IQ – INTERMODAL QUALITY

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Partnership

The consortium is composed of 19 partners of diverse types. It includes European research institutes, transport professionals and representatives of the intermodal sector:

- *Research Institutes*: INRETS (France), NEA (Netherlands), TFK (Sweden and Germany), MOLBAY (Spain), SYSTEMA (Greece), Ecole Centrale de Paris (France), Université de Paris-Dauphine (France),

- *Transport Professionals*:
  - Terminal operators: DUSS (Germany), CEMAT (Italy), TCC Sea Train (Spain), Rhein-Ruhr Hafen (Germany), Interporto Quadrante Europa (Italy),
  - Networks operators: SJ (Sweden), SNCF (France), CEMAT (Italie), TCC Sea Train (Spain),

- *Companies and consultants*: Technicatome (France), AND (Netherlands), EDS (Italy), Metis (Italy), SCI Verkehr (Germany), Temaplan (Sweden),

- *Associations of users*: EIA (Belgium), ITF (Netherlands), Uniontrasporti (Italy).

An Advisory Committee chaired by an operator (M. MUZIO – CEMAT) worked in conjunction with a scientific Steering Committee chaired by INRETS (C. REYNAUD): this collaboration between the two committees was very helpful in achieving a good equilibrium in IQ developments.

Executive summary

The aim of IQ is to improve the quality of intermodal transport, and the quality is considered at the level of the final user.

In IQ it is assumed that the demand side of the market is heterogeneous and therefore an optimal service to one client might not be optimised for an other. The segmentation of the market must highlight this heterogeneity, which was not the case of the previous segmentation proposed, based on supply characteristics.

With this approach all the different aspects of the intermodal transport system have to be taken into account, as well as their interactions, in order to assess the impact of a specific action on intermodal quality: these aspects are economic, organisational, technical, spatial and define what has been called an « integrated » approach for « integrated transport chain ».

The definition of quality indicators is the required, as overall indicators for the final user, (external quality) but also at intermediate level as operation for the transport operator (internal quality).

In the two workpackages, the quality of terminal and the quality of network is assessed for the present situation and an horizon of 2010 with the performance indicators

In a later stage, IQ will integrate the element of terminals and networks analysis along the lines of spatial, professional and technological consistency requirements. Extensive database on terminals and network services will allow the creation of a tool for simulation of services improvements.

The project will then be successful only if the results are accepted and implemented in the market. Demonstration cases are introduced in IQ. Therefore the outputs will be a set of recommendation for a transport operators and policy makers and an evaluation framework for concrete experiments, which in term, should also validate the IQ indicators and the IQ integrated methodology. An important dissemination of the results will then be possible as soon as first reports are available.

The Consortium, regrouping research teams and professional organisations has defined a first segmentation of the market, proposed performance indicators for terminal, and investigated the main technological developments (hardware, software) in order to measure their impact, the former progress report covered a period of completion of workpackage 1 relative to terminals as well as the workpackage 2 relative to the networks with in particular the launching of a field survey with a sample of 250 large companies, representatives of European final users.

Objectives of the project

The ***main objective*** of the project was to supply the necessary tools for enhancing European intermodal transport by improving: inter-operability among terminals, inter-connectivity and accessibility, and taking for base the quality of the transport chain.

It must be admitted that there is no generally accepted definition of the terms Intermodal or Combined Transport. Any chosen definition must therefore be justifiable in heuristic terms, and, in practice, be targeted to meet the aims of the enquiry. According to the methodological approach, technical, legal and/or political elements may be utilised in a definition.

There is a consensus that intermodal transport constitutes a transport process in which at least two of the following conditions are fulfilled:

- two or more different transport modes (lorry, train, barge, ship, plane) are deployed,
- the goods remain in one and the same transport load unit for the entire journey.

This perspective finds clear expression in the recent definition adopted at the European Transport Ministers Conference (ECMT) of 1993, and also in various definitions adopted by the EU.
There, first “multimodal transport” is defined as: “the transport of goods by at least two different transport modes”.
A subset of this is “intermodal transport”: “the transport of goods in one and the same load unit by various transport modes, whereby a change in the load unit does not entail a transfer of the transported goods themselves. The load unit can be either a vehicle or an intermodal transport unit (ITU)”.

The development of the intermodal transport requires that the quality is adapted to the logistic requirements of the different market segments within a competitive environment characterised by low costs and low road transport rates. Quality is considered as a very important factor of competition being aware that “non-quality” appears clearly as a source of cost in operating intermodal transport which cannot be accepted by users or operators. In doing this IQ analyses not only the economic performances of intermodal transportation but also its commercial performance.

First of all, IQ refers to the quality resulting of the final customers needs : the “External Quality”, based on a market segmentation and quality indication.

Secondly, IQ refers to the quality resulting of the production and commercialisation modalities of intermodal transportation : the “Internal Quality” which provides a dynamic understanding of the system. The internal quality is based

- on an analysis of the determinants of the quality criteria as they can be identified from a system analysis of the intermodal transport,

- but also on the actors strategy within a competitive environment which is itself affected by structural and institutional changes.

This double approach of the quality has enabled to develop a prospective analysis and ***the construction of scenarios***, in order to put into perspective the different quality determinants, and their effects on the future of intermodal transport.

The ***approach*** used by IQ was firstly very analytical and considered the different components of the chain through an analysis of the Quality of the Terminals (WP1) and the Quality of the Networks (WP2), for different countries and different segments, at European and national level.

The aim is not to separate the different components but a contrario to focus in a second step on the synergies and interactions of these two elements within an integrated approach of the system (Interactions : WP3).

Demonstration cases (WP4) enrich the results thank to a double movement of validation of the hypothesis but also in return with an improvement of the evaluation method of demonstration cases.

For each research phases, IQ has been developed on a qualitative and quantitative basis the different technological, spatial, economical and institutional aspects which interact between each other. Databases, simulation models, GIS are produced in parallel with proposals of implementation measures (WP5) to stimulate intermodal transport wider hypothesis of contrasted policy scenarios.

IQ appears today as a global project with a wealth of information and numerous documents which are going to be published and be accessible on web site, with a large variety of interrelated subjects as well as a set of tools (WP6).

Finally, it is important to stress that IQ has realised several surveys on intermodal transport to collect data and validate results with in particular a wide European face to face survey among (possible) customers of intermodal transport (final users point of view), a terminal operators survey, and an intermodal transport operator survey for the identification of best practices throughout Europe, and finally several national monographs, covering all countries of the European Union concerning terminal policy and investments as well as policies developed to face capacity constraints in rail operations.

Means used to achieve the objectives

Among the means used to achieve IQ objectives there was first the composition of the consortium with a wide representation of the parties concerned by intermodal transport : research organisation, intermodal operators, railways operators, organisations who represent transport professional association and experts in new technologies.

The consortium members were also representative of the different European countries from north to south of Europe.

In the first part of the project an important effort has been devoted to capitalisation of data through surveys initiated towards major terminal operators. For rail operations best practises have been identified and detailed throughout Europe.

Since the quality for the final user was the main concern of the project, an important survey has been conducted with a sample of almost 200 companies chosen in different countries : the interviews were conducted face to face in native language on the basis of a detailed, structured questionnaire. The results were used to validate the hypothesis on the segmentation of the market and to assess the different quality criteria. Questions relative to the evolution of intermodal transport system were also discussed in order to bring a sound basis for a prospective analysis.

Demonstration cases were also developed in order to test hypothesis and to improve the understanding of implementation conditions.

Furthermore a database has been constructed with information on intermodal network and quality of service so that a modal, SIMIQ, could be elaborated for the location of rail hub : consolidation of flows is a major question for rail efficiency and rail quality of service.

Finally the interest of decision makers could be simulated with the comparative analysis of national policies as regards intermodal transport and the elaboration of scenarios in order to better understand the different possible futures of intermodal transport.

Formulation of hypothesis, collection of data, construction of a database and modelling, co-operation between different types of organisation, from different countries, validation of results with demonstration cases were the most important means used to reach the objectives.

Scientific and technical description of the project

Introduction

Intermodal Quality was a four-year project (1996-1999) that was part of the European Commission’s 4th Framework Programme within the “Integrated transport chains” programme.

The *main objective* of the project was to provide the necessary tools for enhancing European intermodal transport by improving interoperability between terminals, interconnectedness and accessibility, with particular reference to the quality of the transport chain.

It must be admitted that there is no generally accepted definition of the terms Intermodal Transport or Combined Transport. Any definition must therefore be heuristic, and, in practice, be targeted to meet the aims of the enquiry. Depending on the methodological approach, the definition used may involve technical, legal and/or political elements.

There is, however, consensus that a transport process which fulfils the following conditions can be described as intermodal:

- two or more different transport modes (lorry, train, barge, ship, plane) are deployed,
- the goods remain in one and the same transport load unit for the entire journey.

This view finds clear expression in the recent definition adopted at the 1993 European Conference of Ministers of Transport (ECMT), and also in various definitions adopted by the EU.

The ECMT defined “multimodal transport” as: “the transport of goods by at least two different transport modes”.

A subdivision of this is “intermodal transport” which has been defined as “the transport of goods in one and the same load unit by various transport modes, whereby a change in the load unit does not entail a transfer of the transported goods themselves. The load unit can be either a vehicle or an intermodal transport unit (ITU)”.

In order for intermodal transport to develop quality must meet the logistical requirements of the different market segments within a competitive environment characterised by low costs and low road transport rates. Quality is perceived as extremely important with regard to competition as its absence is clearly a source of additional intermodal transport operating costs which cannot be by either users or operators. Our analyses of IQ take account of not only the economic performance of intermodal transportation but also its commercial performance.

Firstly, the IQ project is concerned with quality as measured with reference to the end customer's needs: the “External Quality”, based on a market segmentation and quality indication.

Secondly, the IQ project is concerned with the quality resulting from intermodal transportation's internal mechanisms of production and commercialisation of intermodal transportation, namely the “Internal Quality” which provides a dynamic understanding of the system. Internal quality depends on:

- the determinants of the quality criteria as identified by a systems analysis of intermodal transport,
- but also on the strategies of the players within a competitive environment which is itself affected by structural and institutional changes.

This double approach to quality has made it possible to conduct an exploratory analysis and *the construct scenarios*, in order to put the different quality determinants and their effects on the future of intermodal transport into perspective.

The *approach* used by IQ was initially highly analytical and considered the different components of the chain through an analysis, at European and national level, of the Quality of the Terminals (WP1) and the Quality of the Networks (WP2) for different countries and different segments.

The aim of the next stage was not to separate the different components but rather to focus on the synergies and interactions between these two elements within an integrated study of the system (Interactions: WP3).

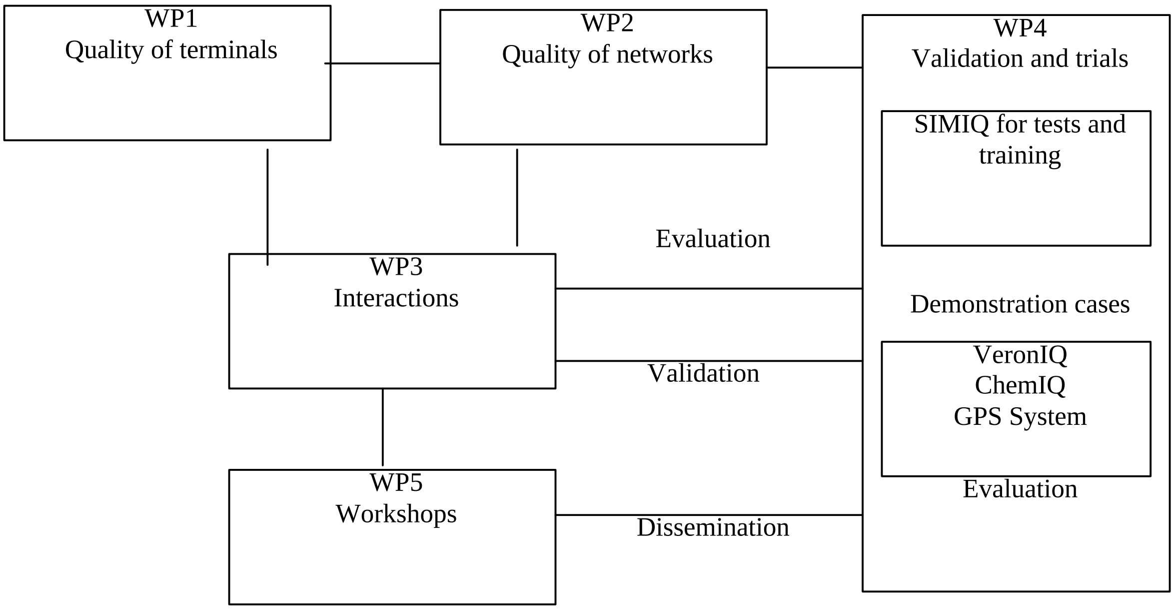
Demonstration cases (WP4) enriched the results by means of a dual process which involved validating the hypotheses but also in return with an improvement of the evaluation method of demonstration cases.

Within each phase of the research, the IQ project has analyzed, on a qualitative and quantitative basis, the different technological, spatial, economic and institutional aspects which are in interaction with each other. Databases, simulation models and a GIS have been produced together with proposed implementation measures (WP5) aimed at stimulating intermodal transport in a wider hypothetical framework of contrasted policy scenarios.

IQ is now a comprehensive project with a wealth of information and numerous documents which are to be published and made accessible on a web site. It covers a large range of interrelated subjects and includes a set of tools (WP6).

Finally, it is important to stress that IQ has conducted several surveys on intermodal transport to collect data and validate results. In particular, it has conducted a large Europe-wide survey involving face-to-face interviews of potential intermodal transport users (to gather the point of view of the end user), a survey of terminal operators, and a survey of intermodal transport operators in order to identify bets practice throughout Europe. It has also produced several national reports, covering all countries of the European Union and dealing with terminal policy and investments as well as the policies that have been developed to cope with rail capacity constraints.

Figure 1: The structure of the work



When the working hypotheses had been established (definition of concepts relating to quality and market segmentation) and validated by interviews with experts and surveys, WP1 and WP2 collected a wide range of information guided by the following aims:

- to cover of all EU countries and draft monographs for terminal and rail operation policies
- to develop typologies for terminal and rail operating systems in order to structure a data base (which also included inland waterways)
- to identify major innovations (technological and organisational) and best practises, and assess their impact
- to interview operators and users about present-day and future developments
- to set up a data base containing traffic flows, infrastructure (links and nodes) and services.

For this part of IQ the participation of major operators in the consortium was essential in order to access and analyse the data.

WP3 contains the results of major review and formalisation activities conducted under the leadership of research institutes. Original methods and tools have been developed: DIQIT, an interactive tool for professional integration, an assessment methodology for the integration of new technologies in intermodal chains, a “5 layer-model” for a systems analysis. Attention was focused on the interfaces between terminal and rail operations, and on the synergies which can develop between different components of the system. Quality in rail operations has been highlighted as a major determinant of the overall quality of intermodal transport. The current state of “institutional transition” of the intermodal system has also been analysed; this has a major impact on both the behaviour and the strategy of the players.

WP4 contains demonstration cases that provide a concrete application of the analysis. They are situated at different levels of the intermodal chain in order to provide a better understanding of applications. The demonstration cases also play a part in the process of validating the analysis with reference to the following specific cases: a terminal (Verona and Munich), a rail operating system (transport of chemical products to Poland) or the connection between different parts of a transport chain (transmission of information along a chain between Scandinavia and Continental Europe).

As part of WP4, tools for quantitative projections were also developed in order to examine the potential market in the year 2010 on an origin-destination basis, to simulate hub locations (SIMIQ) and to assign flows onto the networks (GIS-IQ).

Once the main determinants had been identified and the projection tools modified, a forward study was performed with the aim of helping decision-makers, institutions and operators to identify the most appropriate actions to improve the performance of intermodal transport. This is the subject of WP5, and elicits a number of remarks:

- WP5 was added to as the project developed to take more account of the major findings of the first workpackages and the changes that have occurred in recent years within intermodal transport. In consequence there has been a certain reallocation of resources.
- WP5 produced scenarios which were intended to assist strategic decision-making, but which also helped with the development of an implementation plan
- WP5 focused on the main determinants of the system; it is based on a seven projection segments, produced by aggregating the initial market segments (23 quality segments) and on the basis of important supply characteristics (taking price/cost changes into account).
- WP 5 developed scenarios for both northern and southern Europe and also considered developments affecting short sea shipping.

This description shows how the balance was maintained within IQ between research and application objectives, from definition of the tasks (theoretical and applied) to the direction of the project (scientific and advisory committees).

The final report is in 4 parts:

- Part 1 - Market analysis; quality requirements for different market segments (the working hypotheses and their validation)
- Part 2 - Performance of the intermodal transport system, including terminals, networks and their interrelations. In a more detailed version of the report, this chapter has been broken down into three parts (WP1, WP2, WP3)
- Part 3 - Demonstration cases and simulation tools (WP4)
- Part 4 - Projection: intermodal scenarios and policy packages (WP5)

1. QUALITY AND MARKET SEGMENTATION

The objective of the Intermodal Quality project (IQ) was to assess and improve the quality of intermodal transport. But what does the customer want?

In this project, the customer has been defined as the organisation which offers the full load unit (known as an FTL or FCL) as a shipment to the intermodal operator ; in practice, this means that the customer can be a shipper, a shipping line, or a forwarder working on behalf of one of these for example when consolidating small consignments from several shippers into one box (known as an LCL, LTL).

An important starting point for research is the trivial fact that intermodal transport is part of a supply-demand chain. The quality requirements are set by shippers and by transport companies/forwarders working on behalf of shippers. These requirements may differ. The shipper may focus on maximum safety and reliability but may be less demanding as regards transport speed. The transport company, on the other hand, will of course make the shipper's requirements known to the intermodal operator but also add requirements of its own, such as high transport speed in order for its equipment to be available for the next shipment as soon as possible (early equipment return). The intermodal operator has no choice but to satisfy both sets of requirements.

Hence, intermodal quality is defined with reference to the various maximum requirements which are voiced within the entire transport chain and, with long-distance road haulage being the main competitor, within other transport chains.

1.1. Quality criteria and market segmentation: preliminary analysis and working hypotheses

To assess quality, it is crucial to have a clear picture of the different types of customers and their demands, as one can assume that different groups of customers different groups of customers have very different demands. Market segmentation provided the starting point for this. The market segmentation was validated by interviews with experts and by a large-scale European customer survey.

However, first of all, the concept of quality must be defined in greater detail. Quality will be measured by performance indicators which quantify and compare all aspects of quality in different situations, for different types of customers and under different conditions.

1.1.1. Quality criteria

Quality has been defined using 7 quality criteria :

- time indicators - e.g. the total length of time between when the load unit is ready for transport and when it is delivered,
- reliability - the absence of unforeseen lowering of performance,
- flexibility - the ease with which the system adjusts to an unexpected change in logistic requirements,
- qualification - the capacity to cope with complex logistic requirements,
- accessibility - the ease with which the intermodal transport system can be used,
- monitoring - this relates to whether and to how well the cargo or load units can be monitored and the ability to obtain information about the status of the cargo,
- safety and security - the risk of losing equipment and goods.

Price cannot be considered as an element of quality. It is, however, included in the analysis in order to assess the monetary impact of quality indicators.

1.1.2. Market segmentation

It was also necessary to develop a market segmentation for IQ which meets the following scientific and practical requirements:

- it must be possible to link demand segments with logistic requirements,
- each segment should be as homogeneous as possible and differ clearly from other segments,
- segment definitions should be clear enough to link them to individual clients or individual transport chains,
- there should be neither too few nor too many segments,
- it should be possible to link market segments to basic transport projection dimensions (e.g. sectoral, commodity or company class approaches, etc.).

Based on previous studies and the criteria set out above, a preliminary segmentation was developed. This was then tested by a number of expert and company interviews.

As a starting point, three dimensions for segmentation were proposed:

- user type (shipper, forwarder, large or small road transport company, sea carrier),
- distance / O-D class (intercontinental or continental, long or short distance and international or domestic (for the inland leg)),
- commodity type (hazardous, perishable, high value general cargo or low value general cargo).

These segments could be expected to differ with respect to the following quality aspects:

- for user type - differences in :
  - the need for additional services (renting, repair, etc.),
  - requirements for monitoring,
  - requirements for flexibility,
  - requirements for reliability,

- requirements for commercial accessibility (ease of use for occasional users).

- for Distance / O-D class:

time pressure was expected to be less for intercontinental (maritime) transport than for continental transport,

for long distances, time and commercial accessibility were expected to be less important, while monitoring was expected to be less important. The need for additional services was considered likely to be greater on long distances,

for international transport, more emphasis on monitoring and more need for additional services such as pre- or end-haulage services were expected.

- for commodity type:
  - monitoring and reliability were expected to be relatively important for hazardous goods and perishable goods,
  - security, qualification and safety were expected to be important for hazardous goods, ,
  - for low-value cargo, modal choice was expected to be mainly determined by price; no quality features are expected to be of more than average importance.

So far, priority has been given to commodity type in the segmentation of the transport market, and the combination of the three main characteristics of the intermodal market is an original contribution of the IQ project.

After the consultation of experts, 23 segments were identified as relevant for our analysis. The concept of “logistic profiles” (see annex 1). Has also been applied in order to test the segments with reference to the maximum requirements voiced within transport chain as a whole.

Market segments
Maritime transport: 1. carrier haulage 2. merchant haulage / LCL or FCL / export 3. merchant haulage / LCL, import 4. merchant haulage / FCL, import 5. maritime transport / hazardous goods 6. maritime transport / perishable goods *Continental transport:* 1. hazardous goods / medium-distance 2. hazardous goods / long-distance 3. perishable goods / medium-distance 4. perishable goods / long-distance *Continental transport of general cargo for shippers:* 1. medium-distance / high-value goods 2. long-distance / high-value goods 3. low-value goods *Continental transport of general cargo for forwarders or road transport companies:* medium-distance / high-value or consolidated goods / regular users long-distance / high-value or consolidated goods / regular users medium-distance / high-value or consolidated goods / occasional users long-distance / high-value or consolidated goods / occasional users low-value goods *Others:* captive short-sea transport (Ireland, Greece, Scandinavia) captive rail transport (truck-restriction areas such as the Alps) inter-plant transport for large shippers waste transport transport of empty container boxes

1.2. Consulting experts : the first stage of qualitative validation

Experts in intermodal transport (representatives of the industry, government, researchers and consultants) were interviewed. The respondents were asked to comment on a preliminary segmentation of the market.

Most agreed on the fact that a demand-oriented segmentation is an innovative approach. There is, however, an overlap with supply-oriented segmentation so a clear distinction must be made between the transport of maritime containers and swap bodies.

With regard to demand-oriented market segmentation, these remarks have been taken into account for the definition of the 23 segments, and the other relevant comments have been retained for subsequent analysis of the intermodal system.

1.2.1. Relevance of the types of segmentation

The three dimensions of segmentation were regarded as being appropriate. Additional comments and suggestions have been:

- With regard to user type

The distinction between road transport and forwarding companies was regarded as being rather vague. It was argued that a road transport company using intermodal transport acts, by definition, as a forwarder.

It was proposed to distinguish between small and large companies. The importance of the small transport company as a customer was doubted. Several respondents emphasised the importance of volumes shipped and this must be remembered later, when analysis will no longer be restricted to the “load units” market.

The requirements for consolidated shipments were expected to be stricter than for complete loads (LTL vs FTL).

- With regard to commodity type

The distinction according to commodity type was approved by all respondents.

Several respondents mentioned the type of load unit. This had been ignored because it was assumed to be a feature of supply rather than demand. However, occasional customers may not have standardised load units at their disposal. The link with quality requirements remained unclear.

- With regard to origin-destination classes

The distinction between intercontinental and continental transport was approved.

Quality requirements for captive short-sea traffic differ from overseas transport and continental shipments. A separate segment should be considered.

Some of the respondents felt that the distinction between domestic and international transport links is not relevant to quality requirements. This segmentation was regarded as a feature of supply.

The distinction between medium- and long-distance transport was regarded as unclear. A line may be drawn at the distance a lorry driver can cover in one day.

Short-distance transport should not be ignored, for example, the high-volume Rotterdam-Antwerp link over a distance of less than 100 km.

- ***Comments on other quality aspects***

Again it was often stressed that a volume-oriented criterion should be included. For companies that generate high transport volumes on certain links (e.g. intra-company deliveries) investment in either tailoring intermodal solutions or adjusting internal logistics to existing intermodal supply will be worthwhile. This has been taken into account in WP3 in what has been called “professional integration” and by the development of an “interactive” tool (DIQIT) which should facilitate this type of adjustment. Tailor-made solutions are less likely in the case of the scattered delivery of smaller volumes.

The distinction between occasional and regular users is related to the previous point. This will have an influence on the likelihood of using additional services. Users will have different requirements if they see intermodal transport as a solution for only a small proportion of their shipments.

The importance of logistic strategies is also pointed out: producers of the same product may develop different industrial logistic services. Hence, the quality requirements for a particular type of goods may vary from case to case. A behavioural dimension should be added, but, of course, such a dimension is difficult to use in evaluating and projection activities.

The importance of price was also mentioned. Although price is not a quality characteristic it should be taken into account as it is the most important service feature for most (potential) users.

Niche markets may involve considerable volumes. An example is waste logistics, whose requirements differ from all the previously mentioned segments. The same holds for the transport of empty container boxes and for inter-plant transport between factories belonging to the same company.

- ***The spatial aspect***

It was argued that quality requirements are much influenced by local transport supply. Obvious examples are trans-Alpine transport or Channel-crossing shipments. Road transport encounters specific obstacles in these areas which means that intermodal transport can be of lower quality and remain competitive.

Experts were asked to rate the importance of specific logistic requirements in the individual market segments by filling in two tables. In the first they were asked to indicate which quality variable was the most important for each of the market segments. In the second table they were asked to rate the importance of the quality variables for each of the market segments (a rating of 10 meant extremely important, a rating of 1 meant extremely unimportant).

In practise, this proved to be difficult. However, the most interesting results are given below.

1.2.2. Consolidation of 23 segments

1. Carrier haulage: Here the deep-sea shipping company is the customer. As it is a regular user, high equipment productivity (including early equipment return) is very important.

2. Merchant haulage: In merchant haulage the customer is the forwarder (in some cases the shipper). Customers are always regular users and thus familiar with intermodal transport.

In the case of export operations, the main constraint is the need to arrive in time for the load to be handled physically and administratively in the sea terminal prior to loading onto the deep-sea vessel. For import operations, logistic requirements are either determined by the needs of consignees and/or by the forwarder´s optimisation of the transport chain.

3. Hazardous goods and perishable goods are almost always FCLs. Emphasis will be on control, security and qualification. Hazardous goods transport needs specific knowledge and skills. Transport companies and forwarders who deal with hazardous goods are specialised, sometimes even working exclusively for this segment. Differences between the requirements of shippers who carry out transport on their own account and the requirements of contractors working for shippers (forwarders) can be ignored. The customers are always regular users. Distance is important because of differences in monitoring and flexibility. The approach for perishable goods is very similar to that for hazardous goods.

4. Continental transport of general cargo for shippers: Shippers who carry out transport on their own account and use intermodal transport are always regular users. In comparison to forwarders and road transport companies, shippers will make more frequent use of use additional services (e.g. rental services or warehousing at terminals). They are more interested in the cargo than the productivity of transport equipment and may therefore be less demanding as regards time and reliability. They are likely to have specific requirements as regards monitoring (e.g. EDI). By definition shippers have full loads. For low-value goods, no distinction on the basis of distance classes is made, but for high value goods this distinction is important, mainly because of requirements as regards monitoring.

Continental transport of general cargo for forwarders or road transport companies: For continental transport, forwarders and road transport companies are not separate segments. A road transport company using intermodal services can be considered to be a forwarder. In practise, differences may be apparent, for example road hauliers use more semi-trailers than forwarders, but this has no effect on quality requirements.

In this segment, the distinction between occasional users and regular users is important with regard to organisational requirements, equipment efficiency, etc.
Consolidated goods are treated in the same way as high-value goods. The value of consolidated goods is hard to determine. The logistical requirements are determined by the (temporally speaking) last order for a given shipment.

- ***Others:***

1. Captive short-sea transport: Here, short distance sea transport is inevitable, or at least the most obvious choice of mode (e.g. Ireland, Finland, Greece). Quality requirements can be expected to be lower since there is no immediate competition from road hauliers.

2. Captive rail transport: The same arguments apply to rail in the Alpine region where trucks encounter specific obstacles

3. Inter-plant transport: The automobile industry runs a number of intermodal block trains throughout Europe. They travel, mostly on a regular basis, between plants in different countries (e.g. Sweden-Belgium, Germany-Spain). Their “in-house” character results in specific requirements such as flexible volume planning, high demands as regards monitoring and low demands as regards transport time.

4. Waste container transport: Some countries use dedicated containers for low-distance waste transport; obviously, there are specific requirements for these.

5. Empty container transport: In the case of un-balanced transport flows or strict equipment regimes, maritime shipping lines need to return their own or leased empty boxes to their ships or to inland depots. These shipments are usually characterised by low logistic requirements and focus on low cost options.

The basic list of 23 segments presented above is well suited for player-oriented, and flow-oriented analysis. In some cases, for example terminal and network design work, this list may need to be transformed into a logistics-oriented approach.

It should be kept in mind that intermodal transport is only part of a transport chain connecting shipper to forwarder, road haulier and final consignee. They are all either direct (e.g. forwarders) or indirect clients (e.g. the shipper giving orders to the forwarder) of the intermodal operator. As previously stated, the requirements of the different parties may differ. The shipper may focus on maximum safety and reliability but be less demanding as regards transport speed. The transport company, on the other hand, will of course make the shipper´s requirements known to the intermodal operator, but also add requirements of its own, such as high transport speed so its equipment is available for the next shipment as soon as possible (early equipment restitution).

The chain is, therefore, characterised by the sum of all respective maximum quality expectations. Together, these form the logistic profile of a transport chain. These profiles differ and can be classified on the basis of quality dimensions such as transport time, reliability, control, safety, accessibility etc.

One transport chain may feature high monitoring demands and low transport time demands, and another high transport time and high flexibility demands.

The 23 segments listed above had to be examined with regard to this in order to discover if they have distinctive logistic profiles.

Interviews with professionals with regard to each of the 23 segments were conducted to identify these profiles.

The concept of “logistic profiles”: an examination of segments taking account of the transport chain

Example: Intercontinental / Merchant haulage / Export / FCL & LCL

Customer type	Trade flow	Distance (inland)	Commodity type
Shipper	*Intercontinental / maritime*	*medium haul*	*general / high value*
Forwarder	Continental / International	*long haul*	*general / low value*
Operator	Continental / domestic		*hazardous*
			perishable

Profile: A shipper or, more often, a forwarding company acting on the shipper's behalf, selecting and organising the most appropriate combination of inland and maritime transport for overseas export shipments.

Comments: If a shipper (or the forwarder) takes such a close interest in the organisation of transport, it is not only to find the fastest and/or cheapest solution, but also because it wants to be sure that the shipment receives the right treatment (handling, surveillance, customs, etc.) at all stages of the transport.

Transport planning involves the selection of the best route, shipping line, port(s) of call and inland carriers. Timing, sailing frequency, port handling facilities, service, quality and, of course, costs are all important criteria.

Key issues:
- flexibility in service coverage (to several ports),
- quality assurance,
- information.

Specific requirements:
- responsiveness to special requirements for handling and documentation,
- tracking & tracing,
- equipment provision.

1.3. The shipper survey: a second step for validation, with quantification of results

In 1997 and 1998, 196 standardised interviews were carried out with customers and potential customers of intermodal transport in all countries of the European Union and Switzerland. 176 of these interviews were suitable for standardised evaluation (60 with shippers from industry and trade, 91 with forwarders and road hauliers engaged in continental transport and 25 with forwarders or shipping lines in intercontinental transport). The interviews were conducted face-to-face, usually in the mother tongue of the interviewees by different members of the consortium.

The objective of the survey was not only to validate or correct the IQ project's initial hypotheses concerning the quality of intermodal transport and the definition of market segments which differ with regard to quality, but also to prepare conclusions for quality improvement for the projection part of IQ.

The main findings concerning the current position of intermodal transport are summarised in this section. They are a complement to the initial comments made by the experts, and are drawn from a sample which is fairly representative of the European market. It was possible to quantify such aspects as the relevance of quality criteria, the competitive position of intermodal transport and the reasons for modal choices.

1.3.1. Quality and price: the crucial factors in modal choice

Reasons for choosing intermodal transport

Price is the most important reason for choosing intermodal transport. Its role in explaining modal choice is equal to or considerably greater than any of the quality aspects for all segments. This is not in contradiction with the IQ approach which focuses on quality as a necessary condition for the promotion of intermodal transport but the reast of the project will not ignore all price and cost considerations.

The second most important single reason is that it is able to match the customer's logistic structure. This is mainly due to its ability to haul large volumes, thanks to on-site rail terminals or equipment. All other reasons, flexibility in particular, score low ,with some exceptions in the field of reliability. Surprisingly, excessively long transport times were an important but not a crucial obstacle for intermodal usage. Time was even selected as the reason for choosing intermodal transport in 10% of cases.

There are clear differences in the segment profiles.

In maritime hinterland transport, price is the most important factor, followed by reliability and logistic structure (high volumes, port rail terminals)

In the hazardous goods sector, price and logistic structure (equipment); are again the most important factors surprisingly control and safety score rather low here; this qualifies earlier findings concerning the performance of intermodal transport in the field of safety and security. The conclusion is that intermodal transport has good performance in this field but this is not an important reason for preferring it to road transport.

In the perishable goods sector, the reasons are more evenly distributed between reliability, flexibility, control, safety/security, price and logistic structure. It is striking that transport time is never the reason for choosing intermodal transport in this segment.

In the shipper segment, choice is based on a combination of price, logistic structure and reliability – all factors which are important for large inter-plant haulage.

In the large forwarder/road haulier segment, the results are particularly important because this is where the greatest potential for intermodal is to be found. Price is of paramount importance for intermodal here, followed by logistic structure and transport time.

The quality requirements are set by shippers and, in most cases, by transport companies/forwarders working on behalf of shippers. These requirements may differ. The shipper may focus on maximum safety and reliability but be less demanding as regards transport speed. The transport company, on the other hand, will of course make the shipper´s requirements known to the intermodal operator, but also add requirements of its own, such as high transport speed so its equipment is available for the next shipment as soon as possible (early equipment restitution). The intermodal operator has no choice but to satisfy both sets of requirements. This is important insofar as the rapidly changing role of companies in an intermediary position between transport providers and shippers has a large impact on intermodal quality requirements.

Reasons for choosing road transport

The reasons for choosing road reveal the areas in which intermodal transport has not managed to be competitive. In general, flexibility was the most important reason for choosing road, followed by time and price levels. This means that intermodal transport has major problems competing with road due to its lack of flexibility, high prices and transport time.

Apparently there are large competitive differences between links. In some cases road is chosen, in other cases intermodal is chosen. The same holds for logistic structures.

Some specific observations can, however, be made:

Decisions in the perishable goods sector are even more strongly based on flexibility requirements than in other segments.

For the hazardous goods sector, the qualification of road staff is an important reason.

For forwarders/transport hauliers, reliability and price are of slightly more than average importance as decision criteria.

With regard to the areas where flows are located:

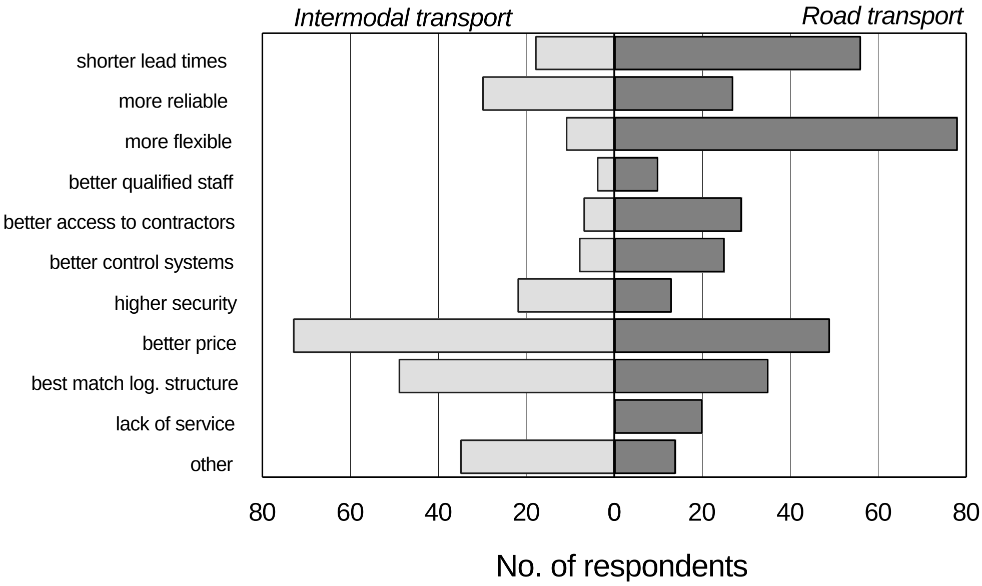
In Eastern Europe the combination of safety/security and monitoring is one of the reasons for choosing intermodal transport.

The desire for more flexibility and reliability in intermodal transport differs between regions and is particularly high in France and Italy. This is mainly due to the fact that the railway companies in these countries are inflexible and unreliable.

Surprisingly, complaints about transport time are not so numerous except in the case of Italy.

In Italy, the intermodal system is generally judged to be very poor. This country suffers from a particularly striking combination of poor transport times, poor reliability and poor flexibility. This also affects the natural barrier segment (mainly trans-Alpine traffic).

Figure 2: Decisive factors in the modal choice between intermodal and road transport (number of respondents).



1.3.2. Performance comparison: Intermodal transport vs. road transport

This section compares the performance of intermodal transport and road haulage with regard to a range of quality items. First, some general findings on market segments are presented.

Intermodal transport is able to compete with the road (i.e. achieve performance that equals or betters that of road) in the sectors of booking and planning. It performs least well in the (much more important) areas of:

length of delays,
frequency of delays,
transport time.

With regard to other areas of quality, i.e. where intermodal is able to compete successfully with road, support generally reaches 50% or more.

In the case of *individual segments*, it is clear that:

in the hazardous and perishable goods sector, intermodal compares very poorly with road, especially in the areas of transport time and delays, but also for of damage and monitoring,

in the maritime sector, intermodal is generally slightly more competitive,
surprisingly, in the forwarder/road haulier sector, intermodal is in a comparatively strong position as regards transport time and delays.

Some specific findings concern *cross-border flow areas*:

In dense areas, intermodal transport is particularly weak as regards transport time and is considerably outperformed by road transport in such areas.

In natural barrier areas and remote regions, the problem is more to do with the length and frequency of delays.

In Eastern Europe, intermodal transport is in a comparatively good position as regards quality and attains more than 50% support across the board.

