had a different regulatory framework. As a result, the evolution and pace of liberalisation has been different for each mode, for example, road transportation was the first mode to be fully liberalised, while rail transportation is still in process of liberalisation. Table 2 presents the main legislative acts and current status, for different regulatory issues.

3.6.2 Road Transportation

At the very beginning of the last century road haulage, as any other means of transportation, was regulated in most European countries (few of them, like the United Kingdom, had already more liberal approach). The official reasons pointed out for regulation were the need to stabilise the market (prevent an uncontrolled competition from other modes, particularly, road) and control the undesired effects of free competition; however, the main actual reason was related with the protection of the railways. In those times, the railways were a rather important and profitable sector (contributing considerably to financing the public budget), and any competition especially from road haulage could put at stake that advantage. Although the regulatory frameworks varied among the European countries, there were many common features, for example, they usually fixed
tariffs and set quantity restrictions for market entry (licenses), set quality requirements (capital, reputation - proof of professional competence for entrepreneurs), set working conditions (driving time) and imposed standard for vehicles and operations (weights, measures, speeds, access). After the World War II, the road freight transport undergone major expansions (with the unemployment rates were very high and with an oversupply of old war trucks, people found very easy to start their own transportation company). It were distressful times with fierce competition, frequent bankruptcies, unreliable service, road damage, accidents, disturbance to residents, and drop in tariffs with a consequent crowding out of the railways.

The first relevant step towards liberalisation was done in 1968 when the European Council decided to introduce a batch of community authorisations, which allowed the operator to engage in cross border road haulage operations between any member state in the European Union. The first set of authorisations comprised 1200 for the six member states. The number of community authorisations grew very slow over the years and twenty years later, in 1988, there were 17153 authorisations for the twelve member states. So, for almost two decades the regulatory framework of the international road haulage remained practically unchanged. New and relevant decisions were only taken after the initial stimulus given by the European Court of Justice in 1985. Some of the most important measures were: harmonisation of maximum weight and axle loads, agreement on upper and lower limits for fuel taxation, abolishment of obligatory tariffs for national transport, an increase in European Union haulage licences, easier access to the road freight transport market through an increase in the number of licences awarded and less severe qualifications for entrepreneurs, and agreement on extending quotas for permission of cabotage in road freight transport and free cabotage in the year 1998.

Admission to the occupation

The rules concerning the admission to the occupation were first laid down in the Council Regulation 74/561/EEC and mostly recently amended by Council Regulations 96/26/EC and 98/76/EC. Nowadays, activity is open to all companies and people (which effectively run the company) that comply with the three following criteria: to be honourable, to have appropriate financial standing, and to have necessary professional competence. It is the member states that define the conditions companies must fulfil to be considered
honourable, nevertheless, it usually entails the person who manages the transport operations has not been convicted of serious, repeated or recent criminal offences, being necessary a certificate of good conduct not older than three months. Furthermore, authorisations can be withdrawn if convictions or repeated offences related to transport operations are done. The professional capacity is proved by means of an official certificate. This certificate is strictly personal; it is issued to a natural person and is only valid within a single undertaking. Finally, the financial standing is met if the company has available capital and reserves as defined by the regulation.

The fulfilment of those criteria entitles the company with a Community licence, indicating that it is in conditions to be a road haulier. Finally, it is foreseen the mutual recognition of diplomas, certificates and other qualifications: member states must accept as sufficient proof the certificates and documents issued by another member state certifying that these conditions are satisfied.

Access to the market

Aiming to fully liberalise market the international market (international carriage of goods by road for hire or reward for journeys carried out within the territory of the community) by 1 January 1993, the European Council has decided to increase the number of authorisations by a rate of forty per cent per year, as a result, in the year 1992 there were 67259 authorisation which made regulation rather non relevant. As scheduled, from 1993 onwards, market access is ruled just by qualitative criteria defined in the Council Regulation 881/92 amended by the Council Regulation 484/2002 that have to be met by haulage and applicants for a Community road haulier licence.

Cabotage operations (transportation of goods by non resident carriers in the national market), which were not fully liberalised by 1 January 1993, were nonetheless allowed under restricted conditions. The Council Regulation 4059/89 introduced, for the first time, a batch of 15000 community cabotage permission valid as from 1 July 1990 (these authorisations were valid for a period of two months). Meanwhile, the European Council has decided to fully liberalise the cabotage operations until 1 July 1998 (Council Regulation 3118/93 amended by Council Regulation 3315/93). To cover the period in between, the Council decided to raise the number of permissions up to 30000 and to define an interim rule which laid down the community authorisations be increased by a rate of
thirty per cent per year. From 1 July 1998 onwards market was fully liberalised and any quantitative restrictions (quota) was abolished, being only necessary road hauliers to own a valid licence to access to the market. Furthermore, only those community carriers authorised to operate international road haulage services are allowed to operate domestic haulage services in other member state. Finally, cabotage operation are subjected to both community laws and member state laws, regulation and administrative provision in the following areas: the prices and conditions governing the transport contract, weight and dimensions, requirements relating to the carriage of certain categories of goods, driving and rest time for drivers and VAT on transport services. In any case, the host member state must, when applying its national provisions, should take into account the principle of proportionality.

In what concerns the carriage of goods between member states and third countries, two situations may arise. First, if the countries belong to the European Economic Area (EEA), market access is free, since the rules in force within European Union are still valid within EEA. Second, if the third country is outside EEA than carriage of goods is provisional upon extra community authorisations, namely the bilateral authorisations and the European Conference of Ministries of Transportation (ECMT) authorisations. Commonly, the bilateral authorisations cover bilateral carriage, transit carriage or a combination of the two countries. These bilateral agreements are done at EEA level, which means that any EEA company is allowed to carry goods between any EEA country and a third country, where a bilateral agreement exists with the third country in question. The ECMT authorisations allow the company to engage international transportation between the thirty eight ECMT countries to the exclusion of domestic transportation.

*Competition Rules*

The road haulage sector is totally under the scope of the European competition rules, with no exemptions.

*Pricing Policies*

The regulatory framework has imposed for many years a system of reference tariffs. This system reserved the right, via bilateral agreement, to fix marginal tariffs which were compulsory within certain limits (fifteen per cent either way). The idea behind was to achieve greater transparency in the market. The European Council Regulation
4058/89/EEC brought an end to the compulsory system, and as from 1 January 1990 prices are freely established between actors of any transportation contract.

**Technical and Social Regulation**

In road haulage sector there is also community regulation concerning social and technical harmonisation. Since, the establishment of a common integrated transport market is only feasible if all parties are subjected to the same rules. The Council Regulation 3829/85 on the harmonisation of certain social legislation relating to road transport (it applies to all crew members of vehicles engaged in passenger or goods transport), defines among other things the minimum age for drivers of vehicles and make provisions regarding driving time and rest time. In what concerns technical harmonisation, there has been for many years an effort to end with the traditional different standard requirements between member states and to establish a uniform regulatory framework, since, the existence of different technical legislation hinders the free flow of vehicles across European Union. Technical harmonisation applies to four chief areas: dimensions of vehicles and maximum authorised weights of vehicles (Council Regulation 96/53), environmental norms and safety norms.

**Own Account Transportation**

In the road haulage a significant proportion of operations is still in the hands of own account operators. To be considered own-account transportation the following conditions must be met: goods transported must belong to the company, or have bought or sold, rented or leased out, processed or repaired by the company; the purpose of the transportation should be to carry goods to and from the company, or to move goods outside for the company’s benefit; vehicles have to belong to the company or have been purchased on the credit by the company; drivers must be company’s employees; and transportation must only be a secondary activity within the overall activities if the firm. Naturally, the rest of the market is taken by the professional companies, which concern all regulation presented above.

On the other hand, the own-account transportation is free from regulation (there is not need an operator’s licence, there is free access to market and there is no price regulation). Yet, naturally, any vehicle must fulfil the technical requirements and comply with all traffic and safety regulations.
3.6.3 Air Transportation

The first air cargo services, at the beginning of the twentieth century, were mainly for the carriage of mail. As they were initially unprofitable, governments had to support them through direct subsides.

Furthermore, the rise and development of the air transportation industry has changed many of the social, political and economic aspects of human activities by providing people and goods a superior mobility. As a consequence, soon, most of the air transportation services became heavy regulated, with most services severely restricted and bounded - air transportation was considered public utility. Regulation was always seen as the most suitable framework to serve both state interests (for example, increase and expand national economy, promote exportation of aviation services, or grant status and market presence) and public interests (for example, maintain market stability and safety standards, protect population from market failures, provide a comprehensive network of services). So, most of the national aviation market have become sooner or later regulated.

As regards the international market, an attempt to establish a relaxed and open regime was made at the 1944 Chicago Convention, where fifty two countries gathered to debate three main topics: air traffic rights, control of fares, and control of capacity. The participants were hoping to reach a multilateral agreement, however, negotiations failed and there was no consensus. Nonetheless, some improvements concerning standardization and regulation of international services were achieved. Firstly, a set of rights and permissions called “Freedoms of the Skies” was developed, with all participants granting automatically the first and second freedom rights. These freedoms have been the basis for all subsequent agreements. Secondly, two international organizations were created: ICAO - International Civil Aviation Organization, under auspices of the United Nations, and IATA - International Air Transportation Association. ICAO is an intergovernmental agency mainly concerned with the improvement of the civil aviation industry and unification of the air transportation market worldwide. IATA is a much more technical organization concerned with the practical issues of the civil aviation industry.

After the Chicago Convention, countries have developed a complex web of bilateral agreements that have been ruling all (international) market operations (both passengers and goods). These agreements were ratified at governmental level under the auspices of IATA.
Thus, although the exact terms varied considerably, they usually had similar formats: usually, only one public or national private company could operate on routes previously defined and on a point-to-point basis; capacities and flight frequencies were established at governmental level, and fares were agreed at IATA conferences (but governments had the final decision); furthermore, pooling of revenues was a common situation (for instance, if one company had 60 per cent of revenues, it was forced to share 10 per cent with the other).

For more than thirty years, the civil aviation market has evolved within such regulated environment. Market stagnation has been the outcome, with many companies depending on subsidies to survive.

The United States were the first country to fully deregulate their national market, in 1977 with the passage of the Domestic All cargo deregulation state. In other regions of the World, countries have been following the United States’ model and have been opening their domestic and international markets - Canada, Australia and New Zealand are a few examples of this. Yet, the most relevant development concerning civil aviation market rules has occurred in Europe, when in late 1980s the European Union members have agreed to open their national markets to other member states’ companies. The move towards the establishment of the single market, the so called Liberalisation process, was carried out in three phases between 1988 and 1997; in each phase a set of legislative measures - Liberalisation Package - was implemented gradually removing the former restrictions and implementing uniform rules across European Union. Nowadays, with the growing importance of freer trade and globalisation, the bilateral structure of air services agreements has been eroded, nonetheless, a large legacy remains and many services are still strictly regulated.

In what concerns European Union, the Liberalisation process was taken in 3 main phases. In each one, a set or “Package” of legislative rules were defined aiming the establishment of a free and competitive market. The First Package was introduced in 1988, the Second Package in 1990 and the Third Package in 1993, with a transition period until 1 April 1997.

The First Package has introduced only minor changes with limited scope into the European air transportation market, leaving the rigid bilateral framework almost intact. It was
introduced a (rather restricted) automatically approval fares system and market access rules have been slightly revised introducing some freedom. Furthermore, only the international market has been subjected to changes. Nevertheless, important achievements were succeeded: first, the (international) air transportation industry was brought under the European Union competition rules, enabling, for the first time, the Commission to apply antitrust policies directly to the airline services (yet, in this first phase many relevant exemption remained); second, it was established the notion of Community air carrier - only the Community carriers are allowed to use the freedoms and rights of the Liberalisation process. By having introduced, for the first time, the competition spirit envisaged in the Treaty of Rome, this Package has represented a major breakthrough for European civil aviation business.

The Second Package has revealed to be a simply extension of the First Package since, basically, it relaxed the previously adopted measures not introducing new ones. Nevertheless, the existing framework was further more relaxed with companies being able to enjoy from a less restrictive environment.

The final step was given with the Third Package that defines and establishes the regulatory framework in force nowadays within the European Union area. European regulation has been extended into member states’ national markets and an uniform and (almost) liberalised market has been implemented.

*Admission to the occupation*

Council Regulation 2407/92/EEC stipulates the current necessary requirements companies have to fulfil to be allowed to engage in commercial activities. Those requirements are solely qualitative: first, company’s principal place of business and, if any, registered office have to be located in that Member State; second, company’s main occupation have to be air transport in isolation or combined with any other commercial operation of aircraft or repair and maintenance of aircraft; third, company must be owned either by a member state or member state national; and, forth, company must prove their financial and technical ability. Proved these requirements, the company may apply for the Air Operator’s Certificate, which specifies the activities covered by the operating licence and complies with the criteria established in the Council Regulation.
Access to the market

As laid down on Council Regulation 2408/92/EEC, access to the international and national European Union market also became completely free to all companies owning a valid Air Operate Certificate, as of 1 January 1993. However, until 31 March 1997, cabotage operations were restricted up to fifty per cent of the capacity and as an extension (or as a preliminary) of a service from (or to) the state of registration, and member states could regulate access to routes. From 1 April 1997 onwards all cabotage restrictions ended, and with it the last market access restriction. This means that, nowadays, any community air carrier may exercise traffic rights between airports or airport systems within the Community where these are open to civil air services.

Although, regulation defining a free and transparent regulatory framework, member states still have some control (albeit indirect) on market access.

In what concerns transportation of goods between European Union members and third countries no common European regulation exists. This means that outbound European Union traffic is still regulated by bilateral agreements between member state and the third country, for example, environmental restrictions and traffic distribution rules have been introduced, with most of the power of decision remaining on member states’ hands.

Competition Rules

The various Liberalisation Packages have successively brought the commercial air transportation under the European competition rules, yet, not all exemptions have been banned and nowadays this sector enjoys some immunity. Council Regulation 2410/92/EEC and 2411/92/EEC laid down the types of agreements and moves that have been exempted from the scope of the European Union competition rules. They are: joint planning and coordination of airline schedules, consultation on tariffs, joint operations on new less busy routes, slot allocation at airports and airport scheduling and common computer reservation systems. These exemptions are mainly concerned with passenger transportation; however, a relevant part of good transportation is done on mixed flights (in plane’s belly), therefore, these exemption have a major influence on cargo market.
Pricing Policies

Council Regulation 2409/92/EEC states the end of any form of regulation concerning pricing formation and defines an open free market as of 1 January 1993. Prices are nowadays defined directly and freely between the actors involved in the operations.

Technical and Social Regulation

Concerning social regulation, there is no common rules within Europe. Each member state defines its own rules and norms. The same occurs with the technical regulation, however, in this case the aviation sector has an history of high security standards. ICAO (created in the 1944 Chicago convention) has the mission to define the standard patterns companies must fulfil, and despite not being compulsory the majority of countries follow its directives. Therefore, the need of common European technical regulation is somewhat reduced by the existence of an international body with that mission.

3.6.4 Rail Transportation

The railway transportation has a long tradition of public regulation. Across Europe, usually there was a large single company operating on a country wide level (commonly founded still in the nineteenth century) and responsible for both infrastructure and service provision. This situation was related essentially to question of the economic reasons (the railways infrastructure are a natural monopoly and, so, there was no reasons for more than one company) and social questions (in those times rail was the only mass transportation means and naturally had to provide a universal social service, which is naturally a governmental obligation). Albeit each country has defined its regulatory framework, regardless other countries, usually, the access to market was allowed only to a single company: the stated owned company and all tariffs and service levels were defined by the government. The official reasons pointed out for railways regulation were the need to stabilise the market (prevent an uncontrolled competition from other modes, particularly, road) and control the undesired effects of free competition; while the unofficial (yet, actual) reason was to protect the railway companies from competition and preserve their ability to transfer profits to the public budget (after all, most of them operated profitably).

