Final Report for Publication

APRICOT – Advanced Pilot Trimodal Transport Chains for the Corridors West – South/South-East Europe of Combined Traffic

Contract N° IN-97-SC.2151

Project
Co-ordinator: Krupp Fördertechnik GmbH (KRUPP)

Partners: Hannoversche Consulting GmbH (HaCon)
Euretitalia S.r.l. (EURET)
Transman Kft (TRANSMAN)
Niermeijer Consultancy (NC)

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4TH FRAMEWORK PROGRAMME

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0 PARTNERSHIP

Company/Institution [Status]	Postal Address	Contact Name	Phone/FAX/E-Mail
European Commission DG Energy and Transport [EC Project Supervision]	Rue de la Loi 200 B-1049 Bruxelles Belgium	Patrick Mercier-Handisyde	32.2.296.83.29 32.2.295.43.49 patrick.mercier-handisyde@cec.eu.int
Krupp Fördertechnik GmbH [Co-ordinator]	Altendorfer Straße 120 D-45143 Essen Germany	D. Zimek	49.201.828.4429 49.201.828.4620 zimekd@kf. thyssenkrupp.com
Hannoversche Consulting GmbH [Contractor]	Königstraße 53 D-30175 Hannover Germany	M. Gaidzik E. Riebe	49.511.336.99.30 49.511.336.106.30 49.511.336.106.55 eckhard@hacon.de
Euretitalia S.r.l. [Contractor]	Via Corridoni 11 I-20122 Milano Italy	A. Caprini	39.02.76.051.1 39.02.-76.051.333 caprini@libero.it
Transman Kft. [Contractor]	Hercegprimas utca 10 H-1051 Budapest Hungary	J. Monigl	361.353.14.84 361.311.02.65 transman@ transman.hu
Niermeijer Consultancy [Contractor]	Röellstraat 2 NL-6814 JD Arnhem The Netherlands	A. Niermeijer	31.26.442.1690 31.26.445.3823 niercon@tref.nl

1 EXECUTIVE SUMMARY

The Project Co-ordinator is Krupp Fördertechnik GmbH, Germany (Logistics, Fast Handling System). Contractors are HaCon, Germany (consulting, calculation program design), Euretitalia, Italy (analysing the potential volume), Transman, Hungary (volume and chain design to South-east) and Niermeijer Consultancy, The Netherlands (database Rotterdam).

Objectives

The APRICOT project has been conceived to meet the challenges set by the Integrated Transport Chain scheme of the 4 FWP to increase the competitiveness of intermodal transport and offering an initial step forward towards the goal of sustainable mobility.

The APRICOT project achieve this through a series of four complementary workpackages designed to

?? isolate the required data base and establish a requirements profile for integrated transport chains.

?? structure advanced trimodal transport chains for the corridors under review from a technical and organisational point of view.

?? prove of cost effectiveness and efficiency of advanced trimodal transport chains

?? evaluate the economical and ecological impact and formulate recommendations for future implementation.

Technical Description

The innovative aspect of the APRICOT project is the systematic integration of the inland waterway system in optimal logistic chains by linking the benefits of inland navigation to the merits of rail transport to the destination areas in South and Southeast Europe and road service for the final distribution in the local areas.

The project acquires the database of the traffic regarding trimodal transport chains, the potential of goods flows and the environmental situation with the external factors net energy, accidents, noise, air pollution, surface impairment, area cutting, area consumption and optical impairment.

The principle layout solutions for trimodal terminals, operation systems for the main haulage on inland waterway and aspects of possible communication systems are found out.

The real situation in the eastern and south-eastern countries creates a trimodal chain from south-east on road till to the next Danube inland port and from there on the river till Budapest or Vienna or Linz or Regensburg. Railways are the third traffic mode from the Danube port to the port of Hamburg and in special cases to Rotterdam or Antwerp.

The possible flow along this chain today is very low so that the trimodal traffic there is not worth mentioning. But the regional development in this countries allows the forecast that there will be enough traffic volume for trimodal chains in the future. The consequences for the work to be done: A short and global view to the trimodal chains between east/south-east and the ports of Hamburg and Bremen.

But the main aspects are according to the traffic volumes between Rotterdam and the inland ports at the river Rhine.

The special corridors are:

- The Netherlands - Germany - Switzerland - Italy,
- The Netherlands - Germany - Austria - Italy
- The Netherlands - Germany - Austria - Hungary.

Typical terminals in inland ports are not suitable for effective trimodal chains. The short length of 200 – 400 m transhipment area, the low transhipment capacity and usual the bad access of the terminal by train are not helpful.

New concepts can combine new and conventional technique to improve the characteristics of the terminals in access, capacity and train operation. For different capacities different layouts will be designed and compared with conventional configurations.

The suitability for trimodal chains are found out with terminal profiles.

A focussed view to the main haulage on the river Rhine gives the chance to find out the possible operation systems in principle. Important aspects are the time and capacity conditions of the travel. The capacity of a 700m-train is nearly 60 to 70 ITU, the capacity of the barges is 100 to 400 ITU. Both traffic means need additional volumes from roadside. So the trimodal function inside the trimodal terminal will be only a part of the terminal freight volume. Other volumes are regional traffic flows to the traffic means barge and train.

Communication systems of the inland ports today are only in-house systems of the terminals inside a port. There is no umbrella communication system which gives the connection to the different existing terminals in a port and to the other means of transport. For the future the ports should give this possibility with an information and communication system using an international standard.