Finally, some findings relate to *national intermodal transport:*

In France, the frequency of delays and the effectiveness of monitoring seem to be the major obstacles for the use of intermodal transport, which performs rather well in the areas of transport time, length of delays and damage.

In Germany, the situation is similar with the striking exceptions that intermodal performs much better with regard to delay frequencies and monitoring.

Spain has greater intermodal quality problems, with poor performance both for transport times and delay.

In Italy, there are very clear weak points: extremely poor performance as regards transport time, length and frequency of delays, frequency of delay and damage. Other aspects score quite well.

The profile of the quality judgements for each aspect shows that *in most cases road transport outperforms* intermodal transport. This position is confirmed by the observation that the major reason for choosing intermodal transport is its better price or - to a lesser extent - its better match with the logistic system of the customer.

The most important reasons for customers to choose pure road or intermodal transport are[1]:

for choosing road	for choosing intermodal
1. higher flexibility 2. shorter lead times 3. better price	1. better match with the logistical structure 2. better price 3. higher reliability

A “better match” implies that disadvantages in tariffs or quality are offset by a reduction of costs in other logistic operations. Road transport is often chosen because of its better quality or its more competitive price. Since nearly all respondents were already customers of intermodal transport, this can also be an indication of a lack of quality on the part of intermodal transport for these flows.

Many customers of intermodal transport have indicated that it does not perform as well as road transport. However, they remain intermodal customers because of the lower costs of using intermodal and, apparently, because intermodal is still able to provide the required level of performance. A similar pattern of quality judgements is to be found in each of the market segments.

One option for the intermodal industry is to focus on *price competition*. This would imply directing efforts towards more efficient operation and would necessitate a consolidation of the

[1] compare with IQ-report 2.4.2

present position of intermodal transport in the transport market - a strong focus on trans-Alpine traffic, on seaport related flows and on long-distance flows.

The other option is to *improve external quality*. This could attract traffic flows which are currently transported by road onto links where there are not significant differences between the prices of road and intermodal. Quality improvements can only be achieved by measures within the intermodal chain (internal quality). There is a need for analysis of the internal chain in order to assess the possibilities for improving quality aspects.

The *main reasons for choosing road* were related to flexibility, transport time and reliability: the strength of road transport is its flexibility. The great majority of transport orders are planned one day or more before dispatch. Better timing of departures and arrivals, extension of terminal opening hours or offering (temporary) storage facilities for load units could ensure that intermodal operations match customer requirements better.

Analysis of the intermodal chain should highlight the phases of the chain where speed is reduced (pre- or end-haulage, terminal dwell times, rail or vessel speed, border or other delays) in order to seek opportunities for improvement.

The reasons for delays should be identified. Possible reasons are that schedules are too tight, players in the chain may perform badly, specific circumstances (weather) may cause disturbances, documents may be incomplete, etc.

Quality improvements must be orientated towards the customer. An appraisal should be made of whether the improvement really reduces the gap between the requirements of customers and the performance of intermodal transport.

1.4. First conclusions for quality and segments

In conclusion, we shall highlight some general findings regarding individual quality aspects. They can be reviewed through the 7 quality criteria.

- ***Time***

In general, the importance of transport time was less than expected, although time requirements were extremely varied.

In some sub-segments requirements are obviously too high for intermodal transport. This is the case for both very short distances and long distances once intermodal transport takes more than three days for delivery.

The “continental perishable goods” segment is very sensitive to the time parameter: the results of the survey confirm that about 45% of the interviewees expect a maximum transit time of 48 hours whatever the final destination of the goods may be.

As to flow areas, intermodal transport performs best in natural barrier areas where in some cases it can be even faster than road.

In Germany, time requirements for national transport are so demanding they can only be met by overnight shuttle trains. The same holds for Belgium. Here the fast NEN train system was the first successful intermodal response.

- ***Reliability***

There is a clear difference between national and international transport. National haulage does not accept delays of more than four hours whereas international transport is much less demanding in this respect.

Maritime customers are more tolerant because there is often a large time buffer before the departure or after the arrival of vessels. In addition to this, the proportion of empty boxes is rather high in this segment.

With regard to forwarders, there is often a buffer resulting from the operation of their internal network or because congestion is a daily occurrence in dense areas. In contrast with this, hazardous and perishable goods transport are very demanding and do not accept delays of more than 4 hours.

The less demanding attitude of shippers (buffering stocks) can be contrasted with a very demanding shipper sub-segment which relies on reliable just-in-time deliveries.

When hauling to and from Eastern European countries about 55% of the respondents accept a delay of more than 12 hours and 35% of more than 24 hours. The constraints linked to customs and infrastructure/organisational obstacles are the main reasons for this.

Dense areas are also fairly undemanding as regards delays. This is due to the daily congestion experienced in urban areas and the high share of maritime hinterland transport which is more cost oriented.

- ***Flexibility***

Lack of flexibility is perceived as the paramount obstacle for intermodal transport. The rigid timetables with only one departure per day or less, and an insufficient short-term response to unexpectedly high demand force many potential customers to use road transport.

If there are minor logistic changes in the customer's system the daily train departure may be missed - resulting in a delay of 24 hours or even longer. On the contrary, road transport can adapt more easily to the timing of its clients, especially when transport is required at short notice.

As regards volume changes, it takes too long for the production system of the railways to be changed, by adding new trains, changing the destination of trains or increasing capacity with dedicated intermodal trains. This deters large potential customers who need fast and flexible responses to their requirements.

The commercial and sales conditions and procedures are seen as a constraint for the development of rail intermodal transport services. At the national, but even more, at the international level, long and complex allocation and pricing procedures prevent the combined transport operators from providing a smooth response to market requirements.

- ***Control/Monitoring***

Control is another very important issue for potential intermodal customers. The lack of information in the event of unexpected delays or other problems makes the use of intermodal transport too risky for quality-sensitive market segments.

There are a large variety of requirements. The answers reflect two different situations. A high level of control is required in logistically advanced regions because the general level of logistic services is high (e.g. Germany/Benelux/UK; in less developed regions there is also a considerable need for monitoring because reliability/safety/security levels are low and risks rather high (Eastern Europe, Italy, Greece).

With respect to distance, requirements are lower for short transport distances since the situation of these is more transparent. Maritime hinterland clients have comparatively high standards because of their complex box round-trips and because of the high standards which exist in maritime and port systems.

The most frequent answer of all respondent types was that they only need to be informed if there is a problem. Requirements seem most strict for maritime related transport and for forwarder/logistic service providers. Permanent real-time monitoring is usually not required.

- ***Accessibility of terminals***

For 65% of the respondents, the accessibility of terminals is good. However, satisfaction with terminal access conditions is particularly low in some areas:

- in Eastern European countries, 50% of the interviewees found the accessibility of intermodal terminals poor. The lack of adequate infrastructure and locations that are too close to city centres are seen as the main reasons for this.
- in France (60%), Spain (50%) and Italy (50%) rates of dissatisfaction are also high: the terminals in these zones are close to major cities with heavy congestion; the main bottlenecks in France are Paris, Lyon, Marseilles, Le Havre; in Spain they are Madrid, Barcelona, Valencia; and in Italy the Torino, Milan and Verona regions.

- ***Safety & Security / Qualification / Commercial accessibility***

In general, intermodal performs well in these quality areas. Safety and staff qualification are often mentioned as reasons for preferring intermodal to road.

- ***Pricing***

Pricing plays a specific role in our quality analysis. Although, in order to focus on quality, it is not one of the seven criteria but it cannot be ignored in an appraisal of competitiveness. Pricing covers two different aspects: price levels and pricing regimes. Price is the most important single reason for choosing intermodal. Apparently, road prices are higher on a number of long-distance links as soon as two drivers are needed, or when using just one driver would delay the journey too much. As for price regimes, the lack of transparency and the frequent changes of railway prices have been mentioned as negative points.

2. PERFORMANCE AND QUALITY OF TERMINALS

Within the IQ project, WP1 “Quality of terminals” considered intermodal terminals using spatial and technological approaches and through analysis of investment projects and the costs of terminal operations.

This research on the “quality of terminals” is also related to later phases of research concerned with the “quality of the networks” and “interactions”, for which results on performance are particularly relevant.

As has been shown in the “Quality label study”, terminals are meeting points between infrastructures, modes and operators. They are very much affected by their environment, both the rail environment and the regional environment, with regard to long term planning and accessibility. Therefore, a first step for the IQ project was to establish a typology of terminals based on size, function and geographical scope and construct a database structured around this typology. For large European-size terminals (of which there are 30 to 40), in-depth interviews were conducted in order to assess the performance of terminals and to measure the impacts of different technologies. The conclusion of the chapter is that it is difficult to identify the mechanisms that govern terminal development; there is no clear economic or commercial logic behind land use, criteria are highly dependent upon the local or national institutional environment and it remains very difficult for transport operators to construct a strategy solely on the basis of terminal activity.

2.1. A typology for a large variety of terminals

The first phase of research was to construct an IQ database which contained 398 intermodal terminals (inland, inland waterway and maritime):

- 231 continental terminals (of which 17 are located in port areas),
- 31 inland waterway terminals,
- 136 maritime terminals.

The inland terminal sample was examined with reference to physical, managerial, activity-related and logistical services aspects. Two smaller samples (of 100 and of 40 terminals) include information on expansion possibilities, performance indicators, links and investment. Comparable levels of detail have been obtained for maritime terminals.

Analysis of this data has allowed us to make a number of comparisons and create typologies. With regard to the inland terminals in Europe, 50% are located in Germany, with 15% in France and also in Italy. In total they handled 4 million ITU compared to the 23.7 million handled by maritime terminals.

The size and handling volume of *inland terminals* reflected the variety of situations, a 1:1 ratio (1 ITU handled per year per sqm) was observed with the exception of two clusters. One 7 terminal cluster had a ratio of 1:3, and another 7 terminal cluster had a 5:1 ratio, i.e. an extremely high surface productivity. The largest terminals (17% of the sample) handled 51% of the total inland volume and the smaller terminals (58% of the sample) just 19%.

The maritime terminals were subdivided into larger mother vessel oriented terminals, smaller feeder vessel oriented terminals and full ro-ro terminals. Maritime terminals are, on average, much larger than inland terminals. In fact, small maritime terminals exceed even large inland terminals in size and volumes handled.

Inland terminals could be differentiated on the basis of the type of logistical chain of which they are a part. Inland waterway terminals could be subdivided into full container and multipurpose terminals.

In addition to this, a detailed description of *capacity bottlenecks* in European intermodal terminals was produced. The terminals were again subdivided into maritime, inland waterway and inland road/rail terminals.

However, major inland and maritime terminals are easier to compare. It is possible to arrange them in a single hierarchy according to the following general considerations:

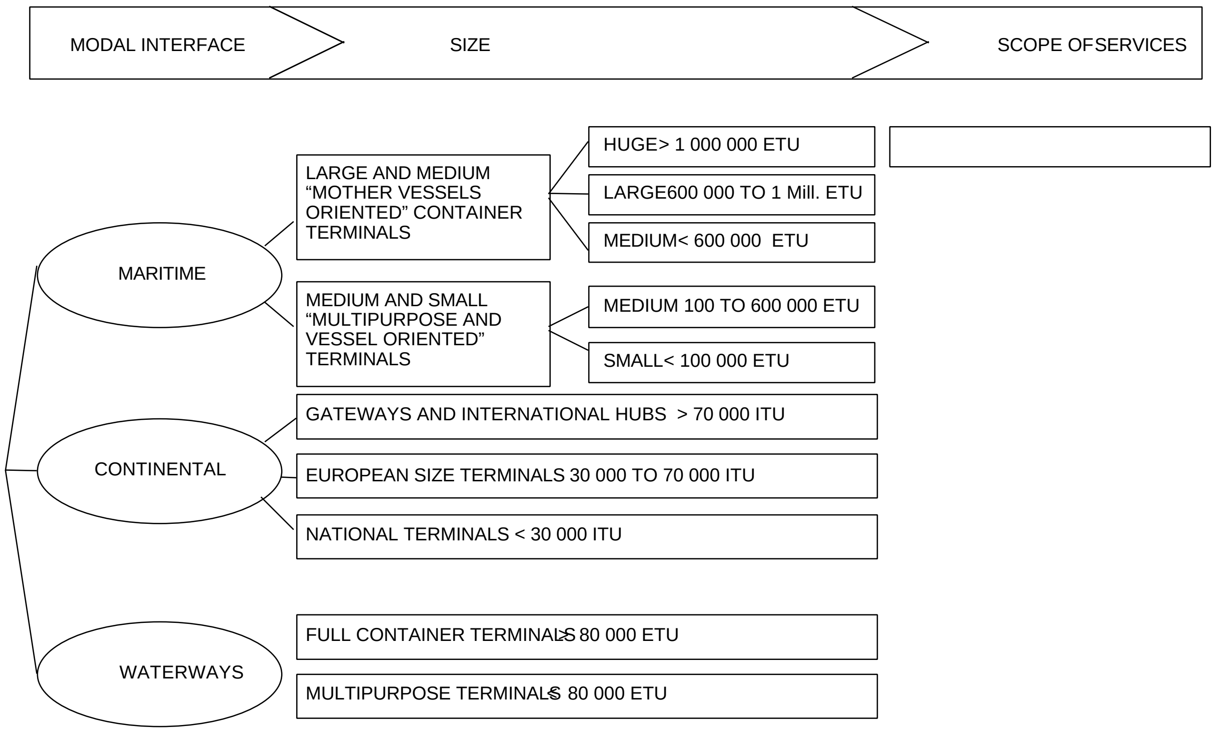
- site, including equipment for the transhipment of ITUs with both technical and physical limitations,

- zone, which involves a particular area and brings together service providers of all types,

- pole, describing a region which features a high concentration of industrial and logistic activities.

The typology of terminals has been constructed with reference not only to their technical specifications, but also their function within the networks and their ability to satisfy the needs of the market (volume and surface area, logistical services offered), as shown in the figure below.

Figure 3: Terminal segmentation



The terminals in the database connect modal networks, European and regional areas, and the characteristics of each terminal as regards size, equipment, capacity and available logistics services have been identified.

Analysis of investment projects related to the creation or expansion of terminals has enhanced the database by giving an idea of the future capacities of major terminals at the year 2010.

The IQ Database also has a three level structure, depending on the geographic scope of terminals:

- Level 40: this market level of the database contains only 40 terminals which are analysed in depth, with detailed descriptions of each terminal. Analysis of this market segment has been based on a survey carried out by the IQ Consortium: it consists of 19 maritime, 5 inland waterway and 19 inland terminals.

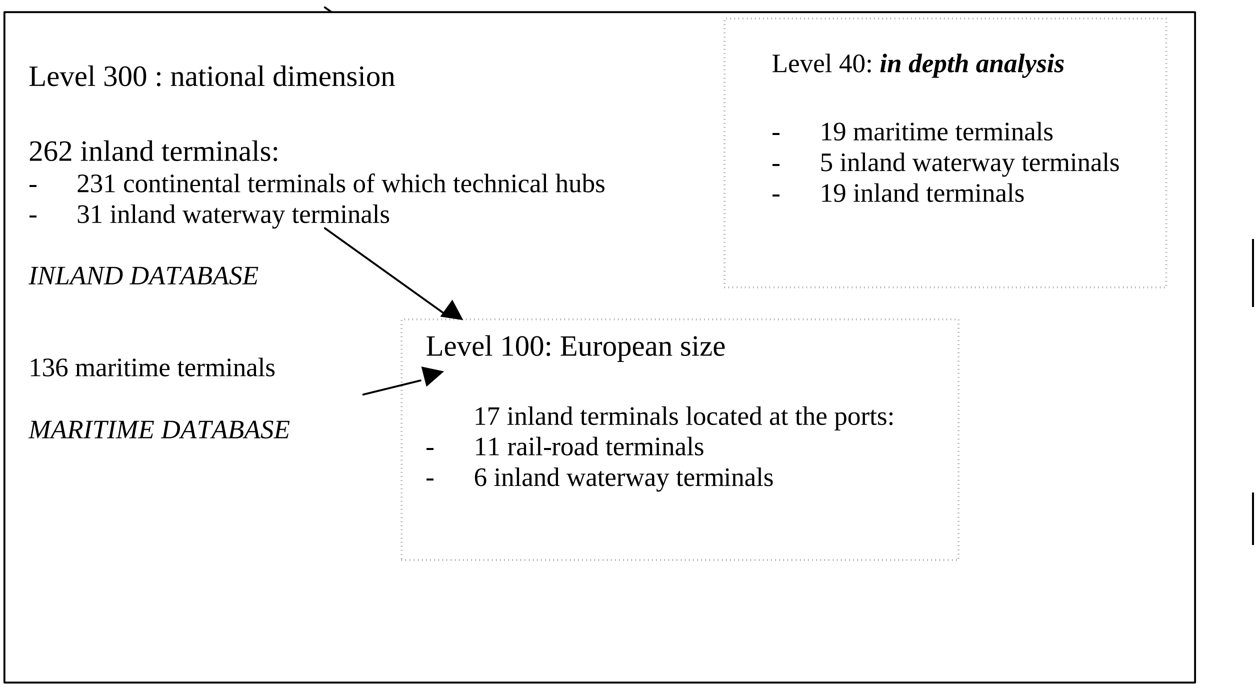
- Level 100: for this level, the objective is to identify terminals of “European size” including the main port terminals for maritime containers. Main terminals were identified using quantitative criteria (mainly volume of activity and sometimes number of services).

- Level 300/400: terminals of “national” size. These terminals are those that were first listed for different countries in the original “Euroterm” database; they are connected to the European networks.

A further division was made between inland terminals and maritime terminals.

The diagram below shows that some terminals, located in the port areas, are included in both databases: they are located in the port areas.

Figure 4: terminal levels



How to measure terminal performance
A terminal's performance can be assessed in the following ways: • by referring to terminal operators: the terminal operator is the intermodal service provider with (potentially) the most insight into internal quality. Terminals are nodal points in the flow of goods and information. If terminal operators are concerned with quality improvement they will have some records of operational data (the extent of such records should be checked beforehand). • by referring to intermodal operators: a second type of source is the intermodal operators, who are responsible for integration of the chain. Their prime concern is to satisfy the requirements of the customer, which means they have a responsibility to guarantee external quality. It is worthwhile for intermodal operators to measure the internal quality of the those forming the logistic chain. • by referring to the users of the terminal: rail or vessel operators, and road hauliers. In the first instance, in the case of the level 40 terminals, performance was measured by interviews, using a structured questionnaire. The interviews were conducted face-to-face, in order to: • obtain the involvement of respondents in order to improve the quality of the answers, • make it easier to judge the accuracy of information, • obtain background information that explains specific circumstances. At a later stage, intermodal and transport operators were approached, in order to: • fill gaps in knowledge, • confirm the values obtained from the terminal operators. The interests of intermediaries and transport operators differ from those of the terminal operators and the two may therefore have a different perception of performance. Finally, time measurements at terminals were considered. Mainly time parameters were measured, as other types of indicators often require information which cannot be obtained from observations of visible (physical) terminal processes (e.g. it is not possible to notice whether a load unit is handled in time). A time measurement is only useful if it is made intensively: performance during both peak and slack periods should be measured, and information should be obtained for all time phases and all units (load units, trucks, trains or vessels, documents). Observation of terminals could be used to appraise demonstration projects.

2.2. Economic analysis of inland terminals

The problem of cost transparency combined with other factors makes it very difficult indeed to analyse the profitability of terminals, in view of the fact that inland terminals are often described as non profitable operations, and are justified on the grounds of other commercial accessibility criteria.

One might think that it would nevertheless be interesting to conduct separate analysis depending on the configuration of the terminal, the volume of activity and the position of the terminal in the network, but it is clear that this type of information is not always available. In addition, no detailed cost accounting data is publicly available. As a consequence, cost estimation can only be global or in partial detail for each terminal interface and it is almost impossible to measure the full effects of economies or diseconomies of scale due to an increase or decrease in traffic volume.

Furthermore, analysis of the profitability of terminals and the economic logic of inland terminal development is affected by the problem of the balancing out of flows. The infrastructure cost allocation constitutes the central difficulty because, generally, the railway companies are responsible for infrastructure investment and should invoice the operators for the use of this infrastructure. But, the infrastructure costs are allocated to the operation accounts at the freight cost amount. Thus, it is difficult to evaluate the proportion of total infrastructure costs to allocate to the combined transport terminals, especially since it is only partially invoiced. In addition, unlike the situation with terminal operation costs, balancing out and competitive reasons mean that it is not possible to identify differences between the cost and the price.

A study of the economic aspects of terminals requires an examination of the relationships between the costs, prices and services at the terminal.

Different terminals have been examined according to their size and the typology. The costs were then broken down into infrastructure costs, superstructure costs, fixed costs and variable costs.

The infrastructure costs of a terminal can vary considerably from one site to another according to the price of land or the amount of preparatory work required to stabilise the ground: in dense areas land prices can be 10 times higher than in rural areas. However, land prices rarely account for more than between 10 and 15% of the infrastructure cost, although in some areas a figure of 30% can be reached.

This means that the preparatory work for a terminal can be very expensive, as much as 500 ECU per sqm for rail equipment, i.e. 20 M ECU for a 40,000 sqm terminal and 40 M ECU for a 80,000 sqm terminal.

The shunting area can also account for a fairly high percentage of infrastructure costs since two tracks are usually necessary for each track in the rest of the terminal. In percentage terms the cost of this can vary between 10 and 20% of the infrastructure cost. This figure is high and cannot be precisely evaluated because the shunting area is sometimes included within the network of rail companies.

With regard to superstructure costs, the price of the equipment is much more predictable and more in proportion to the expected volume of traffic. Equipment can represent 20% of infrastructure costs, but may be much higher in the case of a large high volume terminal: this is the case, for example, in a large port area where the gantry cranes for unloading ships are extremely expensive.

To return to the nature of terminals, if we consider on the one hand a small terminal handling less than 30,000 ITU per year, and on the other a European type terminal, on the basis of the analysis of terminal cost performed by EIA, their lay-out could be defined as follows:

- 2 tracks with a surface area of between 20,000 and 30,000 sqm,
- 2 x 2 tracks with a surface area of between 30,000 and 50,000 sqm.

In addition, the intermediate configuration of a 3 track terminal may also be of interest since, under certain operating conditions, it can cover a fairly wide range of traffic capacity, between 50,000 and 90,000 units.

Furthermore, this range must be extended with reference to the current situation with, on the one hand, small terminals with very limited equipment (for bimodal techniques or a limited number of wagons) and, on the other hand, very large terminals on the main European routes (for large ports or trans-Alpine traffic).

By extending the range, it can be seen that for the largest inland terminals, there are some 2 x 3 track terminals (or even larger) with a maximum capacity of 150,000 or even 200,000 units.

The analysis revealed that *the infrastructure cost for the construction of a new terminal is very often more than 50 % of the total cost*, the rest being shared between superstructure cost and other fixed costs, mainly wages. The superstructure cost and variable costs are proportionately greater for large terminals.

As a consequence, it is very tempting for a transport operator not to construct a new terminal but either to try to extend existing terminals and use existing railway shunting equipment, or alternatively look for subsides which will cover at least the infrastructure cost.

However, such policies affect the nature of the rail operating systems, the quality of access to the rail network and the road egress of access cost (since the existing location might not be optimum as regards the local road network). These two operations represent a much higher proportion of the door-to-door transport cost than the terminal cost as such.

Concerning the prices of terminal operations with reference to the type of service provided, it is clearly apparent that market prices are fairly stable and quite independent of costs, infrastructure costs in particular.

Storage prices are very often not directly linked to the service. Shunting services are often included in the rail traction costs, which is a questionable practice since the shunting equipment and operation are dependent upon the terminal's lay-out and operation. A consequence of this is that the shunting cost is rarely known and rationalised, although it is clear that it is often higher than transhipment costs.

In any case, the level of this price is such that *it is hardly ever possible to cover the total cost of the terminals* with their present flows.

Since the fixed costs, and in particular the infrastructure cost, represent the major share of the cost, the profitability of the terminal improves with an increase in traffic, with different thresholds, for a small, medium or large terminal. However even full use of capacity will not, in general, make investment in a terminal profitable, at least for inland terminals.

It is, therefore, difficult to analyse the economic performance of a terminal without making hypotheses about rules concerning the financing of infrastructure as well as an accurate identification of the role of terminal services in the functioning of the whole chain.

This begs two questions:

What proportion of the infrastructure cost should be publicly subsided ?

How can terminal operations be invoiced separately from other transport operations, since currently most operators include terminal costs within their larger operations for the whole transport chain or, at least a larger segment of this chain than just terminal operations?

Again, this last statement is only partly true for container terminals in ports.

In other words, two questions are raised:

Can the revenue from terminals cover superstructure costs and other costs except infrastructure costs?

Or can terminal the price of terminal operation be increased so it accounts for a larger proportion of the overall price (it currently accounts for only 5 to 7 %) ?

Such a development could bring a more economics-based approach into terminal operations and investments since at present “the economics of terminals” are completely subordinate to economic or strategic considerations which relate to the other segments of the chain. At present, it is not possible to know whether or not services are priced, they only exist within a broader system of all sorts of adjustments or compensations between segments of a transport chain with public and private co-financing of infrastructure.

Having decided on this general analysis framework, the rate of return on an investment in a terminal can only be improved by an increase in the volume of traffic or, possibly, by a reduction in the cost of the investment in question.

The case of small terminals, or terminals with limited equipment and manpower, must also be considered. Rolling road and bimodal techniques for example, can make these viable. There are also terminals with little transhipment equipment providing services for a limited number of destinations involving a small number of loading operations.

However, in most cases, the approach will consist of an attempt to *increase the volume of traffic* for a given size of terminal by serving several trains on the same track. Again the level of improvement will depend upon the type of rail operating system (in particular whether the train schedule can be modified) and often also upon the speed of loading and unloading. If the schedule is flexible, the train can wait in a shunting area nearby (in the case of a shuttle train, for example), and if not the boxes can be kept in a storage area close to the transhipment yard.

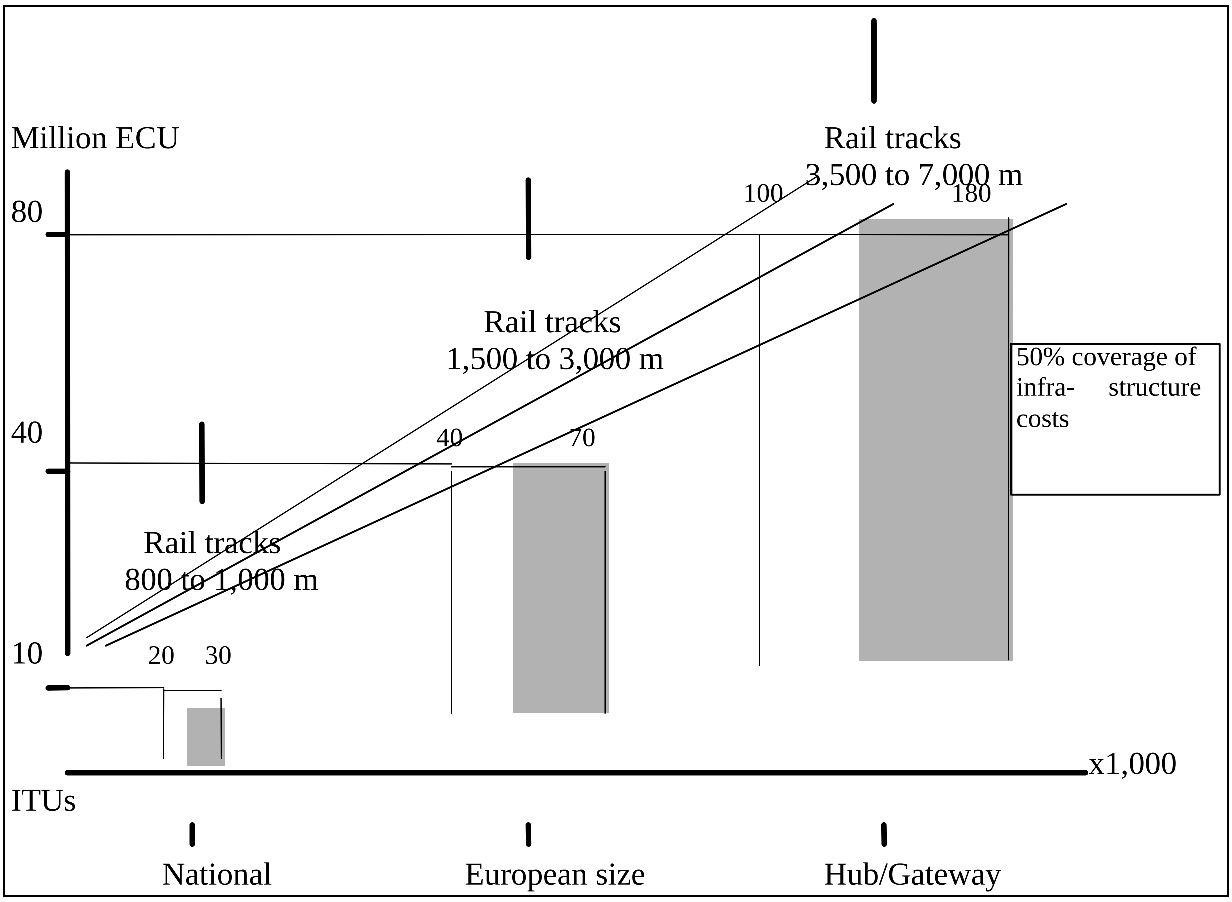
Such improvements are therefore dependant on the rail operating system and the equilibrium between terminal operating constraints and rail operating constraints. New operating systems allow more diversity, as was shown in Workpackage 2, and terminal performance can only be assessed with reference to rail operating performance.

Shunting, or the elimination of shunting, is one of the major factors in this equilibrium, although it is important to consider compatibility with the road interface which may require more flexibility in terminal operations (for example, larger storage units).

In conclusion, it has emerged from our analysis of costs and tariffs that inland terminals in Europe cannot be profitable without public subsidies. Only an improvement in combined transport productivity could improve profitability and this would require the implementation of new techniques or a new organisation of the structure of the terminal as well as an improvement in the performance of network operating systems.

The following diagram shows the traffic volume required to cover operating and infrastructure costs for each type of terminal.

Figure 5: Coverage of operating costs and 50% of infrastructure costs



2.3. Economic analysis of maritime terminals

Our analysis of infrastructure and superstructure funding in European ports reveals the extreme diversity of public and private commitment, ranging from the privatised ports in the UK, to the governmental harbour administration in Greece. With regard to the financing of harbour infrastructure and superstructure, the European Community insists that ports should operate on a commercial basis and that all port costs including capital costs should be recovered through port fees. However, it is difficult to say whether there are competitive distortions between ports and their terminals because of differences between port authorities.

Major investments are planned in many European ports to cope with the growth of container traffic. These investment programmes can be seen as both:

- **“quantitative” investments, to cope with projected growth in container traffic; according to OSC projections, European container port volumes will rise to 44,75 TEU by 2000 and nearly twice this level by 2010 (between 80,85 and 86,87 million TEU),**

- **“qualitative” investments, to cope with changes in the shipping industry, i.e. the formation of global alliances of players, appearance of 6,000 TEU vessels...**

An estimation of the cost of a new large maritime container terminal reveals the difference in scale between maritime and inland terminal infrastructure planning. The EIA estimates a cost of 38 million ECU’s for a medium-sized 8 ha, 60,000-70,000 ITU/year inland rail-road combined transport terminal. In comparison, investment in quays can cost up to 45,000 ECU per metre of quay and total infrastructure investments (quays and surfaces) can be evaluated at about 150 m ECU’s for a new terminal with a capacity of 600,000 TEU - including rail and road infrastructure (tracks and internal road) at the terminal.

In the short term it is unlikely that there will be a European Port Policy which seeks to co-ordinate port infrastructure at European level even where there is excess capacity. The European harbour owners act in many respects as autonomous bodies, within a “landlord” port authority model which allows the emergence of larger private stevedoring companies. Several of these private stevedoring companies are not only becoming multi-port companies but are also considering diversifying into other related activities, including physical distribution and combined transport activities.

Information collected on harbour investment programmes and capacity enlargement reveals these to be motivated by current and projected growth in sea-port demand. This concerns particularly deep-sea and feeder traffic. All ports are paying special attention to the consequences for the “main port”, both with regard to marine aspects (facilities for handling “mother vessels” and/or “feeder vessels”) and inland aspects. For inland aspects the focus is on:

- the consolidation of container flows which is required to attract the largest vessels, as the main concern of the shipping carriers is to fill their vessels and,

- potential congestion of terminal and harbour caused by this consolidation process.

The use of larger vessels requires changes to the harbour and terminals on the marine side, and consequently the anticipated increase and change of scale in combined transport services necessitates new infrastructure and superstructure at intermodal interfaces. New harbour facilities now include plans for the development of combined transport modes (either rail or inland waterways) in their layout and organisational scheme. *The total cost of infrastructure and superstructure investments* includes the land side interfaces - rail tracks and equipment, road gates and internal roads, waterway berths and equipment- and is estimated at 30 to 35% of the total amount.

Maritime terminals are not isolated nodes, but are part of a *harbour logistics centre* offering a large range of services for container units. Therefore, analysis of intermodal facilities cannot be limited to the terminal but must also to take into account the facilities available at the port as a whole. The report lays emphasis on the restructuring and organisational changes that are taking place at several ports and terminals in order to reduce interface costs at the terminal and harbour interfaces.

These new developments raise doubts about the “traditional” harbour operating system in which wagons are positioned on each maritime terminal and there is a sequence of shunting and marshalling operations in the harbour before the trains gain access to the main rail network. This system requires costly organisation (and the individual elements that make up this cost are not easy to determine) and provides low quality of service.

A “physical” consolidation process takes place at the port level to concentrate a high volume of traffic at one point of the interface and provide the necessary infrastructure and superstructure facilities there to form block trains or barges of feeder vessels. This system provides a higher quality of intermodal services at harbour level and also a better estimation of the costs which are incurred there at the interface with combined transport systems. The main objective is to reduce the costs of harbour rail traction, shunting and marshalling operations by creating block or shuttle trains which are formed at one physical consolidation point.

A first type of harbour configuration involves a specific facility which is distinct from the maritime facilities, namely a dedicated intermodal facility (a Rail Service Centre) located more or less beside the various container terminals within the harbour area. However in such configurations, an analysis of costs and tariffs highlights the costs of inter-terminal container transfers - the cost of local road haulage of the container from the marine terminal to the specialised combined transport terminal.

Indeed the harbour players favour the building of facilities that can form block trains directly at the largest marine terminals. The planned rail transhipment facilities at the new large container terminals fulfil the technical requirements for forming complete block or shuttle trains.

This last configuration however raises the question of the smaller container terminals (and access from these to the combined transport interface) and the competitive advantage of the largest marine container terminals where the rail interface is located.

A «commercial» consolidation process which allows the aggregation of low volume demand within the harbour where many players are present supplements this «physical» consolidation process in the harbour. Harbour and maritime players are no longer considered just as “external” entities, but viewed as customers of combined transport services. With the involvement of major shipping companies, stevedoring companies or the harbour community (which may be brought together by their port authorities in order to develop combined transport services and inland “pre-ports”) they are participating in the development of a supply of services at European level.

These harbour and maritime players agree that there is a *current insufficiency in the capacity and the quality* of services at existing inland terminals, with regard to the surface area for stacking large flows of maritime containers, integration of the port and the inland terminal EDP systems, treatment of hazardous cargoes, stacking and management capacities for empty containers... They also agree that there are too many small or medium-sized terminals (particularly on the Rhine).

Moreover, two different types of intermodal transport services for maritime containers can be identified:

- “feeder” combined transport services, from one maritime terminal to another not only through feeder and maritime combined transport, but also through rail or inland waterways,

- “pre- and end-haulage” combined transport services, to or from a maritime terminal or to or from an inland combined transport terminal.

In addition to these two types of services several stevedores and port authorities now propose the *integration of each capacity and service level with inland terminal services and combined transport services fully integrated with the maritime terminal services* and deep sea or short sea transport services. This organisation requires:

- that the inland terminal will serve as a consolidation point for combined transport services scheduled with the harbour sea services,

- the use of the common 2-3 days standing time of imported containers at the maritime terminal before removal to inland container terminals,

- integration of administrative and information related aspects.

In summary, both the anticipated *quantitative growth* in European maritime container traffic and the *strategies of players* in the harbour and maritime environment have imposed new constraints on inland terminals, primarily of a quantitative but also of a qualitative nature. The anticipated restructuring and investment in harbours at the interfaces with intermodal systems are crucial for the competitiveness of maritime terminals and ports as access links are increasingly considered to be key elements for the success of container terminals and ports. Such investments are therefore essential for the promotion and development of competitive European intermodal transport services.

The lack of transparency as regards costs makes it very difficult to estimate the profitability of terminals.

It would be interesting to conduct separate analyses on the basis of terminal configuration, the volume of activity and the position of the terminal in the network, but it is clear that this type of information is not always available. In fact no detailed analytical accounting information is either available or obtainable. As a consequence, the cost estimation can only be global or in partial detail for each terminal interface and it is almost impossible to quantify the economies or diseconomies of scale due to an increase or decrease in the volume of traffic.

On the other hand, analysis of terminal profitability and the economic rationale of inland terminal development are affected by the problem of adjustment and compensation. The central difficulty is infrastructure cost allocation because, generally, the railway companies are responsible for infrastructure investment and should invoice the operators for the use of this infrastructure. Thus, it is difficult to evaluate the proportion of the infrastructure cost which is allocated to the combined transport terminals, and therefore only part of this amount can be invoiced. Consequently, it is difficult to relate prices to costs and vice-versa.

Having said this, our analysis of costs and tariffs clearly shows that European inland terminals can only become profitable if public subsidies cover most of the infrastructure costs. An improvement in the productivity of combined transport remains however possible and can sometimes significantly improve the situation. Such an improvement would involve the implementation of new techniques or new terminal organisations, or an improvement of the interface between the terminal and the network.