The tight regulatory framework has remained essentially unchanged for several decades. Some countries, nevertheless, had meanwhile adopted a more liberal approach, like the UK, in which the railway companies were commonly private but subjected to heavy
governmental regulation. With the economic and social environmental deterioration in the aftermath of World War II, countries kept a heavy control over railways, and even in some liberal countries have strengthened their control, for example, in the UK there were several nationalisations and the railways become state-owned.

The existent regulatory was directly against the freedom envisaged with the European construction and, naturally, the European Commission has been taking diverse actions to bring the railways regulatory framework into line with the European Union principles. However, given the very low railway undertakings’ willingness to change the current status quo and introduce a liberalised market, the highly complex and unknown organisation of railway operations and services, and, as a consequence, the very low pace of change, the liberalisation process of the railways is still on-going.

The first attempts were given at more than thirty years, when the European Commission has issued directives aimed at adapting the Community’s railways to the basic principles of European transport policy. A set of regulation were laid down in 1969 and 1970 aiming to define the conditions and procedures for financial compensation payments to railways undertakings (Council Directives 1191/69, 1192/69 and 1107/70).

Yet, the first truly step was done by Council Directive 91/440 (amended by Council Directives 95/18/EC and 95/19/EC) on the accounting separation between infrastructure and operations. This directive comprised some basic requirements for bringing the railway sector into the line with the needs of the Single Market and, ultimately, making it more competitive and market oriented. There were four main goals: to ensure the management independence of railway undertakings; to separate the management of railway operation and infrastructure from the provision of railway transport services (separation of accounts was compulsory, while, organizational or institutional separation was optional); to relieve railways of old debt and establishing a commercially viable platform aiming to introduce a commercial spirit in the operation businesses; and to ensure access to the networks of Member states for international groupings of railway undertakings and for railway undertakings engaged in the international combined transport of goods. Although the opened up of the railway networks to foreign companies engaged in freight transport, only a part of the European Union has been made accessible: the so-called Trans-European Rail Freight Network that comprised 50% of EU railway networks and 80% of traffic.
Moreover, the Directive indicated member states should adopt the laws, regulations and administrative provisions necessary to comply with this Directive not later than 1 January 1993. However, the rate of transposition into national laws was rather low (in 1996 only nine had fully transposed, five had partially transposed, and one had not notified any national changes) and, as a consequence, only in 2001 has been possible to lay down a new set of Directives.


This package, once again, only refers to rail freight and was brought forward with five key objectives: to encourage the development of the rail freight market through enhanced access to a wide range of freight commercial and operational facilities; to fully separate railway from the state, by becoming commercial operations with transparent finances; to finalise the separation between infrastructure and the operation of passenger and freight services; to regulate the infrastructure operations in order to avoid base of its natural monopoly and to make it easier for new entrants to enter the market; and to define a qualitative framework for market access. The Council Directive 2001/12/EC, first, stipulates a clear and total separation and independence between the management bodies for the infrastructure and the railway undertakings and, second, extends the access to all undertakings to the Trans-European Rail Freight Network as defined in Council Directive 91/440/EEC.Council Directive 2001/13/EC lays down that each member state shall designate the body responsible for issuing licences and carrying out the obligations imposed by this Directive and that the task of issuing the licences shall be carried out by a body which does not provide rail transport services itself and is independent of bodies and undertakings that do so. Finally, Council Directive 2001/14 on the allocation of railway infrastructure capacity and the levying of charges for the use of railway infrastructure capacity and the levying of charges for the use of railway infrastructure and safety certification. Furthermore, a number of technical directives had been added so as to


With this package four main goals are expected to be achieved: the completion of the internal market in rail freight services; the development of a common approach to rail safety regulation across the European Union, an improvement of the fundamental principles of interoperability; and to set up an effective centre of expertise - the European Rail Agency - to advise European Commission and member states on railway technical issues.

The Council Directive 2004/49/EC is based in five main vectors, which together are expected to contribute for the accomplishment of the main goal, that is, to ensure the development and improvement of safety on the Community's railways, and improve the access to the market for rail transport services. The vectors are, first, the harmonisation of the regulatory structure in the Member States; second, the definition of the responsibilities between the actors; third, the development of common safety targets and common safety methods with a view to greater harmonisation of national rules; fourth, the establishment, in every Member State, of a safety authority and an accident and incident investigating body; and, fifth, the definition of establishment, in every Member State, of a safety authority and an accident and incident investigating body. It is expected that member states transpose this directive into their national laws until 30 April 2006.

The Council Directive 2004/50/EC intends to establish the conditions to be met to achieve interoperability within Community territory of the trans-European high-speed rail system, aiming a substantial increase of the interoperability of the trans-European high-speed rail
system. Furthermore, it is expected an improvement and development of international rail transport services within Community territory and with third countries, which, ultimately, would contribute to the gradual creation of the internal market in equipment and services for the construction, operation, renewal and upgrading of the trans-European high-speed rail system. It is expected that member states transpose this directive into their national laws until 30 April 2006.

Council Directive 2004/51/EC stipulates that international groupings shall be granted access and transit rights to the Trans European Rail Freight Network (as defined by European Regulation 91/440/EEC), in both the member states of origins and all member states of transit. Furthermore, it is laid down that as from 1 January 2006 access should be granted to the entire rail network, for the purpose of operating international freight services; and that as from 1 January 2007 freight cabotage operations should be allowed.

Moreover, this directive stipulates that price of infrastructure utilisation should be agreed between the railway undertaking and the infrastructure managers on the basis of public or private law, and, that the conditions governing such agreements should be non-discriminatory and transparent, in conformity with the provisions of Council Directive 2001/14/EC. It is expected that member states transpose this directive into their national laws until 31 December 2005.

Being so, currently member states should be finalising the transposition of the first package and be preparing for the second, particularly in what concerns the Council Directive 2004/51/EC, which means that international freight in the Trans European Rail Freight Network should be free to all companies (that fulfil the states requirements) with an expected increase of the competitive levels. But, because member states are free to transpose the directives into their national laws and some may have important delays in the transposition process, that picture may show a wide range of variability across European Union.

Finally, the European Commission brought forward in March 2004 a new set of proposals for a new railway package: the Third, focusing mainly on the passenger segment (as the freight will be highly liberalised from 2007 onwards). The Commission is proposing the opening up of the market for international passenger services in 2010. Other proposals
include the harmonisation of train drivers' licenses, the inclusion of passenger rights requirements and freight service quality.

3.6.5 Sea Transportation

Admission to the occupation

There is not yet a common regulation concerning the admission to the occupation. Therefore, admission to the occupation depends on the member states’ national laws company is registered.

Access to the market

The access to the market is defined by the Council Directive 4055/86/EEC (amended by Council Regulation 3573/90/EEC) applying the principle of freedom to provide services to maritime transport between member states and between member states and third countries. From 1 January 1993 onwards any authorised member state shipping company (and non-Community shipping companies using ships registered in a member state and controlled by a member state nationals) is free to transport goods (and passengers) between any port of a member state and any port or off shore installation of another member state or of a non-community country. The cabotage maritime transport operations were also fully liberalised on 1 January 1993, as laid down by Council Regulation 3577/92/EEC.

In order to protect the European shippers against non-Community countries that unilaterally can take actions to restrict free access to the transport of cargo by European Union shipping companies (or ships registered in a member state), a Council Regulation (4058/86/EEC) was laid down, defining the coordinated actions the Community should follow to end with such abuses: diplomatic representation to the third countries concerned, in particular where their actions threaten to restrict access to trade, or counter-measures directed at the shipping company or companies of the third countries concerned or at the shipping company or companies of other countries which benefit from the action taken by the countries concerned, whether operating as a hometramer or as a cross-trader in Community trades.
**Competition Rules**

The maritime transport has a long tradition of exemption from the European competition rules. Only after the 1985 European Court of Justice’s decision, actual steps were given to bring the sea transport under the European Union competition rules.

The Council Regulation 4056/86/EEC laying down detailed rules for the application of the Articles 81 and 82 to maritime transport, was the first attempt. As of 1 July 1987 all international transport services done within European Union ports became subjected to the European competition rules. However, several exemptions were given: first, tramp vessel services (the transport of goods without a regular timetable where the freight rates are freely negotiated case by case in accordance with supply and demand); second, technical agreements whose sole object is to achieve technical improvements or cooperation; and third, restrictive practices engaged in by members of one or more liner conferences (a group of carriers who provide international liner services for the carriage of cargo within specified geographical limits and who agree to charge uniform or common freight rates and to apply any other agreed terms for the provision of liner services) as long as they seek to coordinate shipping timetables, determine the frequency of sailing, allocate sailings among members of the conference, fix rates and conditions of carriage, regulate carrying capacity, or allocate cargo or revenue among members.

On 1 May 2004, a second step was given with the Council Regulation 1/2003/EC, which amends Council Regulation 4056/86/EEC. This regulation strengthened the scope of the first regulation. Firstly, it ends with most of the existent exemptions, now only the tramp vessel services are outside the scope of the competition rules; despite, to continue concerning solely the international services within European Union. Secondly, reinforces the powers of the European Commission that now has the power to withdraw benefits of exemption whenever it finds that in any particular case an agreement, decision or concerted practice are incompatible with the competition rules. Thirdly, replaces the centralised system of prior notification by a directly applicable exception system: competition law is now enforced by any competition authority and the courts of the member states.

**Pricing policies**

With market liberalisation in 1993, actors engaged in the transportation services became free to agree about the prices. To prevent negative consequences from unfair pricing
practices engaged by third countries (an actual possibility due the relevance of non-Community trade), a regulation was defined (Council Regulation 4057/86/EEC) stipulating the procedures to be adopted by the European Commission to cope with such situations.

**Technical and Social regulations**

Due to the usual impact of maritime accidents and the European environmental concern, relevant efforts have been made aiming a harmonisation of the technical standards of all ships moving along the European coast. The efforts have been vast and in many areas, although the safety requirements have been receiving special concern. However, since most ships are non-Community, these efforts have been made difficult.

In what concerns, the social regulation some attempts have been made to harmonise the sea transportation market and bring into line the member states laws with the European view. The most relevant action have been the organisation of the seafarers’ working time (Council Directive 1999/63/EC), the seafarer training and recruitment (COM(2001) 188 final) and the organisation of hours of work on board ships using Community ships (Council Directive 1999/95/EC).

**3.6.6 Inland Transportation**

In north and central Europe, inland navigation has always played a rather relevant role, mainly along the Rhine river. This mode of transport was so important that in 1868 the neighbouring countries of the Rhine river signed the Mannheim Agreement liberalising the freight traffic. The agreement guaranteed free shipping and equal rights to all shipping companies of the signatory countries. Moreover, signatory countries agreed in defining uniform rules with regard to ship and navigation safety, establishing common judicial procedures for shipping and navigation in the Rhine courts, and defining the obligation on States to maintain and improve the Rhine. There were some restrictions concerning cabotage on canals in Germany, the Netherlands and France (that were only abolished in 1994); and on the waterways in Northern France/Benelux, freight was allocated according to the order of registered notifications and tariffs were fixed (that were only abolished in 2000). With the traffic on the Rhine river deregulated, governments could only intervene (to protect national companies) in form of subsidisation and infrastructure provision. Naturally, the various countries heavy subsidised their companies either in form of tax reductions or investment aids for new vessels and premiums for the demolition of old ones.
This subsidy driven business cycle resulted in over capacities and reduction of prices indicating market instability. Aiming to end with such situation, the European Commission took its first action concerning inland transportation and brought forward the Council Directive 70/1107/EEC which harmonised the subsidisation policy of the various member states.

In 1976, the Council Directive 76/135/EEC was laid down establishing a uniform framework within European Union concerning the navigability licences for inland waterway vessels. Six years late, in 1982, the Council Directive 82/714/EEC on the technical requirements for inland waterway vessels was defined. The directive divides European waterways into four zones. Moreover, all vessels must as from 1 July 1998 carry either the ‘Certificate issued pursuant to the revised convention for the navigation of the Rhine’ or the ‘European Community inland navigation certificate’. The Community certificate which is granted to any vessel that satisfies the conditions laid out in the directive, is valid for all European waterways with the exception of the Rhine (to navigate on the Rhine, the Rhine certificate is still required).

As a results of all these actions, when, some years later, the European Council decided to implement the single internal market, the inland transportation sector did not undergone major distresses; since, the most relevant market was fairly liberalised and a relevant body of European regulation already existed.

Admission to the occupation

Admission to the occupation of inland transport operator (national and international) is regulated by the Council Directive 87/540/EEC. The directive defines a number of conditions related to professional competence, good repute and financial standing that the operator has to fulfil in order to apply for a certificate. However, in case of national inland transportation, the member state may exempt inland transporters from European rules.

Moreover, member states are obliged to mutual recognition of diplomas, certificates and other evidence of formal qualifications in the activities of carrier of goods.

Access to the market

The admission to the market is laid down on the Council Regulation 1356/96/EC that states that any operator transporting goods or passengers by inland waterway is allowed to carry
out the transport operations (either between member states or in transit through them) provided that the operator, first, is established in a member state in accordance with the laws of that member state; second, is entitled in that member state to carry out the international transport of goods or passengers by inland waterway; third, is using for such transport operations inland waterways vessels which are registered in a member state or, in the absence of registration, possess a certificate of membership of a fleet of a member state; and, fourth, is satisfying the conditions laid down in Article 2 of Council Regulation 3921/91/EEC laying down the conditions under which non-resident carriers may transport goods or passengers by inland waterway within a Member State.

Additionally, the European Union adopted the Council Directive 96/75/EC stipulating the end of all exemptions until 1 January 2002, like those that existed in Northern France/Benelux.

**Competition Rules**

The inland transportation sector is completely under the scope of the European Union competition rules.

**Pricing Policies**

Nowadays, with the inland transportation market fully liberalised, pricing is freely defined between the various actors. It was the Council Directive 96/75/EC that stated that pricing in the national and international transport market by inland waterways in the Community had to be completely liberalised as from 1 January 2000.

**Technical and Social regulations**

Due to the long time importance of the inland transportation, common technical standards to be met on the Rhine river on an initial stage, and at the European level more recently have been defined; as a result, nowadays, there is strong regulation concerning the technical standards the European inland waterway shippers have to fulfil.

In what concerns social regulations, however, no common regulation within European Union does exist. Shippers are bounded at the member state’s national laws in which they are registered.
3.6.7 Summary

The following table summarises the current situation within European Union concerning the regulatory framework.

<table>
<thead>
<tr>
<th>Regulatory issues</th>
<th>Road</th>
<th>Inland</th>
<th>Maritime</th>
<th>Air</th>
<th>Rail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admission to the occupation</td>
<td>96/26/EC, 98/76/EC Based only on qualitative criteria</td>
<td>87/540/EEC</td>
<td>None</td>
<td>2407/92/EEC Based only on qualitative criteria</td>
<td>None</td>
</tr>
<tr>
<td>Competition Rules</td>
<td>Competition Rules (articles 81º and 82º Treaty of Maastricht)</td>
<td>Article 81º and 82º Treaty of Maastricht</td>
<td>4056/86/EEC</td>
<td>2410/92/EEC, 2411/92/EEC</td>
<td>None</td>
</tr>
<tr>
<td>Pricing</td>
<td>4058/89/EEC Directly between actors from 1 Jan 1990</td>
<td></td>
<td></td>
<td>2409/92/EEC Directly between actors from 1 Jan 1993</td>
<td>91/440/EEC, 2404/51/EC Directly arranged with the infrastructure supplier</td>
</tr>
</tbody>
</table>

Note: none - means that there are no harmonised regulations at European Level. Each member state has its own regulations.