The project APRICOT gives information about the real costs of transport chains from the North to the South and South-east. The comparison between the different types of chains shows the advantages and difficulties in relation of time and price. There is a visible tendency between price and time consumption: The lower price the more time consumption.

The report shows in detail realistic transport chains focused on the analysis of the traffic including the river Rhine. Unimodal transport, bimodal and trimodal transport chains are in competition together. The main aspects for an evaluation would be the total price and the time to realise the whole transport chain. Both characteristics grow into different directions, so that different weights of the criteria create different optimal points for several products and clients. For different industrial or trade sectors different development centres make sense: In the North for sectors with fast traffic, near the Middle Rhine between Mainz and Mannheim for a compromise and in the South near Basle for products with long travel time possibilities.

The visits of several terminal sites mainly gives information for the evaluation of the rail access situation for direct incoming trains or wagon groups. The collected data includes information also about the volume of transhipment during the last years. Concrete data are not always available because competition of terminals grows more strong. But for the assessment of the suitability of the site such concrete data are not important.

The created calculation program gives additional security of choice for terminal locations. The findings of the report are integrated in a calculation program in such a way that the selection of a location grows easily. The involved parameters are journey time, handling, barge size, ship operation service, rail operation and prices.

Important results in concrete values for time and price are named for the variations unimodal, bimodal and trimodal.

The handling of the calculation and evaluation program is possible without problems for all users. So the user get an impression what trimodal chains can reach. The existing ROMI-Shuttle is an example for the rightness and reality of the trimodal chain design.

Information and recommendations about the comparison of existing and innovative trimodal transport chains regarding cost/price and time relation, quality of service and environmental aspects are found out.

The analysis considered different scenarios in order to compare the innovative tri-modal integrated transport chain with possible evolutions of the present market conditions, and evaluate therefore the sensitiveness of the results to these possible variations.

The outcome of the preliminary investigations regarding trimodal traffic on the river Rhine directed us to restrict the investigation of alternative location for a trimodal transhipment point to the areas of Duisburg, Mainz, Mannheim and Basle.

The determination of the price to apply for transhipment between different modes was one of the more discussed and investigated issues during the whole project.

The route to Milan shows a clear advantage on the cost side to use the barge as far as possible along the Rhine. Using the barge up to Basle the possible cost saving is around the 30% compared to the pure-road haulage. Clearly the price to be paid is in term of lower performance on delivery time.

A good price performance is obtained placing the intermediate transhipment barge-rail in Mainz or Mannheim (about 20% lower than road), but with better performance.

Monetary cost is not the only factor taken into account for the choice among alternative modes of transport. Several attempts have been made in order to identify the criteria by which the final decision of mode choice is taken.

For the development of tri-modal chains along the Rhine the most critical aspect is reliability. We observed in fact that many factors such as low and high water and other meteorological factors can produce unforeseen effects over the Rhine navigation, especially far upstream. For this reason a location not too far from Rotterdam could be favoured.

On the basis of the parameters for environmental aspects we performed some comparisons of the possible impact produced by a modal shift from existing chains to alternative chains using barges.

Results, Conclusions and Recommendations

The main results of our work were the following:

?? Only the tri-modal chain is besides rail+road a good choice to have a real reduction of the impact on the environment. The bimodal chain barge+road, in fact, leaves unaltered the heavy impact of the road transport on the alpine environment, which is the most sensitive area along the chain.

?? The most effective location of a tri-modal terminal in terms of reduction of external costs produced by the transport modes is Basle, with a reduction of the external costs of about 44% in comparison to Combined Transport, which is the present terms of reference.

?? The positive impact is, however, limited to the northern section of the corridor, leaving almost unaltered the present situation across the Alps, since most of the traffic considered is already on rail.

?? A more accurate environmental impact assessment would, however, take into account also other side effect of a location of terminal in the middle part of the Rhine course (Mainz, Mannheim), i.e. the shift of present road transport from that regions to Italy/Switzerland due to an increased supply of Combined Transport services set-up to complete the tri-modal chain.

Recommendations:

?? Interoperability is a basic precondition for the success of trimodal transport chains.

?? Infrastructure in trimodal terminals has to correspond to the requirements of both transport modes inland waterway and rail transport. An innovative integrated terminal design reduces conflict points and travel distances.

?? The improvement of barges (design and technique) can be a key for the success of trimodal transport chains.

?? Important for the success of trimodal transport chains is the introduction of an European-wide multi-modal ITU (technical interoperability).

?? Organisation, management and control of trimodal transport chains have to be done in a co-operative way (neutral concerning modes).

- ?? Important for success of trimodal transport chains is the introduction of efficient information systems.
- ?? For the further determination of possibilities for trimodal transport chains specific market studies should be carried out.
- ?? During the implementation phase trimodal transport chains can be supported by policy makers.
- ?? For quantity reasons and capacity of inland waterway trimodal transport chains should mainly be set up on the Rhine axis and in the future also along the Danube.

2 OBJECTIVES OF THE PROJECT

The APRICOT Project is aiming at the systematic integration of the inland waterway system in optimal logistic chains door-to-door outside the narrow scheme of the river Rhine area by linking the benefits of inland navigation to the merits of rail transport to the destination areas in South and Southeast Europe and road service to the final distribution in the local areas. The Project is carried out under the 4th Framework Programme Research and Technical Development of the European Commission, Directorate General Transport.

Fig. 2/1: Candidate Corridors

The APRICOT project has been conceived to meet the challenges set by the Integrated Transport Chain scheme of the 4 FWP to increase the competitiveness of intermodal transport and offering an initial step forward towards the goal of sustainable mobility.