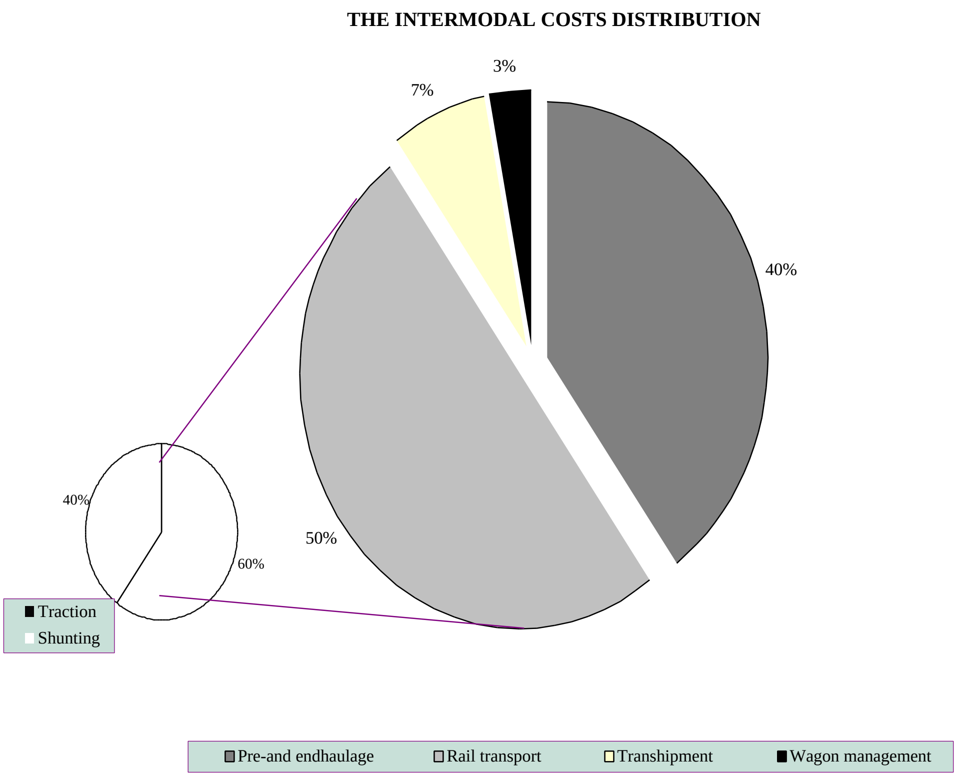
This is why the strategies of the players involved, particularly on the supply side, are an essential factor in the investment decision process.

2.4. Importance of interfaces and new roles of terminals

Our research on terminals, as well as the demonstration case of Verona, has shown that improvements to just terminal operations will marginally increase the overall quality of the rail-road transport chain. This can be seen by a rough estimate of an average distribution of costs between different operations in the transport operating system.

IQ estimates that, on average, terminal operation accounts for 7% of the total cost of the transport chain.

Figure 7: intermodal cost distribution



However, one of the most important results from IQ is that the key to improved terminal performance is in the interaction with the quality of the rail and road networks with which they interact rather than the quality of terminal operations themselves. For example, a terminal cannot be efficient when trains are often delayed or when road access to the terminal suffers from congestion.

IQ focuses upon the importance of *operational innovations* in the operating systems for the development of intermodal transport and improving its quality.

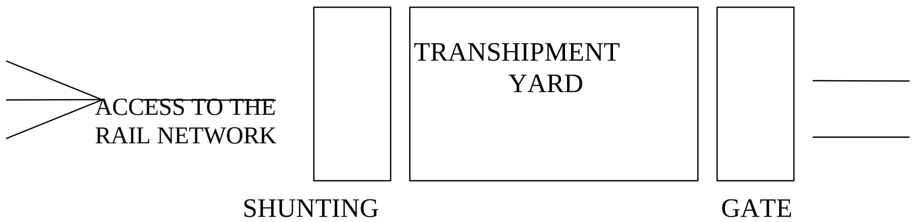
These innovations in operating systems are based upon the new roles given to the nodes. Therefore, policies as regards implementation and terminal capacities have to be modified so that the operating systems and the capacities (infrastructure and equipment) can be adapted to these new roles.

2.4.1. Rail, road and maritime interfaces

A consequence of this is that the main potential in terms of productivity and quality of services is at the terminal "boundaries". Our analysis of inland, inland waterway and maritime terminals has identified these terminal boundaries as critical points in the chain.
These findings were supported and validated by later work on the " quality of the networks ", the " interactions " and the demonstration case of Verona Quadrante Europa.

These terminal "boundaries" are characterised by access to the rail network by shunting operations, and the access to road network by gate procedure in particular.

Figure 8: The intermodal transport chain



- *The quality of the connections to the main rail network are critical.*

Rail traction costs can account for 55% of the total costs within the intermodal transport chain. Shunting operations and short distance traction from the terminal to the main rail network probably account for between 35 and 50% of these rail traction costs. However, with some rare exceptions (HUPAC, Eurokaï), the shunting operations are generally undertaken by the railway companies and it is not easy to identify the corresponding costs and assign them to the rail network or terminal operations.

Modifying the shunting operations and the traction to and from the main rail network so they are compatible with the transhipment operations appears to be a key factor for achieving productivity and quality in terminal operations.

Several innovations in rail haulage or terminal management require changes to the sidings. For instance, the introduction of shuttles or of dynamic terminal management modifies requirements as regards the number and length of sidings.

The demonstration case of Verona also underlines the importance of innovations in the operational processes and administrative procedures at the rail interface. It has been estimated that such improvements would result in time savings of 1.17 hours at Verona, which would allow the boxes to arrive later for departure, resulting in a considerable improvement for marketing the service and management of pre- and end-haulage and transhipment operations.

- *The maritime and rail interfaces at maritime terminals.*

At *the maritime interface*, the terminal operator has no control over the cost or the quality of the port services for the vessel: the quality and the cost of the operations of piloting, stowing and other port procedures are critical for development of short sea shipping.

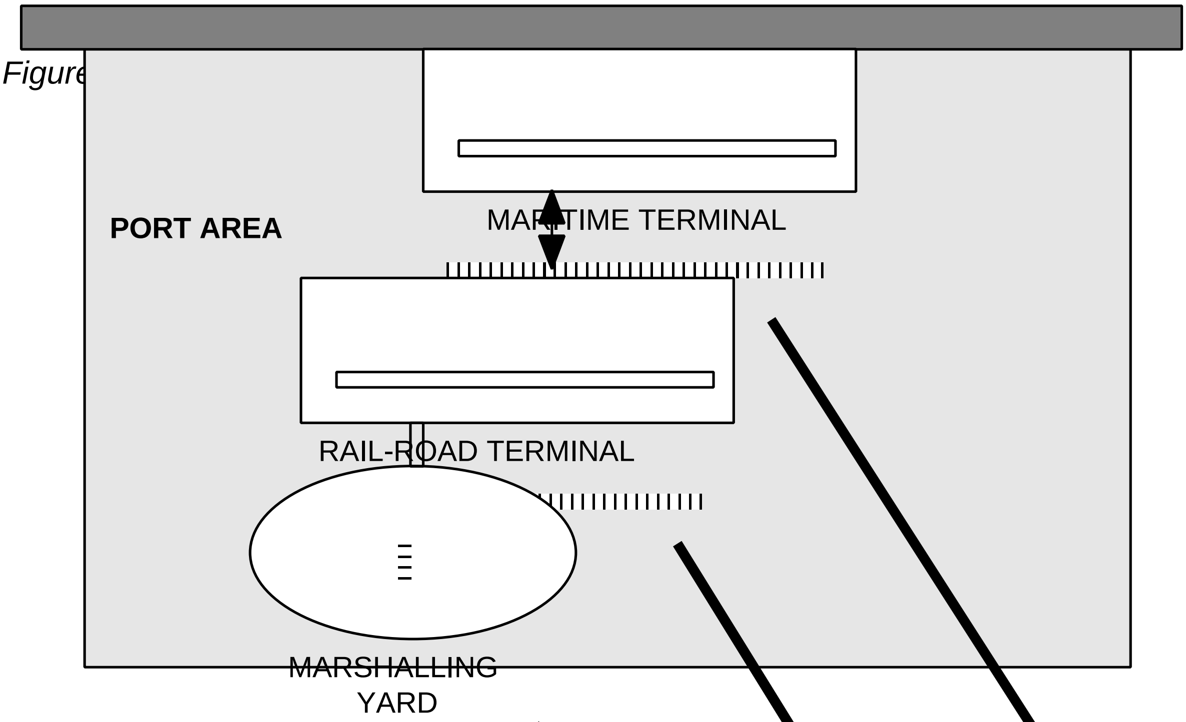
IQ's analysis of rail operations in the major European ports has highlighted the importance for intermodal transport of the restructuring of maritime terminals and/or the harbour rail-road terminals. Huge investments have been made or are planned to construct new terminals or restructure intermodal facilities (Port 2000 at Le Havre, Altenwerder at Hamburg or the new yard at Antwerp).

At present, harbour-rail interface costs for intermodal transport are very high:

- inter-terminal transfers are extremely expensive (road haulage of a maritime container to the rail-road port terminal costs between 40 and 137 Euros). Added to this is the cost of additional transhipments (up to 26 to 38 Euros from stack to wagon or from stack to trailer, up to 32 to 60 Euros for stack-barge transhipment),

- The costs of rail transport within the port rail network (wagon positioning at the quays and composition of the train at the port marshalling yard) are high and lack transparency. In addition the quality of this transport is poor.

Figure



- *The road terminal interface.*

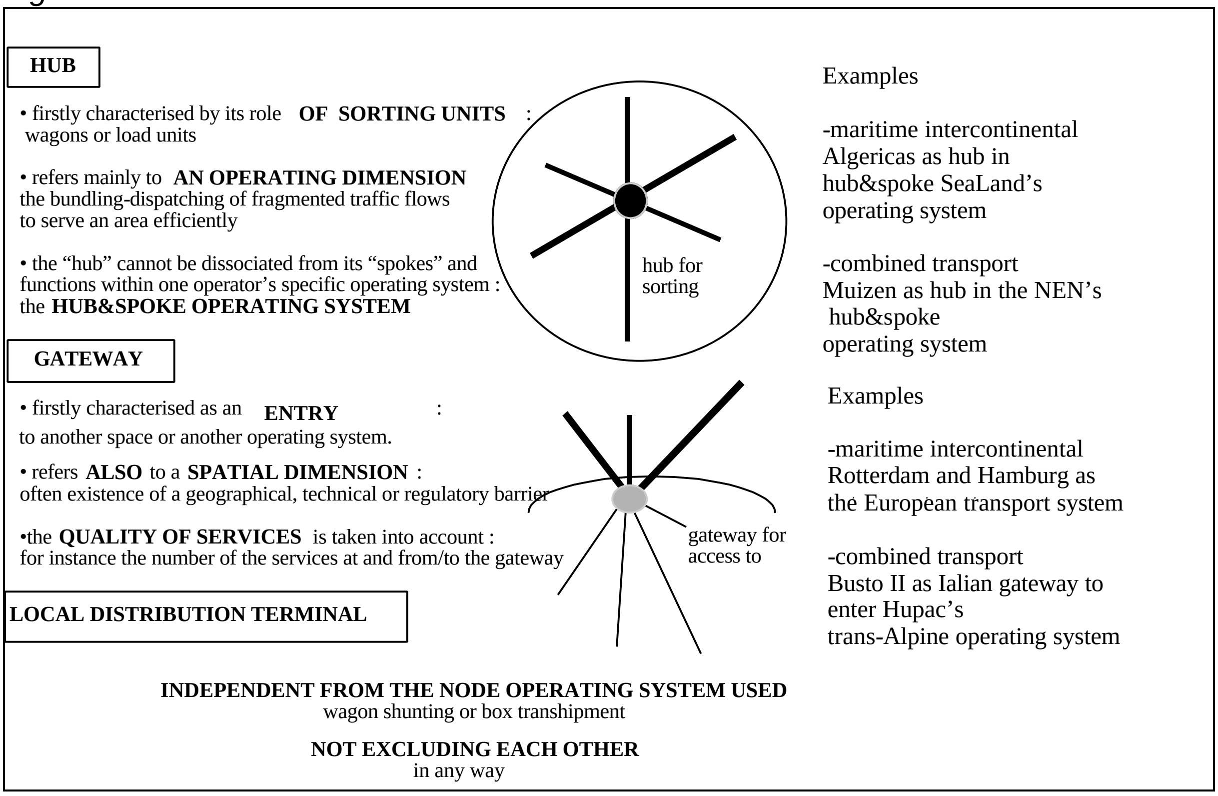
The quality of operations at the road terminal interface (the “gate”) is also critical, as is emphasized by the importance given to innovations at this interface by the maritime terminal operators. Indicators such as the opening hours of the terminals and the waiting times at the gates, the services provided to the vehicles, goods or the driver (parking, customs) have been taken into account when analyzing the “quality of the terminals”.

At a later stage the IQ research will use the DIQIT tool to show the possibilities for commercial and organisational innovations in this field: better appreciation by the customers of their time constraints could reduce the rigidities that prevail at present as regards the organisation of pre- and end-haulage operations.

2.4.2. Towards new roles for terminals in the rail operating system

From case studies and an analysis of the operating systems implemented by the intermodal transport operators, IQ proposes an extension of the “functional” definition of the intermodal transport node. This is considered not only through its function as an interface between two modes (intermodal function) but also through its function within the intermodal operating system, which will be described in the project's next Workpackage.

Figure 10: New roles of the nodes



These definitions are quite separate from the techniques used: examples show that the hub or the gateway function can be performed by either wagon marshalling or box transhipment.

However, the IQ project results show that :

- while innovative technological solutions (often prototypes) have been investigated for box transhipment in mega-hubs (Commutor, Noel–MegaHub), the example of the NEN in Muizen demonstrates that the performance of the hub can be significantly improved using existing infrastructure and technologies, when passing from variable to fixed wagon marshalling (change from block trains to shuttles in hub & spoke operating systems),

- whilst the role of the Wembley marshalling yard makes it a gateway for entering the British network, the example of Busto Arzizio II (HUPAC) demonstrates that a combination of shuttles and box transhipment using conventional handling technologies performs this gateway function more effectively.

- ***Opportunities for a more intensive and continuous utilisation of capacities.***

These new roles of the nodes are not mutually exclusive. One of the terminal operation innovations introduced by the operators is to combine the different functions. This permits more intensive use of the infrastructure and equipment. The Italian gateways provide good examples of nodal points which combine the role of collection and distribution terminals with a gateway function. An important innovation in the terminal’s operating system is the change from “static” to “dynamic” management.

Generally, at rail-road terminals trains are kept stationary for many hours and the maximum number of direct transfers between wagon and road vehicle are performed. In the past, terminals very often handled one train per day on each track. Now, large terminals tend to handle several trains per day on each track. The surface area allocation, the number and the length of the tracks and of the sidings are the subject of new requirements.

- ***New strategic, operational and commercial dimensions of nodes.***

For historical reasons, rail-road terminals have often been considered as belonging to the rail infrastructure: their intrinsic role as a component of the intermodal operating system was not really taken into account. There was no competition between inland terminals. The intermodal transport operators stress that they are not always able to choose the destination terminal (this choice being dependent on the allocation of slots).
In the European intermodal transport network, the only competition between intermodal nodal points is between the maritime terminals, as these are not dependent on the rail network.

However, the new roles of the nodes will transform the terminals into critical points, as:

- whether hubs or gateways, they are of key importance for the performance of the operating systems : good management of these nodes is a key part of operator strategy (IFB at Muizen, CNC at Villeneuve, ICF at Metz, HUPAC at Busto II…),

- whether collection or distribution terminals, they are the entry point to the market area. IQ showed the commercial risk for an operator of using a competitor's terminal. Whereas its customer portfolio is determined by the location of its terminal, good management of the terminal is critical for service differentiation, as, at the present time, operators have limited scope for differentiating their services by means of rail operations. This commercial role of the terminal is given great importance by, for instance, Freightliner. However it requires considerable investment in training and in order to develop an adequate information system.

With regard to terminal operations, more importance has to be given to terminal boundaries.

Particular attention is paid to rail interfaces: reducing the time spent and increasing reliability at these has a major impact on the flexibility of intermodal transport, on the organisation of road pre- and end-haulage, and also allows transhipment operations to be rationalised and better managed.

A transfer of responsibility for these operations from the railways company to the terminal operator could lead to a substantial improvement in the quality and performance of terminal operations.

An improvement in the performance of terminals and the transport chain is to be found in the way they interact with rail and road networks. The improvements associated with the “quality of terminals” are limited if we only consider terminal operations, as these account for just 7% of total transport chain costs. But the stakes are critical if we consider the interaction between the quality and the performance of the terminals and the economic quality and performance of network operations (road pre-and end haulage and rail operating systems).

The effect of the terminal-network interaction on the quality and the competitiveness of intermodal transport services is all the more critical because rail-road terminal operators generally favour direct transfer between wagons and road trailers. Also, the operator can limit pre- and end-haulage operations because, beyond a certain distance between the terminal and the customer, road transport becomes too unreliable, and there is a risk that road transport delays will jeopardise either the reliability of train departure or filling rates.

2.5. European terminal Survey and impact of new technologies

This section aims to identify promising technology for intermodal transport. Based on the results of a terminal survey, it presents a snapshot of European terminal performance and an assessment of new technologies.

2.5.1. European terminal survey: main problems and solutions

Interviews were conducted at 42 European terminals (27 inland terminals, 5 inland waterway terminals and 10 maritime terminals) in order to conduct an in-depth analysis of the impact of new technologies (hardware and software) on terminal performance (measured by quality criteria such as transit times, reliability, qualification and accessibility).

The terminals were classified according to surface area, performance and transhipment categories. The following main terminal operation problems were identified:

- ***customer-oriented problems:***

    - information: due to internal procedures customers cannot be supplied with a large amount of up-to-date information,
    - reliability: some trains arrive late; this problem is often linked to customs procedures,
    - lack of standards: the diversity of special containers and swap bodies.

- ***internal problems:***

    - lack of space at the terminal, which means that storage services had to be reduced in some cases,
    - lack of handling capacity at peak times,
    - breakdown of gantry cranes,
    - rail tracks too short to load/unload complete trains,
    - lack of information exchange between different terminal operations,
    - poor terminal access,
    - inadequate staff training.

The managers named three innovations as the most promising solutions to these problems:

- automated load unit and wagon identification systems,
- more equipment (especially gantry cranes),
- an efficient terminal information network which integrates internal procedures and provides links to customers.

2.5.2. New Information and Communication Technologies

The intermodal industry uses both general and customised information and communication technologies (ICT). The latter serve specific local or customer needs.

Given the lack of co-ordination in the transport chain as regards ICT development, electronic data exchange is difficult and often inefficient. This situation is further complicated by the co-existence of small and large intermodal clients. Large clients are less willing to adapt their existing major in-house systems to the needs of other players in the intermodal transport chain. Small clients lack the resources for major ICT investment.

New ICT could provide a number of quality improvements in intermodal transport. Terminal access control systems, various equipment and cargo identification systems, ICT links between terminals, etc. would improve terminal operation with respect to reliability, security, safety and other quality features. As regards time, modern ICT would reduce the terminal time of trains, trucks and vessels and accelerate internal load unit movements.

The development of a new terminal operation information system would take, on average, 1-2 years and cost 2-4 million ECU.

The analysis has made it clear that investment in de-facto standard ICT applications would help to improve the quality of intermodal transport. The return on investment, however, depends to a large extent on the degree of integration and standardisation which can be achieved. Some major intermodal companies have already started to define the core of such an integrated ICT system.

2.5.3. New handling equipment

In addition to the above information tools, terminal hardware has been classified and assessed. This hardware has been divided into the following different categories depending on their scope:

- new terminal concepts,
- new technologies,
- new technological components.

New terminal concepts such as bimodal, ACTS, Kombilifter, seaport arrangement, Noel equipment, Transmodal, Krupp transhipment technology, Tuchschmid Compact Terminal, Rolling Highway, Autoroute Ferroviaire, Floating Ro-Ro Highway and Thyssen terminal technology have been classified according to their effects on time, reliability, flexibility, safety, security, maintenance and speed.

The following table shows some conclusions.

Table 1: Performance of terminal concepts

terminal concept	performance indicators				
	1	2	3	4	5
bimodal	-	+	0	+	+
ACTS	+	++	+	++	+
MB Kombilifter	-	+	0	++	+
Sea Port Arrangement	++	+	+	+	+
Noel	+	++	+	-	+
Transmodal	++	++	+	0	+
Commuter	++	++	+	0	+
Krupp	++	++	+	+	+
Compact Terminal (Tuchschmid)	++	++	+	+	+
Rolling Road	+	0	++	+	+
Autoroute Ferroviaire	++	++	++	++	+
Floating Highway Ro-Ro	0	+	++	+	++
Thyssen	++	++	+	+	+

The symbols mark the performance and range from very bad "—" to neutral "0" to very good "++".

The performance indicators 1 to 5 refer to:
1. load unit moves per hour,
2. dwell time of load unit or vehicle,
3. reliability, maintainability, availability,
4. flexibility and automation,
5. safety and security.

For improved handling, systems such as new rolling gantry cranes, reach stackers, straddle carriers, other mobile transfer equipment, MTS trailer system and automatic guided vehicles (AGV) have been examined according to the same categories.

As regards new *handling components* the following technologies have been analysed: technologies for positioning, identification, displacement, navigation, vision; gripping, hoisting and rolling devices; anti-sway techniques, electric engines for hoisting, cabin driver, radio, actuator and sensor technologies.

The new handling technologies share the following features:

- improved ergonomics,
- low noise levels,
- more automation,
- quick fault diagnosis,
- flexible production.

In general, there appears to be a trend towards large-scale solutions and high-performance equipment. However, terminals have to respond to their specific economic and social environment and no standardised answers can be given.

2.5.4. New load units and rolling stock

Intermodal load units have been assessed as well as rolling stock related technologies such as wagon brakes, wagon buffers, wagon coupling, wagon components, truck cabin driver related technologies, gripping devices, positioning, identification and localisation innovations. In addition, new modular train sets allowing fast coupling and sharing will bring significant improvements to the productivity of intermodal transport.

With regard to load units and wagons, there is no single standardised technology that would meet the requirements of all parties involved in the transport chain.

On the other hand, the variety of load units demands high flexibility from terminal operators who often have to deal with more than ten wagon types at the same time. Standardised wagons would reduce restrictions at border crossings and with respect to clearances and weight. From the terminal manager's perspective, a higher degree of standardisation would be useful but the intermodal system needs to adapt to the technological systems of its clients (road hauliers, shippers, shipping lines).

The general direction is towards heavier, larger and more specialised load units. Given the constraints that operate in rail transport, this trend is a major threat to the future of intermodal transport.

2.5.5. Modelling the introduction of new technologies

In the last subtask, eleven terminal operating companies were asked to evaluate the quality variables (e.g. train delay). The results of the terminal interviews in WP 1 were then processed using these weighted variables.

On a scale ranging from 0 (worst situation) to 10 (best situation) the present performance of inland, maritime and inland waterway terminals was assessed. On average, European terminals scored 7. For inland terminals, there appear to be some problems as regards delays, although these are usually quite small.

Finally, the expected effect of new technologies on terminal quality was assessed. In the case of inland terminals, the following technologies are likely to produce the most positive effects on Europe’s terminals:

- terminal information systems,
- rail-road rolling gantry cranes,
- ACTS technologies (horizontal transhipment technology),
- new manipulators,
- new terminal concepts (parallel, sequential, compact terminals),
- new consolidation systems (mega-hubs).

Modelling

The model developed is specific to the evaluation of the performance of intermodal terminals. A total of 36 variables are present in the model, 19 of which are related to terminal operations and 17 to accessibility and safety. The weights are determined for each of the variables in a hierarchical manner, according to their relative importance. The structure and the corresponding weights are presented in Figure 6 below.
The hierarchy we have applied has four levels: The first level hierarchy has three transport-related variables: operations, accessibility and safety. The second level has 2 variables, the third level has 2-3 variables, and the fourth level 2-4 variables. At each level the total of the assigned weights is always 100.

In addition to the weights, the variables at the lowest level of the model will each receive, according to a set of criteria, a numerical value ("score") based on the responses in the questionnaire.
Given the weights of all variables and the scores received by the lower-level ("micro") variables, it is possible to apply the weighted-average method.
The weights for the variables in the model are obtained by averaging the weights assigned by different operators. This has been done to avoid bias from the weights assigned by individual operators.
The following figure shows the weights, as determined by the model application. As shown below, the operational aspects (which include time and reliability) account for more than 60% of the total.

share of transport variables

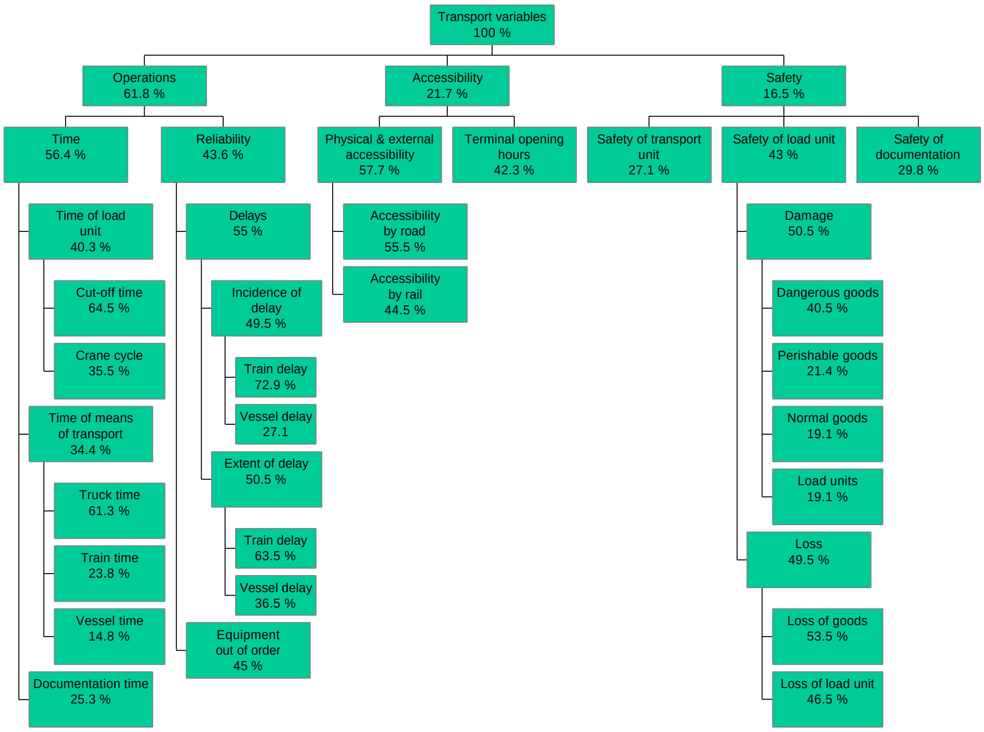


Table 2: Evaluation of terminal quality by micro-variables / current situation

Description	Maritime Terminals	Inland Terminals	Overall Average
Time	7.3	6.9	7.0
Reliability	8.0	7.5	7.6
Accessibility	7.5	6.6	6.9
Safety	8.8	7.9	8.2
Average	*7.8*	*7.1*	*7.3*

Table 3: Evaluation of level of quality of the current situation

Variable description	Maritime terminal	Inland terminal
Loading time	5,6	5,6
Movement within terminal	6,0	6,0
Documentation time	6,3	5,5
Time	5,9	5,7
Incidence of delay	7,5	3,5
Extension of delay	6,0	7,0
Delays	6,7	5,2
Efficiency of equipment	7,0	6,0
Reliability	6,9	5,6
Operations	6,3	5,7
External physical accessibility	1,1	5,0
Terminal operating time	7,1	6,6
Accessibility	3,7	5,7
Damage	6,3	5,7
Loss	5,6	4,9
Safety of load unit	6,0	5,3
Safety of documentation	9,0	6,0
Safety	7,2	5,6
Overall performance	5,9	5,7

New technological options can be identified at all levels: software, technical components, technical systems and complete terminal concepts. No general assessment of individual technologies can be made because problems differ considerably between terminals according to their economic and social environment.

Also, it should be noted that terminals are just components of the intermodal network. The effects of new terminal technologies depend to a large extent on two factors:

- the quality and features of the intermodal network,
- network-wide technology standards.

As the lowest common denominator, however, terminal management systems and tracking & tracing systems appear to be promising pilot technologies.

This analysis of possible changes to the supply side for the quality of terminals has taken into account, probably for the first time, the different types of terminals, inland terminals and port terminals that exist in the different countries of the European Union.

2.6. Trends in terminal planning and financing

This section considers terminal planning and investment strategies in the European Union. A number of conclusions have been drawn on the basis of National Reports on inland and maritime terminals as well as conceptual work on the economics of terminals.

- ***More cautious investment policies***

Most European Union countries have active intermodal transport policies. These range from nation-wide long-term plans (D, I, F) to more commercially driven strategies involving individual companies (NL, UK).

However, many long-term investment plans are being cut or delayed. This is a response both to budgetary problems, the disappointing growth of intermodal transport over the last five years and a more cautious investment policy on the part of some railway companies.

In most countries, a change is taking place from a supply-driven terminal policy to one which is more demand-driven. This approach also reflects the danger of excess terminal capacity in some countries where regional policy considerations tend to override realistic market expectations, while in other places investments in capacity are required to cope with increases in long-distance traffic.

- ***Lack of a European perspective***

Despite the fact that the growth of intermodal transport essentially depends on cross-border links, terminal planning in Europe is still characterised by national perspectives. With a few exceptions, location and lay-out policies are developed independently from planning in other countries.

The organisation of a European intermodal network requires investment to increase capacity at some transhipment terminals or marshalling yards.

The quantitative analysis of intermodal transport conducted in the IQ project indicates that, even in the case where intermodal transport fails to increase its market share (5%), total intermodal volume will double by 2010. The analysis of terminal capacity planning shows that the intermodal transport system requires investment to increase the capacity of the nodes – not only terminals, but also large marshalling yards used as hubs – to permit such an increase in volumes.

However some political and strategic choices have to be made: it is necessary to invest in either a limited number of large and very large terminals or invest to create a dense network and general accessibility to intermodal terminals. An intermediate choice would be create the European core network which requires particular attention to be paid to the capacity of hubs and gateways that structure cross-border traffic.

The lack of a European perspective is evident in the current context where investment programmes have been reduced or postponed and doubts have been raised about the completion of several announced public investments.

Such uncertainty appears all the more problematic because :

- the decision making processes for terminal investments are long and complex,

- analysis shows that terminal facilities need to be much more able to evolve than is the network infrastructure generally. A good example of this is given by the different phases of restructuring the terminals within the seaports.

In the planning of the terminals, the public or private status of the terminals is not critical. An important aspect is the implementation of regional planning policies that guarantee:

- the development of public terminals, because the open access to the terminal is a prerequisite for open access to the intermodal network for all operators,
- rail access from private terminals to the main rail network (and for other industries, open access to the rail network from private sidings),
- that local road and rail services do not cause intermodal transport to loose the competitive and environmental advantages which it possesses for long distances,
- that the question of the planning of intermodal terminals within one region (linking the different “sites” located in the different “zones” of one economic and industrial “centre”) is also raised.

- ***Diversity of players and planning goals***

A number of different players influence terminal planning: for example, local and national authorities, railway companies, private investors and intermodal transport operators. These players have differing interests, ranging from regional development policies and general rail policy to improving customer service and high rates of return.

This variety stabilises the support for intermodal transport policies but, on the other hand, creates conflicts and affects the economic performance and productivity of terminal networks. Public goals may be different from the commercial goals of intermodal transport operators and (independent) railway companies.

- ***Terminal planning cannot be separated from rail network policy***

Most national and regional intermodal transport policies focus on terminal-related measures. It should be pointed out, however, that there is no point in developing a dedicated terminal policy which does not take rail network policies fully into account. It can be observed that this co-ordination is becoming increasingly difficult, especially in countries where railway companies have to pursue purely commercial goals.

Due to the distinct identities of terminal and network operators in most EU countries, there is an absence of cost transparency for terminals. Even if there were full commercial separation between the two, the operational interlinkage would be too close to allow a clear separation with regard to costs or productivity. "Network" factors such as train timetables, shunting systems and electrification which have a marked influence on the productivity of terminals spring to mind.

The physical connection between terminals and the main railway network appears to play a particularly important role. The quality of this link to a large extent determines terminal productivity.

- ***Terminal financing and profitability***

It has been stated that the costs of financing terminal infrastructure amount to an average of 50% of total terminal costs. The market prices for inland terminal operations are in almost all cases too low to cover all costs, even in the case where capacity is fully used. In other words, hardly any of the inland terminals in Europe are profitable.

Again, this shows clearly that terminals must be seen as one element in the transport chain and that terminal planning cannot be separated from network planning. This aspect is analysed in more detail in Workpackage 2 (Quality of networks).

The economics of terminals could be improved by new network policies (e.g. a more even distribution of train arrivals and departures during the day), by separating (public) infrastructure from (private) superstructure investment, or by a general increase of terminal pricing levels. But again, isolated improvements at terminals may be outweighed by additional costs in other elements of the intermodal transport system.

- ***Seaport terminals adapting to intermodal mega flows***

Seaport container terminals depend on intermodal hinterland connections. Land-side interfaces (e.g. rail tracks, road gates, etc.) can amount to one third of total terminal costs. With rising container volumes and ship sizes, new forms of transport services are being implemented.

Shuttle trains to and from individual seaport terminals are the most productive system. For smaller volumes, there is a trend towards seaport-level intermodal interfaces which consolidate container flows between sea terminals and hinterland destinations. Dedicated solutions are being developed for individual major shipping lines.

New services and facilities for the maritime sector make transhipment companies and shipping lines an integral part of the intermodal transport system. They make specific demands on network capacity, transport schedules, telematics, inland terminals, etc.

Given the considerable increase in container flows and quality demands, the maritime sector requires ongoing development and adaptation of inland intermodal terminals.

2.7. General findings concerning the quality of terminals

In conclusion, there is no comprehensive view of the situation with regard to terminals in Europe and, as consequence, there is no consistent planning of terminal infrastructure capacity. National policies do exist, but these are rarely based on a detailed analysis of market needs and are not co-ordinated at international level, despite the fact that international traffic is the main target for integrated transport.

Intermodal policies tend to focus too much on terminals. Our findings suggest that terminals cannot be separated from train and road operating systems. Rail systems in particular should occupy a central position in future policy. This would seem to be a more effective starting point in order to improve overall system performance and, even more importantly, in order to link policies with operator strategies.

The IQ project has analysed public and private national investment projects related to the capacity of the intermodal terminals. This analysis:

- shows the diversity of national policies and highlights the fact that several investment programmes have been reduced or postponed and even that some planned public investments may be called into question,

- underlines the limited role of private players in planning new infrastructure or increasing existing capacities. Numerous players are involved in the process of planning and financing but their interests do not always coincide. The decision-making process is long and complex, which limits the ability of the intermodal transport operator to react to the market and sometimes jeopardises terminal profitability,

- highlights the following with regard to the location of the terminals:

    - for historical reasons many terminals have been built on existing rail infrastructure at sites which are not conducive to efficient road pre- and end-haulage,
    - the creation of terminals is not always justified by flow consolidation opportunities, which will lead to high rail operation costs

- recommends that public and private terminals should receive equal treatment as regards access to the rail network.

Our analysis has also allowed us to differentiate between different commercial and operational configurations for inland terminals. These are as follows :

- the terminal facility is operated by a number of different operators who co-operate to consolidate the flows during train formation (for example, the terminals at Le Havre or Hamburg, or the adjacent CNC and Novatrans terminals),
- the emergence of a terminal operator which is independent from the intermodal transport operators (RSC at Rotterdam),
- co-operation agreements between intermodal transport operators for access to terminal operations (UIRR partnerships).

However, the analysis of the players' strategies and of the introduction of increased competition between intermodal transport operators emphasises the need to give operators equal treatment with regard to access to terminals.

The terminals play a strategic role in the marketing of intermodal services (access to the market area) as well as in the operation of an intermodal network (role of a gateway or hub). This gives terminals a critical role with regard to competition between operators and the differentiation of their services.

However, an analysis of the costs and cost assignment shows the limits and the difficulties of such a clarification as soon as the terminal operator is not differentiated from the intermodal transport operator. The study confirms the difficulty of establishing an economic logic intrinsic to the terminal.

An increase in competition between intermodal transport operators therefore means that it is necessary to raise the question of introducing open access to terminal infrastructures. A clarification of the rules of access to public terminals (and from private terminals to the main rail network) is required. But the question of the conditions which should be implemented at these infrastructures (terminals and marshalling yards used as rail hubs) still remains unanswered:

- regulation, contracting, a professional agreement ?

- or an increase in the number of terminals in order to increase competition between inland terminals, but at the risk of creating excess capacity and lowering the efficiency of the flow consolidation processes ?

• underlines the nationally-based approach to terminal planning and the lack of a European perspective. This in a context where:

  - the surveys of shippers and operators and the flow analysis show that intermodal transport growth is expected to occur primarily as a result of an increase in European cross-border services,
  - the analysis of the players' roles and strategies reveals an international dimension to their strategies of alliances / co-operation and their operating strategies,
  - the interaction between terminal capacities and international services is often a European problem. For instance, congestion at Italian terminals is a major obstacle to the development of new rail services between Germany and Italy.

3. RAIL TRANSPORT PRODUCTION AND THE QUALITY OF NETWORKS

Rail operating systems were studied in particular with reference to best practices. The main factors for the organisation of traction operations were thus identified as follows:

- the *flow consolidation* necessary for high productivity and an increased quality of service on the main leg of the intermodal transport chain,
- economical and efficient *flow distribution* on a dense and accessible network.

This chapter also considers the complex question of network capacity and the bottlenecks encountered by the operators which hinder the development of their services. This analysis clearly highlighted the fact that network capacity is determined by numerous *organisational and operational factors* and not only by the physical and technical characteristics of the network and the equipment.

Analysis of the players' strategies was therefore essential. When analysing network capacity, national reports and interviews with operators aimed to identify how the operators manage to integrate capacity constraints into their operating strategies.

However, these operating strategies are also closely linked to the development of *commercial strategies* of either co-operation or competition between operators, which may quickly adapt to the dynamic institutional environment.

Our analysis of the players' strategies enabled operating scenarios to be built in order to study the impact on the structure and density of the network and hence on the required capacity expansion.

3.1. Train operating systems

This chapter deals with different trains and train operating systems and focuses on the performance aspects of specific train operating systems. But in order to analyse all the relevant cost elements, for example wagons, information services, empty hauls, etc., trains must be considered within a specific network context.

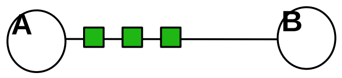
Depending on the volume of traffic, the type of network and the strategy of the operator, various train operating types are used for intermodal transport in Europe:

- conventional freight trains carrying single intermodal wagons,
- part trains carrying intermodal wagons for various destinations,
- block trains travelling directly between two terminals,
- shuttle trains travelling like block trains but with a fixed combination of wagons,
- bimodal trains replacing wagons with special bogies and trailers,
- liner trains travelling like stopping passenger trains,
- circle trains for short-distance feeder services,
- horizontal transhipment trains like ACTS.

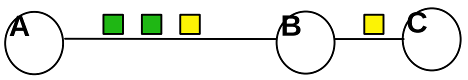
How well these train types perform depends on the *specific situation and network design*. It is therefore more appropriate to speak of train operating systems in most cases. The most important and most discussed train operating systems are presented below.

3.1.1. Block and part trains serving hub systems

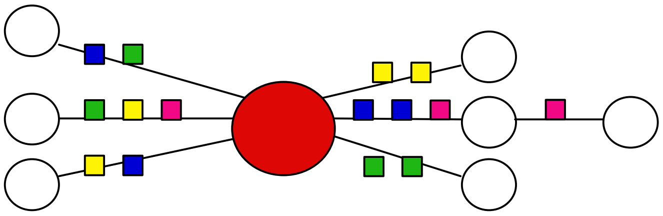
Hub and spoke networks are generally based on the use of block trains and part trains. Block trains are complete trains travelling directly from departure terminal A to arrival terminal B, without train recomposition during the haul. Nevertheless, the composition of the wagons is not fixed and can be adapted to the traffic volumes of a given day or period (in contrast to shuttles).