3.2. Market

Transportation is present in all situations goods need to be conveyed between two different locations, both, during the productive process in which value is added, and during distribution of the final product. As transports are conducted with some type of vehicle, whenever a transport service is required, a mode of transportation or several combined modes have to be selected. This selection is the result of multiple factors, however, in function of both, the characteristics of the goods to be transported, and the characteristics of the various modes of transport (in particular reliability, speed, and costs), each mode of
transportation has competitive advantage for certain segment of products. And statistics do confirm the competitive advantage of a mode in some product segments.

Since intermodal transportation entails the conveyance of goods between different modes, the knowledge and understanding of the segments in which the various modes are more competitive is vital to assure a competitive transport.

Being so, the purpose of this chapter is to present a brief overview about the most relevant products transported by each mode of transport and the justification for that situation.

3.2.1. Road Transport

Road haulage is responsible for more than half of the total transport of goods within European Union. The high reliability and flexibility, combined with acceptable average speeds and costs, are the main underlying factors for its success.

Road transportation is nowadays a competitive industry in multiple segments of products. On the one hand, road haulage is highly reliable and flexible being able to successfully cope with both, customers’ demands (e.g. nowadays many companies manufactory work following stockless principles - Just in Time or Lean production - which impose strict demands - constant flow of goods and arrival within short windows time) and unexpected situations during transport (e.g. in case of heavy congestion or bad weather new paths can be chosen any time during the journey). On the other hand, despite the growing congestion in many roads of central Europe and the resting times imposed at both diver and vehicle, road haulage’s average speed fits into the demands of manufacturing companies. Moreover, costs of road operations are perfectly bearable by the manufacturing companies, in special, when transportation’s cost commonly represents a minor fraction in companies’ total costs. Therefore, road transportation fulfils the demands of most manufacturing and retail industries.

Furthermore, road transportation ensures the initial and final legs of all other modes (rail, sea, air and inland), as these modes can not provide a truly door-to-door service, which further enlarges the scope of goods road transportation is moving.

Finally, rail transport that is (at least potentially) the road transport’s direct competitor in the intra European transport is not being able to cope with nowadays demands, meaning the intra-European transportation market is served by road haulage.
As a result, road haulage transports a wide spectrum of goods; nonetheless, it is possible to identify several types of goods with special relevance for this mode of transport. The following figure presents the relative importance (in terms of tonnes kilometres) of 24 segments of products, as defined by the Eurostat, for road transportation conducted within European Union, for the year 2004.
4 ASSESSMENT OF INTERMODAL TRANSPORT CHAINS

The generalisation of intermodal transport solutions has become possible with transport market deregulation. This kind of transport refers to those transport solutions that use at least two modes of transport in a coordinated and integrated way. The underlying principle is that by making the best use of each mode, we can get a solution with better performance than using any mode in an isolated way. Since there are neither limitations to the maximum number of modes and types to use, nor restrictions on the arrangement of each mode within the transport chain, it is virtually possible to arrange an infinity number of combinations or, in other words, to define a solution that meets each customer or market segment’s needs.

The characteristics of an intermodal transport solution are drawn from the characteristics and influence of each participating mode of transport. The goal, as it is explained below, is to use each mode at the best of its capacities, so that, higher performance may be achieved than using each mode stand alone. Yet, when combining modes with different characteristics, there is always a lost of performance on some properties due to the influence of underperforming modes. Naturally, this influence should be minimised by keeping at minimum the influence of those lower performance modes. So, although in general the intermodal solution presents higher quality and lower costs when compared to each single-modal solution, when analysing single characteristics the single-modal solutions may surpass the intermodal one. For example, considering an intermodal solution combining air transport and road transport, the final transit time is always higher than using air transport alone (and lower than using road transport alone); yet, on the other hand, the costs are lower than using air transport alone (and higher that road transport alone).

When assembling an intermodal transport solution the service provider has total freedom in choosing the number of modes, the type of modes and the influence of each one. Therefore, knowing the market segment’s characteristics the service provider is able of building an intermodal solution that best fits into customers’ needs and demands. Consequently, the potential market for intermodal transport is vast, because the service provider can adapt the solution to any customer. The only market segments that may lay outside intermodal transport scope are the modal-based captive ones. A captive market segment is a market segment that due to its particular characteristics only fits into a single
mode of transport and cannot be profitably transport by any other solution; and, most of the
times, the service transport providers have developed dedicated transport solutions.
Examples include: maritime transport of petrochemical products between ports, or the
transport of cereals between railways terminals. Captive intermodal transport market
segments can identically be identified. For example, all intercontinental freight flows use
intermodal solutions: the intercontinental movements are done by air or maritime transport
and than the continental distribution is done mainly by road transport, also some very
valued freight is transported by rail or maritime and road, in order to decrease the transport
costs. Although the great potential of the intermodal transport solutions, in reality, there are
multiple barriers and problems (operational, legal, technological, etc) that hinder the
performance of this kind of solution reducing its potential.

4.1 Definition of intermodal transport

The association of two or more modes of transport along a transport chain is a mature and
regular practice in the freight transportation business (Lowe, 2005, pp 3; Slack, 2001, pp
141).

Several reasons may be pointed out for the utilisation of such transport solutions. Firstly,
the existence of obstacles of either natural (e.g.: mountains, rivers, oceans, etc.) or artificial
(e.g.: urban regions) nature that may hinder the utilization of certain modes of transport
and compel suppliers using others to complete the journey (e.g.: in presence of a river a
barge might be need to convey goods between banks). Secondly, the recent decades are
characterised by a growing environmental awareness notably within European Union
where sustainable development is nowadays at the foundation of its development
(COM(2001)264 final, pp 2). Meanwhile there was the consciousness that the excessive
utilisation of certain modes of transport (notably road and air transportation) may
jeopardise that goal because of their burden for the environment. Consequently, legal
restrictions at either European or member state level imposing conditioning the utilization
of certain modes of transport (commonly road and air transport) while favouring others
(commonly sea, inland and rail transportation). Such situation is guiding suppliers to the
utilization of configuration of transport services that involve several modes of transport
Thirdly, there are situations where the utilisation of transport chain is either the only economic viable solution or the most competitive one. Each mode of transport has certain inherent technological properties which make them the most suitable transport solution in certain situations (e.g. whenever time is of crucial importance, air transport is normally used), leading to the association of several modes of transport. Furthermore, the optimal combination of the technological properties of different modes of transport linked to flawless information flows may yield highly competitive transport solutions (e.g. the so-called freight integrators like FedEx or DHL combine more than one mode of transport to deliver added value transport solutions).

In the sixties, the competitiveness of this kind of transport solution has had a major leap with the introduction of the containers (De Wit, 1995, pp 4) and the concept of containerisation. For that moment onwards, goods were no longer handled but instead a container that carry them. Standardisation has resulted in significant time and cost reductions at the transhipment points (Slack, 2001, pp 147-149), which resulted in significant gains for the transport chains solutions.

Later on, in the seventies, new phenomena began sweeping the Globe leading to profound changes in the envelope of the freight transport market and consequently in this market as well. The emergency of Globalisation and other phenomena worldwide has led to major changes in the demand for freight transport services. Companies and enterprises have developed new supply chain management techniques (like for example: just in time or lean production) which not only resulted in a gradual increase of the quality standards for freight transport services, as has been resulting in longer and complex transport networks. The suppliers on the other hand are responding by bring into the market new transport solutions, many involving multiple modes of transport in different configurations. In parallel, there was a steady technological progress, which has overcome multiple operational incompatibilities between modes of transport, reducing costs and increasing interoperability, further increasing the appealing of the transport chain solutions. Summing up, transport chains are not only common as often are the most suitable transport solution on face of the existent restriction or demand patterns.
The co-existence of transport solutions that make use of more than one mode of transport following different levels of organisation has created the need of a taxonomy both for scientific and legal purposes. Throughout the years, various different definitions have been put forth in the international fora mainly by the international organisations, although the academia has been also involved in that task. Yet so far no consensus on a universal definition has been reached so far. Such situation may be ascribable to the fact that the research and interest about this kind of transport is still in its youth and there was not enough time and knowledge to develop a consensual definition (Bontekoning et al., 2004, pp 8). The point is that different authors tend to see the world through different lens leading them to write different definitions. As a result, a variety of concepts and definitions co-exist nowadays, some with different other with some overlapping. The most common terms to refer to a transport solution involving two or more modes of transport are multimodal transport, combined transport, intermodal transport and co-modality. Now the question that naturally arises is if these concepts refer to equal or similar transport solutions or de facto refer to different ones.

Looking firstly to the definitions proposed by the international organisations, one of the first attempts was done by the United Nations in 1980 on the United Nations Convention on International Multimodal Transport of Goods, where a definition on multi-modal transport was brought forward:

“international multi-modal is the carriage of goods by at least two different modes of transport on the basis of a multimodal transport contract from a place in one country at which the goods are taken in charge by the multimodal transport operator to a designated place for delivery in a different country”

This definition provides a broad definition of what is a multi-modal transport. First, it recognises the existence of a multi-modal operator that is legally responsible for providing services for international freight transport. Second, it has a legal dimension by considering the existence of a multimodal transport contract amongst the companies involved on the transport service. Third, it only considers international carriage.
Some years late, in 1998, the European Conference of Ministers of Transport (ECMT) proposed its own definition for multimodal transport (ECMT, 1998):

*Multi-modal transport is a carriage of goods by at least two different transport modes*

In comparison to the previous definition, this one only imposed the need of existing different modes of transport to be considered multimodal transport

The same organisation, in 1996, for combined transport:

*At the European level, combined transport has to be understood as an individual mode of transport which makes maximum use of the advantages of the various modes of land transport and short sea shipping, choosing those modes which are most suitable. Combined transport thus implies the organisation of intermodal door to door transport by transferring the goods from one mode of transport to another without changing the loading unit. To be more precise, combined transport is based on an Intermodal Transport Unit (ITU) in which the goods are transported from door to door by using the most adequate modes of transport:*

*the road for initial and terminal hauls only,*

*rail and/or inland waterways and/or short sea for the major part of the journey, the choice of modes depending on the itinerary, whereby the transfer between the different transport modes must be handled as efficiently as possible.*

*Combined transport therefore is an example for a rational network which combines the benefits of the various transport techniques and can be understood as a candidate for all evolutions or adaptations which help to improve the transport chain. Since combined transport is a means of shifting traffic off the road, it also helps to achieve the aim of sustainable mobility, as already pointed out in the White Paper on Transport issued by the European Union.*

This definition reflects the beginning of the political concern on the protection of the environment. Some comments may be drawn. First, it carries a significant political commitment on the promotion of sustainable development. As a result, the definition has some bias towards some modes of transport and ignores other ones (e.g. air transport is not

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considered which also reflect the environmental awareness). Second, it is oriented to the externalities produced by the transport service and not to the transport service itself. Third, it introduces the concept of intermodal transport unit (for example, container, swap body, semi-trailers, etc.) as the key to the development of this kind of transport, which is a relevant breakthrough. Forth, it introduces the term intermodal transport, but does not define it or provide any details about its nature. This term would be defined in the following year in 1997:

“intermodal transportation is the movement of goods (in one and the same loading unit or vehicle) by successive modes of transport without handling of the goods themselves when changing modes”

This definition assumes that intermodal transportation involves at least two modes of transport, and considers that goods are not directly handled during the journey. Instead, they are packaged within unit loads – intermodal transport unit, which are the objects handled (Janic et al., 2001, pp 471).

Also in 1997, the European Commission (EC) proposed its own definition for intermodal transport:

“intermodality is a characteristic of a transport system that allows at least two different modes to be used in an integrated manner in a door-to-door transport chain. In addition, intermodal transportation is a quality factor of the level of integration between different transport modes. In that respect more intermodality means more integration and complementarity between modes, which provides scope for a more efficient use of the transport system”

The definition represents a step forward on the concept of intermodal transport since it recognises the need of existing some sort of integration and coordination between modes of transport to consider a transport service as an intermodal one. In other words, the simple association of various modes of transport, without any integration level, should not be considered intermodal transport. Therefore, this definition adds a new dimension to the intermodal transport service by considering intermodality as a quality variable of the

33 COM(97) 243
integration level between modes of transport. A point in contrast with the definition from ECMT is that this one is absent in what concerns the way goods should be handled throughout the transport journey. Conversely, to the definition of ECMT clearly states the need of being within an intermodal loading unit.


*the efficient use of different modes on their own and in combination,*

This new concept places the emphasis on efficiency. As a matter of fact, the word *efficiency* is the only novelty comparing to the concept of multimodality. The explicit rationale is that the optimisation of the modes of transport and the chain organisation “will result in an optimal and sustainable utilisation of resources” (COM(2006)314 final, pp 4), promoting the ultimate goal of sustainable development in Europe.

In the body of literature, the emphasis has been placed on the concept of intermodality (Janic et al., 2001, Panayides, 2002, Zografos et al., 2004, Lowe, 2005, Slack, 2001, OECD, 2001, OECD, 2002, Bontekoning et al., 2004), although definitions for the other terms do exist (e.g. De Witt, 1995, pp 2, Lowe, 2005, pp 7 for multimodal transport, or Lowe, 2005, pp 7 for and combined transport). The following table presents some of those proposed definitions found by Bontekoning (Bontekoning et al., 2004) on their recent literature review concerning transport chain involving road and rail transport.