The APRICOT project achieve this through a series of four complementary workpackages designed to

?? isolate the required data base and establish a requirements profile for integrated transport chains.

?? structure advanced trimodal transport chains for the corridors under review from a technical and organisational point of view.

?? prove of cost effectiveness and efficiency of advanced trimodal transport chains

?? evaluate the economical and ecological impact and formulate recommendations for future implementation.

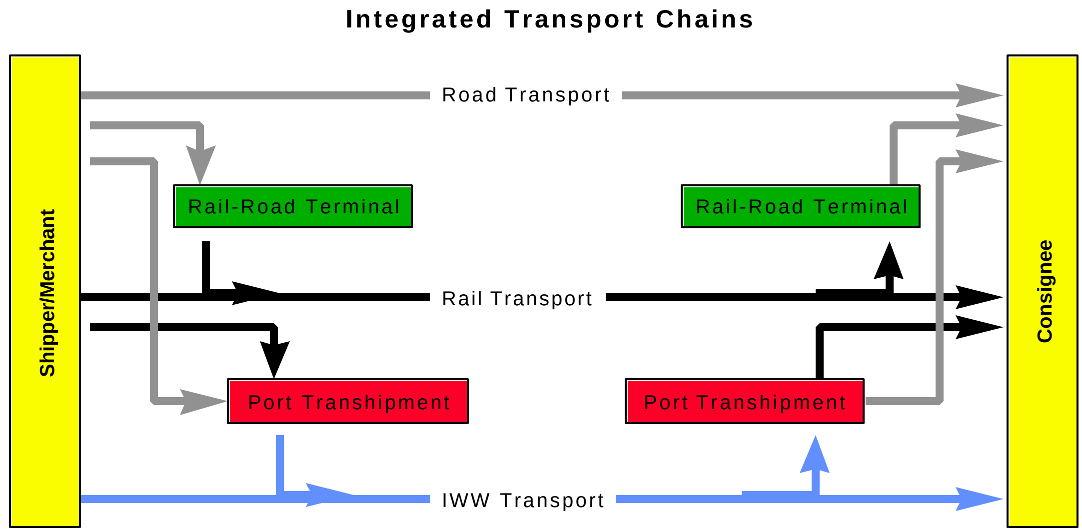

Fig. 2/2: Structuring of Integrated Transport Chains

The workpackages were carried out consecutively. At respective milestones Deliverables containing the Project technical achievements and recommendations were presented.

Work has been carried out by means of studies along the potential Corridors:

?? The Netherlands - Germany - Switzerland - Italy,

?? The Netherlands - Germany - Austria - Italy

?? The Netherlands - Germany - Austria - Hungary.

During the execution of the Project it appeared that most export from Hungary are destined for Austria, Italy and Slovenia whilst most of the imports are from Austria, Germany and Italy. The port of Hamburg estimates that freight transport between Hungary and Germany is growing at a rate of 26% a year with much of this freight to and from the ports of Hamburg and Bremen for shipment to Asia and other world destinations. Therefore the corridor was examined trying to extend the tri-modal concept to this relation while using barge transport on the Danube.

On the one hand, integration of inland navigation in intermodal transport chains in the corridor is suffering from

?? limited infrastructural capacities outside the river Rhine area

?? bridges allowing only to layers of containers

?? time lost for sluicing process

?? limited opening hours

?? limited speed in canals

?? weather conditions jeopardising regular service

?? recent organisation structure of shippers

On the other hand the clear benefits have to be seen in their free capacities and the relatively low costs as well as environmental advantages.

In view of this aspects these actions are carried out on a European level by a trans European consortium consisting of partners of different competencies and experience and the integration of a high-powered user group.

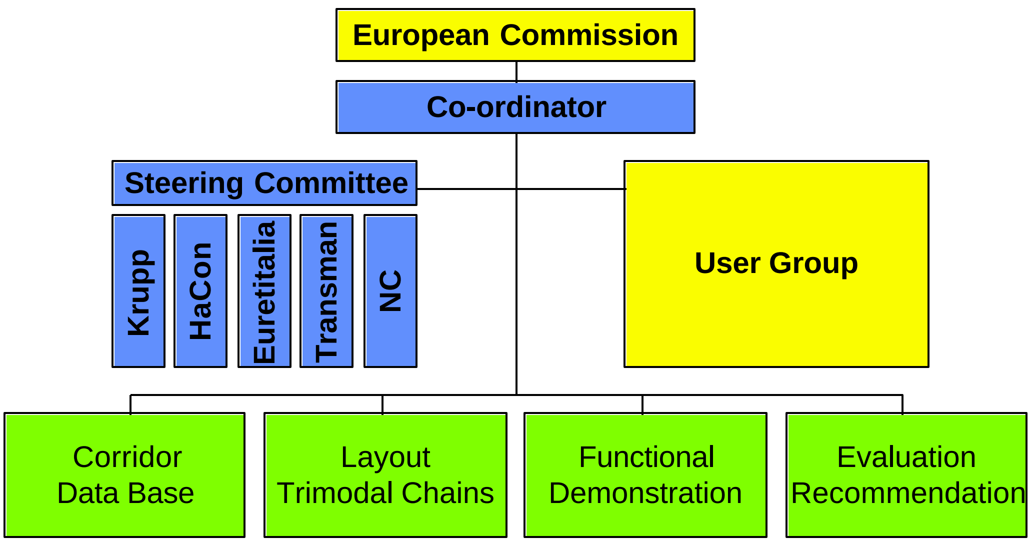

Fig. 2/3: Project Organisations

3 MEANS USED TO ACHIEVE THE OBJECTIVES

In the run-up to the project we agree that we can reach acceptable results if we concentrate our work on the main chains in Europe. For this it is necessary to know the main goods flows from the harbours to the hinterland destinations.