Part trains consist of wagons for various destinations (two to five in general). The composition of the wagons is not fixed.



Block and part trains can be merged in hub and spoke systems. Hubs are marshalling yards (or terminals) for train recomposition. They consolidate flows between different origins and destinations.



Block and part trains are suitable for less regular or smaller intermodal traffic volumes, which must nevertheless be large enough not to be transported as wagons added to conventional trains.

In the case of operating systems with block or part trains, train formation costs vary between 25% and 50% of the cost of the complete transport chain, while the cost of wagon management is estimated at 10%. Regarding wagon management, hub trains create costs which are 15% higher than shuttle trains. Studies assume average rail traction costs for block trains (over a 400 km distance) of 0.5 ECU per box-km. Traction cost for part trains are on average 30% higher.

Fixed and variable costs for hub yards are considerable and can only be justified by a large number of daily trains, such as with DB Cargo, ICF and CNC. Interestingly, DB Cargo has recently abandoned its mega-hub project for Germany. Three or four state-of-the-art mega-hubs with box transhipment were to replace a larger number of normal shunting turntables. The objectives of this change to rail-rail transhipment were:

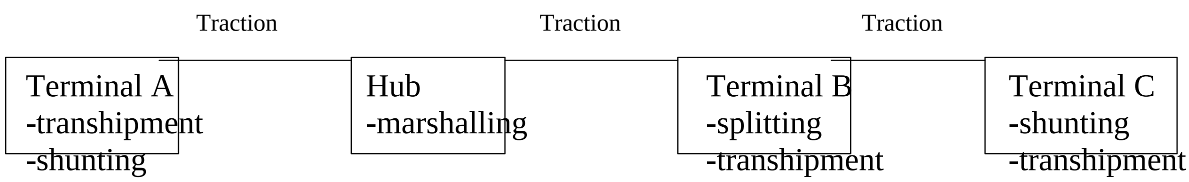
- to speed up operations,
- to allow the operation of shuttle trains with fixed combinations of wagons,
- to reduce the risk of damage and the cost of wagon rearrangement

According to DB officials however, the financial risk of installing and operating the new system is too high.

A successful example of a shunting-based mega-hub is the ICF hub at Metz-Sablon. Multi-destination block trains coming from the north and the south meet at the hub to be marshalled into single-destination trains. In the case of a Scandinavia-Portugal journey, for example, a sufficient volume would need to be achieved at two or even three hubs. 30% of ICF's traffic passes through the hub & spoke system which handles about 500,000 ETUs yearly (185,000 wagons or 6 millions tons). 400 to 600 wagons per day are dealt with at the rail hub.

The Metz-Sablon rail hub consists of three parts : the train reception area, the bumping zone and the train disconnecting zone. Train formation activities are carried out by ICF staff and not by railway employees as is the case elsewhere in Europe. This allows the operator to have a higher degree of control.

As regards the costs at the hub, the following scheme applies:



Average cost estimates are always difficult to produce but are nevertheless useful to provide an order of magnitude

- shunting operations at Terminal A: 57 ECU/box
- rail traction between Terminal A and hub: 163 ECU/box
- marshalling operations at hub: 8 ECU/box
- rail traction between the hub and Terminal B: 163 ECU/box
- splitting operations at Terminal B : 0,5 ECU/box
- rail traction between Terminal B and Terminal C (distance 200 km): 163 ECU/box
- shunting operations at Terminal C: 57 ECU/box.

This gives a total of 610 ECU/box. If transhipment costs are added, the overall transport chain costs amount to 680 ECU/box. Assuming road haulage costs of 0,92 ECU.km, the distance at which a hub & spoke system based on part trains becomes competitive is over 740 km.

Applying the same calculation for a *bi-hub system*, i.e. when two consolidating hubs are necessary for the consolidation of flows, we obtain a figure of 850 ECU/box including transhipment. The corresponding minimum distance to achieve competitiveness with road transport is 950 km.

However this type of computation remains theoretical ; real costs vary considerably around the average, and pricing is far from uniform throughout Europe. Synergies between incoming flows or between different operating systems are sometimes possible, allowing greater economies of scale for rail traction and the purchase of equipment.

3.1.2. Shuttle trains and Y-shuttles

As soon as demand is high, regular and predictable, the flexibility provided by block and part trains becomes less important, and cost-efficiency and transport quality aspects become more relevant. *Shuttle trains* provide benefits in these areas because of their fixed combination of wagons. Shuttle train wagons are dedicated to a specific link and do not require any routing or wagon management. They improve the utilisation rate of rolling stock and reduce both shunting costs and terminal costs. The cost savings amount to 15% - 20% when compared to conventional block train operations. The downside, however, is the lack of flexibility when demand falls, since the fixed costs are high compared to variable costs.

In principle, because of their fixed composition, shuttle trains require a smaller number of tracks at the shunting zone,. In the case of HUPAC, the shunting area of Busto Arzizio II consists of only three rail tracks for 20 trains / day (entry and exit) passing through the transhipment yard. However, the trains stand still most of the day and consume valuable track space either within the shunting area or under the gantries in the transhipment yard.
HUPAC’s strategy is therefore to move the shuttle trains immediately from the yard to the main departure station. The train is unloaded within one hour (30 boxes/hour/gantry).

Y-shuttle trains combine two systems: shuttle trains and part trains. The train has a fixed composition of wagons but can be split up in two or three parts at a nodal point before reaching its final destination. Y-shuttles differ from part trains in that their fixed composition means they only require a splitting operation and no shunting operations.

3.1.3. Hub shuttle trains

The NEN hub system at Muizen represents an innovative use of shuttle trains for short distances. The shortest train connection - Antwerp-Mouscron - is just 100km. Trains arrive during the night and leave, after shunting, the same night. This is a concrete example of an original system which differs from the theoretical core described above and which appears to be performing very well in its specific context.

These fast and reliable shuttle trains are necessary in order to match the fierce competition from road. The combination of shuttles and hubs creates:

- consolidation of flows,
- higher equipment rotation,
- reduced staff costs,
- high frequencies.

These generate both economies of scale and improvements in quality.

3.1.4. Other trains

Over the last two decades, alternative train operating systems have come to the fore - at least in research and public debate. These aim to speed up the system and to reduce problems of capacity utilisation.

It needs to be stated, however, that with the exception of CargoSprinter and small bimodal initiatives, none of the major innovations such as liner trains, ring trains, fast transhipment facilities etc. have progressed beyond an experimental phase. Future development of these trains seems unlikely mainly because their profitability is in doubt.

Cargo-Sprinter is a new modular five-wagon train using railcars instead of locomotives. The modules can easily be coupled together or split up according to production needs. One module has a capacity of approximately five truck loads. R&D has been completed, and the first trains are now being tested. The advantages of Cargo Sprinter are:

- it does not require locomotive shunting,
- Cargo-Sprinter units are easy to couple and split up,
- it is a modular system,
- many components are used in trucks and are therefore less expensive,
- Cargo-Sprinter could revitalise small rail sidings or the Ringzug concept.

A future problem could be that the track fee system does not favour short trains. The fees could be proportionally excessive and put the whole concept at risk.

The continually debated concept of *stopping trains/liner trains,* which, like passenger trains, sequentially serve stations or terminals, represents a further modification of the block-train philosophy. It is based upon the recognition that only 50% of combined transport consignments actually need a rapid overnight service.

A system of stopping trains could have advantages in that production costs are lower and a far greater number of terminals could be served - albeit more slowly than before. An efficient stopping train system, however, also requires an appropriate terminal system: here small terminals with mobile equipment, or automated fast-transhipment facilities would be on offer.

Existing terminals, however, are not suited for this performance profile since they allow neither drive-through operation nor efficient selective loading (as opposed to the complete loading/unloading of a train). Also, only a few terminals provide overhead electrification.

A further train operating system, with an organisational rather than a technical focus, is the "*ring train*" (circle train). Using a stopping train which halts at 10 to 15 locations, containers and swap bodies are loaded, unloaded and transhipped in the shortest possible time by means of simple transhipment devices. In contrast to liner trains, ring trains focus on intra-regional connections and not on long-distance links. Ring trains can be regarded as a multi-stop regional feeder system. The containers are then transferred at the long-distance transport terminals from the ring train to the long-distance freight train by means of cranes. Test cases are being promoted in Germany but suffer from very long delays.

Bimodal trains represent a technical variant that almost completely solves terminal problems. The first large-scale implementation was left to the private BTZ Bayrische Trailerzug Gesellschaft. They use special rail bogies and trailers which allow train coupling and loading without a terminal, cranes or other devices. In addition, no wagons are needed (replaced by bogies). However, bimodal trailers require additional investment by the customer. Moreover, it is difficult to mix normal and bimodal wagons efficiently. This makes future application less likely.

3.2. Traffic structure and operating systems

The utilisation of rail operating systems is closely linked to the traffic structure and the targeted market segments.

3.2.1. Importance of consolidation processes

The analysis of best practises in Europe gives concrete examples of the benefits consolidation processes provide to intermodal transport operators :

- a *rail consolidation process,* to improve intermodal transport productivity through the use of full through trains (block or shuttle),
- a *consolidation process at the network nodes*, to improve intermodal transport quality, whereby organisations combine the productivity of full through trains with flexibility with regard to volume, number of links and frequencies.

In terms of unit cost and the quality of the traction service, it appears that the most efficient option is the operation of direct full through trains with rail transport plans to reduce the number and the duration of intermediate stopovers (thus improving transit time and reliability).

Yet the choice of a type of rail operating system (from the isolated wagon to the full through train) also depends on the equilibrium between *scale economies* in rail consolidation and the *financial and commercial risks* of large capacity. Moreover, the results of the IQ project also emphasise the importance of a *diversity of rail operating systems* to permit flows to be distributed to numerous destinations and / or low volumes.

However, in many cases, the alternative operation systems with isolated wagons, part trains or Y-shuttles, liner or circle trains, suffer from high sorting costs or high investment costs for innovative terminal or rail equipment. As noted above, these operating systems also provide lower quality in terms of transit time and reliability / control of the operations of rail transport and train sorting.

Consequently, it is more advantageous for operators to use rail operating systems which combine the *advantages of full through trains* with *flexibility in volume, number of links and frequency* by implementing rail hubs or gateways.

This system, with a *consolidation process at the nodal points*, is the key to intermodal quality, ensuring that the trains are filled, in order to improve the productivity of the operating system.

The issue of *control of the consolidation process* is at the heart of the strategies of the different players. The sharing of roles between the railway companies on the one hand and intermodal operators on the other is therefore crucial to the efficiency of the operating system. Likewise, the financial and commercial risks, and the good management of rail haulage and nodal points are important factors for intermodal operators.

3.2.2. Improved flexibility and intermodal quality

The various train types provide a useful mix in relation to the functions of economies of scale and capacity utilisation risk.

The huge technical and organisational gap between the appendage model and the industrialisation model can be bridged by stopping train systems and, above all, by *hub & spoke systems*. These are production models which have already proven successful in aviation and in maritime shipping. The system seeks to establish a compromise, in that it exploits the cost advantages of block trains without neglecting the low-volume catchment areas.

The most important players (DB, SNCF, Intercontainer) are currently developing systems designed to reduce the difference between the flexibility of the production systems. Hub & spoke systems, rather than stopping trains or bimodal systems, are being favoured. These new systems have lower costs than block-train systems, as long as the transport distances and volumes remain low. It is only over longer distances that block trains are to be preferred.

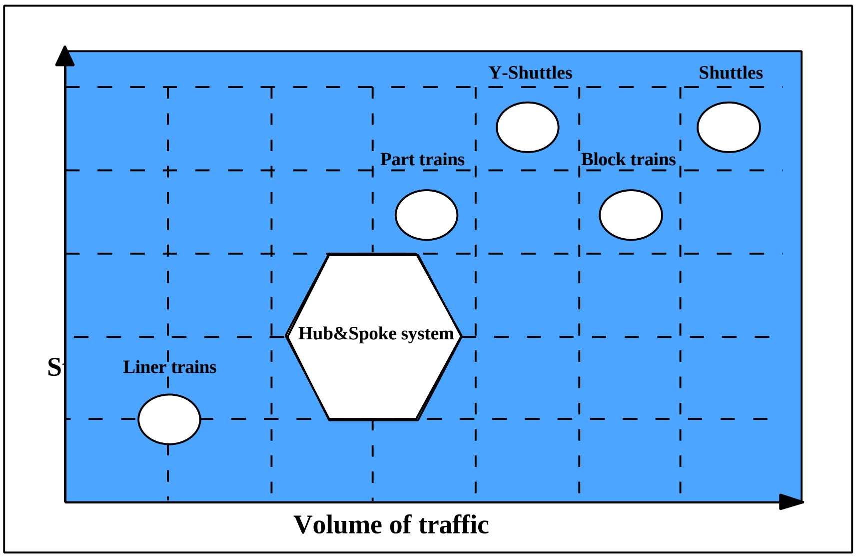
This division suggests that a *complex combination of train operating systems* will have to be devised in order to translate the cost curves of block trains and flexible train operating systems into appropriate market sectors.

Concerning the trains themselves, it is clear that not much is expected from new train and transhipment technologies except in very specific cases.

The challenge today is *cost efficiency and reliability*. This is the main reason why railway companies and intermodal operators are hesitating to invest in technically innovative approaches which entail cost and quality risks. Moreover, most new techniques can only be profitable when applied on a broader network scale, which at present does not seem likely. Innovation efforts therefore tend to focus more on the aspects of organisational quality and efficiency.

- The following diagram shows more clearly the conditions under which the different rail operating systems can be implemented with regard to the stability and volume of traffic

Traffic structure required for the implementation of specific rail operating systems



Such relationships can also be established between train "filling risks and economies of scale " and between "distance and train profitability".

- The appropriateness of the various operating systems also depends on the economic and commercial risks, the distance and the market segment as shown in the following table.

	Shuttle/Y-shuttles	Block/Part trains	Liner trains
Gateway	1) maritime full containers 2) maritime empty containers 3) continental long distance 4) hazardous goods 5) inter-plant transport 6) captive rail transport 7) captive short sea shipping	1) maritime full containers 2) maritime empty containers 3) continental long distance	N/A
Hub & Spoke	1) continental long distance 2) continental medium distance	1) maritime full containers 2) continental long distance 3) continental low value goods	1) continental medium distance
Terminal	3) maritime full containers 4) maritime empty containers 3) continental long distance 4) hazardous goods	4) maritime full containers 5) maritime empty containers 3) continental long distance 4) continental medium distance 5) hazardous goods 6) perishable goods 7) inter-plant transport	1) continental medium distance

In conclusion, the full through train provides the best performance in terms of unit cost and quality of the rail service, but requires good management of the flow consolidation and distribution processes.

3.3. Best practices : lessons and analysis of cases

Intermodal networks are facing three basic operational challenges which can be summarised as follows :

- integration of transport chains which aims to achieve high quality,
- industrialisation of transport processes which aims to achieve significant economies of scale,
- a flexible response to demand which aims to minimise investment risks.

These challenges all have to be met at the same time and in a specific economic and spatial environment. Intermodal operators seek to achieve this by using different train systems which together form a variety of network approaches in Europe.

Consequently, intermodal operators have chosen different network approaches which reflect their respective situations. The following basic typology has emerged during the IQ research.

3.3.1. The lessons : six types of approaches

1. The Corridor approach based on shuttles

This approach focuses on the development of high-volume corridors and ignores the development of low-volume capillary links. The favoured train systems are shuttles which are suited for high, regular volumes of traffic. Infrastructure links between the individual corridors are limited so that this system barely seems like a network approach.

The major downside of the shuttle system is its inflexibility to demand changes because of the fixed composition of the trains. The load factor is a risk taken by the intermodal operator as the railway company will always invoice the same traction costs.

This small-scale corridor approach is typical of the new intermodal operators. Their maritime container services usually connect major ports with Italian Interporti or other hinterland destinations (NDX, ERS). They compete with the more network-oriented approach of ICF or Transfracht.

2. Corridor approaches with specific transport technologies

The Rollende Landstraße (Rolling Highway) system can transport articulated lorries with their drivers on medium distance (200-300 km) corridors. This system originally existed for both national and international links, but due to low profitability all the national links were closed down in 1994 and present services focus exclusively on trans-Alpine and East-West links.

The few bimodal services available in Europe also fall into this category of technology-based isolated corridor approaches.

3. The Gateway approach

Whenever traffic volumes are too low for direct shuttles, gateways can be used as interfaces between national and international flows. They complement direct shuttle connections and make it possible to build Y-shuttle or block trains.

Gateways often combine increased competition on the corridor with increased co-operation in order to serve capillary network systems. In this way they contribute to European cohesion and the accessibility of the intermodal system.

Gateways are a typical feature of peripheral countries where they provide a "gate" to the country but they are also present in core regions, with HUPAC probably being the most highly developed example (see *5.3.7 Examples of Best Practices in Europe*). Another example is the Belgian CORTAX system which is run by TRW and other operators.

Gateways can be combined with different train systems such as Y-shuttles in the case of HUPAC or block/liner trains in the CORTAX and UK cases with Wembley serving as a gateway to the Continent. In terms of transhipment volumes, the North Italian Interporti are the most important examples.

4. The Hub approach

Whenever traffic flows are neither stable nor sufficiently high, block or part trains allow more flexibility and a higher load factor than fixed shuttle sets.

However, these flexible train types mean that shunting and train formation activities are necessary and these take time and result in additional costs (around 15% higher than shuttles). The minimum distance in order to be competitive with road transport increases.

The most elaborate means of combining the flexibility of block or part trains with short transit times and regular servicing are hub & spoke systems. They represent the most striking development for intermodal networks over the last decade.

This is not only due to their operational advantages. It also reflects the increasingly active role of railway companies in the intermodal business. Since rail companies have all the infrastructure assets at their disposal, they are in a position to develop *and to control* main hubs at national or European level. This strategy is much more difficult to pursue for, say, UIRR operators who would have to rely on railway-owned equipment and infrastructure.

Hub systems take various forms:

- European multi-hub systems (see 5.3.2, 3 on the ICF system) for low-volume long-distance links,
- large national hub systems for peripheral regions (see 5.3.2, 2 on the CNC system),
- small national hub systems for short-distance links (see 5.3.2, 4 on the NEN system).

5. The appendage approach

The oldest approach, but one which is still widespread, brings intermodal wagons onto conventional train networks. This can involve either individual intermodal wagons or groups of wagon which are simply appended to a conventional train. Not surprisingly, transit times and quality standards are not very high, but in many cases low operational costs and high frequencies outweigh these problems. Empty maritime containers, for example, tend to travel under very low time pressure.

Appendage approaches can be found throughout Europe. They are exclusively applied by national railway companies. For example, leaving aside rail-siding transport, in 1995 DB's intermodal volumes broke down as follows:

- through trains -just 36% of DB´s intermodal volumes,
- wagon group trains - 41%,
- and single-wagon transport - a still impressive 23%.

In France the situation is quite different. Only 4% of intermodal traffic is routed through the conventional wagon load system. The SNCF strategy is to reduce this traffic (in 1994 the share was 16%). By mid-98 the intermodal traffic mix was approximately:

- 4.2% wagon load,
- 59% direct trains (including shuttles and block trains),
- 36% through nodal points.

For several destinations where no dedicated intermodal service is provided (for example Novatrans services to German or Scandinavian destinations), the intermodal transport operator uses conventional train systems with very poor transit times.

6. Multi-layer network approaches

Here various network approaches are employed by the same operator in the same region and overlap. Most large intermodal operators and railway companies have a complex network approach, but DB Cargo may be the most striking example, displaying an interconnected network of all train systems for national and cross-border links which are routed over a complex system of direct links, international gateways and several national turntables at different spatial levels. There are dedicated high-performance intermodal shuttles (IKE), normal intermodal block trains, national hub block trains, conventional trains carrying intermodal loads, and Rolling Highway links.

Additionally, DB Cargo is pursuing a strategy of acquisition and merger in order to expand its European activities. The planned fusion with NS Cargo, and the purchase of shares in NDX and Polzug (through TFGI) underline their ambitions to service a truly continental network of intermodal links. DB Cargo (together with its affiliate TFGI) not only controls the largest national intermodal network, i.e. Germany, but also successfully competes with its European intermodal railway affiliate, ICF, in which it is the largest share-holder.

Another example of a multi-layer network approach is ICF, which moves 30% of its volume through its hub & spoke system, another 10% in shuttles, 15% in part trains and another 15% in isolated wagons in conventional trains. The remaining 30% is not known about.

3.3.2. Analysis of cases: examples of best practices in Europe

More than 25 cases have been identified in Europe, but only 4 of them will be reported in this synthesis, to provide a concrete illustration of the approaches described above.

1. The HUPAC shuttle system

The HUPAC network is based on a combination of the concepts of gateways, shuttles and Y-shuttles. It is an outstanding example for the efficient and successful implementation of high-quality intermodal trains throughout Europe.

Traffic flows are highly bundled: 90% of the company's volume is carried by shuttles operating to and from eight main destinations: Rotterdam, Hamburg, Hanover, Duisburg, Cologne, Mannheim, Pomezia and Verona.

For smaller volumes, the Y-shuttle/gateway concept applies: a gateway is defined by HUPAC as an intermodal entry point to a country. In the case of Italy, the gateways are at Busto Arsizio and Novara. From here, other Italian destinations are serviced by means of a partnership with CEMAT. Other countries are served in a similar manner.

A Y-shuttle combines the concepts of shuttle train and part train. The composition of the train is fixed in terms of the number and type of wagons, but it can be split into two parts at a nodal point before it reaches the final destinations. In partnership with CEMAT, Kombiverkehr and Trailstar, HUPAC has developed a system of Y-shuttle trains for medium-volume destinations in the Netherlands, Germany and Italy.

2. The CNC hub system for France

France is characterised by a large number of small and medium-sized freight corridors interlinking all regions of the country. Moreover, the flows are often not balanced. A considerable degree of bundling and consolidation is therefore required to reach the minimum load for intermodal trains.
CNC has overcome this problem by setting up a national hub near Paris at Villeneuve Saint-Georges. This hub permits regular links to low-volume destinations throughout the country and can serve as a successful example of regional intermodal services.
About 50% of the CNC traffic first travels to this hub and wagons are shunted and recomposed to form single-destination trains within a few hours. The boxes will reach their final destination within 24 hours. 350 combinations are possible and 26 trains with on average 850 wagons are built every day. However, the investment costs associated with this hub are high and it requires a high load factor. For this reason it is owned by SNCF and dedicated to CNC only for 5 hours per day.

In addition to national services, this hub system is inter-linked with other European networks and their hubs such as Wembley (near London) and Muizen (Belgium).

3. Qualitynet: the ICF hub system for Europe

ICF has developed a hub system which allows the bundling of long-distance, medium-sized flows travelling between northern and southern Europe. Without a hub, many of these flows would be too small to justify regular connections of sufficient quality.

The ICF Metz-Sablon hub links 14 northern European terminals with 24 in southern Europe. Between 400 and 600 wagons are shunted per day (or 0.5 million TEU per year), the capacity limit being 1200. These hub & spoke flows represent 30% of the company’s traffic volume. There are second-level hubs in Salzburg and in Sopron. Here instead of wagons being shunted boxes are moved from one train to another. ICF has a high degree of control over its hub activities, even though the premises and most equipment are railway-owned.

According to estimates, the Metz-Sablon hub is competitive with road transport beyond a distance of 740 km, when transhipment costs are included. If a second hub has to be used, the break-even distance would be in the region of 950 km (again including transhipment).

4. A small-scale hub system for Belgium: NEN Muizen

Belgium has successfully solved its production problems at both international and domestic levels through a combination of links to supra-national hub & spoke systems (ICF, CNC 24), national hubs (NEN Muizen) and high-frequency shuttle services (Rotterdam, Munich). The Belgian example shows that networks of fast and efficient short-distance shuttles in small countries are feasible once the critical mass of cross-border links - feeding the national hub - is achieved.

The Muizen Dry Port is the starting point of the so-called NEN "North European Network" created in 1996, which represents an innovative hub approach. At present, NEN consists of links to Zeebrugge, Antwerp, Rotterdam, Duisburg, Athus, Lille, and (soon) Mouscron (replacing Lille) at the Belgian-French border and for UK destinations.

The advantage of NEN over conventional links is the dedicated network of fast shuttle trains which travel regularly over the short distances between Muizen and the above mentioned Dutch and Belgian seaports or other destinations. In all cases, the Muizen-based NEN serves as a fast hub facility providing transhipment, track capacity and organisational support.

This efficient network proves the profitability of short CT links, the longest one, Rotterdam-Athus, stretching over just 350 km. The shortest link, Antwerp-Mouscron, is just over 100km. All services are offered on a A/B basis with the exception of Muizen/Duisburg which is even A/A. The composition of the trains is fixed.

Key features are high frequencies and hence high equipment rotation, reliability, flexibility and high service standards.

In conclusion, network approaches aim to find an optimum equilibrium between transport quality, cost efficiency and flexibility.

Before the introduction of efficient hub systems, there was a dilemma between on the one hand, part trains or wagon groups, which are cost efficient and flexible but slow and unreliable; and on the other hand shuttles which offer high transport quality but also lack flexibility since they need high and stable demand.

Hub systems are a new type of industrial organisation which provides greater flexibility than rigid shuttle operation. Such hub systems have already proven successful in aviation and in maritime transport. The system seeks to establish a compromise, in that it exploits the cost advantages of block trains without neglecting low-volume catchment areas. This allows higher frequencies and more reliable services, compared to previous services, without increasing costs.

The new developments suggest that a complex combination of train systems will have to be devised in order to translate the cost curves of block trains and flexible train operating systems into appropriate market sectors.

However, a *difference in strategies* can be noted, between new intermodal operators, who mostly focus on high-quality shuttle links, and the railway companies and their subsidiaries who are increasingly developing hub systems.

For example, even large nationally-based UIRR operators place an emphasis on "care-free" shuttles or block trains without developing large network systems. In contrast the railway subsidiary ICF focuses on hub development.

These strategic differences show basic control problems and an underlying conflict of interests. Whereas a number of high-volume corridor solutions are profitable on their own, network approaches tend to expand in order to secure a profitable load factor (which is not compatible with individual corridor approaches). Not surprisingly, DB has announced that intermodal operators will have to carry the load risk not only in international but from now on in national corridors, too.

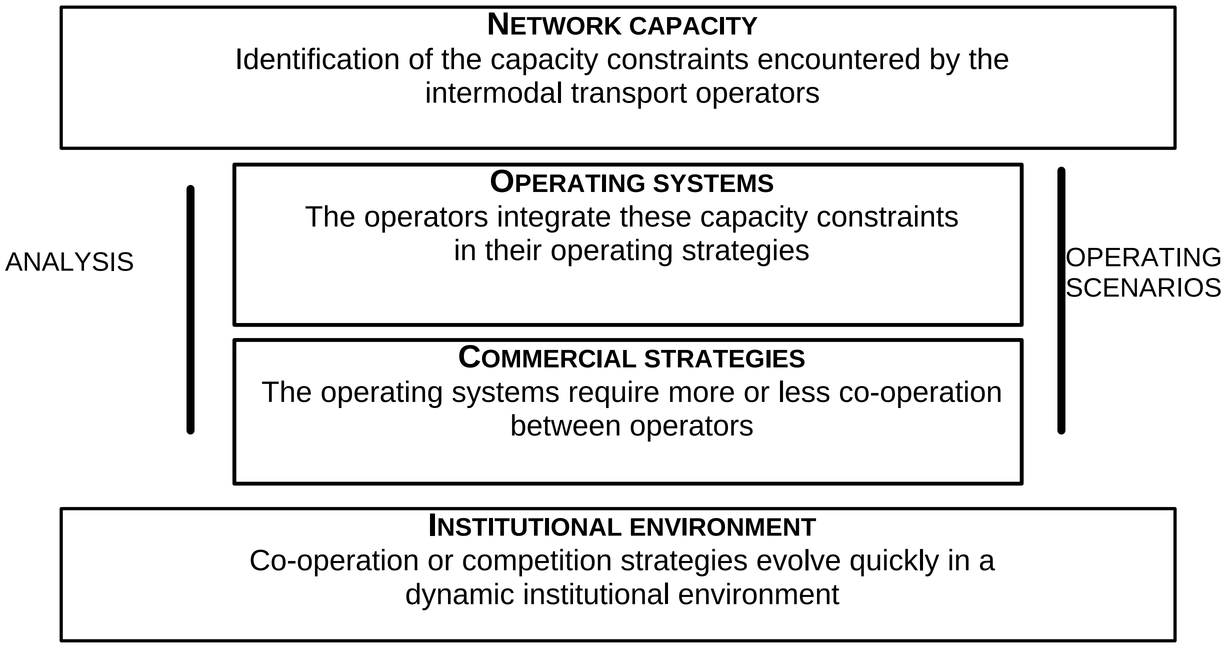
From the other perspective, this means that high-quality corridor solutions would loose their high level of control and independence when working under a network regime. There is thus a fundamental conflict between intermodal railway operators and other small operators who focus on single corridors. This could be resolved in a number of ways, through increased co-operation, leading to the small operators leaving the market, or alternatively, the small operators becoming involved in railway operations with their own assets.

3.4. Capacity constraints

Capacity constraints are also a major problem for the quality of networks. Capacity constraints can be caused by the physical characteristics of the network, in particular the existence of bottlenecks in dense areas or natural barriers. However, capacity constraints can also result from a lack of technical harmonisation in the face of interoperability problems ; capacity constraints cannot be solved just by considering investment as they are directly related to the operating system.

The analysis in this section is based on the national reports and interviews with the major national intermodal operators and includes analysis of operating systems and modelling of infrastructure planning and financing.

Capacity constraints are not only determined by the technical characteristics of the infrastructure and equipment, but also by the operating system and the institutional environment.



The analysis shows the complexity of the capacity constraint problems encountered by operators. Examples are given in the national reports.

3.4.1. Infrastructure, equipment and capacity constraints

Capacity constraints are clearly linked to the network infrastructure and the technical characteristics of the links and nodal points. *The operators highlight the constraints of gauge, gradients and limitations as regards train length and weight, the utilisation of high-size ITUs etc., hence a precise analysis of the interactions between these technical capacity constraints and the additional costs (limitation of the productivity of traction operations, additional cost of low wagons) is necessary.*

Capacity constraints are also linked to the equipment; the availability of locomotives, drivers, wagons and ITU are the main determinants of network capacity. A precise analysis of the interactions between equipment-related capacity constraints and the chosen operating systems is therefore necessary.

3.4.2. Physical infrastructure capacity constraints, for links and modes

Inland waterways :

Only a few European countries have an inland waterways network which means that at a European level interconnections are often very difficult or impossible ; the inland waterways network is fragmented with many restrictions (air draught under bridges, water draught) which limit the efficient use of barges for intermodal transport.

General rail network capacity problems :

As far as rail infrastructure is concerned, the interviewed operators stress that during recent years, capacity investment on the rail networks has mainly been concentrated on high speed lines and passenger traffic. A survey of relevant European programs (the TENs) confirms that - despite largely unsolved difficulties in tapping financial resources from both governments and the private sector- huge investments to build a new generation of specialised high-speed rail networks have been and still are a key part of European programmes to modernise the railways in the continent and provide additional capacity.

The combined transport players do not always perceive the construction of these new high speed lines as providing extra capacity for freight traffic or as providing a large number of time slots for combined traffic. In France, the operators point out that the high speed lines currently reach the urban centres through shared sections of conventional line. For example, the rail node of Dijon is expected to become a major bottleneck as a result of the increase in the number of TGVs, traditional passenger trains and freight trains. In Spain, the assumption that the improvement of the passenger lines (UIC gauge, high speed lines) will also benefit intermodal transport because the new infrastructure will remain common, is questioned on the basis of the example of the Madrid-Seville high speed line which is used by AVE passenger trains while freight and other passenger trains travel on the poorly maintained old line.

On the contrary in Germany, the completion of a 3200 km high speed network by 2010 is expected to provide additional capacity for freight, in particular along the Rhine corridor (Cologne-Frankfurt high speed line) and on East-West connections.

The main characteristics of the national network are also to be taken into account. The infrastructure constraints for combined transport will differ in the case of radial rail networks (France, Spain...) which contain few efficient transverse links, and for the German network lay-out that gives more opportunities for an alternative route suitable for freight traffic. In particular, the German "NETZ 21" approach is highlighted, which involves a systematic increase in the use of the large number of second-level links that often run parallel to the existing trunk links.

Additionally, in Europe there are several major natural barriers which influence the lay-out and capacity of the European rail network: black spots are clearly identified at the Alpine and Pyrenean barriers, and recent infrastructures such as the Channel Tunnel or the fixed links between Denmark and Sweden will play a structural role in the development of European combined transport. European geography also influences the location of “gateways”.

Profile and gauge problems

These relate to the gauges of tunnels and bridges, track gradients, axle loads, maximum total train loads, but also and wayside information and positioning equipment.

Capacity of marshalling yards and shunting areas

With regard to the nodes of the combined transport network, national reports and interviews emphasise the importance of the capacity of marshalling yards and shunting areas. The number and length of the shunting tracks are identified as a determinant of capacity. For example, in Spain the insufficient length of the shunting rail tracks is highlighted as a major capacity constraint.

The physical characteristics of shunting areas (i.e. the number and length of the shunting tracks) could become a crucial factor for the implementation of innovative intermodal transport operating systems such as the shuttle system as tracks are required in order to store complete shuttle trains to avoid any shunting cost. The length of the shunting tracks, like the length of the tracks at terminals and the characteristics of the rail access link, are also to be considered for innovations in railway operation which involve a substantial increase in the total length of trains.

Capacity of rail-road terminals

The national reports describe how several transhipment terminals are currently facing congestion problems as a result of both their location (major rail and road access problems in dense urban areas) and their limited extension possibilities.

To give one example, Freightliner stresses that its terminals are former British Rail terminals which were built in the 60’s at locations and with lay-out which do not allow productive operations: rail tracks served by gantry cranes are very short (which prevents rapid unloading and reloading of liner trains); several terminals are dead-ends and require a second locomotive (and extra cost of this is high due to the UK-wide lack of modern locomotives); several terminals are quite far from the trunk rail network and require time-consuming access rides.

At the present time, the location of rail-road terminals appears less dependent on the rail network infrastructure. The combined transport operators can find alternatives to the use of railway assets, including privately operated rail distribution terminals (as for example in the UK at Doncaster, Daventry and Hams Hall) or their own privately operated terminal (as illustrated in Italy by Ambroggio). For terminals, policies in the areas of capacity planning and financing therefore need to consider both public terminals (public access) and the development of private (dedicated) terminals. This issue raises new questions about what is meant by "open access" to the nodal points, about new types of competition and, in the case of the inland waterways, about the risk of excess capacity which hinders economies of scale.

The increase in number of rail-road terminals with a risk of excess capacity is highlighted, for instance, in the Netherlands. The question is then raised, at both a national and a European level, of a policy which combines the necessary:

- polarisation - in order to consolidate traffic flows at major terminals, to capture the freight from the largest economic areas and dispatch these traffic flows over long distances to other large national or European economic centres;
- and spreading - based around the concept of a network of smaller terminals through which traffic flows can be dispatched throughout the territory;

The key question with regard to this polarisation and spreading is how to cope with the expected growth in intermodal traffic. Possible solutions to the current intermediate situation could involve modularity, which would allow a gradual increase in capacity with a gradual funding of investment.

But the field studies also show that an increase in capacity of the terminal is not only an infrastructural issue. Spreading out peak times at terminals through improved organisation, the introduction of a multiple train departure system at major terminals to enable better use of terminals and combined transport trucks and the modification of opening hours, are amongst the critical issues identified by the professionals. In particular, severe congestion problems, which result from intensive storage of non stackable unit loads at terminals, often turn out to be more of a commercial power question than a pure infrastructure and equipment issue. Consequently, the theoretical capacity of many terminals is far higher than can be used in practice.

Finally, with implementation of Directive 91/440 and the separation of infrastructure and operation, critical issues such as the way the infrastructure manager will intervene, and charging for assets are to be considered, both for the transhipment terminals put at the disposal of the combined transport operators and for the traditional rail hubs.

3.4.3. Rail equipment capacity constraints

- ***Rail signalling systems***

According to the interviews, equipment is an important factor for the development of intermodal transport capacity, in particular rail intermodal transport capacity. The short sea shipping sector appears to be far less constrained by the characteristics of its equipment than other modes (rail and the inland waterways).

Physical infrastructure constraints on links in the rail network, such as gauge or load restrictions, are worsened by restrictions and limitations due to operating rules and signalling. As will be emphasised below, besides physical infrastructure investment on links, rail network capacity is expected to increase through improved use of the available infrastructure. Some other solutions for more efficient use of available infrastructure for freight and combined transport rely on investment in track and signalling equipment. One example is the implementation of a new train signalling system which reduces the minimum distance between trains (moving blocks) and therefore enables an increase in capacity in terms of the number of trains.

Other issues concern voltage and the interoperability of the rolling stock and crews. Physical infrastructure characteristics affect equipment choices. An example of this is the UK where there is a complex traction regime. Part of the south-east network is not electrified at all, the rest is a patchwork of electrified stretches with different voltages and non-electrified stretches on the access tracks of terminals. Consequently, Freightliner uses Diesel traction throughout the country.

- ***Locomotive availability***

The national reports illustrate the impact of the availability and technical characteristics of the locomotives on reducing the cost of traction, improving its quality and reliability, implementing innovative rail operations and improving interoperability.

With regard to engines, not only interoperability is considered, but also the potential for lowering traction costs through the use of less expensive locomotives. A number of railway companies are considering replacing their rolling stock. One example is the SNCF which is buying locomotives that are better suited to freight transport and which will reduce its production costs. The UK national report mentions that the Freightliner fleet is elderly and sometimes lacks the power to pull heavy trains. Occasionally, trains cannot be fully loaded because of insufficient locomotive power.

It was mentioned that implementation of an innovative short train concept could also depend on the infrastructure access pricing system, for example in Germany, the track fee system does not favour short trains. The same remark is made by Freightliner: Railtrack's charges are independent from the length of trains. These charges account for 20-30% of total cost, so the pricing system does not favour short trains.

The professionals interviewed do not reduce improvements in interoperability to just technical requirements. For example, the Freeway process emphasises the importance of the reduction or elimination of border crossing delays. The focus is placed on reducing border crossing time (matches between the national timetables). But in practice, the proposed path improvement will only be obtained if operational issues, such as changeovers and crew scheduling are dealt with. For example several of the interviewed operators stress train delays and the misallocation of locomotives at border crossing which lead in many cases to delays of 24 hours.