<table>
<thead>
<tr>
<th>Author (date)</th>
<th>Proposed definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jones et al. (2000)</td>
<td>The shipment of cargo and the movement of people involving more than one mode of transportation during a single, seamless journey;</td>
</tr>
<tr>
<td>Southworth and Peterson (2000)</td>
<td>Movement in which two or more different transportation modes are linked end-to-end in order to move freight and/or people from point to origin to point of destination;</td>
</tr>
</tbody>
</table>

34 Later, in 1998, the European Commission added the terms “interoperability” and “interconnectivity” to emphasise the integrated service in the scope door-to-door transport chains (Integrated Strategic Infrastructure Networks in Europe, EC DG VII, final report of the Action COST328, Luxemburg, pg. 111).
<table>
<thead>
<tr>
<th>Reference</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min (1991)</td>
<td>The movement of products from origin to destination using a mixture of various transportation modes such as air, ocean lines, barge, rail, and truck.</td>
</tr>
<tr>
<td>Van Schijndel and Dinwoodie (2000)</td>
<td>The movement of cargo from shipper to consignee using two or more different modes under a single rate, with through billing and through liability (Hayuth, 1987);</td>
</tr>
<tr>
<td>D’Este (1995)</td>
<td>A technical, legal, commercial, and management framework for moving goods door-to-door using more than one mode of transport;</td>
</tr>
<tr>
<td>TRB (1998)</td>
<td>The movement of goods in containers that can be moved on land by rail or truck and on water by ship or barge. In addition, intermodal freight usually is understood to include bulk commodity shipments that involve transfer and air freight (truck–air);</td>
</tr>
<tr>
<td>Ludvigsen (1999)</td>
<td>The movement of goods in the same load-carrying unit, which successively use several transport modes without handling of goods under transit.</td>
</tr>
<tr>
<td>Tsamboulas and Kapros (2000)</td>
<td>The movement of goods in one and the same loading unit or vehicle, which uses successively several modes of transport without handling the goods themselves in changing modes (European Commission, 1997).</td>
</tr>
<tr>
<td>Van Duin and Van Ham (1998)</td>
<td>The movement of goods in one and the same loading unit or vehicle, which uses successively several modes of transport without handling the goods themselves in changing modes (European Conference of Ministers of Transport, 1993).</td>
</tr>
<tr>
<td>Murphy and Daley (1998)</td>
<td>A container or other device which can be transferred from one vehicle or mode to another without the contents of said device being reloaded or disturbed (Jennings and Holcomb, 1996).</td>
</tr>
<tr>
<td>Newman and Yano (2000a,b)</td>
<td>The combination of modes, usually ship, truck or rail to transport freight.</td>
</tr>
<tr>
<td>Taylor and Jackson (2000)</td>
<td>The co-ordinated transport of goods in containers or trailers by a combination of truck and rail, with or without an ocean-going link (Muller, 1995).</td>
</tr>
<tr>
<td>Slack (1996)</td>
<td>Unitised loads (containers, trailers) that are transferred from one mode to another.</td>
</tr>
<tr>
<td>Spasovic and Morlok (1993)</td>
<td>The movement of highway trailers or containers by rail in line-haul between rail terminals and by tractor-trailers from the terminal to receivers (termed consignees) and from shippers to the terminal in the service area.</td>
</tr>
<tr>
<td>Niérat (1997)</td>
<td>A service in which rail and truck services are combined to complete a door-to-door movement.</td>
</tr>
<tr>
<td>Harper and Evers (1993)</td>
<td>One or more motor carriers provide the short-haul pick up and delivery service (drayage) segment of the trip and one or more railroads provide the long-haul or line haul segment.</td>
</tr>
<tr>
<td>Evers (1994)</td>
<td>The movement of truck trailers/containers by both railroads and motor carriers during a single shipment.</td>
</tr>
<tr>
<td>Nozick and Morlok (1997)</td>
<td>The movement of trucks and containers on railcars between terminals, with transport by truck at each end.</td>
</tr>
</tbody>
</table>


There is therefore a significant dispersion around the concepts of intermodal, combined and multimodal transport. Taking into consideration the definitions presented so far both by the governmental bodies and researchers, along with other definitions find elsewhere we defined the following figure, which attempts to show the hierarchical relationships amongst concepts. Naturally, it is a simple attempt and thus subjected to discussion due to
the diversity of definitions; nevertheless, we believe that it provides an interesting looking over the current body of literature.

In our understanding, multimodal transport is the broadest concept of the four since it encompasses all kind of transport chains solutions. The only required for a transport chain to be considered multimodal transport is the presence of at least two different modes of transport. In other words, it is an umbrella-definition covering all the other concepts. The other three definitions are more restricted in the sense that they require some sort of organisation or coordination - integration - amongst modes of transport.

The difference between intermodal transport and the other two lay on the perspective upon which the transport service is seen. The former places the emphasis on the level of integration, while the latter place the emphasis on sustainability issues. As a matter of fact, intermodal transport is the concept where the need of existence of integration is the most pronounced. A transport service to be called intermodal is required to have a high level of integration. Integration is so relevant that may be used to measure that level of quality of the transport service.

A transport service to be called as co-modal or combined transport has to follow a different perspective. The emphasis should be on sustainability and on the optimising of the consumption of natural resources. Thus, in these transport services integration is a requirement (but not the only one) to achieve the ultimate goal of reducing the burning up of resources. Yet, combined transport definition has a higher concern than co-modal concept. A combined transport should make extensive use of the so-called sustainable modes of transport (rail, sea or inland transportation), while reducing at maximum the others (road and air transport). Co-modal concept, although placing emphasis in the
achievement of sustainable transport solution, refers that modes of transport should be used at maximum efficient, which opens the door for the utilisation of not so sustainable configurations (as long as they are the most efficient ones).

A particular aspect of the transport chains solutions concerns the way goods are handled between modes of transport. In both multimodal and co-modal transport definition there is no reference about this issue, but in the other concept definitions tend to agree on the need of utilisation of loading devices (containers or others). So, which is effectively handled are the loading devices and the goods themselves. This requirement is somehow natural, bearing in mind that the need of integration underlies both concepts. The utilisation of (standard) loading devices is a key issue to achieve higher integration levels and reducing time and energy resources at the transhipment points. In this way, the need of using loading devices is more a consequence than a requirement.

Bearing in mind that the success and validity of a research process depends at large extend on the use of clear and precise definitions and concepts, the current variety of definitions around the concept of intermodal transport is non acceptable. A precise definition allows for the identification of what lies within and outside the concept’s boundaries; therefore, rigorous definitions are the cornerstone of successful research. On the other hand, dubious or not so clear definitions likely to double meaning or misinterpretations raise difficulties of interpretation of what is the object of analysis or what is being analysed, which may lead to wrong assessments.

Therefore, we have felt the need of presenting the concept of intermodal transport as it is understood in this Thesis. The type of transport chains in analysis in this thesis are the intermodal transport chains, because first the goal of the thesis is studying the nature and influence of the type integration amongst modes of transport in the performance of the transport service; and second the issues of sustainability are not touched in this thesis.

For the terms of this report intermodal freight transport should be understood as a concept of freight transport, ruled by a single transport contract, where at least two different modes of transport participate in an integrated manner.
This definition is made of three key conditions: first, the existence of a single transport contract ruling the entire transport service; second, presence of at least two different modes of transport; and third, the need of some sort of integration amongst the agents participant in the transport service.

The second condition in line with all definitions present above. An intermodal transport is a transport service where at least two modes of transport should participate. The connexion between two consecutive modes of transport is assured through a transhipment terminal where goods are handled and shifted between vehicles; they can also be stored or undergo any other activity allowed under the transport contract terms.

The third condition is the most important one for distinguishing an intermodal transport from any other type. Integration can be understood as the existence of coordination or alignment amongst modes of transport, and can be felt at different levels, namely: technological (when agents decide to more towards higher level of interoperability), procedural (when agents decide to align and uniform the processes along the transport chain), or legal (when agents decide on simple and fair mechanisms to compensate clients for eventual losses). Integration is of paramount importance because it generates synergies amongst modes of transport allowing them to achieve levels of performance that otherwise would be unattainable.

Integration does not emerge spontaneously in along a transport chain, by the contrary it results from the existence of a specialised agent that actively seeks and promotes that integration. This agent is called as Freight Integrator or, in some cases, as Freight Forwarder. This agent has the mission of, firstly, arranging and assembling the transport chain that potentially better fits into the client’s demands and, secondly, managing that transport chain so that it actually delivers the expected performance. So, in practical terms, the freight integrator serves as intermediary between the client and the transport providers.

The first condition is only referred on the definition proposed by the United Nations concerning multimodal transport. An intermodal transport service should also act as a single entity in case of legal responsibility situations. The freight integrator although providing the necessary cohesion in terms of behaviour leading, cannot legally bound independent companies. Indeed, an intermodal transport chain can be compound by a set of
independent companies (for example: each one participating with a single mode of transport). In these situations, the necessary legal cohesion is only granted through the existence of single contract, that bounds all agents to the same terms and conditions, making them to behave as a single entity. Naturally, in those cases where one agent owns the various modes of transport, this situation does not exist, simply because the single entity is granted due to common ownership (like what happens in the so-called Integrators, like DHL or TNT).

Finally two comments about the way goods should handled throughout the transport chain and the need of arranging sustainable transport solutions. In our point of view this is not a relevant issue for defining an intermodal transport chain. The point is that an intermodal transport solution has to compete in the market with other transport solutions; therefore, it should the most competitive possible. If the use of loading devices yields higher competitiveness, so naturally it will be used; however, if the direct manipulation of goods is the most appropriated then there is not reason for not manipulating them. Ultimately, it is the competitive pressure that dictated the use or not of loading devices.

A second comment is related with the sustainable concern of a transport solution. Once again the fact of being more or less sustainable should not be a condition to be considered intermodal transport. Sustainability should be attained by deploying correct policies, so that the mode the most competitive transport solution are also the most sustainable ones.

4.2 Barriers and Challenges to the Production of Intermodal Transportation

There are multiple obstacles and challenges to the production of competitive intermodal transport solutions. The sources of those barriers lay down on the very nature of intermodalism. An intermodal transport service is by definition a transport service that utilises at least two different modes of transport in an integrated manner. Integration implies some sort of alignment or synchronisation between all dimensions of the various single-modal transportation systems.

A transportation system comprehends three basic dimensions: physical, logical and legal. The physical subsystem consists in the infrastructure and equipment. Infrastructure is made of nodes and links. The nodes are the terminals like for example the seaports. Links are the
routes on which the vehicles convey cargo, like for example: railways, roads or waterways. The logical subsystem refers to the information required to process the transport service. The information can be transmitted either on hard copy format through documents or on an electronic format using for example the EDI - Electronic Data Interchange format. Information may follow with the cargo (the truck driver may transport some documentation) or be transmitted directly between transport agents. The type, format and origin-destination of information depend upon the mode of transport. Finally, the legal subsystem refers to the body of law that regulates the transport activity and defines the transport agent’s liability. The transport activity rules concern, for example, the admission to the occupation, access to the market, technical regulation, social legislation, pricing policy, or aid and competitive policy. The transport agent’s liability regimes define the responsibility of a transport agent in case of damage or destruction or cargo, or non-compliance of the transport contract rules. Again, each mode of transport has a specific body of law.

The vertical separation of each mode of transport into distinct single modal transportation systems results from the historical mode specific approach followed by most governments and non governments organisations (OECD, 2001, pp 14). Governments have for a long period of time kept (and some still keep) tight control over their economic sectors. By that time, business and trade were conducted under considerable restrictions at both national and international levels. Freight transportation sector was no exception. Regulations have been established by different modes of transport (Slack, 2001, pp 150). Normally inter modal competition was not accepted; and regulations were so heavy and time consuming that there was also no reason for inter modal cooperation. Even the international transport services, which normally evolved two or more modes of transport (sea or air transport for the intercontinental leg plus road or rail for the continental one), were produced over such myriad of regulations, in particular the customs clearance process (Slack, 2001, pp 150), that in practice consisted in a set of single-modal transport services.

The majority of the transport agents were then modal based as there was no rationale to operate more than one mode of transport: no significant synergies could be obtain from their joint operations. Throughout time, both modes of transport and transport agents have evolved in isolated islands, although working side by side. The lack of interactions meant
the independent development without taking into consideration the others, which has resulted in different freight transport solutions.

The production of competitive intermodal transport chains entails therefore the seamless operation of various single-modal transportation systems. Additionally, and bearing in mind that many transport agents are single modal, most likely, more than one transport agent will participate in the intermodal transport services. Often, their strategies or processes do not match, which introduces further complexity to the management of the transport service. Nowadays, the freight transport sector is a complex jigsaw of regulations, technologies, agents and processes most of these segmented by mode of transport. Such nature raises diverse challenges and barriers to the production of competitive intermodal transport services. These have been identified and catalogued by diverse authors.

In their work (Bontekonong et al., 2004), Bontekoning, Macharis and Trip proceed to a literature review identifying the most often researched problems concerning rail-road intermodal freight transportation: They distinguish eight research categories (Bontekonong et al., 2004, pp 8):

- **Drayage** - research is around the development of tools to study behaviour of these operations for reducing costs (Bontekonong et al., 2004, pp 14);

- **Rail haul** - there is a vast body of research concerning intermodal rail transport, but the most research problem is related with the organisation of this mode of transport (Bontekonong et al., 2004, pp 14-16);

- **Transhipment** - research is focused mainly on the development of new rail-rail transhipment techniques and the evaluation of methodologies to quantify the result of changes in intermodal freight terminal operations (Bontekonong et al., 2004, pp 17);

- **Standardisation** - few literature has been found out addressing this topic. The existing one is focused on the development of new standard load units, rail cars and truck trailer devices (Bontekonong et al., 2004, pp 17-18);

- **Multi actor chain management and control** - the subjects researched include the coordination of multiple transport agents, the role of information and communication
technology on that task, the role and market power of each player and the lack of a legal framework for determining an intermodal carrier’s liability ((Bontekonong et al., 2004, pp 18-19);

*Mode choice and pricing strategies* - there is a vast body of literature, with several topics still raising concern, namely: mode choice attributes, cost structure and competitiveness (Bontekonong et al., 2004, pp 19-20);

*Intermodal transportation policy and planning* - research problems include to understand how and which public policies may favour intermodal transport, also there is concern around the formulation of policies so that their efficient could be maximised. In terms of planning problems address the locations of terminal, development of freight villages, and regional development (Bontekonong et al., 2004, pp 20-22);

*Miscellaneous* - this group includes a set of research like for example: decision support tools for shippers, optimal routing, historical perspectives, definitions or other economic studies (Bontekonong et al., 2004, pp 22).

Peter Keller (Keller, 2004) adopts the term separation (Keller, 2004, pp 43) to the obstacles to the construction of both passenger and freight intermodal transport chains. He groups these separations in seven main types:

*Separation in time* - many existent transport infrastructures have been planned and constructed at different periods of time, which different perspectives and requirements, not always compatible (Keller, 2004, pp 43);

*Spatial separation* - often planning and spatial development impose constrains to the construction of terminals or infrastructures, resulting in suboptimal transportation systems (Keller, 2004, pp 43);

*Separation by companies* - the optimum of an intermodal transport solution may result in the sub optimal for one or more single modal transport agent, which may not be acceptable (Keller, 2004, pp 43);

Commercial separation - documentation and ticketing differs amongst modes of transport (Keller, 2004, pp 43-44);

Informational separation - there problem lays on the difficulty of exchanging information amongst transport agents and the clients (Keller, 2004, pp 44)

Legal separation - many legal frameworks are modal specific and do not foresee multi modal arrangements, which brings some problems in case of conflict (Keller, 2004, pp 44);

Institutional separation - concessions for operating transport networks and regulators are often single modal based, which difficulties the construction and operation of multi modal transport networks (Keller, 2004, pp 44)

Slack points out eventual incompatibilities at the technological level have been fairly solved (Slack, 2001, pp 149) and that nowadays the most relevant barriers affecting intermodalism concern:

 Liability - there is no liable regime for intermodal transport operations instead a set of single modal liable regimes with different terms. This diversity likely introduces noises to the production of this kind of transport services (Slack, 2001, pp 150)

Documentation - each mode of transport utilises a specific set of documentation, which in case of intermodal operations adds complexity and costs (Slack, 2001, pp 150)

Intermodal intermediaries - transportation sector has undergone profound changes over the past few decades, in parallel with the opening of the markets, with new agents entering into the market and the incumbents incorporating new functions. These diversity and complexity has reduced at some extend the transparency in the market, particularly in what concerns the role of each player (Slack, 2001, pp 150-151);

Regulatory issues - although over the past few decades there has been a trend towards deregulation and privatisation, there is still important legal barriers that constrain or prevent the full utilisation of intermodal transport services, namely: controls over rates, entry or ownership (Slack, 2001, pp 152);

Zografos and Regan draw attention to relatively recent but already prominent problem in intermodal transport operations: security (Zografos et al., 2004, pp 10). Over the past few years security of the transportation systems became an important issue. Firstly, the growing threat of terrorism that uses the transport systems either as targets or as vehicles. Secondly,
fraud and theft have risen in sophistication attacking the weakest links of the transportation systems. The rising of security has followed the development and generalisation of the new technologies, enabling more people and in an easier way to get in touch with powerful equipments. (Zografos et al., 2004, pp 11)

On the other hand, the new demand for freight transport services (namely: increase in speed, volume and on time delivery) coupled with the increasing complexity of the transport chains (namely with the raise of the number of transport agents) have put at a higher the transport services, particularly those who have not implemented adequate electronic protection and processes. The problem lies on the fact of security being time and resources consuming. Additionally, the increase in the number of agents, increase the possibility of existing one with no good intentions, while in parallel reduces the notion of responsibility.