To find a realistic view about the situation in the destinations regions we involve competent consulting partners with extensive experience from this regions into the consortium.

With this partners we used following means to achieve the objectives of the project in the best way:

Data collection with national and European sources, traffic survey, workshops for users, modelling tools for calculation of cost elements, modelling of transport corridors and design of typical layouts of innovative terminals.

Especially for the chain to South-east Europe the partners find out the volume and direction of the real traffic flow from and to the harbours at the Northern Sea. The possible flow along this chain today is very low so that the trimodal traffic there is not worth mentioning. But the regional development in this countries allows the forecast that there will be enough traffic volume for trimodal chains in the future. The consequences for the work to be done: A short and global view to the trimodal chains between east/south-east and the ports of Hamburg and Bremen.

But the main aspects are according to the traffic volumes between Rotterdam and the inland ports at the river Rhine.

One of this main aspects was the decision about the optimal location of the trimodal terminals along the river Rhine. For this several visits were executed by some inland ports. During this visits information regarding the infrastructural situation and possible terminal operation could be collected and a good picture of the differences and common features could be drawn up. The visits were also used to experience bottlenecks of existing situation and desires for future optimum operation.

We included actual users of combined traffic in the discussion about trimodal transport chains along Rhine and Danube.

The analyses carried out in the framework of the whole project together with the response of the expert contacted during two User Group Workshops consolidated the consortium's view about the feasibility of an integrated transport chain including inland waterway services along the routes from Rotterdam to the North of Italy.

4 SCIENTIFIC AND TECHNICAL DESCRIPTION OF THE PROJECT

4.1 FOUNDATION OF POTENTIAL CORRIDORS FOR TRIMODAL TRANSPORT CHAINS [WP 1]

Since several years modal split of goods traffic national in Germany or international always is changing in favour of road traffic. This gives the intention that road traffic will be especially cost efficient and works with acceptable quality. Transport means which will compete in that field of transport have to be more attractive than road transport.

The traffic volume of the different transport modes inform about the importance of the modes and gives information what kind of traffic can be changed to rail and inland waterway.

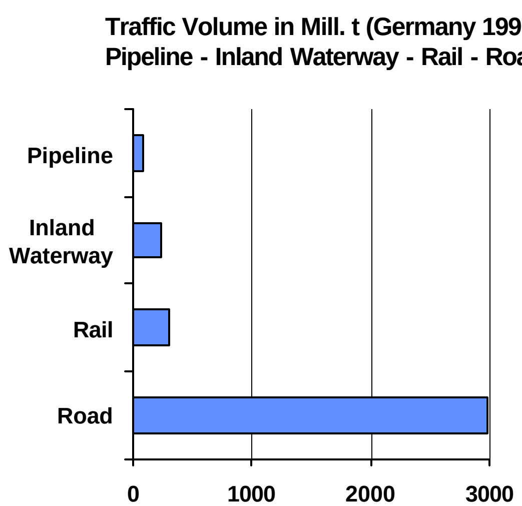

Fig. 4.1: Traffic Volume in Mill. t

4.1.1 Reasoning Inland Waterway by Environmental Aspects

The integration of Inland Waterway Transportation in multimodal transport chains is a function of price and environmental aspects.

At least the great capacities of large rivers with their high assessment are a good argument for acceptance of those transport chains.

In winter and spring inland waterways are dependent on weather. High and low water and ice impair the reliability of inland shipping on smaller rivers and canals.

Low velocity, driving against the flow and sometimes locks are important arguments and reasons for longer transport time indeed. It seems that punctuality can be reached only near by the coast. It is there well related to land traffic. Time for arrival is not to define exactly, but a final arrival time normally will be reached.

That are the reasons for the attractiveness of using inland waterways:

?? Lower costs for transport chain

?? Environmental aspects

?? Available transport capacity of the great rivers

4.1.1.1 Comparison of External Factors Inland Waterway - Rail - Road

For a judgement about preferences of transport modes beside volume, network and modal split and the utilisation of inland waterways for trimodal chains it is necessary to look for environmental factors and useful parameters:

?? Definition of the relevant environmental parameters for the selected means of traffic and routes

?? Estimation of the influence of the selected parameters

?? Quantifying the means of traffic related environmental influences

Proposal for consideration of external costs in economical assessment

Which parameters can be included in a comparison of external costs and which parameters are not external but internal although they are relevant for environment. Especially all costs will be external, if the partners of traffic don't include this costs in their calculation. The following remarks inform about the chosen parameters:

Net Energy

Beside the real external costs also the external effective but internal calculated costs of energy will be compared. Parameter is the specific consumption of net energy in kJ per tkm. Road traffic needs 2290 kJ/tkm, rail traffic 566 kJ/tkm and inland waterway traffic 464 kJ/tkm.

Accidents

Low level of accidents will be the best recommendation for means of transport. Means of transport with a high level of accidents especially with death people passes for insecure and will not be recommended. The real relation of accident costs is in EURO/tkm 0,913 for road, 0,062 for rail and 0,005 for inland shipping.

Noise

Goods traffic means moving so it is linked to noise, but the noise is very different for several transports means. As a standard we used the traffic performance of a unit. The noise of air freight is dominated from noise of the engine, the same we can find on a very low level by inland shipping. Rail traffic is dominated by noise of the wheels. Road traffic has noise from engine and wheels.