Labour issues are, of course, often mentioned by rail-road operators in connection with the quality and competitiveness of railway services. It is also mentioned in the context of harbours. While recognising that the situation concerning labour and the working conditions in ports have gradually been improved, short sea shipping operators have identified restrictive regulations and practices that still reduce the efficiency of port operations and have a considerable impact on cargo handling costs. For example, agreements on working hours limit handling operations. Furthermore, cargo handling and inter-terminal transfers can often only be performed by personnel who come under a certain labour agreement. This results in additional transhipment costs for short-sea transport, and is particularly significant where the maritime sector is in direct competition with land modes.

- ***Wagon availability***

The decisions concerning wagon purchasing and wagon dedication are eminently strategic decisions for railways and combined transport operators, at both operational and commercial levels. The shortage of railcars for intermodal transport in Spain, the shortage of special low-bed railcars for 9ft6 containers for UK traffic are capacity constraints encountered by the intermodal transport operators. In Italy, the company Sogester states that rolling stock availability is an important constraint for the development of companies. In contrast, the investment by several players in wagons suitable for heavy loads, for example ICF which is investing in Mega-wagons, increases the capacity of the intermodal rail network. Kombiverkehr is also pursuing an own equipment strategy of to increase the number of high-performance wagons (low tare weight, high flexibility): 34 of these wagons are currently used in two shuttle trains and Kombiverkehr considers that considerable productivity and flexibility increases are still possible through wagon technology.

The level of control of the wagon fleet is also a major issue for several combined transport operators, because of expected reductions in management costs, additional control and increased flexibility with regard to market requirements, but also because of increased independence from the railway companies.

Concerning equipment for rail-road transport, innovative solutions are also proposed by companies like BTZ that use special rail bogies and trailers which allow train coupling and loading without a terminal, cranes or other devices. In addition no wagon is needed (they are replaced by bogies). This allow a higher load weight. It is planned to add bimodal wagons to normal combined transport trains in order to keep the cost of bimodal transport low. Combined transport operators could also develop the use of such combined transport techniques as an alternative to conventional increases in terminal capacity.

- ***Lack of standardisation of load units***

We shall first of all consider the differences between maritime containers and continental unit loads (swap bodies and trailers). Obviously, differences in the physical characteristics of these load units have a different impact according to the type of intermodal chain and market segment.

According to some combined transport operators such as Eurokombi, difficulties in management at operational level make it impossible to achieve a the mix of maritime containers and continental units. But, according to others, for example Italian intermodal players, if the transport of continental units and maritime containers still constitutes two distinct markets whose integration seems to be slow, this is more due to "behavioural" factors affecting the users than to "technical" incompatibilities: established relationships between shippers and transport operators are difficult to change.

- ***Transhipment equipment***

The availability, performance and maintenance management of transhipment equipment will to a large degree determine terminal capacity.

It has been emphasised that the position of the terminal in the network will affect the design and performance criteria for its infrastructure and equipment. One example is the Maasvlakte Rail Terminal at Rotterdam, which does not aim to achieve fast transhipment but rather efficient internal transport operations in the harbour. Because the trains stay at the terminal between 8 and 12 hours before they leave, the project has a large number of tracks and a small number of cranes. In contrast the Noell mega-hub was designed for large-scale fast simultaneous exchange of load units, in order to replace conventional shunting yards. It focuses on relatively high peak hourly performance which is achieved with a fully robotized rail operation. However, new transhipment technologies are not always perceived as the critical issue: the Gateway concept implemented by HUPAC has proved, at Busto II, the efficacy of a large-scale terminal using conventional technology that can combine distribution and hub functions.

- ***Information technology***

In the intermodal transport chain, the capacity and quality of production and transfer of commercial, operational and administrative data are strategic production and commercial issues in order to reduce the cost of transactions between the numerous players involved in an intermodal transport chain, to enhance the quality of the operations at each interface between the different players and to enhance the flexibility and reactivity of the combined transport chains.

It appears that rail intermodal transport suffers particularly badly from shortcomings in incident management: several interviews make that point that any incident can result in important delays. Implementation of the TERFF " one stop shop " based on use of the Internet emphasises the importance of improving information links between the different players in the transport chain at the sales and commercial levels too.

However, it has also to be noticed that interconnections within the EDP system and the introduction of the EDI process are part of each operator's strategy: competition or co-operation issues will to a large degree determine the development of EDI procedures with customers, providers and partners.

3.4.4. Capacity constraints, operating system and commercial strategies

It appears from the previous chapter that capacity constraints on the rail network are strongly linked to the operational use of the available physical capacities, for example what priority is given to passenger traffic and how the major conflicts between the development of regional passenger transport and intermodal transport are resolved. In general, the rules which are adopted concerning the mixing of rail traffic will be important determinants of network capacity. This emphasises the importance of a precise analysis of the interactions between capacity constraints and the costs of intermodal transport operations.

The IQ analysis considered the projects of railway companies (DB, NETZ 21, SNCF, NS etc.) and the European Commission (co-ordination of the Freeways or Freightways rail traffic initiatives). It also examined the issue and effects of mixed traffic and the priority given to passenger services, going on to consider possible means of improving intermodal services. These include dedicated freight links such as the Betuwe Line, mixed links with freight priority, mixed links with freight windows priority, and conventional mixed links with passenger priority.

The national reports mention that the availability of suitable time slots is a major capacity constraint encountered by the combined transport operators. At a national level, one exception is the UK where Freightliner and the Channel tunnel operators state the question of train paths is not currently a major issue in terms of growth (compared to problems in terminal capacity and rolling stock availability).

This time slot capacity constraint is primarily linked to the priority given by the railway companies to passenger traffic. Currently, railway companies serve both passenger and freight traffic on their infrastructure, and this mix of traffic to a large degree determines the capacity of links. In addition, the limitation of the capacity of a link is not so much caused by the fact that the observed transport volume exceeds the design limits of the available infrastructure as by decisions taken by the manager of the infrastructure and the traffic planner regarding the allocation of train paths for several kinds of trains (express, combined transport, heavy freight trains, urban trains, temporary trains, etc.).

The capacity of a rail link should therefore be described first of all in terms of the number of trains and the number of suitable time slots for each kind of traffic. Moreover, the combination of different types of traffic, i.e. fast and slow trains which block each other, is an important factor in the creation of bottlenecks. A poor combination may easily reduce the theoretical track capacity to a much lower "timetable capacity" . The conflict between the development of regional or urban passenger traffic and the development of combined transport is also obvious. It is emphasised that the concentration of services at certain times of day - the provision of rail services to terminals at times when urban passenger traffic is high - leads to capacity requirements that are higher that one could believe if only the total volume of combined traffic is considered.

The most critical issue with regard to capacity constraint is thus way timetabling makes use of the available infrastructure and gives priority to combined transport. Projections made by several national railway companies -SNCF, DB, NS. etc.- with regard to improving the capacity of links for freight traffic and the Free- process (which makes it possible to co-ordinate the timetables of different network managers) can therefore be considered within the larger scope of investigation and definition of:

- **dedicated freight lines: infrastructure planning (signalling, axle load, length of trains...) takes account only of the requirements of freight and timetabling permits freight traffic to the exclusion of all passenger traffic. The main example of this is the Betuwe line project.**
- **prioritised freight lines: infrastructure planning takes account of the characteristics of freight: passenger traffic is allowed, but within the constraints of freight traffic management. The French report presents SNCF’s projections.**
- **mixed passenger-freight lines with priority given to freight traffic during a given period (the night-time). Infrastructure planning takes account primarily of the requirements of passenger traffic, but at the organisational level (timetabling) the use of the links is differentiated within distinct periods.**
- **conventional mixed passenger-freight lines. Passenger traffic is given priority both at the infrastructure and organisational level.**

The main issues considered in these projections are:

- increasing capacity by making the speed of the different types of traffic more homogeneous which would allow a substantial increase in capacity on the considered links in term of the number of trains;
- once the speed of the different types of traffic has been made homogeneous, the possibility of increasing the total length of freight trains, which would allow a substantial increase in the total volume handled on the considered links.

3.5. Main findings for the performance of rail operations

With regard to network quality, the IQ project has focused primarily on the performance of the operating system rather than infrastructure specifications as is often the case; the operating system directly influences the quality of rail production and the quality of service.

Performance in the area of rail transport production is dependant on processes of consolidation and densification: concentrated rail flows permit economies of scale and the reduction of unit costs can be combined with an increase in frequency and reliability.

It was then possible to investigate best practices throughout Europe.

The IQ project's research also highlighted the importance of *good management and planning* of rail traffic at the hubs, on the major corridors, on the terminal access interfaces, and at the terminals themselves. In particular this involves improved train time scheduling for intermodal traffic. Improvements could be made in the following areas:

- *for a given railway operator's network*, with the example of the hub & spoke services, enabling the railway companies to optimise use of their infrastructure, with precise co-ordination of train departures and arrivals at the hub for optimum efficiency of train sorting,
- *for the main network*, by calling mixed traffic into question, which would allow an increase in link capacity in terms of the number of trains to be increased (and possibly also an increase in train length and weight), with a decrease (by 15% to 80%) in border crossing waiting times,
- *for terminal access interfaces*, with intermodal trains mixed with passenger traffic,
- *for terminals*, by increasing or spreading out train arrivals and departures for a more intensive utilisation of terminal capacities and less pressure at peak hours.
- But the focus on operating systems does not mean that physical capacity constraints and bottlenecks are ignored; they have been systematically reviewed in all the countries. The elimination of bottlenecks and slot availability become the major concern rather than the construction of new links.

One of the important findings of this capacity analysis is that although congestion points exist and require significant investment, *network capacity reserves* can be created if operating rules are changed and passenger traffic priority is called into question.

This means that the quality of operating systems cannot be analysed without reference to the strategies of the players, operators and the institutions which decide whether priority is to be given to passenger or goods transports.

Two maps can summarise this perception of the European intermodal network.

The first provides a two level picture of Europe, showing national boundaries and physical constraints, with a dense core intermodal system at the centre and connections to peripheral regions where flows are concentrated through hubs.

The second provides a more detailed picture of a European intermodal system of this type showing not only infrastructure investments but also operational developments in the use of existing infrastructure within the core of Europe.

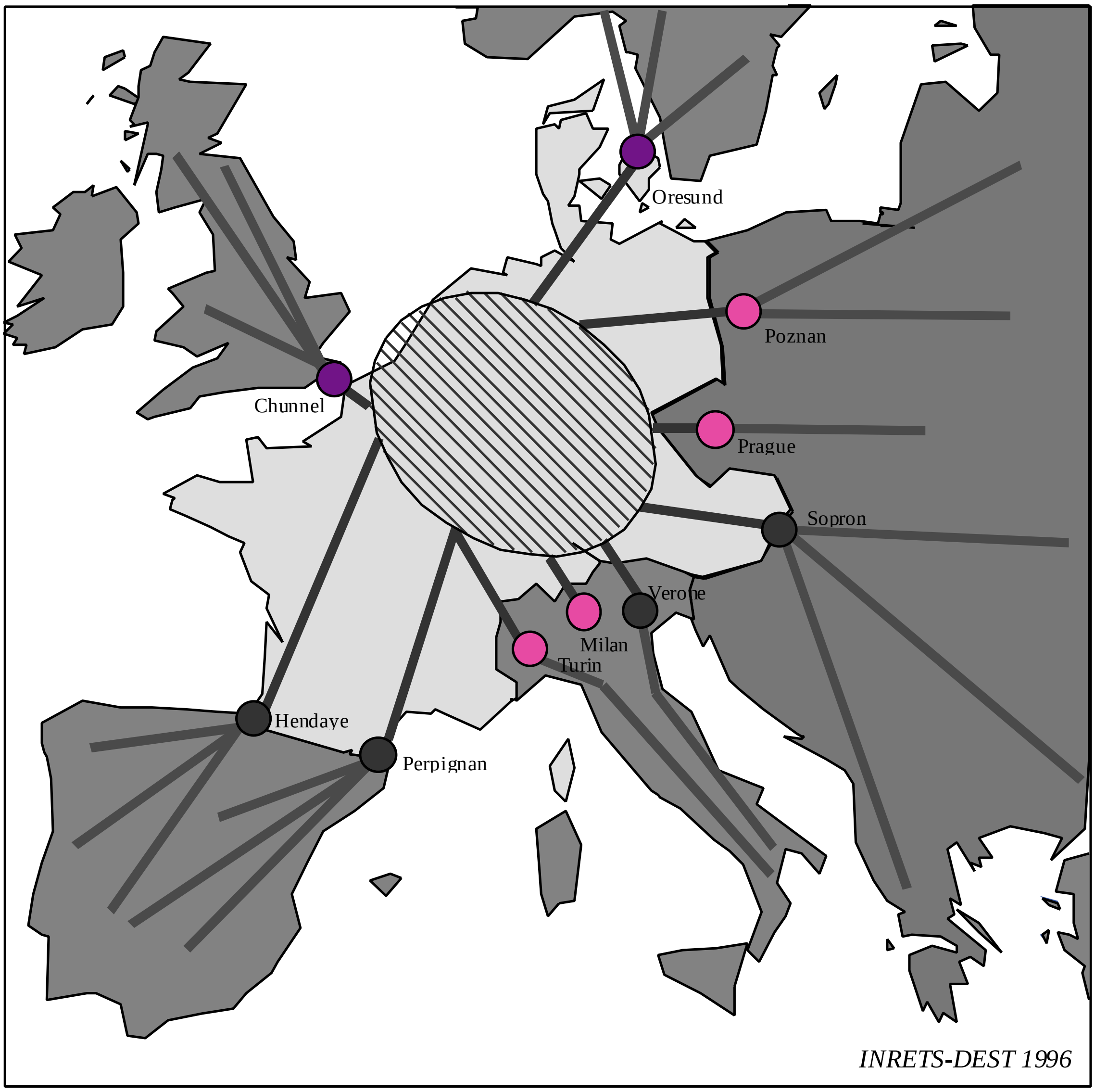
These maps, which refer to infrastructures and their utilisation, probably provide a more useful picture of an intermodal network than would a geographical description of the infrastructures.

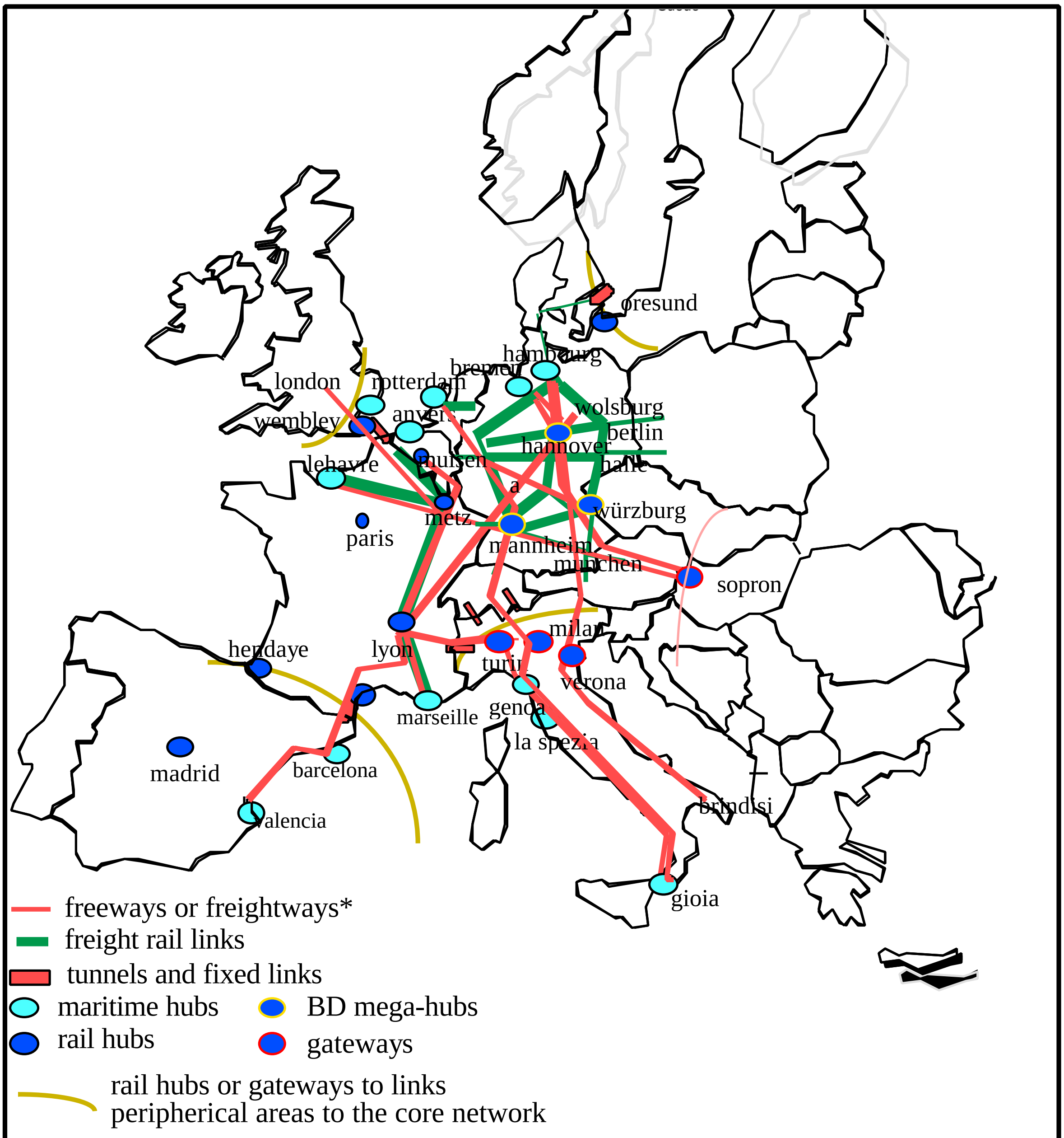
An approach of this type makes it possible to identify the different components of an intermodal network:

- services in intermodal transport corridors with dense traffic and high competition, which cross dense areas and some natural barriers, where problems of slot availability in dense areas are faced;
- services in core networks, joining different links by means of rail hubs in order to consolidate flows and cover a given geographical area;
- gateway feeder services on the periphery of Europe, associated with a corridor or a core network;
- capillary services to improve regional accessibility with the development of different levels of terminals.

This representation shows how the quality of networks is dependent not only upon the strategies of operators but also upon public investment in infrastructure. Intermodal quality analysis requires a consideration of commercial and policy aspects.

A gateway system in Europe to link
peripheral and central EU by intermodal transport





* Freeways and freightways to be set up or still in the design phase.

I.

4. TRANSPORT CHAIN INTEGRATION

The aim of the IQ project is to improve the quality of intermodal transport for the end user. The first two workpackages considered the *Quality of the Terminals* (Chapter 4) and the *Quality of the Networks* (Chapter 5) and indicated areas where improvements could be made to both terminals and networks; these improvements range from infrastructure capacity planning to technological innovations and also involve operating systems and the strategies of players.

The next step is to examine transport chain integration in order to assess overall performance for the end user and focus on the dynamics of the intermodal system:

(i) because our findings with regard to the quality of terminals and networks clearly show the *importance of the interrelationships* between terminals and network quality.

(ii) because the previous work also highlights *fresh possibilities* which require new investigation instruments which can assess the effects of measures on the quality of the intermodal transport system as a whole.

Potential for improvement and innovation exists in different areas, for example capacity (infrastructure, equipment and labour resources), operating systems (terminal or rail operating systems) or the competitive environment of the players (commercial strategies, policies/institutional changes).

This search for *overall integration* was the main objective of WP 3, and emphasised the "*interactions*" within the intermodal transport system. Integration is considered from a spatial, professional, technological, operational and institutional point of view. The ultimate aim is to determine the possible synergies between all the components of the intermodal transport system and to assess their impact on overall intermodal quality.

Integration has several dimensions which have been investigated:

- *Spatial dimension* and the interactions between terminal and network operations for regional accessibility,
- *Professional co-ordination* and the relationships with the (potential) users,
- *Technological dimension* and the problem of its dissemination along the transport chain

In-depth analysis of this integration was conducted which involved:

- use of a system-analysis tool to describe the spread of innovation and the interactions between the components of the intermodal transport system,
- the market and its development which emphasises that intermodal transport has entered a phase of transition.

4.1. Spatial integration: from concentration to cohesion

4.1.1. Spatial distribution and survey findings on external quality

The intermodal network includes all EU Member States. In a basic sense there is Europe-wide accessibility to intermodal networks, but the number of links and the density of flows within and between the countries varies greatly. There is even greater variation if we consider the quality of links, which ranges from high-frequency shuttles to single wagons appended to conventional trains.

There is, in fact, a high degree of concentration on a small number of international intermodal links:

- only 20 cross-border corridors move sufficient volume for a daily shuttle train
- 61 of the 94 European intermodal corridors (i.e. 65%) cannot even justify one intermodal train per week
- the largest 6 corridors carry two-thirds, and the largest 10 corridors carry three-quarters of the total volume of European rail intermodal transport.

This means that train frequencies with high-quality train types (shuttle, block) are definitely too low for two-thirds European intermodal links: there is a clear need for more sophisticated train production models for these low-volume links.

Moreover, there is a concentration of flows in the Alpine region. Intermodal transport is still far from providing a European network:

- trans-Alpine flows, i.e. all flows to and from Italy, Austria and Switzerland account for 80% of all flows on the 94 intermodal corridors in Europe
- the Germany, Austria, Italy corridor (D-I, A-D) alone accounts for 40% of all flows

Not surprisingly, market shares (compared to road) are comparatively low:

- the market share of intermodal rail transport in the EU was 8.2% in 1994, and this figure has hardly changed in recent years;
- the most successful links are between Italy and Scandinavia, where intermodal's market share reaches almost 60%, and between Belgium and Switzerland/Italy, where it is in the region of 50%;
- with a few exceptions, all successful links are to and from the Alpine countries (A,CH,I); moreover, they are all long-distance links of over 1000 km;
- Belgium is the only country with success stories comparable to the Alpine countries; the Belgium-Sweden and Belgium-Spain links are the most outstanding examples - intermodal has a market share of 30% on these.

Even if we only consider the high volume road traffic corridors there are still major "black spots" on the intermodal map of the EU:

- the five largest road corridors in the EU are in the triangle formed by Germany, Benelux and France; here, intermodal rail has very modest market shares of 2% and less, with Germany-Netherlands providing the most striking example with road flows exceeding intermodal rail flows by a factor of more than one hundred (there are, however, considerable inland container shipping flows);

- the only two corridors where intermodal rail is successful in large road corridors are Germany-Italy, and France-Italy;
- however, intermodal rail can be the dominating mode in making remote areas accessible to European core regions (e.g. Scandinavia, northern UK, Spain).

The cohesion between national networks is secured through consolidation terminals or marshalling yards all over Europe. We can identify about 30 consolidation points which handle almost all European cross-border intermodal transport. This list includes: Wien, Salzburg, Brussels, Antwerp, Muizen, Paris, Lyon, Metz Sablon, Lille, Le Havre, Marseilles, Hanover, Cologne, Mannheim, Munich, Frankfurt, Berlin, Hamburg, Turin, Milan, Verona, Rotterdam, Padborg, Stockholm (Arsta), Madrid Abronigal, Barcelona, Valencia, Basel, Willesden and Wembley.

These consolidation points form the backbone of the European network for cross-border intermodal flows. In total, 1821 train connections per week were identified between these terminals (1997). The most important corridors are: Germany-Austria (400 trains per week with both directions together), Germany-Italy (more than 300), and Spain-France (c. 140 trains).

The quality of service in different zones can also be assessed using the results of the 196 standardised interviews which were carried out with customers and potential customers of intermodal transport in all countries of the European Union and Switzerland.

The sample gave information according to types of area: Dense areas, Natural barrier areas, Remote regions and Eastern European countries.

Interestingly, this quantitative analysis shows there is no one respect in which the present transport performance of rail intermodal transport appears inferior to road. Rather it is a combination of factors, time not always being the most important. Flexibility and, to a lesser extent, reliability and control are the main quality factors which discourage customers from using intermodal transport.

Table 4: Percentage of respondents who consider that the performance of intermodal transport is very good

Zones	Time	Reliability	Flexibility	Qualific-ation	Accessibility	Control	Saf/Sec.
Dense areas	33	43	19	47	36	40	58
Natural barriers	26	29	28	52	46	29	45
Remote regions	29	17	14	82	77	25	25
Eastern Europe	20	20	0	0	30	40	55
National France	56	44	19	83	13	38	75
National Germany	33	50	25	75	50	33	67
National Spain	67	67	0	80	33	60	67
National Italy	17	8	25	40	9	9	27

Table 5: Percentage of respondents who consider that the performance of intermodal transport is poor

Zones	Time	Reliability	Flexibility	Qualif.	Accessibility	Control	Saf/Sec.
Dense areas	13	29	31	7	29	40	0
Natural barriers	26	38	50	17	14	23	26
Remote regions	21	8	29	9	15	25	8
Eastern Europe	30	40	64	25	30	30	9
National France	13	19	69	8	38	25	6
National Germany	22	13	25	13	13	22	11
National Italy	58	58	67	0	36	36	36

When asked to make a *performance comparison* between intermodal transport and road, the following deficiencies emerged:

- in dense areas, intermodal is particularly weak as regards transport time,
- in natural barrier areas and remote regions, the problems are related to delays and their frequency,
- in Eastern Europe, the position of intermodal as regards quality is comparatively good, achieving more than 50% support across the board.

Some findings on national intermodal transport are also presented:

- in France, the frequency of delays and poor monitoring seem to be the major obstacles to the use of intermodal transport, whereas intermodal performs quite well as regards time, length of delays and damage,
- in Germany, the situation is similar with the striking exceptions that intermodal performs much better in the fields of delay frequencies and monitoring,
- in Spain, intermodal transport has more problems as regards quality and has poor ratings for transport time and delay,
- in Italy, there are very clear weak points: extremely low performance as regards time, delay, frequency of delay and damage. Other aspects score quite well.

An analysis of the contribution of intermodal transport to European accessibility and cohesion therefore must take "external quality" factors into account .

4.1.2. Case studies and success stories

From the observations of the spatial distribution of flows and the results of the surveys some major cohesion problems have been identified and some case studies selected for further analysis.

Table 6: The case studies

Within	Case studies
Natural Barrier areas	- Trans-Alpine corridor - Channel crossing - Scandinavian link
Dense zones	- German regions servicing: - traffic in Northern Italy - transit through the Netherlands
Remote Regions	- Europe-Spain/Portugal link - servicing of Southern Italy - servicing of Northern Great Britain - servicing of Greece - connections to the Eastern European Countries
Local Distribution	- Seaport of Hamburg - Hamburg-Billwerder - Inland terminal Hanover - Terminals in the Rhine-Ruhr area - Seaport of Antwerp - Terminals in Paris/Ile de France

On the basis of this analysis of case studies, it is possible to divide the regions of Europe into two categories as far as intermodal transport is concerned:

i) *regions generating a high density of traffic*, for which intermodal transport can be very efficient and where it is already helping to open up and relieve congestion in certain areas (Natural Barriers and Dense areas),

ii) regions for which intermodal transport does not play this role and where *organisational restructuring is required* in order to improve its quality of service and ensure its competitiveness. This situation is particularly common in regions which are difficult to serve because of their isolation (e.g. Remote regions).

According to EU and national transport policies, intermodal transport should provide a *Europe-wide transport system* which improves cohesion and accessibility within the Union. The clients of intermodal transport also make the same quality demand: they will only adapt their logistic systems to the intermodal world if it provides adequate access to all major destinations. However, Intermodal Transport is geographically fragmented as a result of spatial factors and companies with national monopolies.

(1) The case studies have demonstrated that the *configuration and size of national territories and bottlenecks* have played a large part in determining the development of intermodal transport.

The scale and structure of national railway networks are important factors, as intermodal transport can only hold its own against lorries once the transport distances become greater. Therefore, from the outset, smaller countries such as the Netherlands found it difficult to establish an efficient CT system, since they could only commence with the provision of international CT services and were thus dependent on the co-operation of neighbouring national railways.

Larger countries, for example France and Germany, were not faced with this difficulty and therefore rapidly developed national networks of CT links, on which the international links were subsequently based.

In addition to country size, the physical and economic geography of the country is also significant. Thus, in Germany a pattern of concentrated north-south transport flows emerged, whereas France witnessed the development of a scattered network of routes. It was only at the beginning of the 1990s that France took active steps to establish a hub & spoke system geared to the requirements of the country's geography.

A third important component is the geographical situation of the Alpine countries with their limited capacity to accommodate through traffic. The limited transport infrastructure available here due to the geography soon prompted the governments of the Alpine countries to adopt a transport policy aimed at achieving an environmentally sustainable concentration of traffic with the help of rail-based CT.

(2) *Until the 1980s, networks were national in focus*. Neighbouring countries are often linked through gateway terminals which collect and distribute flows. This is most apparent in peripheral countries such as Ireland, Greece, UK (Wembley), Spain (interfaces for gauge change) or Italy (Interporti). It is also the case in central European countries such as France and Germany which use hub & spoke systems providing a focal entry hub to the nation's territory. With volumes increasing, however, more and more direct shuttle links have become possible between origin and destination terminals, side-stepping gateways.

Today, the European intermodal network has several layers consisting of:

- direct shuttle corridors between origin and destination terminals,
- direct shuttle corridors between national gateway terminals,
- European hub systems,
- national hub systems,
- conventional train links with appended intermodal wagons.

As regards cohesion and accessibility, three success stories can be highlighted:

(1) France is not a favourable territory for high-volume intermodal links as there are several industrial and population centres in different parts of the country. Also, the size of the country means that flows are dispersed. However, the CNC hub system has provided an adequate response to this challenge. Fast and reliable Day A-B services have become possible through the establishment of an Ile-de-France based marshalling hub through which most CNC trains pass. This system allows regular services even to remote and low-volume terminals in France - thus creating a high level of regional cohesion and accessibility.

(2) In Europe, intermodal transport has its largest market shares (up to 60%) on links between Scandinavia and Italy. There are a number of direct shuttles and block trains routed via gateway terminals which are apparently more competitive than road haulage. They have the advantages of good organisation, high reliability and comparatively fast transit times.

(3) The Channel Tunnel was the key to another intermodal success. With Wembley (near London) as a marshalling hub, a large number of intermodal services between the UK and the Continent have come into being in less than four years. The UK can now be regarded as an integrated subsystem of the European intermodal network.

4.1.3. Major findings for cohesion objectives

Although most European regions have access to an intermodal terminal, European accessibility or cohesion cannot yet be described as adequate. The low number of links, and more specifically, of regular direct links, means that only some regions of Europe have an adequate intermodal transport quality. Moreover, the limited number of high-volume links makes it difficult to build up a basic load for more sophisticated networks such as hub & spoke systems.

The EU has a *"three-class" system* as regards intermodal cohesion and accessibility:

- Metropolitan regions in the EU: core countries plus additional regions in the major industrial corridor (Benelux/Germany/Switzerland/Austria/Northern Italy) have well serviced intermodal rail and high quality inland waterway and short-sea shipping links. Shuttle and block train links prevail. Terminal networks are dense and terminal locations are easily accessible unless they are in city centres.
- Additional regions enjoy the services of good hub and gateway/hub systems, e.g. France, Denmark/Sweden. Terminals are easily accessible, although the terminal network is not dense.
- Most peripheral regions are connected via low-frequency links and gateway terminals, e.g. Greece, Ireland, Spain and Portugal. Rail intermodal quality is in general low and suffers as a result of natural or technical barriers. Distances to terminals can be very high.

The *main challenges* in terms of spatial accessibility and cohesion are the following:

(1) To improve cohesion. Distances of 300-500 km are currently regarded as the minimum for intermodal transport to be competitive. The two major exceptions to this rule are short trans-Alpine links for complete trucks, namely the Rollende Landstrasse and container transport between the seaports of Rotterdam and Antwerp.

The challenge facing European intermodal transport is to compete on medium distances below 500 kms. Here flow volumes are considerably higher than on long-distance links. Smart low-cost shuttle and hub systems should be able to tackle this market segment in the future.

Rolling Highways for short links can only be regarded as a transitional system. These stand-alone links are not suited to integration within larger intermodal systems and doubt can be cast on their environmental soundness.

As regards peripheral areas, it is again hub and/or trimodal services (ship, rail, road) that provide opportunities in some cases, e.g. on the Greece-Italy corridor. However, there is no general solution in sight which would allow intermodal systems to generate a considerable improvement in European cohesion.

(2) To improve capacity. The are idea of separating passenger rail networks and creating dedicated rail freight networks exists. In European core countries and in metropolitan areas in general, there are severe problems involved in harmonising the different quality requirements of passenger and freight rail with respect to train speed, acceleration and braking performance, distances between stops, train weights and lengths.

The present network was established to serve the needs of both types of transport. However, increasing demands in the passenger sector (such as phased timetables, early morning - late night trains, higher speeds and acceleration rates) poses problems for this concept. Another factor is the recent introduction of a railpath (slot) price system. The large regional passenger rail network providers, owned by local or regional authorities, as well as the profitable long-distance passenger trains will be able to buy the most attractive slots at wholesale prices and maintain phased timetables, which would block most (slow) freight trains. Rail freights options would be restricted to marginal and less attractive timetables.

The creation of a freight rail network which avoids passenger trunk lines could greatly improve this situation. Projects like the German NETZ 21 project - currently being implemented - and EUFRANET (an EU financed research project) are examples of this approach.

NETZ 21 involves three stages: the first is to gradually cease to operate slow and fast trains on the same track; the second is to systematically increase use of the large number of second-level links which run parallel to existing trunk lines in order to increase capacity for fast passenger trains; the third stage is to create a dedicated Cargo Rail Network, mainly consisting of second-level (i.e. non-trunk) lines, which would allow freight-specific operational features and on which freight trains would be given priority. At present, DB's total traffic on its 40,000 km rail network amounts to 850 million train-kilometres. Studies indicate that this capacity could be increased to 2 billion train-km by 2020. This separation is also expected to considerably reduce costs. On the Fulda-Göttingen line, for instance, the number of switches (currently 163) could be reduced by 63% and the number of overtaking railway sections (currently 33) could be reduced by 90%. These measures would reduce overall infrastructure costs by 40%. Also, new construction would become easier and less costly. NETZ 21 will be introduced in stages starting in 1998 on three corridors: Hannover-Würzburg, Hamburg-Rhein/Neckar, Ruhr area - Berlin.

(3) To improve terminals. Several Member States have formulated transport policies (for example, target figures for modal shifts) and drawn up infrastructure plans on the basis of an analysis or a description of their terminal networks - irrespective of whether terminals have been developed by national, regional/local or private sector bodies. The rationale for these national level initiatives is to co-ordinate the various projects in order to allocate public and private sector investment more efficiently. EU plans consider that the creation and co-ordination of these national initiatives at European level can contribute to the successful development of the trans-European combined transport network.

4.2. Professional integration: the DIQIT interactive tool

The aim of this task was defined as: "*to support the (potential) users of intermodal transport in making a decision for or against a specific mode of transport*". This support goes beyond the obvious simple decision factors such as "cheaper, faster, better": it rather encourages the user to make a decision in spite of or in harmony with the intrinsic disadvantages of intermodal transport.

This support is given by a software tool, named DIQIT. This tool also benefits transport providers and terminal operators by providing data about users' requirements and decision mechanisms.

In this task, professional integration is thus to be understood as:

- ways of getting transport players involved in, interested in and informed about intermodal transport,
- making use of their knowledge and requirements.

There are therefore two purposes: the first is to *inform* (potential) users and get them involved, and the second is to *understand* the users' requirements and build on their knowledge.

The IQ project and the service providers share similar interests as regards knowledge acquisition, as both wish to support and improve this type of transport.

The work was undertaken in three phases:

- the theoretical foundation, the aim of which was to select the best approach for achieving the aims,
- the fact-finding phase,
- design, implementation and testing of the tool.

4.2.1. A theoretical foundation: the sensitivity approach

One of the early findings of the IQ project was that the answers to questions asked in conventional interviews are often one-dimensional and provide little new information. A conventional interview is designed to gather *information items* one by one. It is not possible to get a good picture of intermodal transport requirements by asking the usual type of questions, for example about whether the price, reliability and frequency etc. are satisfactory. If one compares intermodal and road transport on a step-by step basis with reference to important but separate elements, intermodal transport is bound to emerge as inferior.

A *sensitivity approach* is more promising: the influence of variables on each other is considered so that the picture of intermodal transport is one of a living structure rather than a list of parameters. Essentially, this involves changing the questions from the form "Is factor X satisfactory?" to the from "How would the acceptability of factor Y be affected if factor X improved?". This provides a means of moving away from "killer arguments" such as "too slow, too expensive and too unreliable" to an assessment of the *overall performance of the transport system*.

It is important to understand that this is not just a rephrasing exercise to make unpopular items look better. The core of this approach is the introduction of inter-connected aspects and flexibility.

This approach attempts to move away from all too familiar simplistic judgements, but also allows us to modify the different variables to find out the conditions under which intermodal transport could become more attractive.

One of the important findings from the field work is that all frequent users of intermodal transport have recognised it as being inherently more complex and more complicated and have gone through a more or less painful learning process. In the end, though, only commercial success counts. For the experienced users intermodal transport has proved itself to be competitive or superior.

Whilst such users find intermodal transport viable, others (i.e. non- or ex-users) find it unacceptable. It would be arrogant to assume that the latter group is simply ignorant of the merits of intermodal transport - we have to accept that there are no simple answers.

When asked outright, the majority of potential users demand an unrealistically superior and fast service at extremely low prices. All the negative aspects of intermodal transport, for example the impact of the rigidity imposed by timetables, tend to be exaggerated. The question has to be asked in a more subtle manner: *Under what conditions could intermodal transport become interesting, how could either the services provided or the perception of these services be improved?*

What is more, the interested party has to accept some of the insurmountable disadvantages of intermodal transport by either adapting to them or by implementing work-arounds. In short, users have to be flexible to cope with the inflexibility of intermodal transport.

4.2.2. The fact-finding phase: workshops and interviews

The DIQIT tool was developed on the basis of the results from the field survey of (potential) intermodal transport customers and also by the *important results the IQ project gathered in task 3.5*.

In addition, much of the background knowledge used to design the DIQIT tool was gathered at *two workshops*, one in Hamburg and one in Milan. These workshops were specifically designed to test the appropriateness of the sensitivity approach and the validity of other assumptions. After the workshops a number of transport users were interviewed individually. These interviews built on the outcome of the workshop and provided the opportunity to acquire more individualised and specific information.