Asariotis (Asariotis, 1999) argues that the absence of an intermodal (or multimodal) liability regime introduces uncertainty to the transport service and may result in unfair situations for clients with the consequence increase of costs and discouragement of trade (Asariotis, 1999, pp 46; 1998, pp 4). In an intermodal transport service, the liability depends upon the mode of transport where the problem occurs (because there is no universal regime). Since the various modes of transport have different regimes, at the outset there is no certainty on the total compensation the client is due. Moreover, to responsible entails the clear identification of the source of the problem. However, often either the problem is found late in the transport, or is the result of a cumulative process. These unclear situations do not allow allocating responsibility to a certain transport agent. So, the current piecemeal liability regime is prone to uncertain and unclear situation, which only introduce friction to the transport service.

Panayides (Panayides, 2002) addresses the challenges of the economics of intermodalism and cost structure of intermodal transport services. He argues that both of these topics remain fairly unknown (Panayides, 2002, pp 401), which reduces capacity for either identifying cost inefficiencies along transport chain, or achieving an adequate and fair share of the revenues amongst transport agents.

An OECD report highlights the traditional governments and non-governments organisations’ single modal focus (OECD, 2001, pp 14\(^{37}\)). This segmentation has led to the establishment of a set of specific and closed single modal regulations. Recently, with Globalisation and the emergence of new transportation paradigms, the importance of intermodality was brought to the fore. However, the current legal environment segments the market by mode of transport not favouring intermodal transportation.

The European Union project founded CO-ACT studied the feasibility of intermodal air-rail transport services (CO-ACT, 2002\(^{38}\)). The main barriers identified were at technological level, at organisational and availability of infrastructure. In terms of technology, the key problems concerns the lack of interoperability of loading units between trains and aircrafts (CO-ACT, 2003a, pp 9\(^{39}\)), which do not fit or result in suboptimal utilisation. Secondly, the documentation needed for each mode of transport is different. Consequently, the production of an intermodal transport service requires a larger amount of documentation in order to cover the requirements of each mode of transport (CO-ACT, 2003a, pp 64). Finally, the production of an intermodal transport service is dependent upon the existence of junctions between the various transport networks. Modal transfer is processed at these junctions. However, for certain arrangements there is lack of available or suitable transfer points. The CO-ACT project only found out four airports with suitable freight rail terminal on site (CO-ACT D3, 2003b, pp 90\(^{40}\)), which reduces the scope for the development of intermodal transport solutions.

The research project TRILOG (TRILOG, 1999) followed a different approach and identified the main barriers from the supply and demand sides TRILOG, 1999, pp 61), being:

\[\ldots\]


From the supply side:

Non-adequate infrastructure - limited extension of some transport networks (for example suitable rivers or channels for inland shipping), lack of infrastructure interoperability (for example track gauges differ between countries preventing the free circulation of trains, or bridges’ capacity is not uniform across Europe), lack of terminals and missing links;
Lack of standardisation of load units, information systems and administrative procedures;
Lack of competition in the railway sector;
Lack of marketing and door-to-door service offers.

From the demand side the main problem identified is the “non-compliance of intermodal transport to service requirements”. This problem arises from the inherent complexity of this kind of transport because of, firstly, involving more than one mode of transport and, secondly, being unaccompanied (TRILOG, 1999, pp 61). The project found outs that clients have little information about the actual possibilities of intermodality and perceive it as a low reliable and rather inflexible transport solution. And so, they have some reluctance to abandon the usual transport solution (TRILOG, 1999, pp 62).

The European Commission (European Commission, 200341) brought forward the higher organisational complexity of an intermodal transport service. The need of coordinating and synchronising a set of modes of transport and transport agents is, for the European Commission, one of the main challenges to the production of competitive transport solutions (European Commission, 2003, pp5).

The competitiveness of this kind of transport solution depends upon the ability of adequately coordinating and organising the set of individual single-modal transports, which entails adequate communication channels so that every transport agent can know its role at any given moment. An intermodal transport service may involve several transport agents, which have to be aligned so that losses could be minimised. However, each transport agent has its own strategies, technologies, processes and past experiences, which often do not match the others. Additionally, many transport services are produced on an ad hoc basis, which means that transport agents that normally compete in the market may be...
called to participate in the same transport service. Naturally, they may have some resistance to share some information.

Information flow is of paramount importance in the success of any intermodal transport service. Cargo is always followed by diverse information (for example: type of goods, quantity, owner, or origin and destination). Therefore a correct transfer of information allows a rapid transfer of cargo between modes of transport. And it is of particular importance for customs clearance, where any flaw may result in considerable delays and costs. Additionally, information is required for the management of the transport service. A convenient information flow provides visibility to the transport service, enabling the continuous tracking of the goods. So, any detour to the planning can be rapidly identified and mitigation measures can be applied.

The problem is transport agents have been implementing proprietary information systems that are not able to communicate with others. So, when different transport agents with different information systems are brought together, information exchange may become quite complex, generating losses of information. Additionally, many transport agents lack the financial resources to implement any information system, and continue to use phone or fax for communication. These situations prevent the use of any kind of automatic information transfer.

Finally, the power of each transport agent is not equal. There is the risk of the most powerful to take advantage of its position to get unfair rewards. Such situation leads inevitably to conflict situations, which in turn result in poor transport services. Because the agents that fell unfair will not apply their full resources in the production of the transport service.

Summing up, the main obstacles and challenges to the production of competitive intermodal transport service have two sources, being one concerned with dissimilarities amongst modes of transport, and the other related with the participation of two or more transport agents. Each of these sources produces a set of barriers. The first one generates barriers such as: lack of suitable junctions, lack of interoperability or different liability regimes. The latter source yields a transport service with a higher level organisation and a more complex cost structure.
Technological development over the past few decades have fairly solved, or at least mitigated, many technological related problems (Slack, 2001, pp 149), of which the emergence of containerisation is the most paradigmatic example. Moreover, both governments and privates have been either constructing new infrastructure or upgrading the existent one, resulting an increase of the overall quality and availability of transport infrastructures. In the European Union, for example, the 2001 White Paper (COM(2001) 370 final) addresses the need of “linking up the modes of transport” (COM(2001) 370 final, pp 40) and puts forth a set of initiatives to approach the various transport networks, like for example: investments in Trans European Networks, liberalisation of the railway market, harmonisation of regulation or research and development within the framework programmes. Conversely, few developments have been achieved in the mitigation of the other non-technological barriers like the differences in the liability regimes (Asariotis, 1998, pp 4\textsuperscript{42}), or the higher complexity of organisation (European Commission, 2003, pp 5; TRILOG, 1999, pp 55, Slack, 2001, pp 149, Panayides, 2002, pp 401\textsuperscript{43}).

Consequently, despite the efforts conducted over the past decades and the improvements meanwhile achieved, there are still important barriers and challenges to overcome so that competitive intermodal transport solutions could be achieved. All these barriers arise from the presence and interaction of different single modal transportation systems and transport agents. Each mode of transport has additional challenges and limitations, which further complex the organisation and management of this kind of transport.

4.3 Intermodal Transport Process

4.3.1 Definition of Process

Process is a concept used in multiple situations and for different purposes, which makes difficult any attempt of bringing forward a universal definition. Nonetheless, a Process can be understood as a set of interrelated, coordinated and sequential tasks whose purpose is to produce a determined output or outputs from a given input or inputs. Such act of


transformation consumes a certain amount of resources: manpower, equipment or materials (Figure 20 and Figure 21).

Other authors and organisation bodies have put forth other definitions for process. For example, Sharp and McDermott (2001, p. 58) defined process as “a collection of interrelated works tasks, initiated in response to an event that achieves a specific result for the customer of the process”; while Davenport, T. H. (1993, p. 5) considered process as “a structured, measured set of activities designed to produce a specific output for a particular customer or market” and as “a specific order of work activities across time and place, with a beginning, an end, and clearly identified business and outputs: a structure for action”; and Pall (1986) referred to a process as being “the logical organization of people, materials, energy, equipment and information into work activities designed to produce a required end result (product or service)”.

Recently, the ISO 9001:2000 standard defined process as a set of interrelated activities that transform inputs into outputs.

The basic unit of a process is the task. A task represents an individual and well-defined work conducted by a person, equipment or set person-equipment, through which a set of inputs are converted in something different, called outputs. The inputs and outputs can be of any kind and nature (tangible or intangible), like for example: technology, equipment, information, financial resources, etc.

In order to reduce the complexity inherent of managing or coordinating a high number of isolated tasks, these may be hierarchically organised in several echelons (Figure 20). In this way, a set of tasks engaged may form an activity; while a set of activities may form a sub process. The set of sub processes form the process. Both the number of units within each level as well as the number of levels itself depend upon each specific case. More complex situations, with higher number of tasks, would imply the definition of more echelons and clusters within each echelon, than a less complex one.

As it obvious any process exists as such with the single purpose of fulfilling a customer’s need, otherwise it is useless and should be eliminated. The customer can be either internal (for example: other process, department, etc.) or external to the company (for example:

\[45\] Quoted in Riley, J. F. (1999, p. 6.1)
other company). Moreover, a process is triggered by the presence of all inputs, therefore, it has an occasional behaviour.

A major problem facing process definition is precisely the identification of its limits and the identification of the limits of each hierarchical inferior level. At one extreme, each task could be considered a process, but that would be a non-sense situation, since a process by definition entails a certain level of complexity and the presence of some interrelated tasks; at the other extreme, all tasks could be brought together under the umbrella of a single process, but that would lead to a non-managerial situation, specially in case with a large number of tasks. Therefore, for each situation it is necessary to find out an equilibrium point, where the number process and respective echelons represents adequately the reality and is simultaneously manageable.46

The successive passage of output(s) of preceding tasks to input(s) in subsequent ones generates flows. These flows cross the entire process and represent all kind of movements, such as: products, information, capital, etc. Figure 21 depicts the flows within a process

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46 The main objective of the analysis for which the processes definition is required, is a major factor for the definition of the total number of processes. For example, if the objective is incremental improvement than business processes should be as narrow as possible, on the other hand, when the objective is radical process change than the business processes should be defined as broadly as possible (Davenport, T. M., 1993, p. 28). There are various techniques for the identification and classification of processes see for example: Portougal, V. and Sundaram, D. (2006, p. 6-19), Davenport, T. H. (1993, p. 27-33) or Azevedo, A. and Alves, J. (2002, p. 24-26).
downward to the task level. The same rational is replicated at all levels: the inputs are processed (within the process, sub process, activity or tasks) and converted in output(s), generating the flows.

A process is the schematic representation of how a company’s product or service is actually produced, drawing all parties involved, the relationships amongst them, and the resources consumed by and tasks allocated to each one. Therefore, the behaviour and evolution of an organisation can be assessed through the monitoring and evaluating of the performance of her processes. Two concepts have been developed to infer on the performance of a process: effectiveness and efficiency. A process is effective when its output meets perfectly the customer’s needs. A process is efficient when it is effective at the lower possible cost, which means that frictions within and amongst parties are kept at a minimum level. In this sense, costs represent not only overall costs (the sum of all tasks’ costs) but also the costs at any given moment (the existence of peak periods demanding huge amounts of resources are often more difficult to cope and manage than continuous demand periods). Frictions arise from either, non-optimised tasks, or lack of synchronism

**Analyses of processes - PERT Method**

![Business processes’ hierarchical structure](image_url)
or compatibility amongst parties, which increase the necessary amount of resources to accomplish the assigned tasks and, consequently, costs. Flows also run smoother and faster on more efficient processes where few frictions or hindrances occur than on those less efficient ones.

Although tasks’ positioning within a process is not random, instead following a certain sequence, there are always time windows for the beginning (and ending) of tasks. Therefore, it is possible to define various designs for a same process. Recalling a task consumes time and resources, different arrangements of tasks, although yielding identical effectiveness, surely lead to different efficiencies levels. Therefore, the solution chosen should obviously be that that yields higher efficiency, in other words, the optimal one. To find out the optimal process is, in many situations, not straightforward if not an impossible mission, due to the high number of tasks involved. As a result, methods and tools have been developed to provide assistance and guidance during process design so that the most suitable combination could be attained.

From the various existent methods PERT - Program Evaluation and Review Technique has proved to be robust and easy of use. This method was developed in 1958 by the United States Navy Special Programs Department for the planning and construction of the POLARIS missiles, and is grounded on the mathematical theories of sets and graphs. The most significant breakthrough achieved with this method has been the representation of the process through a web (Figure 22) where the knots represent the activities (or tasks) and the links represent the relationships amongst activities (or tasks). In this way, consumed resources and time are represented at the knots while the sequence is given by the links.

![Figure 22 - Schematic representation of a process](image-url)
This method offers various advantages for the analyses of processes:

- Identification of the critical path;
- Higher degree of confidence on the determination of deadlines and resources needed;
- Easier process management;
- Higher capacity of synthesis - it is possible to effortlessly bring together and work huge amounts of information;
- Uncertainty analyses - it is possible to take into consideration the influence of uncertainty on tasks duration and consumed resources as well as perform scenarios evaluation;
- Easiness of use and simple understanding - applying PERT to a real situation requires little effort and time of learning.

Although all these advantages have contributed for the success of this technique, the most relevant one is undoubtedly the identification of the critical path. The critical path is the series of tasks that determines the minimum time needed for the project. No matter how quickly the other tasks are completed, the project cannot be finished any sooner unless the tasks on the critical path can be done faster. Thus, the increase on the execution time of any of these activities automatically leads to an increase on the time needed to complete the process. This concept will be discussed in more detail later in this chapter.

The application of the PERT method is straightforward, being only necessary to know beforehand the following details: firstly, the activities involved in the process; secondly, the duration of each one; and thirdly, their sequence (or, in other words, which activity or activities precede and follow to each activity). Knowing this information, the process can be easily drawn. Commonly activities are represented along a time axis and their size is proportional to their time of execution, which increases readability. Figure 23 applies PERT method to the process presented in Figure 22.
The process has been drawn along an axis time, in this example it takes fifteen time units to be accomplished. Activities’ execution time is presented in gray and the sequence is materialised with the arrows (links). Activity 1 needs three time units to be accomplished while Activity 5 only needs one unit time. The boxes around Activities 4 and 5 represent the available time windows for the execution of these tasks. The sequence of activities is Activity 1, 4, 5 and finally 6. Between the end of Activity 1 and the start of Activity 6 there is a gap time of eight time units, which far exceed the time necessary to execute both Activities 4 and 5, which both require three time units; therefore, there is freedom for the starting time of each one. On the other hand, for the Activities 1, 2, 3 and 6 no time windows are available. Due to their duration, these activities impose the minimum execution time of the process with any delay (they cannot begin earlier because their execution depends upon the ending of the precedent activity) on the beginning on one of these activities implying an increase in the overall execution time. The path formed by these activities is the critical path.