Air Pollution

Traffic is moving and for this it needs energy. This energy is concentrated in fuel or electricity. For goods traffic the used energy types cause always air pollution, but road traffic causes most of the air pollution and makes five times more CO_2 than rail traffic or inland shipping.

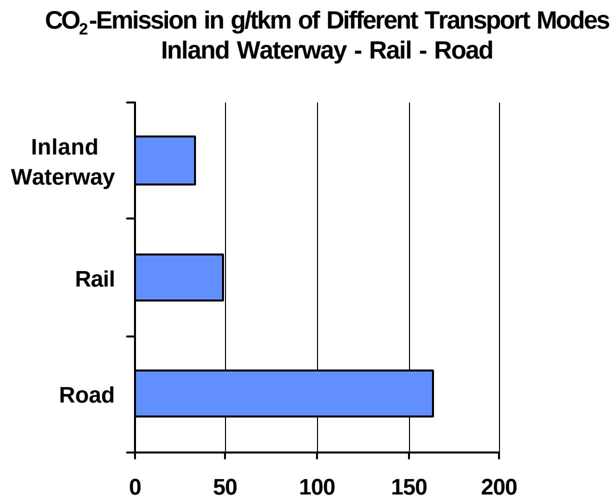

Fig. 4.1.1.1: CO_2-Emissions in g/tkm of Different Transport Modes

Surface Impairment

Building of new traffic ways creates impairment of surface. Reasons are pavement, redesigning and changing of biotopes. For example canalisation:

?? Protection of riverbanks against wave action and sufficient draught needs canalisation, then there are problems, if the rivers are in flood and lowlands at the rivers as backwash basin are missing

?? Ecological problems because of missing bank biotope

?? Ecological problems because of depression of riverbed

?? Ecological problems because of control dams and sluices

?? Optical impairment of the landscape

Area Cutting

Traffic ways usual are cutting landscape in smaller and less efficient usable areas. This effect is not existent by air freight, sea- and inland shipping on natural water. Canals are unnatural buildings and in the same situation as rail and road.

Area Consumption

Different transport means are using per unit different space. This area cannot be used from other side.

Optical Impairment

New traffic ways are changing the optical impression of landscape. Highways and railway tracks are surely an optical impairment, but straight canals are an optical impairment too.

Parameters which are described before can be collected in a cost benefit analysis. All influences are reduced to the unit EURO per 1000 tkm. Summarising all influences inland waterway needs 1,17 EURO/1000 tkm, rail needs 4,88 and road 21,89 EURO/1000 tkm as external costs.

4.1.2 Goods Flow Analysis for Corridors

It is the objective to draw up the required database of goods flows, and to make a first analysis of the freight transport market along the corridors under investigation.

The aim of this analysis is to highlight the potential demand characteristics and the areas of future development of tri-modal integrated transport chains.

The collection of the basic information from road, rail and present combined transport along the corridor and from inland flows attracted/generated by the Port of Rotterdam, has been completed with a sufficient level of detail for the reference year 1994, which is for the moment the last year for which detailed statistics are available for all modes of transport.

An analysis of containerisable flows presently on road, that could be attracted by the proposed chain has been performed, and is presented in aggregate form.

The information collected in this task, together with of the results of geographical and environmental investigation performed in parallel tasks will form the basis for the selection of the most promising terminals to be further analysed for a more detailed proposal of an effective tri-modal chain.

Most of the data needed for the task was available from previous studies, or was successfully gathered by partners of the project.

The main source of information is the database provided by the German Bureau of Statistics. The database in our possession is very detailed: the year of reference is 1993; it contains data at a region to region (RR) level, by 52 NSTR groups. The flows registered are domestic, imports, exports, and cross trade for the modes Road, Rail and Inland Waterway.

An additional source of information was the IMPULSE database, which incorporated the above data at a more aggregate level, but which provide also additional information for traffics to/from Rotterdam. We used it for some evaluation of road traffic flows.

As far as Combined Traffic flows are concerned, for the Rotterdam-based flows we used data collected from the Dutch railways. The spatial aggregation of flows is very detailed, so we could identify the traffics of interest along our corridors.

Combined Transport traffics to/from German terminals were aggregated from different sources for the Year 1994.

Additional information about Hungarian traffics have been included in the detailed database that will be used in the prosecution of the project.

4.1.2.1 Corridors Selection

The determination of the region in the corridors to be investigated has been carried out in co-operation with the geographical evaluation.

The areas, selected on the grounds of the economic importance and the current volume of traffics are the following:

- Netherlands: Rotterdam-area (from/to see below)
- Switzerland: Basle/Zurich-area
- Austria: Linz/Salzburg-area, Vienna-area
- Hungary: Sopron-area, Budapest-area
- Italy Milan-area, Verona/Padua-area, Bologna-area

Transport volume for tri-modal transport chains are the dispatched and received volume of traffic between Rotterdam and the mentioned regions of Switzerland, Austria, Italy and Hungary. In addition to that, the volume of traffics attracted by the intermediate tri-modal terminal and coming/going to/ from the above mentioned regions is to be taken into account.

Therefore an important issue for an effective and successful organisation of a tri-modal transport chain along the Rhine is the choice of the most suitable location of the IWT/rail terminal. The first selection of candidate location include the following areas:

- Duisburg
- Cologne
- Koblenz
- Mainz/Frankfurt
- Mannheim/Ludwigshafen

For each of the considered areas an identification of possible areas of attraction has been detected selecting the regions of interest; for the goods traffic with Austria and Switzerland the catchment area is about 75 km around the terminals, for Italy and Hungary the catchment area is about 150 km, due to relatively long total trip lengths.