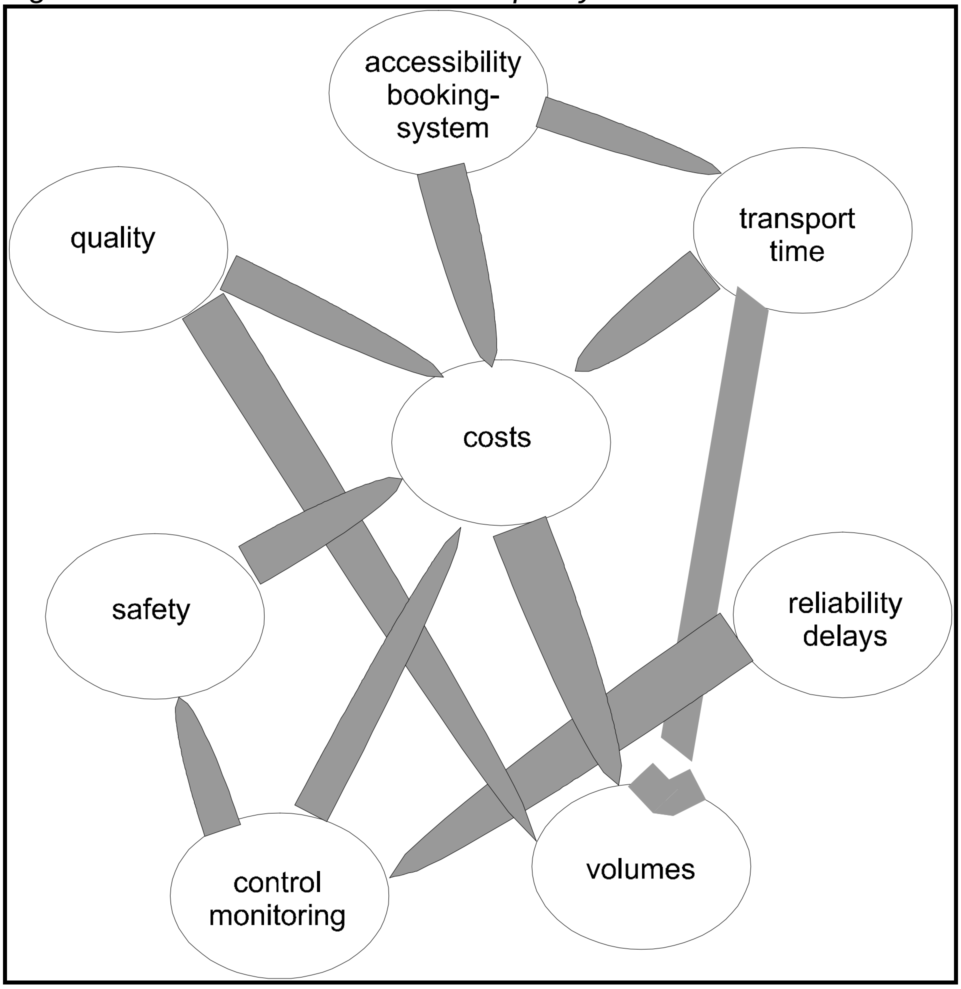
Following the approach described by Frederik Vester (for example in his book “Ausfahrt Zukunft”) we then attempted to establish the areas in which sensitivity is strong enough to be to be included in the DIQIT tool. In line with Vester we wanted to identify the following types of variables: Active, Reactive, Critical or Buffer variables, and find out if any of the relationships is strong enough to base the decision-making support system on it.

TIME ASPECT (example factor)
If terminals and rail transport were much faster, to what extent (on a scale of 1 to 4) would you expect the following effects? • higher costs, • cost savings, • increased intermodal transport volume, • increased intermodal transport frequency, • lower reliability, • change in production flexibility.

The workshop questionnaire used a scale of 1 to 4 (no impact to strong influence*)*. Only a few significantly strong influences were identified, most of them relating to cost factors. More “subtle” factors such as quality aspects rarely ever scored more than 2.

The cost complex appears to be the most influential, both in its affects on other variables and the way other variables affect it. The figure below shows the most important factors (the minor factors are not shown).

Figure 10: The interrelations of the quality indicators / factors



As the figure shows, *improvements in any or all the factors have cost implications*, for example higher reliability will reduce costs for the customer and lower transport costs will lead to larger transport volumes. Note that by "lower transport costs" the interviewees always meant "lower tariffs" - indirect reductions (for example "Better reliability will reduce my internal costs") were always considered to be less influential.

There are some very interesting *cause and reaction links*, such as that better control mechanisms may reduce the impact of delays, which in turn may increase transport volumes. However, the dominant patterns were all related to prices and the resulting pictures of affinities, relations and effects were too straightforward for our conception of the DIQIT tool.

The findings of both the interviews and the workshops with regard to topics other than price implications did, however, reinforce one core idea of the DIQIT tool: it should be *of use in the decision-making process by guiding the user beyond simple cause-reaction patterns and offering useful interactive decision-making support.*

Requirements for better information and easier access with regard to both the organisation of transport and its surveillance were voiced throughout. We also found a small, but significant, opening in the generally rigid pattern of a strong, but not exclusive, focus on prices: if intermodal transport were much more convenient users might consider being more flexible in their decisions. This relates primarily to the planning and organisation of transport services. This flexibility is considered to be of key importance for the development of DIQIT.

Overall, evaluation of the workshops and the interviews provided the following input for the design of the tool:

- a full-blown *sensitivity approach did not appear feasible* for the IQ tool (either because participants were too static in their thinking or because we had insufficient time and resources to unearth good sensitivity values). There was evidence of the fundamental value of the approach and a number of constructive conclusions were drawn (see below),
- important *parameters and values* were identified. This helped us to establish solid foundations for the tool on an absolute rather than a relative basis,
- the *all important role of costs* was re-affirmed, in particular direct transport costs. IQ type quality indicators that reduce or increase the costs of transport indirectly also had a significant influence,
- even regular intermodal transport customers find that the *information aspects* (timetables, features, alternatives) are not easy to understand. Irregular and potential customers therefore have much higher demands for information that are not at present met. Sometimes there almost seemed to be secrecy about simple facts that customers need to know. A tool can try to incorporate as much information as possible and, in particular, can deal with unfamiliar factors such as rail gauges,
- while road transport seems to offer complete flexibility, rail transport is very restrictive because of its timetable type of operation. We concluded that complete information covering the *entire transport chain* would be very useful. The tool can thereby also help overcome harmful fragmentation by providing information covering the entire transport chain,
- even amongst the greatest proponents of intermodal transport an "*everything is bad*" mentality seems to prevail. Alas, this is something a tool cannot change, and the conclusion reached was to adopt a neutral rather than a missionary stance,
- the addition of a "*trend assessment*" section of the tool responds to the bad image of intermodal transport and tries to re-assure tool users that they are in line with general trends such as environmental concerns. This decision was supported by the interview finding that in principle intermodal transport is perceived as a good idea.

In conclusion, the interviews and workshops expressed support for our basic approach. The data collected was not sufficient for full sensitivity-based software, but enough data was collected to confirm the relevance of quality factors which have been considered when designing the tool. Timetable information with information covering the entire transport chain was considered essential. Finally the negative attitude towards intermodal services led to the decision never to display performance values but always to put the demand side before the supply side.

4.2.3. The design, implementation and testing of the DIQIT tool

The DIQIT tool takes into account the important findings of the preparatory phase in the following way:
Transport users are willing to explore the possibilities of intermodal transport. While they have little knowledge about its intricacies, they would like to improve their knowledge. Intermodal transport is considered to be difficult: it adds more parties to the process and makes price and time calculations more complicated.
⇓
DIQIT can help to improve awareness of the entire transport chain by considering many relevant elements.

The investigations proved one of our important assumptions, that on the basis of an item by item comparison, intermodal transport is often considered inferior.
⇓
The tool does not engage in any consideration of whether intermodal transport is better or worse but provides a total picture.

Transport time is an important issue. Users often complain about inflexibility due to terminal opening times, the effects of timetables, etc. Nevertheless, the workshops identified a limited ability to adjust the internal timing of departure and delivery.
⇓
The tool encourages users to change their own timing constraints in order to overcome the intrinsic inflexibility of intermodal transport.

Many negative opinions about intermodal transport were reported in the IQ network study and again in the workshops. In some cases these are based on personal experience, but in others merely on assumptions.
⇓
The tool provides operator data on crucial transport factors such as reliability, punctuality, etc. However, such data is never given in plain figures, information is only given on how it compares with the stated requirements of DIQIT tool users.

With DIQIT, users are encouraged to think seriously about their requirements and also provide the suppliers of intermodal transport with realistic and useful input. The principle of covert information is used throughout, for example a user is never given a reliability figure but is asked to state his or her own requirements; the tool then responds with “requirement met” or “not met”.

The tool aims to receive input from the user and:

- convert it to useful information regarding travel time etc.,
- inform about the suitability of the cargo and similar aspects,
- reflect the users’ assessment of intermodal transport,
- provide data for the service providers.

After a guided interaction, DIQIT shows the (potential) customers of intermodal transport how their requirements fit into the supply side. A screen and a two page printout provide all the data. The tool also allows potential transport buyers to change their requirements and test if they have the flexibility to better match the existing supply side.

The tool is currently limited to the two way Hamburg-Milan link. This is not only because it is known to be a competitive and highly trafficked route, but also because resources for development of the DIQIT tool were limited.

The DIQIT tool is in principle free-standing, but it works best with expert advice. The user is guided through a set of questions and is then presented with preliminary results resulting from his choices and requirements.

IF a user obtains a number of “no go” results, he can go back to the original questions and re-iterate the choices, e.g. by considering and adjusting reliability demands or rethinking delivery times. Eventually he will be given a fair assessment of his choices and requirements with reference to the existing services available on actual transport links.

The DIQIT tool also informs intermodal service providers about the quality requirements of the users of the tool and their concrete transport volumes and demands.

Such data may also be obtained by conventional questionnaires or interviews, but, as has been mentioned above, the interviewees will often demand the impossible. Because the tool offers the possibility of re-iterating choices, it can be used to assess the flexibility of those using it and reveal any concrete facts that suggest improvements to quality of flexibility from the operators’ side. This analysis function is currently limited to a log from which the users’ path can be tracked and data retrieved.

The DIQIT tool is considered to be a valuable first step that follows an alternative mind-set and opens up possibilities for further work:

- deepening, through more and more elaborate interaction,
- widening, through the implementation of more transport routes and services,
- specialisation, through integration.

The DIQIT tool can also be seen as a step towards one-stop information. In the future, the present-day DIQIT tool could be developed to make it much easier to access to various types of information from different service providers.

4.3. Integration of new technologies : steps for implementation

IQ has shown that whilst technological innovations may increase the quality and accessibility of a particular function, technological improvements alone are rarely the solution to a whole problem. As well as improving the quality and accessibility of a function, a technological development also has to improve the ability of the functions within a particular operating system to work together.

The main aim was therefore to propose an implementation method that will create the required *synergies between technological innovations and specific operating systems* allowing the innovations to be competitive in practice. Moreover, the link must be made between technical progress in terminals and technical progress within networks.

Following the discussion of different technologies and operating systems in previous IQ project tasks, the goal is now identify a number of synergies which may arise as a result of realistic technological improvements in a terminal and on the network, and to judge their overall effect on intermodal quality and accessibility.

This involves determining the *inter-linkages* between the most important *technological developments* in the field of information and communication systems, transhipment devices, rolling stock and loading units *and the relevant intermodal operating systems,* both for terminals and networks.

In the light of previous IQ project findings, it is necessary to fulfil a number of fundamental requirements:

- ensure the *interoperability* of the innovations;
- ensure the *modularity* of the system so as to avoid technological bottlenecks and to allow future modifications;
- target *long-life standards* to facilitate the adaptation of ways of working;
- include *the facilitation of maintenance* in the design phase as this has a dramatic impact on delays and costs (a “Life Cycle Cost” approach has to be envisaged).

4.3.1. Methodology for integration

A brief presentation of the “practical” methodology for developing synergy is shown below: sets of technological developments and the adaptation of procedures are considered jointly for specified quality improvement goals.

Rail transport production and quality of the networks

Technological development n°1 + Technological development n°2 +……+ Technological development n°XX + Adaptation of procedures = Effects on quality and accessibility

Functional example 1 :

Wagons tracking (GPS technology) + Container identification (e.g. electromagnetic tags) + EDI Client/Railways + Improved procedures concerning :

- use of location data
- identification standardisation
- selection, hierarchy, filtering of data

=

- Time reduction
- Service for client
- higher flexibility

Functional example 2 :

Anti-sway system on portal crane + Container positioning (Encoded positions) + AGV and central software + New procedures concerning transhipment :

- automatic transhipment on the land side
- manual handling on the ship

= Handling phase optimisation :

- Time reduction
- increased safety
- Working conditions improvement

Functional example 3 :

Shuttle train system + Train positioning systems + Automatic positioning of handling devices + New procedures concerning the handling phase = Semi-automatic rail/rail transhipment :

- Simplification of terminal operations
- Increased reliability and security
- Higher flow capacity
- Short term operating cost reductions

Functional example 4 :

High performance freight vessels (high speeds) + Fast transhipment systems + Central management software (monitoring ships allocation and client demands) + Ports procedures adaptation =

- Higher flexibility
- Quality of service
- Higher frequency
- Time reduction

The integration of a new system involves two main phases which can be described as follows :

a) a first phase during which the decision to integrate has to be taken
b) a second phase during which a transition period has to be managed (this transition period is often followed by minor adjustments)

Each of these steps will encounter different obstacles and problems.

a) The "decision phase"

Before the integration phase, a crucial issue is the decision to "replace" or adapt an old system and implement a new system or a new technology. This decision is by no means easy, and obstacles of various types will have to be overcome, in particular as regards the drafting of the specification: problems of budget, incompatible requirements from the demand side, technological and organisational features implying unusual design and specification features, etc...

Then, once the specification has been written and the technical decision has been taken, it must be accepted by the professional segment affected by it. Indeed, the integration of technological developments is often accompanied by cultural adaptations in the segment: in practice, this is actually the main obstacle associated with a decision to make changes (if asked to choose, workers will tend to say "no" rather than "yes"). Moreover, it is clear that if the acceptability of the technology in question is an important factor as regards the integration decision, it is too in the case of integration itself, as the desired technological improvement obviously has to be accepted by workers to be integrated under the most favourable conditions. It is also clear that, in most cases, the acceptance or rejection of a technological improvement does not depend on technical factors but on social and environmental considerations.

In addition to this sociological obstacle, various other factors can influence the decision maker (e.g. the influence of fluctuations in freight flows, human factors and professional organisation) which will also have to be carefully analysed and managed. Moreover, the fact that the time needed for the transition period is often not known accurately beforehand is another serious obstacle with regard to the integration decision.

In summary, "non-technological" obstacles exist and must be evaluated and analysed in order to be effectively managed. However, even if the management of "non-technological" obstacles is clearly one of the most difficult tasks facing integration, there are also technical impediments in addition to these "social" obstacles which will limit and constrain integration. But, once all the blocking points have been overcome and the integration decision has been taken, the transition period emerges as the most critical part of the integration phase : moreover, its management is so crucial that a well-conducted transition period will often ensure successful integration.

b) The "transition phase"

In practical terms, the transition period involves managing the coexistence of two systems:

- *at a "physical" level* : every new technology presents a set of constraints which must be managed in a way that ensures the smooth running of the system. In addition, it possesses

new operational features which will have to be integrated with operation of the previous system.
- *at an "organisational" level* : that coexistence of two systems will often mean that it is necessary to "mix" two types of organisations and procedures so as obtain a mixed operating system which can then easily be turned into a better "single" system in the near future.

It I also clear that for each of these levels, various obstacles will be encountered during the transition period as a result of various types of factors:

- *"Technological" factors* (e.g. interoperability of systems, their ability to be interconnected, their reliability, the degree of "back compatibility" (possibility of a return to the previous system))
- *"Social" factors* (e.g. the qualification and training of operators, a decline in safety or security, acceptability)
- *"External" factors* (e.g. the clients' ability to modify rapidly the way the use the intermodal chain, a decline in transport safety or security, a decline in the overall quality of service or the flexibility of the existing operating systems, a deterioration with regards to environmental impacts, policy and strategy, the problem of confidentiality of certain types of information (i.e. "Business interests"), a mismatch between the capital and operating costs of the innovation and the actual budget).

These limitations and constraints have to be managed to ensure the transition phase is negotiated without too many problems. Some of these obstacles can be avoided in the following manner:

it is essential to achieve interoperability and interconnection between the innovative and the existing technologies;

an important factor, which is directly linked to the time needed to implement the new system, i.e. to the duration of the transition period, is the nature of the technology to be integrated, in particular as regards the equipment required for the modification.

It is clear that this factor is very important and will have to be carefully managed to ensure that a system is effectively integrated: great care has to be taken when developing the implementation plan, which implies a rigorous integration methodology:

⇒ The new technology must be implemented gradually and a management plan is obviously necessary;

⇒ Modular steps are also necessary to allow the operator to adapt the system to the most recent technological developments and ensure that the chosen technology will not be overtaken by future systems. This implies long-life "standards" and means the systems must allow "come-backs" or modifications. This is particularly true when integration is international in nature.

4.3.2. *Implementation plan*

The implementation plan is a necessary complement to the proposed methodology. The plan for integrating a new technology not only depends on the type of technology but also on the current situation of the receiving terminal or network. Taking into account these two aspects, the adopted methodology for integration highlights the fact that quality can be improved;

- on existing terminals or networks where the potential for increased flows is small:

By implementing technologies that are easy to integrate and with a low investment cost (or with rapid returns). Examples are information and communication systems (EDI, terminal management software, identification at interfaces,...) and technological components. This type of "conventional change" is achieved by optimising the existing procedures before the technological innovation is implemented, so as to optimise the chain as regards performance criteria which have a direct impact on the overall quality of the chain.

- on existing terminals or networks where the potential for increased flows is large

By integrating technologies which are either more difficult to implement or with a high investment cost, but which do not involve a fundamental change in the operating system: the resulting scheme will be an "extension" of the previous configuration and does not entail a conceptual change. Changes affect handling devices and means of transport.

- on terminals/networks that are to be created (new distribution scheme, geographical displacement) :

By integrating a totally new concept allowing a technological and organisational "leap". This involves a radical change in procedures and a change in mentalities and behaviours, and is a "conceptual change": in the case of integrated systems, the created terminal or network is often completely dedicated to the new context (market segment, environment, logistics,...); in the case of technological components some functions are completely changed or eliminated (but this more minor conceptual change will also require a change in behaviours).

The following table presents the time-frame for integrating new technologies (for short, we have used the abbreviation "ET"/"NT" for existing/new terminal and "EO"/"NO" for existing/new operating system (including network)) :

		Structures				
		ET + EO	ET + NO	NT + EO	NT + NO	General time frame
T E C	Information and communication :					
	EDI system :	short term	short term	short term	short term	short term
	Identification and location systems :	medium term	short term	medium term	short term	short term
H N O L	Transhipment :					
	Technological components :	short term	short term	short term	short term	short term
	Handling devices :	medium term	medium term	short term	short term	medium term
	Integrated concept :	medium term	medium term	short term	short term	long term
O G I E	Rolling stock :					
	Technological components :	short term	short term	short term	short term	short term
	Vehicles for transport :	medium term	short term	medium term	short term	medium term
	Integrated systems for transport :	medium term	short term	medium term	short term	long term
S	ITU :	medium term	medium term	medium term	medium term	medium term

A number of case studies have been undertaken to test the methodology:

a) Rail/road or rail/rail terminal dedicated to shuttle traffic
b) Dedicated freight network
c) High speed vessels and Sea/river shipping - the KARVOR concept
d) Hub & Spoke systems.

These all involve technological changes, of different types (in terms of, for example, costs, level of performance, consequences on jobs, etc.). Together with changes in the operating system, these have an obvious effect on intermodal quality and accessibility.

A case study of the steps involved in implementation

“Rail/road or rail/rail terminal dedicated to shuttle traffic”
Transition 0 →1 Transition from the liner or block train scheme (and associated conventional operations) to step 1, shuttle trains. Transition 1 →2 Transition from conventional operation involving the formation of different trains to step 2, Multiple-unit wagon set always consisting of the same wagons. Transition 2 →3 Transition from conventional operation consisting of poorly controlled stopping of the train to step 3, Accurate positioning of the train at the terminal (positioning is no longer dependent on locomotive driver action and is reproducible whereas conventionally, the train stops in random positions on the track (inaccurate and varying positioning). Transition 3 →4 Transition from conventional identification which currently involves reading the numbers printed on the wagon to step 4, an integrated electronic wagon identification system. Transition 4→5 Transition from the conventional configuration of shuttles with different wagons to step 5, Shuttles with identical wagons (same length, same height, same tare). Transition 5→6 Transition from Shuttles with identical wagons to step 6, Shuttles with identical wagons. Transition 6→7 Transition from Shuttles with identical wagons and common boogies to step 7, Shuttles with identical “intelligent” wagons

4.3.3. Conclusions and recommendations

The methodology and associated "scenarios" that have been developed in this document aim to demonstrate that, with regard to intermodal quality and accessibility, synergies can be obtained between various technological developments and operating systems, but only if all the integration steps have been carefully identified and managed. However, their implementation is clearly dependent not only on "organisational" choices and modifications but also on political decisions. It is indeed obvious that technological improvements will not solve all the problems and these synergies will only occur if an impetus is provided and if choices are made and implemented. Major obstacles of a technical, organisational and social nature must be overcome.

These obstacles involve each player in the intermodal transport chain, and the following directions for innovation can be highlighted:

- for the rail segment: at a *technological* level, better communication between partners (EDI and INTERNET use), automatic identification systems, the "Intelligent" wagons concept and decreased axle loads.

At an *organisational* level, management has to be "reoriented" to cope with the demands of intermodal transport and the requirements of users. This point is often linked with the development of freight corridors. But, above all, better management of the existing equipment is necessary and constitutes the first step towards achieving significant improvements in intermodal quality.

- In the same way, the standardisation of wagon types would result in a decisive improvement in intermodal quality. This harmonisation of vehicles has to be considered jointly with the harmonisation process for loading units. Moreover, harmonisation must be considered with regard to standards (problem of border crossings, weight, gauges, etc.) to provide greater technical interoperability. At the very least, special care has to be taken to break down administrative barriers between rail operators and other intermodal players and to manage the interfaces between players as well as possible.

- With regard to the terminal operator segment: terminals act as nodal points within the intermodal chain. Their role is therefore crucial and an improvement in terminal quality will have a direct impact on the quality of the entire intermodal chain. In particular, to promote the exchange of flows, an effort must be made at the interface with the rail and the maritime segment so as to meet the requirements of railway operators and shippers and vice-versa. This could be achieved through better communication, not only with regard to technological features (i.e. the implementation of EDI, management software,...), but also organisational features (behaviours, ...). At the very least, particular care has to be taken to optimise the movement of equipment in the terminal, and the design of future infrastructure must be compatible with projected flows.
- With regard to the social aspect, depending on the country, some behaviours and mentalities will have to change, in particular as regards the acceptance of a new technology, but also to ensure improved reliability (by avoiding strikes in ports, for example). Moreover, management must become more realistic as regards the number of employees.

To conclude, a major point is the joining together of the players in the intermodal chain, in order to assist decisions for technological integration. A new policy and a new type of management has to be developed which will be led by synergy between intermodal players and between interfaced operating systems. Only by overcoming these obstacles will it be possible to improve intermodal quality and accessibility, and thereby ultimately increase intermodal transport flows.

4.4. A five layer framework system analysis

In this IQ task, a system analysis of intermodal transport was undertaken using a 5-layer framework. This approach allowed the key questions and the main findings of IQ concerning improvements to transport operating systems to be integrated within a system dynamic.

4.4.1. The combined transport operating system (CTOS): the core with large potential for improvement

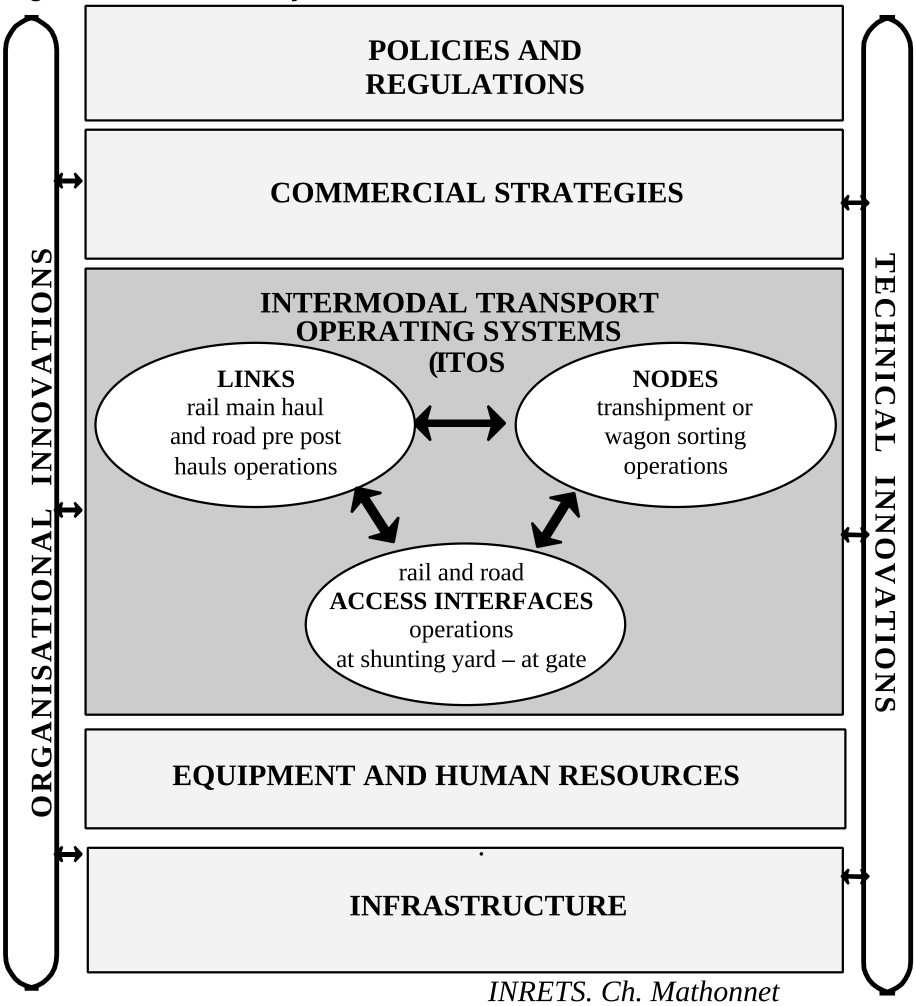
In the approach we have adopted the Intermodal Transport Operating System (ITOS) is defined as a combination of "single operations". Briefly, these "single operations" are : trunk haul services, transhipment services and pre- and end-haul services.

The intermodal transport operator implements the combination of single operations that best meets the requirements of its market segments. An example is CEMAT's ITOS which is based on shuttle trains, gateway transhipment with no pre- and end-haul, another is CNC's ITOS based on block trains, rail hub wagon sorting, transhipment and road haulage service.

By doing this we stress the fact that organisational innovations in ITOS have at least as much - or even more - impact on combined transport quality and economic performance as innovations in other areas, for example physical infrastructure. This can be illustrated by the example of CEMAT's hub in southern Italy, which reduced transit times by 24 hours. It would be difficult and/or costly to achieve a similar improvement with investment in infrastructure or new equipment technologies.

In this document the ITOS is considered as a "technique" which is subject to innovations. To emphasise the stakes of innovation in an ITOS we have referred to the organisational innovations introduced in the intermodal transport operating systems as "operational innovation". Since this document is mainly concerned with rail-road intermodal transport, which is known as combined transport, we shall refer to CTDS (Combined Transport) rather than ITDS (Intermodal Transport) although the same approach could be extended to cover a wider market.

Figure 11: the five layer framework



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1.1.1.1

At the present time, the focus is mainly on the performance and quality of intermodal "shuttle services". Analysis of best practices has shown that the implementation of gateways or hub & spoke systems is also an important innovation in combined transport operations.

This has been explained in the previous chapter and can be clearly illustrated within the 5 layer framework as shown in the figure below.

A new flexibility in the innovation process for intermodal transport...	**...which enlarges the concept of interoperability**
POLICIES Freeways initiative : on voluntary basis, introduce rail liberalisation via the main European corridors	European harmonisation or the rail liberalisation process (Free- or Freightways?)
COMMERCIAL STRATEGIES one OSS per freeway the example of the European road parcel networks : commercial partnerships between independant companies supported by a contractualisation of the services and quality requirements, use of integrated information systems...	the pricing system within one OSS the harmonisation between OSS formalisation and contractualisation of the service and quality requirements
INTERMODAL TRANSPORT OPERATING SYSTEMS Connection between different rail operating systems : e.g. train coupling/sharing for longer trains on main corridors a back-bone of shuttle intermodal services on main european corridors, connected with national or regional CTOS	the compatibility and coordination in the rail operations the compatibility and coordination in hierarchised intermodal operating systems
EQUIPMENT AND HUMAN RESOURCES Railways investing in locomotives adapted to freight CT operators dedicating wagons to a shuttle, to an axis	technical interoperability of the rolling stock of the fleet/tracing/maintenance information systems
INFRASTRUCTURE From prioritised to dedicated freight network concepts	timetable coordination also for access to the regional, local or urban rail networks

From this presentation it can be seen that the implementation of "operational" innovations can initiate a dynamic processes and enlarge the intermodal market.

More precisely, this means,

an increase in the volume of intermodal traffic for long distance shipment, with the final objective of reaching the volume thresholds that make it possible to provide a highly efficient combined transport service, i.e. a shuttle service between points A and B. We refer here to the ability of the operators to run direct block and shuttle trains from their Gateway or Hub & Spoke CTOS.

- a decrease in the distance for which the intermodal transport system becomes competitive with the road transport sector: here again, with conventional technologies the most efficient dynamic process for decreasing this distance depends on the bundling of flows.
This relies on an increase in transport volume and the associated ability to reduce unit cost and hence distance thresholds by means of further economies of scale at the CTOS level.
In addition, the process related to distance is all the more dynamic in that the potential volume of combined transport increases as distance is reduced.

Furthermore, we can highlight that:

- within a hierarchical European intermodal network, the economic performance of the "back bone" intermodal services means that the intermodal transport system can become accessible even with less efficient subsequent national or regional services (even, in the

Italian case, to become accessible to international intermodal transport operations with one long-distance South-North road haul).

This hierarchisation provides a new type of complementarity between combined transport and long haul road transport. A new market for the intermodal transport system that can also be considered as for its commercial dynamic for further use of national or regional combined transport services to or from the Gateway, by final customers already equipped to enter the backbone intermodal network

- the connection between the CTOS allows the combined transport system to benefit from the synergies between flows involving different distances (synergies between long distance shipment and medium distance shipment) or from different intermodal transport solutions (for instance the synergies between Rhine inland waterways and Trans-Alpine continental flows)

"Operational" innovations in the CTOS thus increase the accessible market for intermodal transport with reference to volume and distance criteria, and the spreading mechanism is shown very clearly by the "layer model".

4.4.2. The interaction and spreading of innovations in the intermodal system

The interaction and spreading of innovations can be analysed with reference to the different layers.

4.4.2.1. The Infrastructure layer

For the infrastructure layer, a key issue is the priority given to passenger traffic, in view of the fact that organisational innovation in management and slot allocation is sometimes an alternative to physical infrastructure investment. These interrelations with the Infrastructure layer have an impact on quality of service (part of the Operating System layer) or on the additional cost of rolling stock (Equipment layer).

This issue is also relevant for the Policy layer since, an important objective at European level is to increase and secure the number of attractive slots for intermodal transport.

Other IQ project results, concerning nodes, can be presented when discussing this layer. These involve marshalling yards and terminals, again within the context of a European objective of increasing terminal capacity. Alternatives between infrastructure investments and innovation at the Operating System layer, or even innovation at the Commercial Strategy layer, appear clearly within such a framework.

4.4.2.2.The Equipment layer

For the Equipment layer, the system analysis shows how innovation in infrastructure management must be closely linked to innovation in rolling stock management (also the Equipment layer).

Yet, as regards interactions with the Operating system layer, it is clear that for rolling stock there is great potential for more efficient management as opposed to technological innovation. This also involves innovations in the Operating System layer concerning the improved flexibility in the innovation process itself. For equipment, there may be an improvement in the flexibility of the intermodal transport system to accommodate technological and organisational innovations.

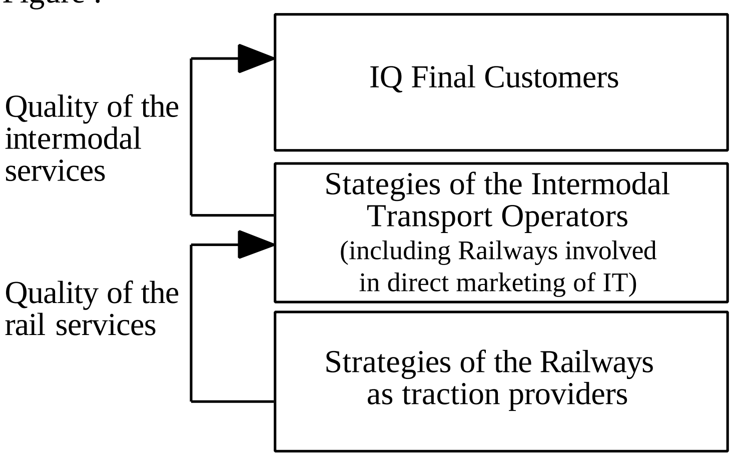
For terminals, it is clear that the position of the terminal in the network will determine the design and performance criteria for its infrastructure and equipment. For the Equipment layer the main question is therefore: *once a node has been given a particular role within the CTOS (local distribution, hub or gateway), what is the best equipment technology to enable it to perform this?*

The IQ project did not always identify new transhipment technologies as being the critical issue. For instance, the Gateway concept implemented by HUPAC at Busto II proves the viability of a large scale terminal concept based on conventional technology that combines both distribution and network functions.

Yet the development of new information technologies is considered as one of the main means of achieving qualitative improvements and reduced operating costs. The layer framework also highlights the value of these information systems as strategic components of partnerships' and players' strategies, considered at the Commercial strategy layer. Likewise, information technologies can provide a more efficient operational "connection" between CTOS considered at the Operating System layer.

4.4.2.3.The Commercial Strategies layer

At the Commercial Strategies layer, the commercial strategies of the railways as traction providers (i.e. the quality of the services provided to the intermodal operators), are distinguished from the commercial strategies of the intermodal transport operators (i.e. the quality of the services to the end intermodal user).
Figure :



With regard to the commercial strategies of the railways as traction providers (i.e. the quality of the services provided to the intermodal operators), the IQ research indicates that whilst rail liberalisation has introduced more competition in rail services, at the present time it has given rise to mergers and alliances and hardly any new players.

What are the possible consequences of this international co-operation and these joint ventures involving different railway companies? It is possible, for example, that the railways will succeed in implementing a real integrated pricing and commercial strategy for international traffic. At present, international transport prices are the result of the addition of each network's pricing system, and the rail services result from the addition of each network's commercial strategy.

However, IQ's results also highlight the risk that, with new commercial freedom and the objective of profitability for their operations, rail operating companies could limit their services to the most profitable links and transfer all the commercial and financial risks to the intermodal transport operators.

With regard to the quality of rail services for intermodal transport operations, at the Commercial layer, one major innovation could be a "contractualisation" of quality requirements.

Considering the commercial strategies of intermodal transport operators (i.e. the quality of the services to the final intermodal user), the results of the IQ project show that the critical new feature of intermodal transport results from the railway companies becoming involved in the marketing of intermodal transport, rather than the entry of new players.

The interrelation between Commercial Strategies and innovation at the Operating system layer, highlights increased competition on high volume European corridors. However, this should not develop at the expense of innovative "network" strategies.

This appears to be a critical factor for interrelations between the Operating System and the Commercial Strategies layers, since there is a risk that the development of door-to-door services and involvement of the railways in direct marketing of intermodal services could distance the road sector from intermodal transport.

It is pointed out that vertical integration would not be symmetrical: the "rail group" of players is not prevented from entering road transport, while the road transport sector -and the UIRR- still has great difficulty entering rail transport. A key question therefore concerns the road hauliers and forwarders who provide door-to-door services to shippers using the UIRR terminal-to-terminal services: will they remain competitive when faced with competitors supplying door-to-door integrated intermodal services to the shippers?

This question is important, since UIRR companies play a crucial role in the development of combined transport, and because they have been able to secure and build up support for rail intermodal transport from the road sector and freight forwarders (business confidence).

This issue is reflected also at the Policy layer where it is apparent that, at present, the political approach emphasises the strategic role of intermodal transport for revitalising the rail transport sector. However, the revitalisation of the rail sector would be limited if combined transport were to loose its road clientele.

The political approach to intermodal transport must therefore not focus exclusively on the revitalisation of the rail transport sector: it is also necessary to introduce a reciprocal consideration of the benefits to road transport.

4.4.2.4.The Policy layer

The system analysis framework approach, highlighting for example interactions with the Operating System layer, stresses the need *for a policy that reconciles corridor development with balanced regional development*. In the context of the Trans-European Freight Freeways initiative, which increases the risks of polarisation, transport policy must also ensure that increased performance of the corridor services is counterbalanced by a network approach and regional development, in order to:

- maintain access within dense zones and reconcile the development of international intermodal transport with the development of local regional passenger transport,
- develop regional connections to the main European corridors and links between regional operating systems and a backbone intermodal network.

At the Commercial Strategy layer it is noted that intermodal transport operators encounter high transaction costs, due to the substantial differences in the approaches to rail infrastructure charging that have so far been adopted by individual Member States.

At the Policy layer it must be noted that the issue cannot be reduced to the harmonisation of infrastructure charging systems. The main criterion is for infrastructure charges for international traffic to use differential scale tariffs and not, as presently, simply add up the tariffs of each network used, following the economic logic of existing rail transport tariffs.

More generally, players require a new institutional policy framework, covering new network access rules and new rules on slot allocation. Players require a new institutional framework which goes one step further and modifies Directive 91/440, calling into question the fact the allocation of time slots is restricted to licensed railway undertakings.

Finally, there is a need for political awareness of present trends, i.e. the conditions of competition with the road transport sector in the context of an expected increase in rail transport prices. The critical issues for intermodal transport will be a harmonised pricing system of fair and transparent levies for infrastructure use, the development of all modes, pricing measures for intermodal transport to contribute to the infrastructure cost.

Overall, the differences in prices must be considered, with increases in prices for *rail intermodal services* (including infrastructure fees) since railway companies need to meet their objectives concerning the profitability of operations (the Commercial Strategy layer). On the other hand, the *road transport* sector is expected to become even more competitive, maintaining a very high innovation rate.

The critical political question is thus how to allocate the infrastructure costs fairly between all the modes, with corrective political measures to fill the gaps, even where the potential for increased productivity in the rail services could benefit rail intermodal traffic.

The system analysis helps to improve our understanding of the context of intermodal transport development, and it has highlighted some *critical factors* for the future.

4.4.3. The intermodal market "in transition"

In recent decades, the rail intermodal transport market has been changing from a strongly institutionalised market towards one which is more competitive. Rail liberalisation aimed to create a dynamic industry with an increased number of competitors in a deregulated European market. However, two main issues must be considered:

- liberalisation was intended to give rail clients *greater choice* between railway traction providers and, at the same time, give railway companies *more commercial freedom*. It would seem that the second objective has been achieved at the expense of the first.
- under the surface of market competition, more and more *operational co-operation* between intermodal operators has emerged. New entrants can destabilise the industry and the quality it provides, since they enter the market on high-volume corridors which are vital for the large operators in order to support their network as a whole.