The overall amount of resources is easily computed by summing the amount required by all activities, while the amount required at a given time is got by summing the resources consumed by the activities that are being executed at that time, which is easily determined.
through a visual inspection. In this way, assuming the resources are interchangeable among activities and Activity 2 consumes more resources than Activity 3, the beginning of both Activities 4 and 5 influences that instantaneous amount of resources needed (delaying these activities yields lowers demand peak resources than anticipating them), which surely has impact on the management of the organisation’s resources.

As already written, the most relevant outcome drawn from a PERT analyse is the critical path, which for this example is formed by Activities 1, 2, 3 and 6. The critical path spans the process being formed by critical activities, which are those with no time windows available. Therefore, the minimum execution time of a process is determined by the execution time of the critical activities.

Affecting either the duration or the beginning time of any of the critical activities automatically leads to an increase of the process duration time. Therefore, the critical activities have a direct influence on the execution time (and, consequently, on the performance) of the process. Naturally all activities are relevant, otherwise they should not exist, but there is a direct link between the execution time of a critical activity and the process. The identification of the critical activities is of paramount relevance whenever systems for monitoring or improving processes’ performance or quality are to be implemented. Improving non critical activities yields marginal gains, because they do not have direct influence of processes’ execution time (which, in turn, is linked with the final performance). On the other hand, improving critical activities has an immediate impact process’ execution time. Therefore, the implementation of those monitoring and improving systems should be, at least on a first phase, focussed on the critical activities. Otherwise, return on investment on these systems may not be guaranteed. Coming back to the example presented in Figure 23, improving either Activity 4 or 5 would lead to marginal gains in the process final execution time, while investing efforts in Activity 1, 2, 3 or 6 would result in substantial improvements of the process’ execution time and, ultimately, performance.

4.3.2 Processes in Intermodal Transport

In an intermodal transport service, agents are meant to perform a sequence of complementary and compatible actions. As such, the mechanism underlying the production of intermodal transport has every ingredient so that the theoretical concepts of processes could be applied: firstly, there is a defined purpose: the conveyance of goods from a place to another; secondly, there are parties: the agents engaged in the transport activities; thirdly, there is a sequence of individual and identifiable
tasks and activities; and fourthly, every task is quantifiable in terms of resources and time consumed.

Applying those theoretical concepts to intermodal transport will allow to get relevant insights upon this type of transport solution. On the one hand, it will shed some light over the complex web of relationship within an intermodal transport chain helping on the clarification of the position and role of each agent. On the other hand, it will depict the mechanisms and relationships involved in this kind of transport solution, promoting the identification of the various tasks, activities and sub processes, as well as, critical activities and, ultimately, the critical path.

The intermodal transport is not a transport solution by itself but instead a concept of transport in which multiple modes of transport are brought together to deliver a tailored transport solution that best fits a given scenario. Therefore, intermodal transport is like an empty box that will be filled up with several blocks - agents - of various sizes - the quantity used of each agent, so that the outcome best serves the clients’ purposes. The agent that plays and fills that empty box is the Freight Integrator.

Furthermore, in function of her own assets and know-how, on the one hand; and on her positioning within the market, on the other, an agent may deploy the resources in different ways - processes - than others to produce a same output. Nowadays, the survival of agents depends upon their competitiveness capacity which is directly linked to their processes. As a result, there is a trend towards specialisation with agents progressively adapting their processes to the specific demands and characteristics of those market segments, which they see as best fitting into their own capabilities. This does not mean the processes are completely differ amongst agents; by the contrary, commonly the bulk of the tasks are similar only differing in determined ones, which have been designed to fulfil specific demands. Those specific tasks make all the difference in the process being the key for the agent’s competitiveness advantage.

Summing up, there has been a growing adaptation of the agents’ processes to the market segments’ demands where they compete, which has led to the creation of a large number of highly specialised tasks and activities, which in turn has progressively enlarged the variety of tailored intermodal transport solutions available.

Despite the variety, the processes are largely similar, sharing many identical tasks, activities or sub processes. The differences arise in particular details and vary amongst situations. In this chapter, a general intermodal transport solution is presented along with the common tasks, activities and sub processes. The purpose is presenting the main architecture of this kind of transport solutions. Since
the specific tasks depend upon the real case, they will be dealt in more detail during the case studies evaluation. Furthermore, many agents keep undisclosed many tasks, as they are regarded as sources of competitiveness.

After presenting the intermodal transport process, the flows that occur along an intermodal transport chain will be detailed. The flows are the tangible result of the tasks’ production. Each task uses as inputs the outputs of precedent ones and, its outputs will be the inputs of the following ones. The successive passage and conversion of outputs into inputs results in the flows. Therefore, the flows depend upon the architecture of the process, which in turn depends upon the actual situation. In this way, once again, it is not possible to detail all possible kinds of flows; instead, only the flows that most probably occur along the general process previously depicted are described. During the case studies presentation those flows are analysed in detail.

The representative of an intermodal transport solution is depicted in the following scheme (Figure 24).
chains with three or more legs, only that they repeat themselves often. The client of this chain is a Shipper that intends to send some goods to a Receiver. To accomplish this need a Freight Integrator is hired, which in turn hire agents for supplying those services for which she does not owns resources. If the Freight Integrator own no assets, so she has to hire all services to other agents; by the contrary, if she owns all assets, so no agents need to be hired. Regardless the situation, for the sake of clarity, services are considered always to be conducted by independent parties. By keeping all parties separated, the flows are better presented and described.

Figure 25 depicts the usual Sub processes and Activities identifiable along an intermodal transport chain. It should be noted that the length of activities do not represent execution time, instead being indicative. The actual length of each one depends upon each real case situation.

In a typical intermodal transport chain like the one presented in Figure 24, it is possible to identify two main Sub processes, each one compound of several activities:

- Sub process 1: Negotiation & Configuration;
- Sub process 2: Transport.

**Sub process 1: Negotiation & Configuration**

This sub process embraces the administrative procedures conducive to both, the establishment of a contract of transport between the Shipper (client) and the Freight Integrator, and the assemblage of the intermodal transport chain. So, during this Sub process, agents are essentially engaged in negotiations to combine all details of the transport service. It occurs before any transport activity takes place.

Sub process 1 is compound of three main Activities:

- Activity 1: Shipper & Freight Integrator;
- Activity 2: Freight Integrator & Agents;
- Activity 3: Freight Integrator & Shipper.

Any transport service begins with a need felt by a shipper (client) to move some kind of goods between two different places. The shipper then, approaches a freight integrator showing her interest. **Activity 1** corresponds precisely to this phase where the shipper reveals her intention of moving some products between different locations. Simultaneously, the shipper provides a full characterisation of the transport service and the goods, so that the fright integrator could define a suitable solution. The information transmitted about the transport service includes: the origin and destination places, the respective deadlines for the pickup and delivery. If more than on service is pretended, the shipper also details the intervals of transport. The information convey about the
goods commonly include: a description of their nature, and the quantity, volume and weight to be transport in each service and in overall (if more than one service is predicted).

Based on the information received, the freight integrator during Activity 2 works on the definition a suitable transport solution. Knowing in detail both the operational and technological properties of each mode of transport, on the one hand, and the portfolio of services, performance and quality (namely: reliability, trustiness and safety standards) of the companies operating in the transport market, on the other hand, the freight integrator draws a few viable architectures for the transport service (each one having either, a different combination of modes of transport, or the same combination but used at different extents) and chooses one or more suitable companies for each position. At the end the freight integrator may arrive at a situation with multiple scenarios. Naturally, if she owns some or all assets (vehicles, warehouses, etc.), then naturally the architecture will embrace them, reducing the range of solutions. This situation is likely to happen when the freight integrator is a so-called Courier (like the FEDEX, DHL or UPS), where she own all assets. So, when the shipper contacts her, only one solution is supplied. After identifying the potential transport companies, the freight integrator may contact them to bargain prices and conditions. Commonly, the transport companies publish their fares, so that task may be not necessary.

Finally, the freight integrator may come up with several possible suitable solutions. When this happen, she may contact the shipper and offer her the option of choosing the final solution. This phase corresponds to Activity 3. If the shipper has no intervention whatsoever on the definition of the transport solution, the final decision falls naturally upon the Freight Integrator, which chooses the solution based on her own judgments. The decision process tends to be non-rational based on subjective factors, namely: own preferences (some Freight Integrators may prefer to use some sort of modes than another ones, or bas past experiences with some modes or companies), privileged relationships with some transport companies, first solution on the list, etc.

One of the logistics trends identified in Chapter ? is customisation, with companies progressively abandoning mass production and engaging on the production of tailored products, which have higher added-value compensating the higher producing costs. This trend is also felt in the transport market, with companies increasingly supplying tailored solutions. In this way, the final transport solution results from an iterative sequence of cooperative efforts between the freight integrator and the shipper. In successive steps the freight integrator presents refined solutions, until a final a best fit solution is obtained. During these iterations, the freight integrators may have to negotiate several times with the other agents. This is the reason for interaction presented between Activities 2 and 3, in Figure 25. After the transport solution being chosen and all intervening agents are contacted and the transport chain is put into motion.
Sub process 2: Transport

This sub process entails all administrative and operational procedures taken to move the goods between the origin and the destination, following the conditions initially agreed. So, this sub process corresponds to an effective transport of goods. The agents engaged in the transport operations are managed and coordinated by the freight integrator, which stands above the transport chain.
Figure 25 - General Sub processes and Activities of an Intermodal Transport Process
Sub process 2 entails the following Activities:

- Activity 1: Loading;
- Activity 2: Transport;
- Activity 3: Unloading;
- Activity 4: Storage;
- Activity 5: Customs’ Clearance;

If the chain had more legs, there would be a repetition of the activities mentioned above. Each extra leg entails four new activities corresponding to Activities 1, 2, 3, and 4. For each time goods had to be cleared, one Activity 5 should be added. Therefore, intermodal transport chains with three or more legs are simple extensions of chains with two legs.

With the intermodal transport solution completely defined, the freight integrator informs the various agents about their roles and duties. After the beginning of the transport service, she has to ensure and enforce that all agents properly conduct and perform the tasks initially assigned. If some deviation occurs, she has to take the necessary procedures to solve the problem. Furthermore, if some unforeseen event takes place, this agent intervenes to re-establish what has been initially programmed.

The transport service begins when the vehicle is loaded with the goods to be transported, at the origin’s location and. This phase corresponds to Activity 1. The loading tasks are specifically chosen for a given situation, since they depend upon the type of vehicle, if it is a container, trailer, cistern, wagon, ship, etc.; and upon the type of goods, if they are in bulk, pallets, liquids, etc. With the goods totally loaded into (or onto) the vehicle, the transport company may warn the freight integrator about the ending of Activity 1. Afterwards, the goods are conveyed towards the terminal, which corresponds at Activity 2. After arriving at terminal, Activity 3 starts with the unloading of the goods from within (or onto) the vehicle. Once again, the precise tasks deployed depend on the type of goods and vehicle involved. At the end of this activity, either the transport company or the terminal agent may send a message to the freight integrator. The unloaded cargo can then be either, immediately moved to the next mode of transport - cross docking operations, or stored - Activity 4 - for either, later carriage, or due to custom’s clearance reasons, which is the case presented herein. As cargo is meant for (or proceeding from) elsewhere, customs’ clearance is required. Automatically cargo is retained (stored) until the duly authorisation to be obtained. It

47 Cross docking operations take place when cargo is simply shifted between vehicles, with storage not taking place.
should be noted that terminals where cargo is cleared are terminals specially conceived for this purpose and properly authorised, which means that not all terminals are suitable for these kinds of operations. Examples of these terminals include the international airports and ports. Naturally, cargo not meant for customs’ clearance can be stored at any terminal. The agent legally entitled to contact and take all steps to clear the goods is the freight forwarder. This agent has been previously contacted by the freight integrator, so, she is aware of the arrival of the goods. During the operations conducive to the custom’s clearance - Activity 5 - the customs may require a physical verification of the goods to certify the declarations presented match with that that is actually being transported. In this way, during this activity goods remain within the terminal, which this is the reason for presenting Activity 5 directly linked with Activity 4 (Figure 25). The tasks done in this activity vary with the specific case: different customs authorities have different procedures (some are paperless while other not, some requires certain documents while others require other documents, etc.). The freight integrator is notified by the freight forwarder about the accomplishment of this activity.

Afterwards, the goods may move forward. From this moment onwards, the activities involved in the transport service have already been presented, repeating themselves. So, the goods are loaded into (or onto) a vehicle, which corresponds to Activity 1. After the completion of this activity, either the terminal or the transport company may notify the freight integrator; and the transport journey begins, corresponding to Activity 2. Finally, the goods arrive at their destination, where they are unloaded from the vehicle, corresponding to Activity 3. Ending this activity, the transport service ends. The transport company then notifies the freight integrator, which in turn notifies the shipper that goods have arrived to their final destination.

As a final note, it should be emphasised that the sub processes, activities, or the tasks described previously may not occur or, alternatively, occur in a different order in real case situations. This happens because there is an almost endless variety of situation and cases, which can not be documented. The example presented herein represents in our point of view a typical chain, where neither special demands nor cargo with specific characteristics are involved, which happen in many situations.

**Flows**

Along an intermodal transport chain there is a continuous interaction amongst agents, whose intensity and frequency depend upon the role each one plays within the chain. From these interactions occurs the exchange and share of different kinds of issues (namely, goods, information,
responsibilities and capital), which generates the flows. Flows can identically be understood as the movement of the tasks’ outcomes along the process. As written previously, the outputs of the activities are consecutively the inputs of the others. The successive passage and the conversion of outputs into inputs generate flows. As different kinds of outputs are produced, identically different kinds of flows occur along the chain. In this sense, flows are like strings that sew the tasks and the tasks to the agents, promoting the cohesion of the transport chain.

The main flows along an intermodal transport chain are: physical flow (Figure 26), logical flow (Figure 26), contractual flow (Figure 27) and capital flow (Figure 27). The physical flow corresponds to the effective movements of the goods between the origin and the destination. The logical flow corresponds to the exchange of information amongst agents. The contractual flow corresponds to the share of liability for the goods between agents throughout the transport service. Finally, the capital flow corresponds to the payments for the services carried out by the agents or due to legal obligations (like customs’ clearance).

As the flows result from the accomplishment of the tasks, they depend upon the configuration of the process of the intermodal transport solution under analyses. Consequently, there are a broad range of possible flows. In this way, the flows presented in the following sections correspond to the example of intermodal transport chain and, respective, process describe above (Figure 24 and Figure 25).

**Physical flow**

The successive carriage of the goods between agents since the origin until the destination represents the physical flow. Figure 26 depicts the physical flow of the intermodal transport chain considered herein. As this flow corresponds to the movement of the goods, it only exists in Sub process 2.