From the analysis of available data and suggestion form Hungarian experts, we have decided to take into account also the corridor Hamburg-Hungary, which at the moment seems the most important relation for overseas traffics to/from Hungary. This corridor could also serve the traffics to/from Romania and Bulgaria. The idea of a tri-modal chain along this corridor is to use the rail until a port on the Danube, to be selected yet, and then the Danube until Budapest and further downstream.

4.1.2.2 Containerisation Factors

The approach adopted for the evaluation of the potential demand of transport services follows the pragmatic approach proposed in the framework of the IMPULSE project.

The methodology, adopted also by most operators for the practical estimation of the potential market for new services they are going to introduce, is based on the selection of the commodities that can be attracted by the service, and the analysis of the present flows between the Origin-Destination couples to be served, together with some information of the general market development trends.

During the IMPULSE project an evaluation of the kind of commodities that can be attracted by combined transport, were defined by means of the estimation of a series of *containerisation factors.*

Containerisation is defined as “the ability of goods to be transported in intermodal transport units; this in general depends on the characteristic of goods and the distance. The dependency on characteristics of goods mirrors weight, shape, state of aggregation, type and value of goods.

4.1.2.3 Analysis of Freight Flows Along the Corridors

4.1.2.3.1 Present Freight Flows on the Rhine

The Rhine is the most important European inland waterway. Even though it is considered an important mode of transport for container flows, the present volume is mainly to inland ports within short distances.

Most of the traffics along the river are bulk materials which are not containerised.

The total flows of goods from the Rotterdam area to the region of influence of the candidate tri-modal terminals is presented in the following tables. It has to be noted that the catchment areas are overlapping and the total volume is overestimated.

O	D	IWT Tons/year
Cologne	Rotterdam	4.816.684
Duisburg	Rotterdam	8.637.002
Frankfurt/Mainz	Rotterdam	1.416.752
Koblenz	Rotterdam	889.248
Mannheim	Rotterdam	2.001.087

Tab. 4.1.2.3/1: Freight flows by inland waterway from German terminal's catchment areas to Rotterdam, 1993

O	D	IWTTotal
Rotterdam	Cologne	32.493.734
Rotterdam	Duisburg	34.913.410
Rotterdam	Frankfurt/Mainz	6.151.255
Rotterdam	Koblenz	3.886.281
Rotterdam	Mannheim	7.872.582

Tab. 4.1.2.3/2: Freight flows by inland waterway from Rotterdam to German terminal's catchment areas, 1993

Reliable statistics about present container flows along the Rhine are not available. The usefulness of official statistic is limited as it is based on data provided by public ports, only, and we have to rely on estimations. Most of them are published by experts of the Port of Rotterdam. Some figures collected by the IMPULSE project, which can be considered as an upper ceiling of current estimations are presented below.

The Rhine valley container traffic is estimated in 1995 at 970 000 containers moved; this would be equal to rather 1 300 000 TEU. All these containers are ISO containers carrying export or import cargo.

An estimation of the European sea-ports contribute to the Rhine container traffic is the following (in 1995):

?? Rotterdam 700 000 containers

?? Antwerp 240 000 containers

?? Amsterdam 30 000 containers

4.1.2.3.2 Present Combined Traffic Flows Along the Corridors

In the following some information about the existing intermodal traffic along the corridor is presented. This traffic is today exclusively combined traffic rail-road.

Origin	Destination	ITU	Wagon	Tons
Rotterdam	**Austria**	**8225**	**6607**	**130890**
Rotterdam	Wien	2036	1583	41044
Rotterdam	Linz	835	673	15509
Rotterdam	Salzburg	620	485	7340
Rotterdam	**Bulgaria**	**200**	**123**	**3733**
Rotterdam	**Hungary**	**515**	**349**	**7525**
Rotterdam	Budapest	139	111	2272
Rotterdam	Sopron	269	161	4350
Rotterdam	**Italy**	**31796**	**19168**	**583953**
Rotterdam	Milan	28789	17032	527516
Rotterdam	Verona/Padova	799	568	14886
Rotterdam	Udine/Trieste	159	83	2983
Rotterdam	Bologna	512	393	9021
Rotterdam	**Romania**	**113**	**76**	**3102**
Rotterdam	**Switzerland**	**8591**	**6915**	**127032**
Rotterdam	Basle	622	486	9750
Rotterdam	Zurich	408	351	4.620
Total export traffic to areas of interest		**35.501**	**22.125**	**646.126**

Tab. 4.1.2.3/3: Annual Combined Traffic flows from Rotterdam to selected destination areas in 1994 (source: Dutch Railways Statistics)

Origin	Destination	ITU	Wagon	Tons
Austria	**Rotterdam**	**4.665**	**3.061**	**85.429**
Wien	Rotterdam	1063	710	8732
Linz	Rotterdam	1292	837	30540
Salzburg	Rotterdam	229	156	3702
Bulgaria	**Rotterdam**	**6**	**3**	**26**
Hungary	**Rotterdam**	**1141**	**862**	**19264**
Budapest	Rotterdam	317	280	7.309
Sopron	Rotterdam	588	366	5.810
Italy	**Rotterdam**	**37403**	**20349**	**589170**
Milan	Rotterdam	30225	15692	472741
Verona/Padova	Rotterdam	3227	2194	51318
Udine/Trieste	Rotterdam	90	39	556
Bologna	Rotterdam	2213	1346	46173
Romania	**Rotterdam**	**2**	**2**	**6**
Switzerland	**Rotterdam**	**10131**	**7618**	**164097**
Basle	Rotterdam	167	108	2475
Zurich	Rotterdam	255	194	4251
Total import traffic from areas of interest		**39.674**	**21.927**	**633.639**