In the previous chapters the importance of organisational aspects and the institutional context has constantly been restated, suggesting a clearer policy to create a new system of intermodal transport. This would highlight a kind of transition whose main characteristics are described in the last part of this chapter which deals with the integration of the intermodal system.

4.4.3.1.The railway companies' rollback strategy: internationalisation without competition

First, rail regimes differ greatly throughout Europe so it is difficult to create homogenous liberalised corridors. For example, the conservative approach in France contrasts greatly with the completely liberalised UK network; the high track access fees in Germany are again different from the Dutch zero-fee region. This complex juxtaposition slows down the creation of new high-quality intermodal services and increases costs.

Secondly, the more liberal environment has resulted in more international mergers and alliances, but there are hardly any new intermodal operators and even fewer new traction providers.

The privatisation of a number of national railway companies (although they remain state-owned) has created a more commercial and market-oriented approach towards intermodal transport. Political aspects have become less relevant. However the *long-term effects of this development* are still unclear:

- there is a risk that the railways will close down loss-making intermodal services which have survived due to political considerations,
- also, the rail companies have a small share in intermodal transport when compared to conventional wagon load transport, where they control the entire transport chain. The railway companies may thus be inclined to favour wagon load trains at the expense of intermodal transport,
- another risk associated with privatisation is the level of track slot fees. Intermodal trains may be ousted by more profitable passenger trains, or the level of attractive slots may be too high for intermodal transport altogether,
- these commercial risks may become even more threatening through the market entry of new intermodal operators who focus on the most attractive corridors (cherry-picking). Cross-financing between corridors as done by the large network operators becomes more difficult.

There is little prospect that further liberalisation will alter the present stable, but also largely undynamic, situation. As long as prices for long-distance road freight transport do not rise, the attractiveness of intermodal transport for capital investment will remain below the critical threshold. This means that an effective intermodal policy cannot be limited to measures affecting only intermodal business. Intermodal services rely on an efficient railway sector and a road sector which has to carry the burden of external costs. Therefore, intermodal policy also implies measures in both the railway *and* the road sector. For these reasons, any intermodal policy needs to be threefold: measures directed at the intermodal industry, measures directed at the rail industry and measures directed at the road industry.

As regards policies for intermodal transport itself, the following positions have been stressed in the IQ summary report:

- Market entry for new operators must be facilitated and market contestability (the possibility of competition) needs to be enlarged through client-oriented *allocation of track slots*. These slots are at present still under the long-term control of the *traction providers*, i.e. the national railway companies. This construction hinders competition since, *de facto*, intermodal operators cannot choose between train operators. Slots are the pivotal point for the acquisition of freight, the establishment of chain management and the build-up of intermodal wagon fleets. The intermodal operators or shippers must be able to secure slots for their transport needs. This would create more competition between traction providers and could increase the quality of railway services. Otherwise, there is a risk of traditional railway monopolies blocking most slots for decades. A possible solution would be to guarantee new operators a minimum share of slots for trunk connections and to support market entry from capillary links.
- *Regulatory and technical access* for new operators needs to be simplified. The Dutch/German locomotives of Short Lines had to install four different safety systems to meet German and Dutch regulations. Also, the granting of licenses and operational access needs to be much faster.
- *Faster liberalisation* would facilitate the creation of genuinely European intermodal operators. Most likely, large (internationalised) railway companies such as DB, SCNF or SBB would play the leading role. This is, however, a two-edged outcome since more competition between traction providers was one of the objectives of rail liberalisation. There is a risk that it will lead to a "business-as-usual" approach at a higher spatial level. This development can also be observed in the US airline industry: liberalisation has led to a reduced number of large companies - but performance has increased and prices have fallen significantly to the benefit of customers.

4.4.3.2.Competition and co-operation between intermodal operators and new entrants

The oligopolistic market structure of intermodal transport has proven stable as shown by the quantitative change in intermodal transport (an estimated 8% share of the international market involves players other than UIRR and ICF). Before considering the disadvantages, the positive aspects should certainly be noted.

For example, customers know that most operators have a stable financial background and a guaranteed market. This helps to build up long-term confidence and long-term logistic structures.

Another positive aspect is the fact that under the surface of market competition, more and more operational co-operation has emerged. Competing companies quite often share the same train or the same terminal to reduce costs and improve departure frequencies. As a result, the products of intermodal transport benefit from scale economies and improved quality.

Alliances and co-operation are vital in order to:

- share risks between intermodal transport operators and railway companies,
- facilitate procurement: train slots, terminals, wagon fleets, information and communication networks,
- develop new combined transport services: the launch of a new (shuttle) train service requires a standing jump into the market and high regular volumes.

New small operators who focus on specific corridors have the potential to improve quality and efficiency through lean management and better response to customers. This is why they concentrate on shuttle services which increase reliability and reduce the amount of management activity. This segment, on the other hand, has high capital risk because it is difficult to adapt capacity to changing demand volumes. It also restricts new offers to a handful of corridors connecting seaports and major hinterland destinations and/or new destinations in Eastern Europe which have not yet received much attention from the major established operators.

But new entrants may destabilise the industry and the quality it provides, since these players enter the market on high-volume corridors which are vital for the large operators to support their network as a whole. More competition and improvements on large corridors may therefore reduce intermodal quality in other network segments.

In terms of intermodal market shares there seems to be more "cannibalism" between old and new operators than attraction of new freight to intermodal transport. Several new pilot schemes have collapsed due to heavy marketing by large established operators. These rise-and-fall episodes are certainly not favourable to the reputation of intermodal transport because customers will only adapt their logistics to intermodal transport if operators can offer a stable mid- or long-term perspective.

There is, however, an indirect positive effect triggered by new operators. To deter new competitors, the established operators have begun to show more flexibility and improve their products. The “rolling back” of the railways and their European subsidiary, Intercontainer, will most probably lead to a better match between organisational structure and services. This will transform the “patchwork” of national intermodal rail services and tariffs into an international service network with uniform procedures, easy access, one-stop shopping and standard documents.

The disadvantages of this competition and co-operation between companies can be listed as follows:

- The market still contains structures which emerged in the 1960s. National companies protect national markets, and there is quite a strict separation between maritime and continental cargo which, for example, deters UIRR companies from entering the maritime container segment or new entrants from competing with ICF.
- As intermodal rail transport is quite a simple product that requires economies of scale and supranational supply, it can be doubted if this market structure is favourable to the quality of intermodal transport. Instead, fierce competition between some genuinely European operators, as opposed to national monopolies, would appear more suitable.
- Moreover, the strong ties between ICF (as well as some UIRR companies) and national railway companies block the vast majority of attractive train slots. This makes it all the more difficult to change market structures or to adapt to European customer needs.

Briefly, the results of IQ have shown that the small number of genuinely new intermodal or rail operators which have resulted from the liberalisation process are not sufficient to create a dynamic environment.

The partially deregulated sector is still beset with various technical, financial and regulatory barriers to entry despite its undisputed strategic significance.

It has become clear that the rise of new operators has pros and cons for the quality of intermodal transport. Cherry picking in single corridors may jeopardise the basic load of networks and hence the cohesion of the European intermodal network. So far, none of the new operators has created a new European network. Moreover, the emergence of new operating systems such as hub & spoke and gateway systems requires a high degree of complex co-operation.

The challenge is, therefore, to foster competition in those fields, which are clearly favourable to the growth and quality of intermodal transport, namely:

- competition with the road transport sector,
- competition within the rail intermodal transport sector.

The following suggestions have been formulated for this purpose:

Apart from internalising external costs in road transport, one specific issue seems important, namely the competitive allocation of favourable train slots in order to create a more flexible and reliable intermodal train production system. At present, the Europeanisation of supply is hindered through de-facto traction and slot monopolies.

Liberalisation in the field of infrastructure and traction seems to have more potential than liberalisation in the field of intermodal operation. Competing north-south railway corridors linking Benelux/Germany with Italy as well as the expected competition within Freeways may serve as examples.

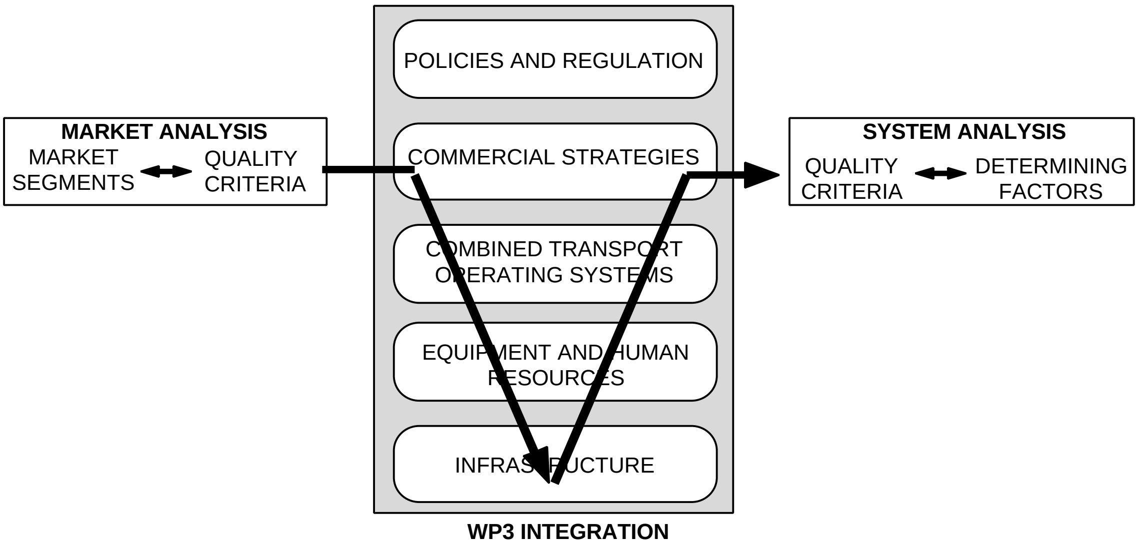
4.4.4. In conclusion: from a Market analysis to an exploratory analysis of intermodal transport

The IQ project results on "Transport Chain Integration" which are presented in this chapter, aimed to go beyond the initial studies on the "quality of the terminals" and the "quality of the networks", to explore the interactions between these two aspects and provide an in-depth analysis of the factors which determine the quality of intermodal transport.

The starting point for the study of intermodal quality was the IQ project *market analysis*, undertaken at the beginning of the project, that resulted in the IQ project Market Segmentation (23 market segments) and the identification of the corresponding external Quality Criteria (7 external quality criteria).

This market-oriented approach to Intermodal Quality can be illustrated by the 5-Layer Model (chapter 6.4.1), which can be used to investigate how the services supplied to the end users (defined by the "Commercial Strategies" of the players) provide the different market segments with adequate levels of quality.

The external quality of intermodal services is the result of operating strategies, which



themselves are highly dependent on the capacity of the intermodal network, i.e. link and node infrastructure and equipment resources.

The *system analysis* identified the key factors that affect external quality criteria. Particular emphasis was placed on the railway services and network, in view of the fact that the rail services constitute a critical part of the intermodal transport product.

The results of the IQ project also show that *operating strategies* are interrelated with the structure, volume and stability of traffic as well as the prevailing quality requirements. The determinants still remain clearly related to the initial market segments although they can be grouped together in a smaller number of categories; the number of operating systems identified rarely exceeds ten and the initial quality requirements sometimes depend uniquely on commercial strategies or a political decision ("upper layers") and might not necessarily involve major changes in the whole intermodal system ("lower layer").

The next stage is based on the market analysis and consists of an exploratory analysis, which is the most relevant to help decision makers and to assess *policy programmes.* The exploratory analysis will consider not only the quality criteria but also the determining factors.

For projections, a new grouping of segments is used, which reflects the major trends affecting determinants and which includes important price/cost differentiation.

The exploratory analysis uses scenarios; both *market scenarios* (change in the demand) and *supply scenarios* (supply side innovations or limitations), in order to assess whether and how those ideas about the future will be reconciled to develop relevant intermodal policies. This will be based on quantitative projection (modelling) and qualitative assumptions again validated by a user survey.

The next chapter concentrates on validation of the analysis by means of demonstration cases and surveys in order to prepare this projection part and to build appropriate tools for quantitative simulation.

The following chapter describes the exploratory analysis whose outputs include recommendations and implementation measures for intermodal policies.

5. INTERMODAL SCENARIOS AND POLICY PACKAGES

5.1. Introduction

Analysis and projections of transport demand in previous workpackages have shown that growth of the potential market is promising. Intermodal transport addresses the segments of the transport market which appear to be the most dynamic.

The main question is how to increase intermodal transport's market share in these segments. On most of the main international corridors intermodal transport's market share is less than 5%, with some exceptions for trans-Alpine flows and some very long O/D links with Scandinavian countries, on which shares may reach 30% or even more. This shows that having a large and fast-growing “potential” market is far from sufficient. The present trend is illustrative in this case, showing that the intermodal market seems to be loosing market share and is sometimes even decreasing in absolute terms, due to the improving performance of the competing mode, road transport.

The *objective* of this IQ project workpackage was to present a framework for implementing improvements in the intermodal industry.

The steps, which are described in this chapter, are:

- (re-)definition of market segments, each of which is likely to be affected in the same way by market trends, decisions and policy measures,
- clustering of possible future developments into a limited number of critical elements which determine intermodal quality,
- identification of the strategic orientations which are likely to prevail in each of the segments,
- definition of so-called action groups which contain the most crucial measures to support future developments,
- assessment of the impact which action groups have on intermodal quality and demand, distribution of roles between players and identification of time frames,
- definition of strategic plans to capture the potential demand for intermodal transport in three regional scenarios. Scenarios concerning three peripheral regions have been developed. The specific measures to improve competitiveness of intermodal transport in these regions have been defined for each type of player involved in implementation. In addition, the barriers to implementation have been identified.
- definition of a comprehensive strategic plan. Strategic options for policy-makers and players in the industry have been set out in three realistic policy scenarios. The associated implementation measures have been grouped together. These can be generic measures, i.e. measures needed to support development in any of the policy scenarios, or as specific measures, which support only one or two of the policy scenarios. The impacts of the different policy scenarios have been assessed.

5.2. Basic elements for the scenario analysis

5.2.1. Towards a new market segmentation

In previous IQ workpackages a segmentation of the market of potential customers of intermodal transport was developed and applied (Chapter 3). The segmentation was based on similarities in the requirements of customers as regards the transport system. Quality requirement profiles differ because of differences regarding which quality aspects are emphasised and differences in the required level of quality.

On the basis of an analysis of the production of intermodal transport and the results of an extensive field survey the initial 23 market segments were regrouped to form 7 segments in which quality and price requirements were highly correlated.

These 7 segments are presented in Table 17. The market segmentation has been used to conduct a scenario-based analysis of demand and develop focused policy programmes which address specific segments.

The table shows that at the present time intermodal transport has only gained considerable shares of the market in those segments where conventional rail has traditionally been strong (Segments 1, 2 and 3). The large potential markets of segments 4, 5 and 6 have been developed to only a marginal degree. In some cases the transport time or price conditions are simply too demanding for intermodal transport and can only be met by road. Segment 7 is a new segment. It fits the profile of intermodal transport quite well but has not yet been developed.

Table 17: The market segments and their characteristics

Quality/price profile of segment (i.e. the most important elements determining modal choice)	MAIN CUSTOMER GROUPS OR CHARACTERISTICS OF GOODS FOR THIS SEGMENT	Size of market	Inter-modal share
1. HERITAGE PRICE SEGMENT Price is dominant *(mainly former conventional rail transport now riding intermodal)*	• forwarders/shipping lines in maritime hinterland transport by rail or barge • shippers with low quality requirements • short-sea shipping • empty container transport	medium	high
2. HERITAGE LOGISTICS SEGMENT Match with logistic structure of client and price are dominant *(mainly former conventional rail transport now riding intermodal)*	• large shippers (inter-plant transport) • maritime hinterland transport • short-sea shipping	medium	high
3. HIGH-QUALITY INTERNATIONAL SEGMENT Reliability, flexibility and control are dominant *(intermodal transport used as a substitute for international two-driver road transport at peak times or regularly in specific corridors)*	• sub-segments of all customer groups but mainly road hauliers and forwarders • maritime clients with tight round-trip regimes	very large	small
4. HIGH-QUALITY NATIONAL CORRIDOR SEGMENT Time, price and flexibility on specific corridors are dominant *(intermodal transport used as a substitute for national road transport at peak times)*	• sub-segments of all customer groups but mainly road hauliers and forwarders	very large	very small
5. HERITAGE SAFETY SEGMENT Safety, staff quality, and control are dominant *(mainly former conventional rail transport now riding intermodal)*	• hazardous goods transport	medium	medium

6. HIGH-QUALITY TIME / RELIABILITY SEGMENT Time, reliability, flexibility and control are dominant *(very high level of requirements)*	• perishable goods • high-value goods, • shippers/forwarders in just-in-time systems;	large	very small
7. NEW NETWORK INTEGRATOR SEGMENT Match with logistic structure of client, network solutions and reliability are dominant *(this is a potential new segment for intermodal transport: integrators offering Europe-wide transport solutions in an integrated multimodal network)*	• network integrator segment (e.g. UPS, large forwarders)	medium	close to zero

5.2.2. System elements for intermodal scenarios

The following table lists and describes the main elements which are likely to influence the quality and size of intermodal transport in the future. These system elements were identified and examined during the IQ project. The list does not try to mirror all existing elements in an exhaustive way, but presents the most important determinants of the quality of intermodal transport.

The system elements may be characterised by:

- one clear trend without any alternatives (e.g. market potential, for which analysis provided sufficient evidence of future growth),
- mutually exclusive alternatives (e.g. intermodal policy, which can be either stable or uncertain) or,
- alternatives which may co-exist (e.g. type of train systems in Europe, which may contain shuttles, block trains and others).

Table 18: Identified system elements and the associated alternative developments

SYSTEM ELEMENTS	ALTERNATIVE DEVELOPMENTS
Intermodal Policy	A) constant promotion of intermodal transport unstable and uncertain transport policy, esp. as regards the liberalisation process and cost internalisation
Intermodal market potential	A) steady and rapid growth of transport demand in sectors which are basically accessible to intermodal transport
Intermodal transport volume on a given link	A) daily shuttle/block train possible B) volume between alternative A and C C) only weekly block train or daily wagon group possible
Rail link between terminal and main rail line	A) high quality/capacity link B) low quality due to technical problems C) low quality due to organisational/operational problems
Rail slot pricing	A) Europe-wide low-price regime B) European high-price regime C) National patchwork regimes ranging from zero-price to complex and high prices
Allocation regime of rail infrastructure (train slots)	A) train slot booking only available to national railway companies B) train slot booking also possible for intermodal operators
Infrastructure priorities (freight vs passenger)	A) a core network of dedicated rail freight corridors B) priority to passenger (as previously) C) commercial approach (slot auction)
Type of train system	A) shuttle trains B) block trains C) intermodal wagons as section of conventional trains D) new train systems (bimodal, cargo sprinter)
Type of train operating system	A) direct links B) gateway system C) hub system D) complex forms (hub + gateway, bi-hub, etc.)
Flexibility of train schedules	A) strict regime of one train per dayleaving in the early evening B) additional trains possible at short notice C) more than one departure per day
Market entry of new intermodal operators	A) alliances of established operators B) new entrants
Terminal/node planning and terminal innovation	A) Terminal planning disconnected from other elements of the intermodal system B) Terminals planned as element of intermodal train operating system C) New transhipment technologies D) Focus on intermodal nodes
New train technologies	A) automated coupling B) new low-cost rolling stock C) fast freight trains D) modular concepts (cargo sprinter)

SYSTEM ELEMENTS	ALTERNATIVE DEVELOPMENTS
Telematics	A) IT-based booking tools B) IT-based invoicing/ accounting tools C) IT-based equipment maintenance and operation tools D) Real-time monitoring tools (tracking & tracing)
Road access to terminals	A) congested road links to terminals B) congestion-free links
Pre-/endhaulage by truck (pick-up and delivery)	A) terminal time windows for pick-up and delivery of load units B) waiting times at terminals (document flow, equipment out of service, train delays, peak traffic) C) isolated pre/ endhaulages per company or coordinated box and truck rotation
Hub vs corridor strategies	A) predominance of the hub system B) erosion of the hub system and the rise of isolated shuttle solutions
Spatial cohesion of the intermodal system	A) focus on high-volume corridors in dense areas and trans-Alpine traffic B) focus on pan-European networks including links to peripheral areas
Strategies of railway companies	A) marketing B) roll-back and vertical integration C) public service approach D) revival of conventional rail transport
Liberalisation of railway sector (see also Freeways)	A) standstill of rail liberalisation B) cautious liberalisation C) strong and fast liberalisation
Freeways	A) freeways as strongly liberalised corridors B) freeways just as examples for better co-ordination between railway companies
Rail infrastructure	A) step-wise realisation of new rail links
Liability system	A) fragmented liability system B) integrated liability system including performance guarantees by railways
Monitoring system for rail transport	A) fragmented low standard offers B) integrated monitoring system C) permanent real-time monitoring
Short-sea shipping	A) faster ships B) better port and customs procedures C) higher volumes

5.2.3. Trend groups of system elements

The large number of system elements in the above table has been allocated to groups according to three dimensions:

- volume,
- space,
- products and production.

The box below shows how this clustering results in trend groups which would support the development of intermodal transport in specific ways.

Trend groups

- *Defensive trends* where intermodal operators aim to stabilise the existing market segments in a largely unchanged environment.
- *Growth trends* where the intermodal industry tries to open up new high-quality and low-cost market segments through new operational and institutional approaches. The objective is to generate a high growth rate for intermodal transport.
- *Corridor-oriented trends* where intermodal operators focus on economies of scale, high productivity and high control levels on selected corridors. Demand for intermodal services on these corridors is both high and regular.
- *Network cohesion trends* where the intermodal operators focus on economies of scope and offer a broad range of links throughout Europe with a large variety of train systems and terminal types.
- *Flexibility-oriented trends* where efforts focus on improving intermodal quality in the field of flexibility, e.g. the number of daily train departures, train capacity, terminal activities, booking, etc.
- *Productivity and cost-oriented trends* where efforts focus on improving intermodal transport in the field of productivity, e.g. as regards the load factor of trains, the use of equipment, etc.
- *Reliability and control-oriented trends* where efforts focus on improving intermodal quality in the field of reliability and control (tracking & tracing)
- *Time-oriented trends* where efforts focus on improving intermodal quality in the field of overall transport time.

By combining the dimensions in different ways it is possible to generate 16 scenarios from these eight trend groups (2x2x4). However, a selection can be made at the outset, because only those scenarios which relate to the profile of the seven intermodal market segments are relevant to IQ's analysis. The table overleaf indicates the trend that would result if development of one of the segments were to be supported.

Table 20: Development orientation scenarios

No.	Scenario title	Volume focus	spatial focus	quality focus
1	heritage price scenario	Defensive	network	productivity
2	heritage logistics scenario	Defensive	corridor	productivity
3	high-quality international scenario reliability/flexibility/control	Growth	corridor + network	flexibility reliability/control
4	high-quality national corridor scenario time/price/flexibility	Growth	corridor	productivity flexibility transport time
5	heritage safety scenario	Defensive	network	control
6	high-quality time/reliability scenario	Growth	corridor+ network	flexibility reliability/control transport time
7	new network integrator scenario	Growth	network	reliability transport time

5.2.4. Measures to support the scenarios

- ***Action groups***

It is possible to draw up a list of measures and decisions that would support the above-mentioned system elements, and hence trends. Such a list, however, could hardly be exhaustive. To rank and weigh measures would be even more difficult, especially with such a large number of interrelated system elements and possible measures is this high.

To give one example, the development “daily shuttle/block train possible” (table 18) is correlated with the overall objective of obtaining sufficient volumes. It supports four of the seven scenarios (4 5 6 7) in table 20. Some possible measures for achieving this are:

- concentrating flows by closing down peripheral intermodal terminals
- the contradictory measure of strengthening peripheral intermodal terminals to attract more volumes by providing excellent services at a low price

Additionally, all the measures that improve the ability of intermodal transport to attract potential goods flows will increase opportunities to run daily shuttle trains, because these are strongly correlated with volume. Also, all price measures that improve the competitive position of intermodal transport in relation to pure road transport are likely to increase intermodal volumes - thereby supporting the development “daily shuttle/block train possible”.

In order to highlight the most important measures or developments that have to take place to increase European intermodal transport, 7 so called *action groups* have been defined. These action groups contain what are regarded as the most crucial measures;

- concentration of flows,
- commercialisation of railway companies,
- client-oriented allocation of track slots,
- harmonisation and acceleration of liberalisation in EU member states,
- harmonisation and deregulation of infrastructure access,
- limited subsidies for establishing new intermodal transport services,
- standardisation.

- ***The players***

Two different groups of players must take measures which can help bring about such developments:

- *Policy makers*. This category includes all legislative bodies and institutions, whose decisions can change the rules that govern transport activities, affect competition and influence the structure of the market. Four levels can be identified: the European Commission, National governments, Regional/Federal governments and Local governments. The distribution of their responsibilities may vary depending on current national constitutions and the balance of power in different European countries.

- *Transport operators*. This category can include the operators of vessels (inland barges, short-sea or deep-sea vessels), ferry operators, ship owners and shipping lines, port authorities, terminal operators, railways, rail network providers, intermodal operators, forwarders and road transport operators. Also the competence of these players will vary, because some companies may have incorporated more types of activities in the logistic chain. Their roles in taking measures will vary accordingly.

- ***The time frame of actions***

With regard to the time frame for actions to support the success of the scenarios, distinctions have been made between: short term (within 2 years), medium term (between 2 and 5 years) and long term (more than 5 years).

- ***One example of action group 1: concentration of flows***

The concentration of flows can have a considerable effect on the quality of transport and on the competitive situation with respect to road transport. A self-boosting effect is even possible if supply matches market demands well so that ever-increasing volumes are attracted. Some examples of efforts to achieve concentration are:

In Germany DB plans to close down a number of terminals, mostly peripheral ones. This has been strongly criticised because it has been interpreted as a step to reduce intermodal transport. Research undertaken in the IQ project has on the contrary concluded that a measure of this type can constitute an essential survival strategy for intermodal transport.

Not only are railway companies merging and co-operating more closely, intermodal operators are also expanding their business by buying competitors to bundle volumes and minimise competition. Examples are the partial takeover of Swekombi by Kombiverkehr and HUPAC and HUPAC's takeover of Trailstar.

The concentration of flows mainly supports the train operating system which consists of direct links, namely the train operating system identified in the WP5 as having the most positive impacts especially on growth scenarios.

WP5 identified the following supporting developments as strongly linked to this action group (the supported scenarios are given in brackets):

- daily shuttle/block train possible (4 5 6 7),
- high quality/capacity link (2 4 5 7),
- new transhipment technologies (2),
- focus on intermodal nodes (1 6),
- shuttle trains (2 4 5 7),
- direct links (2 4 5 6 7).

Most of the measures can be achieved in the short term by the railway and intermodal operators who have to restructure their supply and concentrate their flows. The terminal operators have to concentrate their network and to dedicate their terminals to certain O-D links or network functions.

The table below gives an example of measures undertaken in action group 1.

Table 21: Measures in action group 1

Player	concrete measure	comment on feasibility	time frame
terminal operator	➢ Focussing investments on the main terminal only ➢ Transfer of equipment and personnel from the terminals to be closed down to the main terminals	Terminal operators will try to keep their traditional business going and to maintain their terminals. Their only activity is transhipment. Terminal operators are not interested in an optimisation approach for the whole network. They will fight this optimisation if it reduces their volumes. If there is more than one terminal operator, competition between them will lead to uneven prices for terminal services that will influence the terminal chosen by intermodal operators and hauliers. This influence may blur the optimisation efforts for the whole network and lead to the other players choosing a terminal that is not part of the proposed optimisation model.	medium term

Player	concrete measure	comment on feasibility	time frame
intermodal operator	➢ Implementing optimisation in their next timetable; concentrating supply to attract greater volumes for intermodal transport from the increasing potential ➢ For door-to-door transport: still offering all destinations as before - but with substantially longer truck hauls ➢ For terminal-to-terminal transport: reducing the number of destinations offered, but providing more frequent services to the remaining destinations (the main terminals)	The level of resistance to or support for the measure depends on the possible benefits when the system is optimised. When the intermodal operator system consists of one operator that is responsible for domestic transport and another that is responsible for international transport, each will obtain quite different benefits from an optimised international system. Another issue is whether the intermodal operator provides a door-to-door or just a terminal-to-terminal service. For a door-to-door operator, some cancelled peripheral rail hauls could easily be replaced by longer road hauls. A terminal-to-terminal operator would have to wait for the medium to long-term benefits from concentration and would tend to resist this measure. .	short term
national/ local policy maker	➢ Changing transport policy from a decentralised terminal network to a main terminal network ➢ Changing the political definition of the accessibility of regions from the requirement of having a terminal and adopting a more decentralised view.	Reduction of the terminal network might be interpreted as removing the intermodal accessibility of a whole region. However, the region retains accessibility, it is just that the pre- and end haulage distance is increased. However, this might be unpopular in those regions where this will result in increased truck transport. Resistance from local and regional policy-makers is likely, if their region's terminals will be shut down.	short term[2]
national/ European policy maker	➢ Abrogate all legal definitions (related to tax exemptions, driving bans, etc.) that define intermodal transport by the maximum length of pre- and end haul. Replace these by a definition of intermodal transport without any road haul length parameters.	A variety of regulations including tax reductions and driving bans that are based on a definition of intermodal transport by the length of its road haul part have been implemented. Such regulations must be abrogated. The policy that has existed for decades to support as many terminals as possible must be changed. Political resistance to this major change in intermodal policy is likely.	short term[3]

[2] if this development is desired by the players in question. If not, this is a long term time frame.
[3] see above.

Player	concrete measure	comment on feasibility	time frame
Railways [4]	➢ Focusing investment on the main terminals ➢ Providing market oriented slots from the main terminals to the European mainland	Traditionally, many European railway companies have owned the terminal operator or at least the terminal area. The railways are interested in running their trains in the most efficient way in to maximize revenue. However, this revenue maximization may be difficult to achieve with intermodal transport.	short term[5]

[4] the railways include the stock owners of the railway companies (which are often the national governments - policy makers)
[5] if this development is wanted by the players in question. If not, the time frame is long.

5.3. Regional scenarios

5.3.1. Introduction

Workpackage 5 paid particular attention to peripheral regions. The main objectives were to identify the prospects for the development of intermodal transport and specify possible measures for supporting these within peripheral areas. Three cases were considered:

- one in Northern Europe, where the attractiveness of different network configurations was compared. Measures to establish best practice and barriers to its implementation were identified,
- one in Southern Europe in order to show how measures to better integrate the Barcelona and its seaport into the European network are complex and interrelated.. Massive increases in demand are to be expected from successful integration,
- a third case which placed the emphasis on measures to improve the Short Sea Shipping in the Eastern Mediterranean region, and thereby attract even continental traffic flows.

5.3.2. Scenario 1: Northern Europe

- ***The potential intermodal transport flows***

In 1995, a total of 24 million tonnes were transported by truck between Scandinavian countries and Europe[6]. By 2010, this volume is expected to increase to about 53 million tonnes. These volumes can be considered as potential intermodal transport flows. No technical barrier exists with regard to the transfer of truck-loads to intermodal transport and transport demand involves distances, which are normally sufficient to enable competitive intermodal transport services to be set up.

Table 22: Total potential intermodal transport flows using trucks

	Volume in 1995 (million tonnes)	Volume in 2010 (million tonnes)
Sweden	6,5	16,7
Norway	1,2	2,2
Finland	2,0	7,4
Denmark	14,1	26,8
Total	23,8	53,1

- ***Network comparison***

[6] The volumes and forecasts were derived from the STAN-model. The European countries included in the model were Finland, Sweden, Norway, Denmark, Germany, Austria, Belgium, Switzerland, Spain, France, Italy and Netherlands.

Calculations were performed to compare the costs of efficient road operation with efficient intermodal operation. It was found that on almost all transport links costs for the truck alternatives were higher than for the intermodal transport alternative. This indicates that much of the intermodal potential is indeed accessible to intermodal transport, if good services are provided.

In the next stage, additional criteria were introduced in order to make realistic estimates of the volumes which really are accessible to intermodal transport.

- For an alternative to be attractive a minimum frequency must be provided (3 departures per week). Intermodal transport services can only be provided if volumes are sufficient to set up economically viable services.
- the volume criterion is based on the route direction with lowest volume for each O/D link
- only 50% of these volumes per route direction have been used to represent the relevant intermodal transport potential
- for decision-makers to shift cargo from road to intermodal transport the cost advantage must be clearly apparent. Therefore, only links on which road transport costs were 20% higher than intermodal transport costs were selected.

Analysis was conducted to compare the expected market share of intermodal transport between Sweden and Europe on different intermodal transport networks. Operations in Sweden were via a hub in South-western Skåne, directly linked with either 10 terminals in one network (S1) or only 4 terminals in another (S2). The networks in the non-Scandinavian countries in the EU (EU1 and EU2) were also defined by different numbers of terminals directly linked to Skåne.

The result of the comparison between the networks was that the most competitive intermodal transport solution was the network with only 4 terminals in Sweden. A similar result was observed for the network on the European “continent”.

A limited intermodal transport network on the Continent, linking the Skåne hub directly with only 3 to 5 terminals, attracts higher volumes than the larger intermodal terminal network.

These limited numbers of terminals will attract part of their throughput from regions in which terminals are not connected to the network. This means that the pre- or end-haulage distance will be substantially increased. (Note that because of this a broader definition of intermodal transport has been applied.)

The possible policy implications of this finding are that moving cargo from road to intermodal transport requires a reduction in the number of terminals rather than the creation of a network which penetrates into as many regions as possible.

- ***Implementation measures for the reduced network of terminals***

The following table lists the concrete measures which should be taken by each of the players involved in order to implement the proposed core network of intermodal terminals.

Table 23: Measures for implementing the proposed core network of intermodal terminals

Player	Measure	time frame
Terminal operator	Focusing investment on the main terminals Transfer of equipment and personnel from the terminals to be closed down to the main terminals	medium term
Intermodal operator	Implementing optimisation in their next timetable; concentrating supply to attract greater volumes for intermodal transport from the increasing potential For door-to-door transport this means still offering all destinations as before - but with substantially longer truck hauls For terminal-to-terminal transport the implication is that the number of destinations will be reduced.	short term
National/ local policy maker	Changing transport policy from a decentralised terminal network to a main terminal network. Changing the political definition of the accessibility of regions from the requirement of having a terminal and adopting a more decentralised view.	short term
National/ European policy maker	Abrogate all legal definitions (related to tax exemptions, driving bans, etc.) that define intermodal transport by the maximum length of pre- and end haul. Replace these by a definition of intermodal transport without any road haul length parameters.	short term
Railways	Focusing investments on the main terminals. Providing market oriented slots from the main terminals to the European mainland	short term

Implementation must consider not only a theoretical simulated optimisation of the system but also take account of the influential market players and their behaviours. Benefits and margins are unequally distributed among the players involved in an intermodal transport chain. Reducing the number of terminals on an existing network may encounter the following problems with players:

- *Terminal operators*: these will try to keep their traditional business going and to maintain their terminals. Their only activity is transhipment. Terminal operators are not interested in an optimisation approach for the whole network. They will fight this optimisation if it reduces their volumes. If there is more than one terminal operator, competition between them will lead to uneven prices for terminal services that will influence the terminal chosen by intermodal operators and hauliers. This influence may blur the optimisation efforts for the whole network and lead to the other players choosing a terminal that is not part of the proposed optimisation model.
- *National/ local policy makers*: the proposed reduction of the terminal network might be interpreted as removing the intermodal accessibility of a whole region. However, the region retains accessibility, it is just that the pre- and end haulage distance is increased. However, this might be unpopular in those regions where this will result in increased truck transport. Resistance from local and regional policy-makers is likely, if their region's terminals will be shut down.
- *National/ European policy makers*: These have implemented a variety of regulations including tax reductions and driving bans that are based on a definition of intermodal transport by the length of its road haul part. Such regulations must be abrogated. The policy that has existed for decades to support as many terminals as possible must be changed. Political resistance to this major change in intermodal policy is likely.
- *Intermodal operators*: The extent of resistance to or support for the measure depends on the possible benefits when the system is optimised. When the intermodal operator system consists of one operator that is responsible for domestic transport and another that is responsible for international transport, each will obtain quite different benefits from an optimised international system. Another issue is whether the intermodal operator provides a door-to-door or just a terminal-to-terminal service. For a door-to-door operator some cancelled peripheral rail hauls could easily be replaced by longer road hauls. A terminal to terminal operator would simply loose the business of the cancelled peripheral rail hauls and have to wait for the medium- to long-term benefits resulting from concentration. He would tend to resist this measure.
- *The railways*: traditionally, many European railway companies have owned the terminal operator or at least the terminal area. The railways are interested in running their trains in the most efficient way in order to maximize revenue. However, intermodal transport might not be in the focus of their optimisation efforts.

Figure 19: Northern scenario: reduced network of terminals between Sweden and the continent via the fixed links

5.3.3. *Scenario 2: Southern Europe – the Barcelona intermodal corridor*

- ***The starting position***

Intermodal transport is currently in a poor position as regards Spanish cross-border transport, in particular to and from the Barcelona region. The distance between Barcelona and the French border is about 200 km. Spain has a different rail gauge from France and other European countries and the maximum train length is 450 metres, compared to 750 meters in France. Consequently, intermodal transport is not competitive at distances of less than about 1500 km. Major trade centres like Ile de France and Lombardy are at distances of over 800 km and would be within the range of intermodal transport if the bottlenecks were relieved.

An important development in demand is that the throughput of the Port of Barcelona has doubled in the last five years. This trend is likely to continue in the future, for a number of reasons:

- deep-sea traffic is expected to increase,
- there will be a very marked increase in deep-sea traffic between Europe and Asia. The Mediterranean seaports will benefit particularly from this increase, because sea transport time to these ports is several days less than to other seaports.
- hinterland transport from southern seaports has improved very much, which further improves their competitive position versus the Northern seaports.
- in future, the major Northern European seaports will increasingly suffer from congestion in hinterland traffic in rail and road transport.
- the improved competitive position is confirmed by the fact that Northern European terminal operators like Eurokai and ECT are taking strategic shares in Southern European seaports.
- Barcelona is in a good geographical position in the Mediterranean area with regard to Latin America and some Maghreb countries,
- commercially, the Port of Barcelona has a good competitive position in this region. The port is a leader in the process of privatisation and has gained the confidence of many operators.

Removal of the infrastructure bottlenecks could boost international intermodal traffic to and from the region of Barcelona, in both the continental transport and port hinterland transport segments. It would also increase Europe-wide transport efficiency in terms of internal and external costs, since a larger share of the intercontinental import and export flows to Southern European regions would enter (or leave) Europe via Mediterranean seaports, closer to the hinterland region.