The goods located at a shipper’s facility are picked-up by the transport company - Activity 1 - and conveyed from this point to the terminal - Activity 2. Here, the terminal’s employees unload the goods from the vehicle - Activity 3 - and either shift them immediately to another vehicle, or stored them for later carriage - Activity 4. In the example presented, goods need to be cleared by the customs authorities. During the operations conducive to the custom’s clearance - Activity 5 - cargo remains physically within the terminal, so that customs authorities could be verify it. This is the reason to present the flow with a different pattern during this activity (Figure 26). After being cleared, goods may continue their journey. They are loaded into (or onto) the vehicle - Activity 1 - and carried out by a transport company - Activity 2 - towards the final destination: a consignee’s facility. Arriving here, goods are unloaded - Activity 3 - and delivered to the consignee.
**Logical Flow**

The key for the success of an intermodal transport chain lays on the capacity of the agents exchanging relevant information in a rapid and accurate manner. Robust information promotes transparency enabling the premature detection of deviations from what was previously established, and the detection of eventual faults or negligences committed by agents. Such awareness enables the quick adoption of corrective actions to minimise the negative effects of those unforeseen changes; and facilitates the clear determination of liabilities, promoting the trust amongst agents and giving incentive for agents excel themselves, which ultimately leads to a progressive increase in the performance of the transport services. Furthermore, an adequate information system eases and makes more accurate the monitoring of the agents and tasks’ performances, as well as the identification of the critical tasks and, consequently, the critical path. This knowledge is critical for an effective implementation of actions aiming the increase of performance, because it is knows where and which are, firstly, the weak links that should be improved; and, secondly, key links with greater influence on the overall chain’s performance.

Figure 26 depicts the logical flow of the intermodal transport chain considered herein. The logical flow occurs in both sub processes.

During Sub process 1, there is an intensive exchange of information between all agents conducive to the design of the intermodal transport solution. The logical flow starts when the shipper approaches a freight integrator with the intension of engaging in negotiations for defining a transport solution for her goods. The shipper reveals what she wants to transport and in which conditions - Activity 1. The freight integrator then - Activity 2 - designs a few solutions and contacts various transport companies to negotiate prices and conditions. This contact may be avoided if prices are public (and there is no place for bargaining) or if the freight integrator is in position of offering the transport services by herself. If necessary, the freight integrator may contact the shipper to clarify specific details or for jointly design the transport solution. After the completion of the design, the freight integrator notifies all agents about their roles and obligations - Activity 3. This activity may be broken down into several stages, because the participation of some agents occurs later on, which is the case of both terminal and freight forwarder. Naturally the timing is defined by the freight integrator and depends on the actual case.

With the transport solution perfectly established and all agents aware of their roles and duties, the physical flow may begin, which defines the ending of Sub process 1 and the beginning of Sub process 2.

The transport company sends a message to the freight integrator informing about the ending of the loading operations - Activity 1, which precedes the carriage towards the terminal. Here goods are
unloaded and, once again, at the end of this operation an information is sent to the freight integrator. This message can be sent either by the transport company, or by the terminal.

The goods are now stored within the terminal and in process of clearance. This operation is conducted by the freight forwarder, which upon completion sends a message to the freight integrator informing about such fact - Activity 5. Afterwards, the cargo is again loaded into (or onto) a vehicle - Activity 1. At the end of this operation, the transport company or the terminal sends a message to the freight integrator. At last, the goods arrive at their final destination where are delivered to the consignee. When this occurs, the transport company informs the freight integrator of such fact, which based on this information, notifies the shipper about the completion of the transport service - Activity 3.

The pattern just described is one of many possible configurations. All depends on the technology available and the requirements set by the freight integrator. If there is real time tracking, then the flows are practically continuous between the various agents and the freight integrator. Moreover, the freight integrator may decide to notify the agents involved in Activities 1, 3, 4 and 5 about the arrival of the cargo and give directives of how to act. In this situation, a new different configuration for the logical flow would generate. So, all depends the case in study.

Regardless the configuration of the logical flow, the freight integrator is the pivot of the transport chain. All agents report directly and only to her, which, in function of what was initially scheduled, processes the new information, sending tailored and relevant message to every agent. So, this agent promotes the exchange of information amongst agents. A Freight Integrator has the mission of coordinating and ensuring that all agents are rightly informed about their roles and duties, and that the transport service is following the schedules.

**Contractual Flow**

During a transport service, goods are prone to damage or even destruction, as a consequence of mishandling, accidents, or deterioration caused by natural sources (like the sun or rain), etc., which may represent significant economic losses depending of the goods’ intrinsic value and the extend of the damage. It is then necessary to define an adequate mechanisms, so that, if such situation occurs the owner could be compensated from her losses. These mechanisms are laid down in the contract established between the owner of the goods - the shipper, and the agent in charge for the transport - the freight integrator. The contract also defines the liability of this agent. Although the precise details of the contract vary from contract to contract, the truth is that these contracts are nowadays considerably standardised, due to the action of international bodies that have been issuing diverse standard-contracts for different types of transport services.
Figure 27 depicts the contractual flow of the intermodal transport chain considered herein. The contractual flow only occurs in Sub process 2, because is where there is physical flow.

In an intermodal transport chain, the ultimate responsible for the goods is the freight integrator, because it is this agent that establishes a contract with the shipper (the goods’ owner). Yet, who actually handles and transports the goods are other agents, namely: transport companies and terminals, which have to bear the responsibilities in case of damage or destruction. So, a contract is established between each of these agents and the freight integrator, where they assume the full responsibility for the goods. It should be noted that this contract is not visible for the client, whom only perceives as full responsible the freight integrator.

From this, results that during the transport service the responsible is the freight integrator - Sub Process 2. Yet, she successively transfers her responsibility to the agent that in that moment has the goods either the transport company - Activities 1 to 3 - or the terminal - Activities 4 and 5.

**Capital flow**

Capital is the *raison d’être* of any economic activity. The very existence of companies is based upon the goal of profiting from their activities. The transport sector is no exception and, naturally, agents only get involved in a transport service in exchange of some financial compensation. Furthermore, customs clearance usually involves the payment of several fees and taxes (whenever goods are being imported). Therefore, along an intermodal transport chain capital flow occurs due to payment of services and, eventually, customs duties.

The capital flows from the client towards the service providers (freight integrator, transport company, terminal and freight forwarder) or the customs authorities. Therefore, in an intermodal transport chain, the capital flows from the client - shipper or receiver - to the freight integrator. Afterwards, the capital flows from the freight integrator towards each agent. The capital corresponding to the customs duties usually flows from the client through the freight integrator then through the freight forwarder until the customs authorities.

The pattern of the Capital Flow depends upon the contracts established both, between the client and the freight integrator, and between the freight integrator and every other agent. The contracts define the moment or periods of payments. Some contracts foreseen the payment should occur before the transport service actually occurs, while others establish a period for payment after the completion of the service. Naturally, each situation results in a different pattern.

The customs duties, on the other hand, are usually payment immediately as this is a requisite for customs’ clearance.
Figure 27 depicts the capital flow for the intermodal transport chain under analysis. It is assumed payment occurs as soon as an agent fulfils her service and customs duties are paid immediately. As a result, there is capital flow during Sub Process 2 or after the completion of the Process.

Under this assumption, the first payment is made after the completion of the first Activity 3, when the transport company delivers the goods at the terminal. The following payments are made upon completion of the Activity 5, when the freight forwarder clears the goods from customs. Two payments are processed: one corresponding to the freight forwarder’s service, other to the customs’ duties.

After customs’ clearance, goods are loaded into (or onto) a vehicle. Activity 4 ends, and the terminal is paid by the services provided.

Finally, when goods reach their final destination, the transport company receives her payment, as well as the freight integration for the completion of the transport service.
Figure 26 - Physical and Logical Flows along an Intermodal Transport Chain
Figure 27 - Contractual and Capital Flows along an Intermodal Transport Chain
5 ATTRACTIVENESS CONCEPT

5.1 Concept of Friction

Intermodal transport is inherently a complex transport solution. This complexity lies at the very heart of its concept: the synchronized utilisation of various individual transport solutions. Recalling that each one presents different, or even contrasting, characteristics, which have to be adequately well-matched and coordinated, the ultimate goal of achieving high performance transport solutions could be rather complicated. This, due to the fact of complexity being fertile in inducing situations, or potential situations, prone to induce losses of performance in the intermodal transport solution. Such nature is perhaps one of the most relevant reasons for the historically low performance (and competitiveness) of the intermodal transport solutions (which is translated into the market with a very low market share and relegated to specific market segments). In this way, it is not surprising the existence of a very rich body of literature devoted to identify, study and solving the processes (sources, mechanisms of actuating and effects) of those problems. However, although major advances achieved, the fact is that intermodal transport continues to struggle (to produce high competitive solutions). Proofs are both, the current low market share for intermodal transport, and the withdrawing of several initiatives or the need of heavy subsidisation to keep them running. Such facts denote the existence of still hidden, or not correctly solved, potential sources that undermine the performance of the intermodal transport solutions.

On the other hand, nowadays, research demonstrates the most relevant problems affecting the performance of intermodal transport solutions are put at organisational level. Furthermore, in systems, like intermodal transport, performance is decisively dependent on the nature of the interactions of its parts and how well they fit together. Therefore, most probably, the remaining potential sources are located at the level of the chain and not at the level of the single elements. This does not mean that all research conducted so far has been useless, only that from now on major breakthroughs could only be achieved if the problems felt at the level of the chain are tackled.

As a result, the nature and scope of the current potential sources of loss of performance call for a holistic approach to solve the remaining potential sources of loss of performance. However, looking to the literature, one notices that it is scattered across the land field of
research, with every researcher focused on his or her own area of research, with very little integration or cross research. Moreover there is no universal definition for designating the processes of loss of performance, which hinders any attempt of both, conducting holistic research and drawing effective solutions to tackle those systemic problems. Therefore, it is firstly necessary to have a common definition, sufficiently generic that embraces all areas of research and that is sufficiently acknowledged by all research parties, so that could be universally accepted and could create a baseline for a common future development of an all-embracing research.

The term proposed here is the well known physical concept of friction. There are various advantages in choosing this concept. Firstly, it is a well-known concept in physics, with behaviour clearly defined. Secondly, its behaviour and mechanism are rather similar to those produce by the sources of loss of performance. Thirdly, it is sufficiently generic and broad to embrace under the same umbrella all potential sources of loss of performance, which are currently treated independently.

In Nature, when an object moves or attempts to move on a surface, as a consequence of external forces, there is a force of resistance opposite to its motion or impeding motion. Because surfaces are more or less rough; they contact only at few points - the peaks on the roughness. At these locations, physical and chemical interactions occur: on the one hand, the peaks of one body block the motion of the others; on the other, chemical attraction between molecules of both objects materialises bonding them (Jewett, S., 2004, p.131-133). Such converse force is called as force of friction or simply friction. Friction arises on the surface of contact and has the direction contrary to motion. So, friction acts in such a way of neutralising those external forces responsible for the object’s motion or attempt of motion. In energetic terms, and when the object is moving, friction is a source of loss of energy because it dissipates the kinetic energy in thermal energy.

Therefore, if one needs of putting an object into motion, either one increases the external force (to counterbalance friction), or one reduces the friction (by for example: cleaning or polishing the surfaces). So, reducing friction is an effective way to reduce the external force need to induce motion in an object, being an effective solution to save resources (to produce force).
Other interesting property is that friction has a dynamic behaviour, this means, it does not assume a constant value for the same two contacting surfaces. When a force is increasingly applied to a stopped object, friction will counterbalance it until a maximum level. Above this maximum value, the force will be able to induce motion and the friction level will drop the lower value. Therefore, there are two types of friction: static friction, when the object is stopped; kinetic friction, when the object is in motion. The static friction represents the maximum force that friction could counterbalance. The kinetic friction represents the value of friction when the object is moving.

Looking to the intermodal transport services, the similarities between the physical concept of friction and the process of loss of performance are clear. The concept of contact can be
considered as being the interactions and relationships between agents. Thus, objects are the agents of the transport chain. The notion of motion of attempt of motion is therefore the action of interaction or engaging in relationships, or the attempts of doing it. In Nature, friction is the consequence of physical and chemical interactions between the roughness of each surface, or in other way, friction results from the interactions between surfaces that have a physical and chemical nature. In a transport chain, the interactions have a very different mechanism, they result from the motion or the attempt of motion of the flows. As already explained there are three main flows along an intermodal transport chain: physical flow, informational flow and institutional flow. Physical flow concerns the movement of the good along the transport chain. Information flow corresponds to the exchanges of information between agents. Institutional flow corresponds to the responsibilities and duties of each agent, defined on the contracts signed or established by the national or international law. In this way, friction arises at the points of contact involved in the process of exchanging or attempting of exchanging the flow. As a result, the nature of the friction depends upon the flow that originates it. Therefore, and how it was expected, the nature of friction differs from that found in Nature, however, interestingly, in both situations friction has the same source: it is the result of motion or the attempt of motion. So summing up, friction in an intermodal transport chain has a completely different nature from that encountered in Nature, but has a similar source.

Considering now the behaviour (or outcome) of the force of friction and the process of loss of performance, both exert their influence in rather similar ways. In Nature friction counterbalances or reduces the force that attempts to move or keep in motion the object. Other way to consider friction is in energetic terms: it transforms kinetic energy into thermal energy. In the intermodal transport, the process of loss of performance acts in the way of reduction of the performance of the transport service. So, there is a clear analogy between these two mechanisms, with the concept of friction representing very well the behaviour of the loss of performance.

From all the reasoning present so far, one believes that the physical concept of friction provides a clear and accurate designation for the process of loss of performance. In this
way and within the context of intermodal transport, friction is the concept used to indicate a source, which by any mechanism, affects the smooth and direct passage of a flow between two agents, resulting in some sort of loss of performance of the intermodal transport service and ultimately in the reduction of competitiveness.

Summing up, one believes that the concept of friction should be used to generically indicate any process of inducing of loss of performance in an intermodal transport chain. It is with this meaning that the concept of friction will be used in this thesis.

5.2 Concept of Fitness

Recalling the concepts of multimodal and intermodal transport, one has that multimodal transport is a transport service made of (compound by) a set of independent and non-related uni-modal transport services. This means that for the point of view of each agent all the others do not exist, which results that each one produces her own transport service regardless the needs, characteristics, etc of the others. Therefore, the overall performance is the result of the simple combination of the various individual transport services. So, in multimodal transport the whole is equal to the sum of the parts.

In an intermodal transport service on the contrary, all agents work together for a common goal: each one is aware of the others, and each transport service is coordinated and tuned (adjusted) with the remaining ones. Such facts generate synergies and benefits for the transport chain, which are added to the performance of each individual transport service, resulting in (leading to) a further increase of the overall performance. So, in an intermodal transport service the whole is more than the sum of the parts. A final note for the fact that synergies are created as a result of the presence of another agent: the Freight Integrator (FI), whose functions are to organise and manage the various agents, aiming to get the most of each party in favour of the overall performance of the transport service.

Let us assume a set of dual systems agents - modes of transport involved in a multimodal transport service. By definition the overall performance is the summation of each individual transport service performance. In the following picture this performance is schematically represented by the left bar. If those same agents are now involved in an intermodal transport service, the overall performance will be higher due to the synergies
created by the FI. Let one assumes that each dual system is being used at the maximum of its performance, yielding the maximum possible overall performance of the transport service. Let one call this performance the theoretical performance, which is represented by the bar at right side of the following picture. This theoretical performance determines the maximum performance attainable for that specific set of dual systems, no more performance could be obtain (because one has assume that each mode is being correctly deployed).

Yet, the world is not perfect and there is always some sort of frictions between all dual systems. Therefore, the performance achievable in the real world is always inferior to the theoretical performance. Let one call that performance the real world performance. So, the real world performance is the maximum performance attainable by a given set of agents and modes. The gap between the real world performance and the theoretical performance is called as Fitness gap and is ascribable to the frictions amongst agents and modes (amongst the dual systems) (Gap 1 - in figure below).