Tab. 4.1.2.3/4: Annual Combined Traffic flows to Rotterdam from selected destination areas in 1994 (Source: Dutch Railways Statistics)

Relation	Operator		Trains	TEU
Budapest - Sopron - Hamburg	Kombiverkehr		513	25121
Sopron - Hamburg	Intercontainer		-	30774
Mainz - Alsancak Sopron - Turkey/Greece	Intercontainer Intercontainer	transit	52 326	5346 12696
Rotterdam - Sopron	Intercontainer		-	6222
Vienna - Halikali	Ökombi	transit	110	2382
Regensburg - Pitesti	Intercontainer	transit	262	5676
Sopron - Bukarest	Intercontainer		205	9180
Budapest - Koper	Intercontainer		-	-
Százhalobatta (Hungary) - Verona	CEMAT		54	1944
Verona/Udine - Alba Iulia	CEMAT	occassion	-	-
Verona/Udine - Zalau	CEMAT		-	-
Budapest - Moscow			-	-

„-“ = no data available.

Tab. 4.1.2.3/5: Annual Combined Traffic flows on Hungarian relation to/from Hungary 1997 (source: Transman based on MAV Freight Statistics)

The analysis shows, that apart from some freight „highways“ with obviously interesting time-price offers, the combined traffic is not very good developed. It is therefore interesting to gain a survey on the potentiality of the transport which may be attracted by compatible offers.

4.1.2.3.3 Containerisable Flows

The analysis of the containerisable flows that could be attracted by the new tri-modal services has been performed following the methodology of EU-Project IMPULSE.

Tables 4.1.2.3/6 and 4.1.2.3/7 show the calculation of import and export freight flows from the Rotterdam area to the final destination of the corridors that are currently transported by Road but could be containerised and therefore transported by a combination of different modes.

Origin	Destination	Road Containerisable flows
Rotterdam Region	WIEN	39.947
Rotterdam Region	SALZBURG	1.337
Rotterdam Region	**AUSTRIA TOTAL**	**111.233**
Rotterdam Region	**UNGHERIA**	**15.881**
Rotterdam Region	Milan	122.898
Rotterdam Region	Verona/Padova/Udine/Trieste	110.439
Rotterdam Region	Bologna	46.846
Rotterdam Region	Italy unknown	27.873
Rotterdam Region	**ITALIA TOTAL**	**390.629**
Rotterdam Region	**SWITZERLAND**	**129.169**

Tab. 4.1.2.3/6: Containerisable annual road freight traffics from the area of Rotterdam (tons, year 1994 – source: Euretitalia elaboration on Dutch Central Bureau of Statistics data).

Origin	Destination	Road Containerisable flows
WIEN	Rotterdam Region	5.628
AUSTRIA TOTAL	**Rotterdam Region**	**78.955**
UNGHERIA	**Rotterdam Region**	**26.117**
Milan	Rotterdam Region	28.147
Verona/Padova/Udine/Trieste	Rotterdam Region	31.781
Bologna	Rotterdam Region	16.536
Italy unknown	Rotterdam Region	7.854
ITALIA TOTAL	**Rotterdam Region**	**113.875**
SWITZERLAND	**Rotterdam Region**	**48.239**

Tab. 4.1.2.3/7: Containerisable annual road freight traffics to the area of Rotterdam (tons, year 1994 – source: Euretitalia elaboration on Dutch Central Bureau of Statistics data)

The analysis of the data contained in the tables shows a rather unbalanced market, with an amount of traffic of about 650.000 tons/year in export and 270.000 in Import. Considering that only a share of this market could be attracted by the new proposed tri-modal chain, we highlight the importance of a good selection of the location of the intermediate tri-modal terminal, in order to combine these traffics with container traffics from Rotterdam to the intermediate terminal, for the first part of the chain (the one using the IWT mode) and with the traffic from the terminals' catchment area to peripheral corridor regions along the second part of the chain (the one using the rail).

An analysis of containerisable flows to/from candidate terminals has therefore been conducted.

All the traffics refer to year 1993.

As an indication for the evolution of the traffics since 1993 we can consider that the annual growth rates for road are higher than any other mode of transport. (+3.8% over the period 1990-1995, to be compared with the -2.9% of railways, +0.6 of inland waterways and + 3.2% of pipelines -source: “EU Transport in figures”, EC-DGVII, 1997).

4.1.2.3.4 Possible Goods Flow South-East to Hamburg

A final analysis we performed is related to the flows along the corridor Hamburg-Hungary The containerisable flows are calculated with the same methodology outlined above, and the results are shown in the following tables. The value of the flows result sensibly higher than those to/from Rotterdam, but as in the case of the corridors along the Rhine, the most appropriate selection of the tri-modal terminal must be carried out carefully in order to maximise the possible impact of the chain.

Origin	Destination	Road Containerisable flows
HAMBURG	BULGARIA	8.788
HAMBURG	ROMANIA	11.956
HAMBURG	HUNGARY	93.618

Tab. 4.1.2.3/8: Annual road freight traffics from the area of Hamburg that could be containerised (tons, year 1993 – source: Euretitalia elaboration on German Statistics data).