- ***Measures for developing the Barcelona-Europe intermodal transport corridor***

In order to set up the logistic intermodal corridor between the Port of Barcelona and Europe a series of actions is necessary. At the present time developing a programme and timetable of actions would be very complicated, because decisions are interrelated and linked with other spatial and traffic planning decisions in the area.

The actions can be divided into three main groups:

- *Actions to improve infrastructure* between the port and the European gauge network. A railway track is planned to link Barcelona with the French network. Administrative procedures to prepare construction have started and funds are available. If the track is constructed, the earliest date of operation for the full length will be in 2004.
- *Actions in the rail-port hub* of the Metropolitan Area of Barcelona. Rail accesses to the Port of Barcelona and rail branches in the port zone must be provided, a rail terminal system in the port should be designed and zones for processing and depositing containers should be created. The plans are to separate road-based intermodal operations and operations related to the seaport terminal. These actions must be integrated in the "Delta Plan" and "Master Plan" of the Port of Barcelona, and should be co-ordinated with metropolitan planning and the planning of road access. The complexity of the situation means that planned operations will not be completed earlier than 2004 and solutions for some areas s are not expected until 2011.
- *Actions to capture operators*. Three target groups have been identified: Intermodal terminal operators from Northern European ports, international freight forwarders – possibly in combination with intermodal operators – and ship owners and shipping lines with interests in the Western Mediterranean region. For success, both infrastructure and operations will probably have to be available.

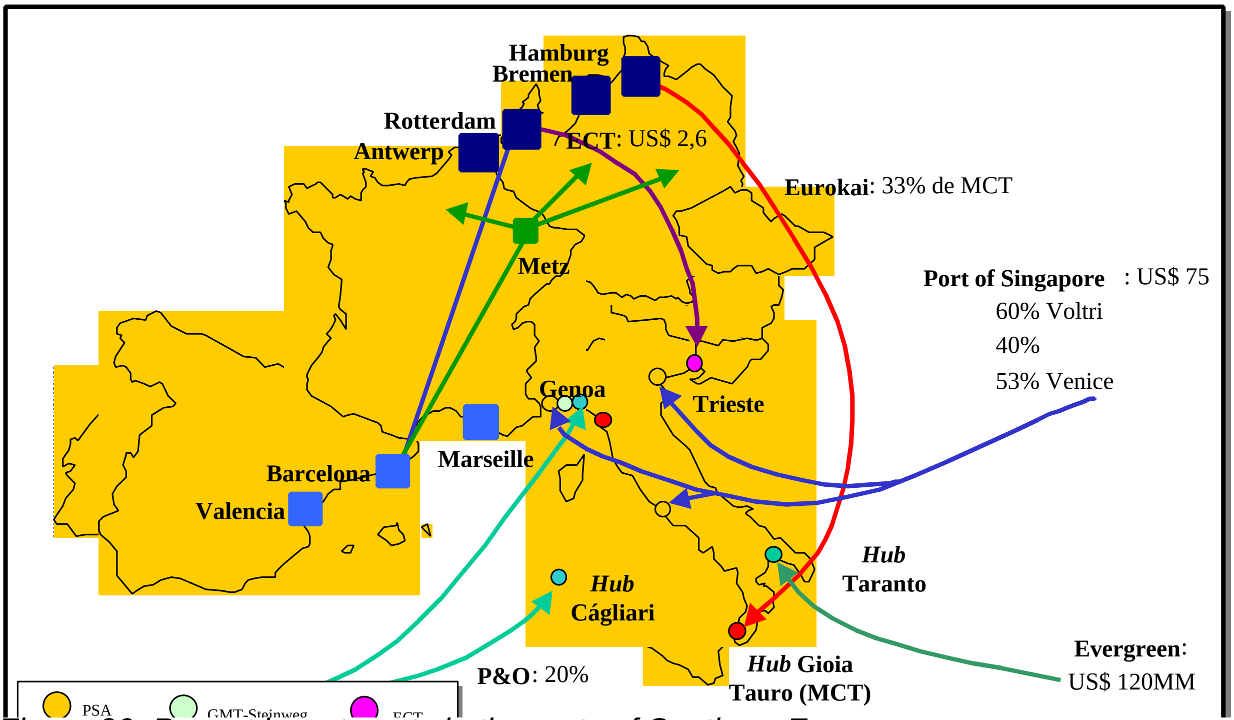


Figure 20: Recent investments in the ports of Southern Europe

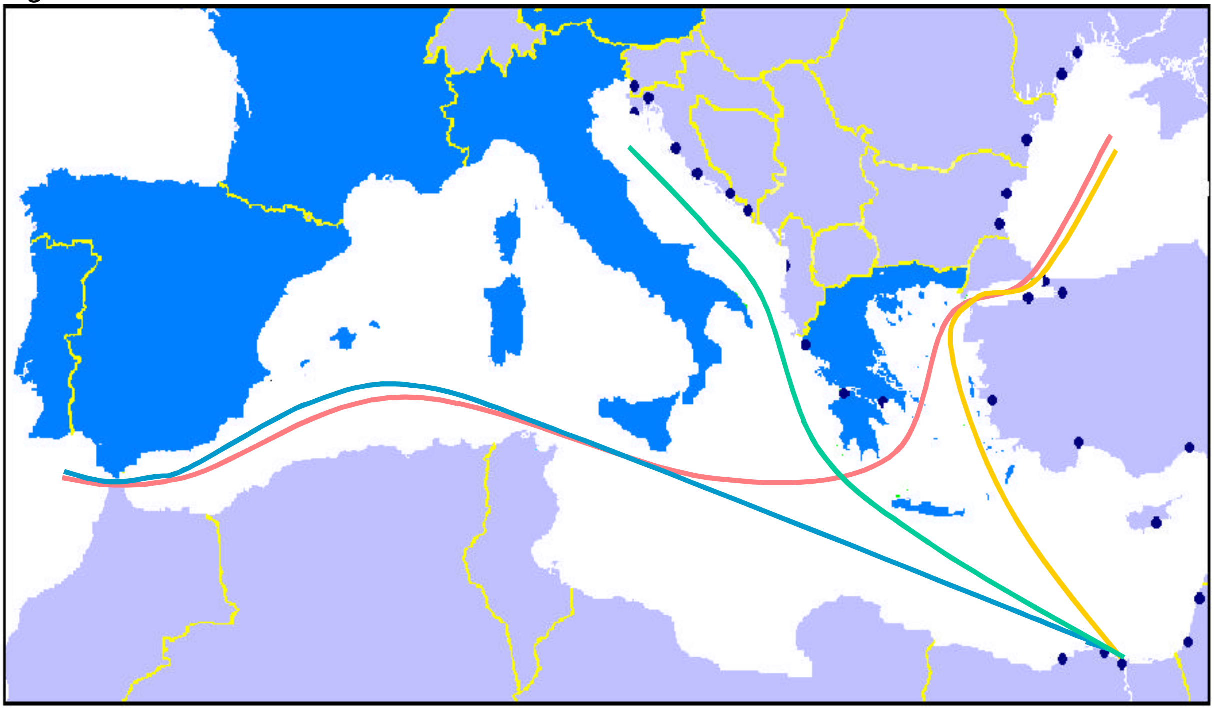
5.3.4. *Scenario 3: The prospects for short sea shipping in Southern Europe*

- ***The present position and the potential of short sea shipping in Southern Europe***

Short Sea Shipping (SSS) in the Mediterranean basin is emerging as an advantageous alternative, even to continental transport. European Transport Policy pays particular attention to the development of SSS. Significant logistical and technological developments are also expected to reinforce the position of SSS in the Mediterranean freight transport market. Fast ferries and information technology are among the important tools for promoting SSS.

However, innovation in the Mediterranean SSS is still marginal. Fast ferries have been introduced for a few services, but most of the fleet is old.

Figure 21: The main routes in the Mediterranean



Three main European-Mediterranean "areas", with different characteristics, can be identified:

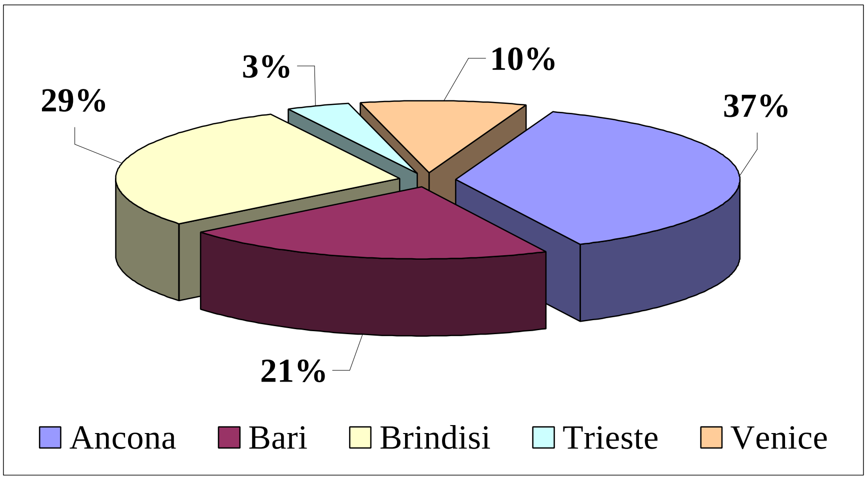
- the Spain-France-Italy basin,
- the Adriatic-Ionian corridor,
- the Eastern Mediterranean-Aegean-Black Sea corridor.

The first and second areas present a quite clear spatial port organisation hierarchy, the ports of Algeciras, Malta and Gioia Tauro being the most important transhipment hubs for the hub and spoke strategies. In the eastern area no clear spatial hierarchy can be identified.

Currently, the European-Mediterranean SSS market mainly involves low value commodities. The unitisation rate for this cargo is low, especially in the eastern area. Traffic is shared between Lo-Lo and Ro-Ro services and most Ro-Ro ships perform both passenger and freight transport.

Two case studies were selected in order to examine and quantify their prospects: the Adriatic-Ionia corridor and the Aegean corridor. A number of hypotheses and an appropriate quantification method were applied and indicated that SSS has an impressive potential for development in these regions: 675350 ETUs are expected to be transported in the Adriatic-Ionian corridor in the year 2010, 617900 ETUs (in the moderate scenario) are expected to use the Aegean corridor in 2010.

Figure 22: Percentages of trucks moving between Greece and Italy, for each Italian origin or destination port (1997)



- ***Measures for supporting the development scenarios for short-sea shipping in Southern Europe***

For the SSS scenarios, the measures required for the potential described above to be effectively captured were grouped into six clusters which related to:

- Commercialisation of Port and Maritime Terminal services (see table)
- Development of the interface concept and the alleviation of friction costs
- Integration of new technological developments, i.e. fast ships
- Other aspects which increase the attractiveness of SSS and the concentration of flows
- Acceleration of the harmonisation of port and customer procedures and of port privatisation.
- The development of efficient data collection and monitoring systems.

As an example, the first scenario is presented in the next table.

Table 19: Measures related to the commercialisation of ports and maritime terminals

Player	Measure	Time frame
European Commission	• Activation of procedures for monitoring and accelerating the deregulation process • Control of budgetary policy in ports, in relation to the rules of fair competition	Short term Medium term
National/ Regional/ Local governments	• Clarification of privatisation procedures • In collaboration with the Port Authorities, definition of clear strategies for commercialisation. Possible cases: a) offer of fixed term concessions or leases to private companies, with supplementary private funding to supplement public investments, b) total transfer of ownership of both infra- and superstructures and equipment and c) division of port activities, based on the creation of mixed public-private enterprises. • Definitive solutions to possible long term debt problems that in the past public port organisations were unable to resolve. • Where needed, financing of major port rehabilitation works before private operators can be persuaded. • Actions for encouraging multinational involvement in partnerships/ownership at ports • Smooth transfer of port labour from its present organisation to private companies; to guarantee jobs.	Medium term Short term Medium term Short term Medium term
Port authorities	• Investigation of specific legal requirements • Financial restructuring • Re-organization of operations and management • Organisational and staff restructuring • Reappraisal of the market • Financial commitments and records of performance • Retraining of personnel	Medium term

5.4. A Strategic plan

5.4.1. From 7 market segments to 3 target markets

An increase in intermodal transport's market share can result from either:

- an increased share in a limited number of market segments or in a larger spectrum of market segments,
- or increased market share on a limited number of corridors or increased share on diffuse links.

For the strategic plan, three main possible target markets for the policy makers have been defined and explored. Each has a different spatial dimension and market context.

The “traditional rail” market of maritime hinterland transport and international inter-plant flows, which can develop can if intermodal transport develops on a few isolated point-to-point corridors. This target market brings together the “Price” and “Logistics” segments (segment 1 and 2 of table 17 page 149).

The “road” market on continental cross-border or long distance corridors, whose development would require good connections between the main European economic centres. This target market is a combination of the “national corridors” and “international corridors” segments (segments 3 and 4, table 17)

The “European diffuse market” of continental national and international flows, which would make intermodal transport a full Europe-wide alternative mode, provided it succeeds in combining a Europe-wide network service with good performance as regards quality and cost.

Two more scenarios can be imagined:

- a black scenario, in which no clear policy is defined and no decision is taken. This will probably lead to a worsening of the competitive position of intermodal transport and consequently a serious decrease in demand. Only few inter-plant or port hinterland services would survive.
- a “utopian” scenario, in which intermodal transport would become a kind of low price Europe-wide public service, without major quality improvements. This would probably lead to an increase in intermodal transport in the short run. It would require high public subsidies for infrastructure and operations. However, such a policy would not last in the long run, because road transport will continue to improve its efficiency and reduce its emissions. Public subsidies would have to increase while becoming increasingly difficult to justify.

These two scenarios have not been explored because they are not realistic. However, they do highlight the fact that the quality of rail services must improve in order to prevent intermodal rail transport demand and services from declining.

5.4.2. Policy scenarios

Based on these target markets three distinct policy scenarios can be outlined:

- ***an "open corridor scenario"***

In this scenario, the development of intermodal transport will be limited to where there are large concentrated flows. Concentration results more from the demand pattern than from rail operation strategies.

In particular it involves the hinterland links of major seaports as well as the services provided to a restricted number of large shippers for inter-plant transport. No doubt crossing natural barriers will increase concentration, so trans-Alpine corridors are considered as part of the limited "network".

The objective of policies in this scenario is to strengthen and possibly increase intermodal's market share on a few corridors where intermodal transport benefits fully from economies of scale due to large volumes using operating systems like shuttle trains and block trains.

This scenario is market-oriented and requires free access to the rail corridors concerned.

- ***a "High Efficiency Core Network" scenario***

In this scenario, intermodal transport will also develop along major national and international corridors. Rail service quality must be significantly improved and rail costs must decrease in this scenario because rail transport will face strong competition with road whose performance is also improving.

In other words, this scenario requires innovative solutions in order to concentrate flows (gateways, hubs) and good rail service performance with shuttle trains and block trains. Organisational innovation is necessary using the rail hub and gateway principles so that network effects operate in favour of intermodality.

The addition of major national and international corridors to the port corridors then leads to the idea that it is possible to design a core network in Europe on which high performance rail services will be operated.

- ***the Europe-wide network scenario***

In this third scenario, commercially attractive intermodal services are offered to all European regions. This means that intermodal transport will be an alternative mode to road transport Europe-wide.

The pre- and end-haulage distance to and from the rail terminal may turn out to be rather long. Also, in this scenario not every European region would necessarily need a terminal.

This is a long-term scenario. It would require considerable public involvement in terms of investment in infrastructure (and in particular in terminal infrastructure), strong and continuous support of intermodal transport, as well as increased road transport costs (with, in particular, internalisation of external costs). In this scenario, policy-makers consider the development of intermodal transport as a "pillar" of sustainable transport policy.

5.4.3. Assessment of the effects of policy scenarios on intermodal transport demand

The graph below gives the order of magnitude of the transport volume which might be expected from the different scenarios when the development of "potential" intermodal markets is considered.

Scenario 1 would imply a substantial short term reduction in market size. After this, intermodal transport volumes would increase again, but present volume levels may not be reached within 20 years.

Scenario 2 would result in intermodal volume increasing at a comparable rate to its potential market. The improvements in rail transport would just be sufficient to compensate for improvements in road transport.

Scenario 3 would mean that intermodal transport would more than double by 2020; intermodal transport would then address a wide market and benefit fully from the growth of its potential market.

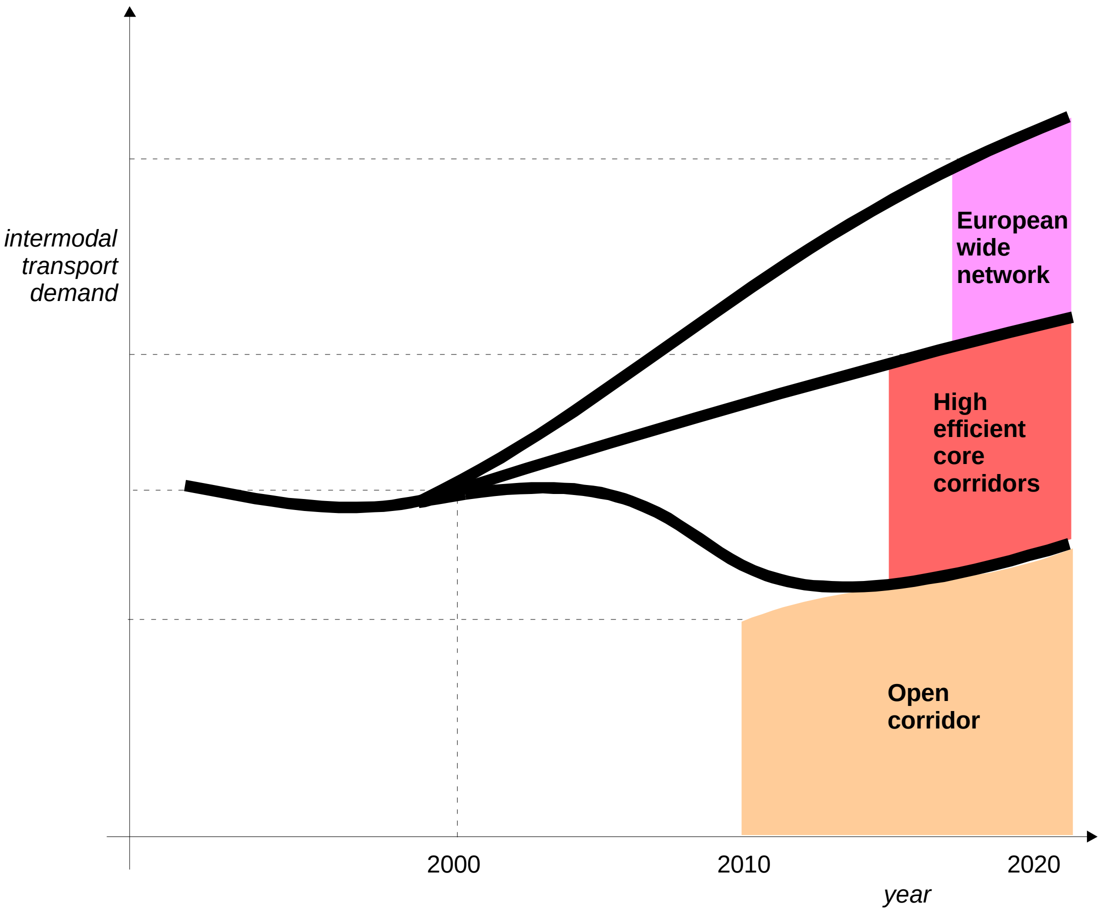


Figure 23: Change in "potential" intermodal markets

The following give some orders of magnitude of the stakes and the challenges that intermodal transport has to face, and also explain the choices made:

- recent scenarios in the SCENARIOS, SEA and SOFTICE projects predict that road productivity will increase by almost 1 % per year, i.e. by more than 20% by 2020,
- on an efficient core network (the EUFRANET model), improvements in rail quality can achieve a 20 to 30% reduction in transport time (with a considerable improvement in reliability) and a 30% reduction in cost.

5.4.4. Generic implementation measures and policy options

The IQ project identified some general implementation measures that appear to be critical for improved quality and cost performance, whatever the scenario.

- ***General Policy framework***

Mandatory long term visibility of rail, road and intermodal transport policies

A clarification of the competition rules governing the relevant players, harmonised European implementation as a mandatory condition for restructuring the rail and the intermodal industry and the favouring of new pro-active commercial strategies.

- ***Commercial strategies of the players***

"Contracting" of quality performance in order to internalise the cost of quality shortfalls: this is a critical incentive for railway companies to improve the quality of their rail services.
Standardised slot allocation procedures with some flexibility; additional trains possible at short notice, reduced transaction costs with implementation of OSS.
International rail and intermodal services with slots defined point-to-point from origin to destination – i.e. an international product – rather than as the addition of national rail or intermodal products.
Rail tariffs that diminish according to distance instead of tarrifs that are simply the result of the addition of the tariffs of each network used as at the present time
Stable and predictable traction prices – clarification of rail operating costs, especially as regards shunting operations.
More entrepreneurial management of railway companies.
Innovative commercial strategies on the part of intermodal operators with financial incentives to adapt the behaviours of end users to the intrinsic inflexibility of intermodal transport – consideration of the stacking of load units as an additional terminal logistic service.

- ***Operating systems***

Use of block and shuttle trains as the critical tool for decreasing transit time, increasing reliability and reducing traction costs.
A self-boosting process where increased rail consolidation reduces traction costs and then distance thresholds for competitive traction costs. Reduced distance thresholds will then increase potential volume.
Increased use of existing assets through more regular and continuous operating systems.
High frequency of block and shuttle trains and higher rolling stock rotation rate.
A continuous and regular terminal operating system for better use of terminal resources, reducing the investment required to cater for peak periods.

- ***Equipment and human resources***

One outcome of the IQ project's research is that new high-tech transhipment technologies are not perceived as a critical issue for improved quality and cost performance of intermodal transport.

Rail technologies that lower the volume threshold for competitive, profitable rail traction services are more critical to support the consolidation based self-boosting process described above: cargo-sprinter, automatic wagon coupling, train coupling and sharing.

The development of new information technologies is critical for improving quality and reducing operating costs in relation to:

- management and maintenance (load units, transhipment equipment, rolling stock) and personnel (wagons, locomotives and drivers), infrastructure (slots),
- tracing and tracking, real time monitoring,
- commercial information, booking, invoicing, accounting.

High training investments are necessary to adapt to:

- new techniques,
- new procedures – high quality procedures(certified),
- new commercial approaches – reconsidering the critical role of the terminal as the point of entry to the market area.

- ***Infrastructure***

Removal of the weak/congested points from the European rail infrastructure network (local capacity problems mainly in some dense areas and natural barrier crossings).

Implementation of a core dedicated freight network. Freight traffic should no longer always be the lowest priority.

Some consultation for planning the European terminal network. Terminal infrastructure planning has to be subordinated to the development of train operating systems.

Harmonisation of technical specifications (gauge, signalling system, electrification) on a Europe-wide network.

These implementation measures will be defined in more detail with regard to the two contrasted scenarios and the intermediate scenario.

5.4.5. Implementation measures for the three selected scenarios

As mentioned in the previous chapter, political visibility is essential in each of the scenarios in order to avoid a durable decline and lack of competitiveness. The present uncertainties cannot last for a long time without damaging the transport system itself and the most recent statements of ministers clearly show that there is a willingness to clarify both policy and the framework. This implies that the political decisions involved in improving intermodal transport should be made clear.

This section describes the political action required for each of the three scenarios.

- ***Scenario 1 – point to point corridors***

The implementation of the first scenario – development of intermodal transport on a few isolated point-to-point corridors – would require a high level of liberalisation in rail transport activities on the main European corridors, serving in particular the main European harbours. A pro-active attitude towards intermodal transport on the part of the maritime players or large shippers needs to be secured. Barriers to entry and to the implementation of efficient rail operations must disappear (for a more detailed account of implementation measures readers should refer also to the Action Group V document “Harmonisation and ease of the regularities for the access to the infrastructure”). A rail liberalisation process would stimulate the maritime transport industry in its search for more efficient logistical management of container facilities (reducing the number of empty container trips) and the implementation of “inland hubs” based on the use of intermodal transport. An attempt to instigate a rail revitalisation process for freight and intermodal traffic would initially involve the creation of Freight Freeways on the main European corridors. However, this would not require any restructuring of the rail transport industry and would therefore barely affect competition with road transport.

Policy visibility remains a preliminary condition for improving intermodal transport even where geographical scope is limited to few major corridors. These corridors are European corridors, which means that a political common understanding is necessary, at least between countries along the corridors, which must be reflected on a European scale, within the CTP. Since these corridors, and in particular those serving major European ports (Antwerp, Rotterdam, Hamburg, Bremerhaven, Le Havre, Genoa, Marseilles, etc.) may be congested, improving the quality of service would require the availability of more slots for intermodal transport. Liberalisation and open access will characterise rail operations so that competition will improve the quality of service, allow both technological and commercial innovation and attract maritime operators as a result of the overall improvement of inland transport. All the other measures are necessary in order to provide the shipper with good quality door-to-door service.

For the first scenario demand is already concentrated along a few corridors, which will not necessarily be the case in the second scenario.

- ***Scenario 2 – efficient core network***

The second scenario – a highly efficient core network which connects the main European economic centres - requires the concentration of flows on a limited number of rail links, operated by shuttle and block trains. Rail hubs will be implemented within the core network and gateways will concentrate flows arriving from outside this network. In order to meet the quality requirements, priority must be given to freight on the core network, which will be located in the centre of Europe with connections to countries on the periphery. It creates the possibility of an intermediate, and perhaps transitional, policy aimed at the rail transport industry that provides opportunities for national railways to prove their effectiveness in a context of liberalisation and/or co-operation between companies.

Intermodal transport will be in direct competition with road transport on major continental corridors. Over a long period road transport will continue to improve its efficiency of service by as much as 1% per year. Charges on road transport will not be significantly increased.

Infrastructure pricing incentives are quite inadequate to promote competitive intermodal transport: in the light of this, operation on this core network will have to focus on providing very efficient high quality rail services. Moreover, appropriate commercial contracts, with a guaranteed quality of service, must be possible, not only on the core network but on a door-to-door basis for the shipper.

On this core network high efficiency would be achieved by giving priority to freight, costs would be reduced and the reliability of shuttle and block trains would be improved by the implementation of flow concentration technologies. This would require a suitable European framework and full interoperability within the core network. (This “core network” could even be a kind of intermediate network through which interoperability between two regions would be achieved).

Two possible paths are open to policy makers: “liberalisation” and a “co-operative” approach moving towards European harmonisation.

- ***Scenario 3 – strong intermodal policy***

To set up a Europe-wide network with good quality and cost performance a policy to revitalise rail transport and a clear policy concerning the road transport industry are required. A key factor for the development of the intermodal transport system is the implementation of TENs, with fair and transparent levies for the use of infrastructure, for each mode.

As a general rule it can be stated that the less road freight transport pays for the use of infrastructure, the less likely it is that intermodal transport will develop into a real alternative to long or medium distance road transport. A harmonised intermodal pricing system for infrastructure is required which will keep prices at a competitive level for a Europe-wide service (for more detail concerning implementation measures readers should refer to the Action Group VI document “Limited subsidies for the establishment of new intermodal transport services”).

In this scenario, a strong and clear European policy in favour of intermodal transport would be formulated and backed up with concrete measures concerning investment, harmonisation between countries and policy towards road transport (in particular increased levies). This means that intermodal transport would be considered to be essential for sustainable transport in Europe. Therefore, a new market environment for intermodal transport would be defined in which intermodal operations could compete with road. Stimulation in order to improve rail service and commercial policies will remain necessary. Technical improvements for rail traction would be developed as intermodal volumes increase along main routes. A high-efficiency core network for rail is essential in order to be able to ensure a socio-economic return from this political involvement in favour of intermodality and reap full benefit in the long term from economies of scale. In this case full interoperability at European level might not be a prerequisite as long as interoperability were achieved on the core network and good transfer conditions were provided at the main gateways, hubs and terminals.

Furthermore, this scenario is not one in which intermodal transport with low efficiency and poor performance would survive just because of public support. Commercial innovations would have to be encouraged. However, political choices would play a role with regard to the functioning of the core network and also with regard to the moment when the model prevailing in the core network (liberal or co-operative) is extended to the entire European rail network. Countries or regions that were not directly linked to the “core” rail operations would have to be compensated, for example by improved interoperability.

Here, one should recall the two other scenarios, the so-called “black scenario" which involves “making no clear political choices” and the “utopian scenario" with “a priori support”, and their long term consequences. Their short term effects differ, but in the long term both would lead to a vanishing intermodal transport industry.

- ***Compatibility of the three scenarios***

The three scenarios help to frame political choices and identify associated implementation measures which have been analysed in detail in the implementation plans.

There may be some incompatibility between scenario 1, based on an open market scheme, and scenario 2. If Scenario 2 is based on co-operation between national railway companies with restricted access to the core network, it may not be compatible with Scenario 1 because in Scenario 1 the improvement of intermodal transport is associated with open access.

Scenario 2 will be compatible with scenario 3 if it is applied within a clear TEN policy in favour of further rail liberalisation within a long-term restructuring of rail transport. Scenario 3 requires more involvement of public organisations and greater public subsidies, as well as a very clear legal framework.

In each of the scenarios rail performance must improve. The core network, where interoperability and concentration of flows will apply, can help solve the problem of interoperability at a wider level, since interoperability will be achieved on entering the core network. In more peripheral countries the rail operators could be more independent.

In conclusion, several paths are open to policy makers:
- scenario 1,
- scenarios 1+2,
- scenario 2 (“co-operation approach”),
- scenarios 1 + 2 + 3 (“liberalisation with progressive spread”),
- scenario 2 + 3 ("co-operation with progressive spread”).

Conclusions

The conclusions the IQ project has reached are of several types, depending on the type of players, professionals, policy makers or researchers.

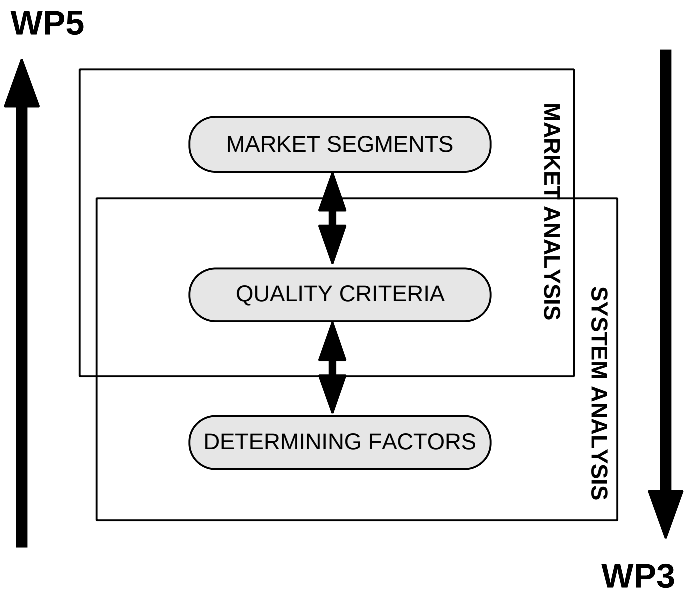
However in all cases, the major achievement of the IQ project is probably to have produced a very comprehensive approach to the intermodal transport system, in which intermodality is considered within a broad transport context that includes the quality requirements of end users, strong competition from the road, questions about the future of rail organisation, the diversity of national and local policies, with, in the background, the attempt to achieve efficient transport on a European scale. New technologies have been investigated and analysed with regard to their integration within a transport chain with technical, economic and social constraints; although information technologies often stimulate integration and quality of service for end users, technological development does not emerge as the most critical issue and the future of intermodal transport is more dependent on the quality of rail operating systems or the stabilisation of the institutional and political environment, to enable professionals to build “pro-active” strategies and not remain in a “reactive” position.

The construction of this intermodal transport system can be represented as a three stage process:

- a market analysis which demonstrates that quality criteria are relevant and must be differentiated for different market segments : there is not ONE transport market for end users but SEVERAL transport markets. The initial hypothesis of IQ has been validated by several surveys and the 23 initial segments give a concrete example of this type of segmentation, although some of the initial segments can be grouped together for some types of analysis.

- a systems analysis which focuses on the production of intermodal services to meet end user requirements. The determinants can be technical, economic or institutional. The quality of rail operations appeared very critical, as did the institutional/political context : the intermodal market is in “transition” and the scenarios for the future are very open. The initial desegregation that was proposed, on the basis of terminal quality and network quality, was indeed relevant but the IQ project has also demonstrated that performance mostly depends on the interfaces between terminal and network operators and that many synergies could be found with intermodal transport chain integration as well as between different layers of the intermodal transport system; although a positive commercial policy is important for the satisfaction of the end user, the overall performance of the system also depends on the availability of rail slots, the priority given to goods transport, a shared vision of a European freight service, international scheduling of infrastructure improvements to eliminate bottlenecks or provide adequate terminal capacity.

- An exploratory analysis which depends on an analysis of both the market and the system. An exploratory analysis is the appropriate framework for the decision-makers, professionals or policy-makers who develop medium and long term strategy. It also tests the consistency of IQ by identifying and projecting major trends in supply and demand. On the basis of the production context, the initial 23 segments were replaced by 7 major “projection segments” which were defined by their demand and supply characteristics. Policy scenarios were constructed to give a consistent picture of the intermodal system, according to different possible policy choices.



The market analysis results can therefore be directed more towards the shipper, the system analysis results more towards the transport operator and the exploratory analysis results more towards the policy-maker - although all of them could be interested in these three interrelated facets of IQ, depending on whether their interest is in the short, medium or long term future.

However, the research community should not only be interested in the results of the IQ project as regards intermodal transport, but also by the methodological developments it contains, i.e.:

- methodologies used for segmentation, system analysis and scenario building
- data collection through surveys (shipper survey, terminal surveys), interviews (experts, operators), monographs, the construction of a GIS database that included infrastructure (multimodal networks and nodes), flows and services, although such a database should be regularly updated.
- The models which have been used or developed within the project a: hierarchical model to assess the impact of technologies at terminals, several projection models (NEAC, STAN), network assignment models (MIRAGE), an original model for hub location (SIMIQ), an iterative tool (DIQIT), a methodology to assess technology integration, a “5 layer model” for system analysis…
- the first attempts to include short sea shipping in intermodal transport analysis.

This research material has been reinforced through extensive national surveys: at several stages during the IQ project national policies were described and best practises identified. National policies were systematically identified for the 15 EU countries by means of individual reports; these cover terminal policies, rail operating systems and rail capacity problems.

Dissemination of the results has been an important aspect of the last period of the project by means of:

- three seminars in London (Intermodal 99), Hamburg and Annecy
- several interconnected web sites at INRETS, EIA and TFK: an IQ Forum was started at EIA in order to disseminate the main findings
- drafting of documents ; more than 60 documents are listed in the annex in order to keep track of the substance of the work, but for wider dissemination, it is important to note

    - this 100 page final report, which will be disseminated by the Commission;
    - a more detailed 250 page final report with more extensive treatment of the system analysis of intermodal transport which should be published as a book;
    - a list of 40 summary information sheets which can be downloaded from the web;
    - several seminar and conference papers.

ANNEXES

Liste of publication, IQ reports and workshops

Report	Title
1	The quality of Terminals - Executive Summary
1.1	Summary of functional analysis
1.1.1.	The segmentation of Intermodal Transport
1.1.2.	Intermodal quality and performance indicators
1.1.3. A	Terminal characterisation - First part
1.1.3. B	Terminal characterisation - Second part
1.2	Summary of the effects of technological change on terminal performance
1.2.1.	Terminal management experience in Northern and Southern Europe
1.2.2. A	Technical note on handling equipment
1.2.2. B	Technical note on ITU and rolling stock
1.2.2. C	Additional document on handling equipment assessment
1.2.3.	Information and communication technologies and electronic data interchange forecast
1.2.4.	Model for evaluation of terminal performance
1.3	Summary of planning and financing “supply side”
1.3.1.	Synthesis of the country reports
1.3.2.	Economics of inland terminals
1.3.3.	Maritime terminals and harbour economics at interfaces with intermodal transports
1.4	Summary of market evolvement “demand side”
1.4.1.	Market involvement “demand side”

Report	Title
2	The quality of networks - Executive summary
2.1	Summary of Infrastructure and service networks

Report	Title
2.1.1.	Infrastructure and service networks
2.2.	Summary of the simulation of different network operation systems
2.2.1.	Presentation of the SIMIQ model
2.2.2.	The rail operating systems used in Belgium
2.2.3.	Intermodal network infrastructure and services Sweden, Finland and Denmark
2.2.4.	The rail operating systems used in United Kingdom
2.2.5.	The rail operating systems used in The Netherlands
2.2.6.	The rail operating systems used in Italy
2.2.7.	The rail operating systems used in Spain
2.2.8.	The rail operating systems used in Switzerland
2.2.9.	The rail operating systems used in Germany
2.2.10.	The rail operating systems used in France
2.2.11.	The rail operating systems used in Austria
2.2.12.	Inland Navigation
2.2.13.	Short Sea Shipping
2.3.	Summary of the planning constraints “Supply side”
2.3.1.	Capacity constraints on supply strategies in Spain
2.3.2.	Capacity constraints on supply strategies in Switzerland
2.3.3.	Capacity constraints on supply strategies in United Kingdom
2.3.4.	Capacity constraints on supply strategies in Scandinavian countries and Germany
2.3.5.	Capacity constraints on supply strategies in Greece
2.3.6.	Capacity constraints on supply strategies in Italy
2.3.7.	Capacity constraints on supply strategies in Austria
2.3.8.	Capacity constraints on supply strategies in France
2.4	Summary of the market evolvement “Demand side”
2.4.1.	Market evolvement - Demand side - Extensions
2.4.2.	Preliminary results of the field survey

3A	Executive summary of the interactions
3B	Executive report of the interactions
3.1.	Executive summary of the spatial integration
3.1.1.	Spatial integration of the intermodal transport
3.2.	Executive summary of the professional integration
3.2.1.	Professionals’ integration to achieve increased Intermodal Quality: DIQIT
3.3.	Executive summary of technical progress, effects on the integration process
3.3.1.	Synergy between operating systems and technological improvements as regards intermodal quality and accessibility
3.4.	Executive summary of the overall integration
3.4.1.	A five layers framework for a system analysis
3.5.	Executive summary of changes in performance
3.5.1.	Summary sheets
3.5.2.	Complementary analysis of the field survey
3.5.3.	Complementary analysis of the field survey – Annex

4	Validation & trials
5	Chemiq , Indinsiq
6	Simiq
7	Workshop in Milan
8	Synthesis report - Implementation plan and recommendations for intermodal strategies and policies
Working doc 1	Market segments, scenarios and implementation
Working doc 2	Strategic plan
Working doc 3	Northern scenario
Working doc 4	Southern scenario
Working doc 5	Short sea shipping in southern Europe
9 & 10	Workshops and findings (London, Hanover, Annecy)

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