To obtain the real world performance, the agents and modes have to be deployed in the best way; otherwise the performance really achieved is inferior. Given that the Freight Integrators are not equally skilled, different ones will certainly get different performances, from the same set of agents and modes. So, the performance really achieved by a set of agents and modes, depends ultimately on the capabilities of the FI that in charge of the transport service. Let one calls the performance really achieved by a FI as actual performance. The actual performance lays between the performance of a multimodal transport service and the real world transport service, which is represented by the third bar from the left in the following figure. The actual performance is higher than the performance of a multimodal transport service because there will be always some synergies created by the presence of the FI, adding to the individual performance of the dual systems agent - mode; and it is lower or equal than the real world performance because this performance is the maximum attainable by a transport chain. The gap between the performance of a multimodal transport service and the actual performance results from the synergies and benefits generated by the FI (Gap 2 - in figure below), while the gap between this performance and the real world performance results from the inability of the FI (Gap 3 - in figure below).
The performance actually delivered of an intermodal transport service depends on three main factors: the performance of each dual system, the ability of the FI and the fitness level; and not only of each dual system by itself. Therefore, the assemblage of high performance dual systems does not necessarily mean that the outcome will be a high performance intermodal transport service, either because there may exist high friction amongst the various parties resulting in very low performance transport chains; or because the FI may no be able to reap all the possible synergies from the resources. Here lies the explanation of why some high performance modes, when brought together are not able to yield a high performance intermodal transport chain.

Therefore, the achievement of high performance chains does not entail automatically the usage of high performance dual systems; instead it could be more rational and useful to use dual systems with very high fitness, even having lower performance. As long as the result is a transport chain with very low fitness gap, the real world performance is higher and the possibility of achieving higher performance solutions is identically higher.

The discussion done so far goes around the concept of fitness level. Fitness level is a concept that represents the level of matching of the profiles of two successive dual systems in a transport chain. In other words, it represents the extend until which the profiles fit each other. In an intermodal transport chain, the flows going trough the various dual systems may find some sort of resistance at the contacts points, due to the existence of friction. The
friction results from the existence of repulsion (factors) amongst the same variables of the two profiles. Such repulsion hinders the correct passage of the flows. On the other hand, if there is (are) attraction (factors) between the variables, then they are correctly aligned and the flow moves smoothly between dual systems, leading to no friction whatsoever.

The following picture intends to present the concept of fitness in a schematic way. Three profiles are represented: Profile 1 in red, Profile 2 in blue and Profile 3 in green. The specific configuration depends upon the identification and valuation of the constituent variables. The profiles are combined in two chains: Chain A and Chain B. When Profiles 1 and 2 are brought together, it is visible that they do not match. The profiles are not compatible, due to the existence of some repulsion factors that yield in friction, represented at gray. On the other hand, there is perfect fitting between Profiles 1 and 3. These profiles are entirely compatible. As a result, no friction arises and no losses occur in the motion of the flows between profiles.

The fitness level of Chain B is higher than in Chain A, because the profiles match considerably better in the former than in the latter. Other way to infer about fitness consists in evaluating the friction level, because it denotes no matching profiles. Since in Chain A there is friction while in Chain B, so the fitness is higher in the latter than in the former. So, fitness is a concept that represents the friction that may arise by combining two dual systems agents - modes of transport along an intermodal transport chain. So, fitness is intrinsically attached with the concept of friction. They may be considered the two sides of a same coin.

Fitness and friction represent the same principle but in opposite ways. Friction is used to designate the problems affecting the performance of a transport chain, which are the reason
for losses of performance. Fitness represents at which extend to dual systems agent-mode match or fit, which is related with the degree of friction amongst them.

Fitness is a concept that represents the level of friction on a set of dual systems agent-mode of transport. The higher the friction, the lower the fitness is. So, fitness represents at which extend the profiles of the set of the dual systems agent-mode of transport match.

5.3 Definition of Profile

The multidisciplinary dimension - different sources and natures - of the problems affecting the performance and competitiveness of the intermodal transport services, calls for a systemic approach embracing the various relevant fields of knowledge. However, when looking to the current state of the art, cross research is rare; on the contrary, most of it is focussed on the field of research of expertise of the researcher. Nonetheless, it should be emphasised the unquestionable value of such investigation for the resolution of many problems.

A holistic approach enables, firstly, to tackle simultaneously the various problems, secondly, to identify which are most relevant and influential ones, and thirdly, to identify eventual cross influences amongst factors, which otherwise would pass undiscovered. Moving towards a holistic research means moving towards a upper level, where various field of knowledge are brought to work together so that common answers and solutions could be obtained. However, such evolution requires for new concepts and definitions.

In the previous section the concept of friction has been introducing, aiming to embrace barriers inducing loss of performance in the intermodal transport service. In this section the concept of profile is presented. A profile is the set of relevant variables necessary for the complete characterisation of an object in terms of service performance taking into account the target requirements of the intermodal transport service.

The definition deserves several comments. Firstly, a profile concerns always to an object. The object can be a mode of transport, an agent or a transport chain. Secondly, the variables compounding the profile have to simultaneously be intrinsic to the object and affect somehow the overall performance of the transport service. Thirdly, the relevancy of a variable is directly linked with its degree of influencing the overall service performance. The emphasis placed on service performance results from the fact of in the present context
being considered as a proxy for assessing the competitiveness of the transport service. Fourthly, the service performance level is, in turn, function of the requirements established by the client for the transport service.

An interesting conclusion drawn from these comments concerns the dynamic nature of the profile. In other words, the set of variables are neither static nor constant; on the contrary they show a wide degree of variability. More precisely, the set of variable is function of three main variables: first, the object of the profile; second, the service performance target, which is in turn levelled by requirements of the client; and third, the time, because the variables considered relevant by the organiser and manager of the transport service - the Freight Integrator (FI) - may evolve throughout time, due to the effect of the learning curve (the FI may realise that a certain is no longer necessary for a given agent, because she has enough knowledge on him).

A second conclusion possible to draw is that a profile is not made of all possible variables, but only by those having some influence on the overall service performance, which makes sense, since the use of neutral variables would only introduce noise to the analysis and decision making process, without any added value.

Recalling the concept of friction explained in the previous section, as being the negative effect on the performance of the transport service. The nature of the influence of the variables of the profile is now clear: it represents the level friction introduced. As a result, a third conclusion can be drawn, which is no more than a re-writing of the second conclusion: the profile is compound for all the variables that potentially may provoke (or induce) friction in the transport chain, and consequently affect it performance.

Summing up, the concept of profile aims to embrace all the factors that may introduce friction within an intermodal transport service. These factors are naturally can be chosen from all fields of knowledge. Therefore, this concept has all properties to allow for a systemic approach to the problem affecting the intermodal transport. Once again the ultimate goal is to unite the research, which is nowadays scattered, around a universal concept.
6 CASE STUDY

The case study corresponds to an intermodal transport service between the port of Sines, located in the south of Portugal, and center region of Portugal. The transport chain comprises three modes of transport, namely: sea, train and road transport. The goods are transport within ISO containers.

The physical flow of the goods is as follows: the containers are shipped from elsewhere into the port of Sines. At this location, the containers are transferred to trains and afterwards transported to two intermodal terminals, located in Bobadela and Riachos (in the center of Portugal). At these terminals, the containers are again transferred to trucks that carry them to the final destinations. The same flow occurs in the opposite direction: containers are transported successively by road from each origin to one of the two intermodal terminals, from here are transported by train to the port of Sines, where finally shipped to elsewhere. Each ship normally transports up to three hundreds containers 20” ISO containers, each train up to 44 containers and each truck up to 2 containers.

![Figure 28 – Intermodal transport chain](image)

The intermodal transport chain is compound of various agents: carriers (sea, train and road), terminal operators, freight integrator and customs authorities.

The sea carrier plays a double role: firstly, she is in charge for the sea transport leg; secondly, she is in charge for all customers’ relationships. Such situation results in real
terms on the dominion of the chain, because she defines both the ships’ schedules and road transport services.

The train carrier is in charge of transporting the goods between the port of Sines and the other two intermodal terminals. This agent receives from the freight integrator the information concerning the number of containers to transport between these locations. However, the train operator lacks some flexibility: first, a weekly fixed scheduled is defines (five block trains per week); second, there are strictly rules to change the weekly quantity of trains, namely: the requisition of an extra train has to been done up 24 hours before the desired time, the elimination of a train has to been done up to 48 hours before the scheduled time, and third, a train service is a full round trip (Riachos’ terminal – Bobadela’s terminal – port of Sines - Bobadela’s terminal - Riachos’ terminal). Such situation means that if even there are no containers to be transport in one direction, the service is paid anyway.

The road transport is assured by a set of road carriers contracted by the freight integrator on an ad hoc basis.

The three terminal operators at the port of Sines and terminals of Bobadela and Riachos receive the information from the freight integrator concerning the containers to transfer between the ships and trains, and the trains and trucks.

The freight integrator is the organiser of the intermodal transport chain. This agent receives the information from the sea carriers concerning the ships’ schedules and the transport services. Based upon this information the freight integrator has to contract the road transport, define which containers to transport (in function of the fixed trains schedule) and decide to require or eliminate extra trains.

In what concerns the contractual relationship the intermodal transport chain’s client is the sea carrier, this is the reason for this agent be in charge with customers’ relationships. This agent has contracted with the terminal operator of the port of Sines the transport of the containers between the port and the two intermodal transport terminals (Bobadela and Riachos). Since the port operator has had no competences on this mater, she has eventually contracted a freight integrator. The remaining agents are contracted by the freight integrator, on behalf of the port of Sines terminal operator.
One of the main issues affecting this intermodal transport service concerns the fact that most of the outbound services are only known within the last 24 hours of each ship, when is no longer possible to require change the number of trains. Despite the efforts conducted by the freight integrator in leading the sea carrier to change her behaviour (and start communicating the service list earlier), the fact is she has no incentive whatsoever to change its behaviour. This situation is the outcome of the awkward contractual structure, which defined that when problems occur the fault falls upon the port of Sines terminal operator. Furthermore, this service only began in 2003, so there is still very little knowledge on the behaviour and agents, which makes further difficult the trains’ management.

Finally, the information system is rather rudimentary, being entirely based on human work supported on e-mails, phone and paper. There is no common information system. As a result a considerably amount of time is spending in useless tasks, like for example: reading e-mails, converting paper based information to digital environment (commonly a spreadsheet), carrying paper documents from an office to another, phoning, processing information ,etc. Furthermore, although the amount of errors is still rather low, for diverse times containers were grounded, due to incomplete processing, with all the inherent problems of these situations.

Following this short presentation, the usage and interest of the concepts of friction and fitness becomes rather clear. This intermodal transport chain presents diverse sources of friction, responsible for losses in the overall transport service performance, and even all agents are operating at the best of their capabilities such frictions will undermine the ultimate chain’s competitiveness.

As presented above, in order to apply the concept of friction, it is firstly necessary to define the agents’ profile. Aiming to keep the example simple and straightforward only three variable have been chosen to compound the each agent profile. Furthermore, only three agents, and respective relationships are being analysed: freight integrator, sea carrier and train carrier.
The variables identified as most suitable for making the agents’ profile are the following:

- Flexibility;
- Commitment;
- Information System.

In function of this variables and recalling the case study description it is possible to positioning of each agent for the various variables.

<table>
<thead>
<tr>
<th>Agents’ profile variables</th>
<th>Freight Integrator</th>
<th>Sea Carrier</th>
<th>Train carrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexibility</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Commitment</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Information System</td>
<td>Rudimentary</td>
<td>Rudimentary</td>
<td>Rudimentary</td>
</tr>
</tbody>
</table>

Looking to Table 19, it is clear the various sources of friction in this intermodal transport service. In what concerns the variable flexibility, the train carrier presents a very low level, which represents a major source of friction since hinders the transport service’s optimisation. The period for changing trains is not adequate to the reality, as a result the freight integrator is compelled to conjecture about the future, which is often turns out to be wrong. Furthermore, the sea carrier, by not showing signs of changing her behaviour in the sense of attempting to communicate the service earlier, poses further difficulties to the freight integrator’s mission. So, the medium flexibility of the sea carrier is also another source of friction.

The sea carrier’s medium flexibility is intrinsically related with her commitment level. As it would be expected this agent behaves rationally and tries to maximise her own benefits, regardless the interest of the others, and the intermodal transport service. Since this agent plays a preponderant role in the transport service, such behaviour often results in situations difficult to manage. An example is the fact of communicating the final list of transport services to the freight integrator too late, when there is no possibility of changing the number of trains. The train carrier has identically a low commitment level, because she
limits to react to the freight integrator decisions, without making any attempt to change her behaviour to better fit into the chains. The freight integrator, is the only agent, with a high level of commitment, an expected position as this agent is contracted to manage the chain.

Finally, in what concerns the information system, all agents use a rudimentary technology which makes the transfer of information difficult and slow, and is prone to errors and faults. Such situation naturally introduces friction in the information flow, provoking an overall reduction in the transport service performance. All these various sources of friction result in an overall losses of performance. Therefore, the fitness level of this intermodal transport chain is relatively weak.

So far, most of efforts devoted to the promotion of intermodal freight transport have been focussed on particular details of the transport chains: either on the elimination of bottlenecks along the transport chains, or on the promotion of each mode by itself. However, nowadays most of those issues are located at the chain level, which is calling for a new approach to the problem. The solution entails necessarily a holistic approach, where the intermodal transport service is considered as a system. At the system level, the interactions amongst agents assume a relevant role, which are necessary to take into consideration when doing research.
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7 CONCLUSIONS

This report summarises the main activities and findings developed in the project ELOFRET - Elements for the Optimization of Intermodal Chains in Freight Transport. The main goals of ELOFRET were: firstly, identifying the variables of the agents’ decision process leading to the preferred configuration of the intermodal chain, based on their potential for integration; and secondly, to identify the information requirements to support the role of the freight integrator. Furthermore, ELOFRET represented the opportunity to transfer to the Portuguese environment the international experience, enabling to provide an effective contribution for the optimised use of our logistic platforms by identifying the key attributes to overcome barriers to intermodality.

An extensive state of the art to the transport freight sector has been made. Firstly, the main drivers and trends that have been occurring in the envelop of the freight transport sector have been analysed and presented. It has been identified five drivers and five trends. The drivers being: economic, industrial and management; technological; political; social; and environmental. The trends being: restructuring of logistics systems; realignment of supply chains; rescheduling of product flows; changes in the management of transport resources; and changes in product design. These have been inducing major changes in the freight transport sector. In the light of this information, the modes of transport and agents have then been fully characterised at various dimensions, namely: technology, liability, information and requirements. Having this information gathered, the process of intermodal transport was finally depicted along with the identification of its critical path.

An innovative theoretical concepts - Attractiveness Concept - has then been developed. This concept brings into the transportation sector the well known phenomenon of friction in physics. Along an intermodal transport chain a set of modes of transport and agents interact with the ultimate purpose of providing a high performance transport service. The core idea is that an intermodal transportation may be understood as a set of block that slide (or attempt to slide) ones against the others. Each block represents a mode of transport and transport agent, while the sliding process corresponds to their interactions. If the ultimate purpose is the sliding of the blocks, the presence of friction will hinder that mission. The same happens in an intermodal transport service: incompatibilities or other problems during the interactions are likely to make difficult the transport process resulting in losses.
of performance. The case study of the intermodal transport chain from the port of Sines presents a good example of the purpose and capabilities of this concept.

The scientific team member Vasco Reis is in his Doctoral Programme developing and researching the concept of attractiveness applied to intermodal freight transport chains with air transport. In his PhD Thesis he will complete description of the concept (that was not possible to do in ELOFRET) and build up a simulation tool that will make use of this concept to infer the friction level of any intermodal transport chain.
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