Origin	Destination	Road Containerisable flows
BULGARIA	HAMBURG	11.598
ROMANIA	HAMBURG	18.753
HUNGARY	HAMBURG	75.394

Tab. 4.1.2.3/9: Annual road freight traffics from the area of Hamburg that could be containerised (tons, year 1993 – source: Euretitalia elaboration on German Statistics data).

After having analysed container traffic data to/from Hungary it was found that the port of Rotterdam does not play a particularly important role in freight transport. This holds also for other CEEC countries.

This introduction does not speak about possible evolution of traffic in this corridor as it is beyond the scope of this study. It is noteworthy to mention however, that recent development shows the slow increase of traffic between the CEEC countries and the port of Rotterdam particularly in terms of overseas traffic.

Present experience however shows that due to traditional factors the main sea port of these countries and especially Hungary is Hamburg in the first place and Bremen in the second. The next table is to support this idea in case of Austria:

	Total flow via Hamburg	Total flow via Rotterdam
1960	805621	10320
1970	1343161	64701
1980	2287474	40749
1989	1028087	153000
1995	781000	282000
1996	876852	135000
1997	979028	258000

Tab. 4.1.2.3/10: Comparison of Freight Flows between Austria and to Sea Ports: Hamburg and Rotterdam (figures in tons including import + export)

It has already been stressed that traditions play a very important role in the shipping industry. Before the completion of the Danube-Maine-Rhine canal Hungary had no waterway connection to Rotterdam and Hamburg was closer to Hungarian cities by rail and road transport than Rotterdam. Hungarian shippers therefore used Hamburg as Hungary's primary sea port and traditional connections and co-operations evolved between Hamburg and Hungary. It is not necessary to stress the significance of these traditional connections.

Currently shuttle container trains travel regularly to Hamburg from Budapest/Sopron much more frequently than to Rotterdam, which reflects the fact mentioned above. This form of transport is very comfortable and convenient for all stakeholders.

Adapting the Trimodal Idea to the Present Conditions

In case of the analysed corridor there are some additional factors that support the idea of using inland navigation and perhaps prefer it to other modes:

?? *poor security of rail transport in the CEEC region*

?? *Insufficient transport times and travel conditions on road*

A possible way of developing a trimodal chain is to collect container traffic from Southeast Europe beyond Hungary (Romania, Bulgaria, Serbia, Ukraine etc.) on the Danube by means of a liner service. Containers were then transported to either one of the upper-Danube ports (Budapest, Gyor, Vienna, Linz, Passau etc.) where it could be transhipped to rail and taken to Hamburg together with goods collected in Hungary or perhaps in Austria/Germany.

Considering the fact that containers were transported to/from the southern inland port by truck this way the chain becomes a (road)-water-rail chain, which differs from the original idea of APRICOT (road-rail-water) but still follows the principles behind the trimodal concept.

Such a chain of course requires the development of a trimodal inland port with the appropriate container handling devices and storage area.

To support the applicability of trimodal transport chains in the south-eastern European area it is necessary to carry out calculations that prove both the financial and the socio-economic profitability of the chain.

The investigations to explore possibilities of applying the trimodal transport chains lead to several conclusions:

- Following the most important container-flow route it is possible to establish a trimodal freight transport chain as follows: road pre/end haulage in south-east Europe, then barge transport on the Danube to the trimodal transhipment port (five possibilities between Budapest and Regensburg) where containers are transhipped to trains and taken to Hamburg;
- In general the trimodal transport chain is considerably cheaper then rail and especially road and is much more secure in terms of robbery. However on the other hand it is much slower.
- Calculations were made to establish 'generalised transport costs' which include all important factors to evaluate the options and investigate the viability of the trimodal idea.
- It was proven that trimodal transport chains are worth to establish if those flows where the value of time does not exceed Euro 2 per hour for the goods and the resulting flow can fill the capacity of a regular liner barge service.
- Examining the total flow between Germany and south-eastern Europe it is envisaged that in the near future sufficient amount of traffic can be attracted and shifted to water to fulfil the above conditions.

These preliminary ideas show that it is worth to deal with establishing the trimodal chain in this region but further investigations should be carried out to determine more accurate results. It will be necessary to carry out a survey to interview potential users of the new system and find out the exact amount of traffic that can be shifted to the new mode.

4.1.3 Geographic Evaluation of the Corridors

Main task of this work package is the drawing up of a database for a theoretical test model in respect to geographical and infrastructural problems to be expected along the routes between the selected terminals. This test model quantifies the resistance in terms of distance, travel time and specific time losses along the selected routes.

One important basis for the work to be done in this work package is therefore the recommendation of potential sites for trimodal terminals as a basis for a first evaluation concerning journey time and comparison of different transport chains between the regions.

4.1.3.1 Trimodal Terminals

Interfaces for efficient trimodal transport chains are inland ports with a high quality integration between inland navigation (waterway-network) and rail transport (rail-network). A further important key point is the efficient transhipment between the transport modes

The „European Federation of Inland Ports“ has worked out a Masterplan for „multimodal freight centres in inland ports“ which is based on a network of inland ports in the EU and parts of Middle- and East-Europe. The infrastructure of these inland ports is suitable for the needs of intermodal transport which means, that they are offering the technical and infrastructural standards necessary for trimodal transport chains.

4.1.3.2 Inland Waterway Network

The European waterway network with its artificial and natural waterways is shown in figure 3/1. In the corridors to be analysed in the APRICOT Project a point to point transport by inland navigation is possible for the traffic from Rotterdam to Switzerland, Austria and Hungary.

Bedeutende europäische Wasserstraßen

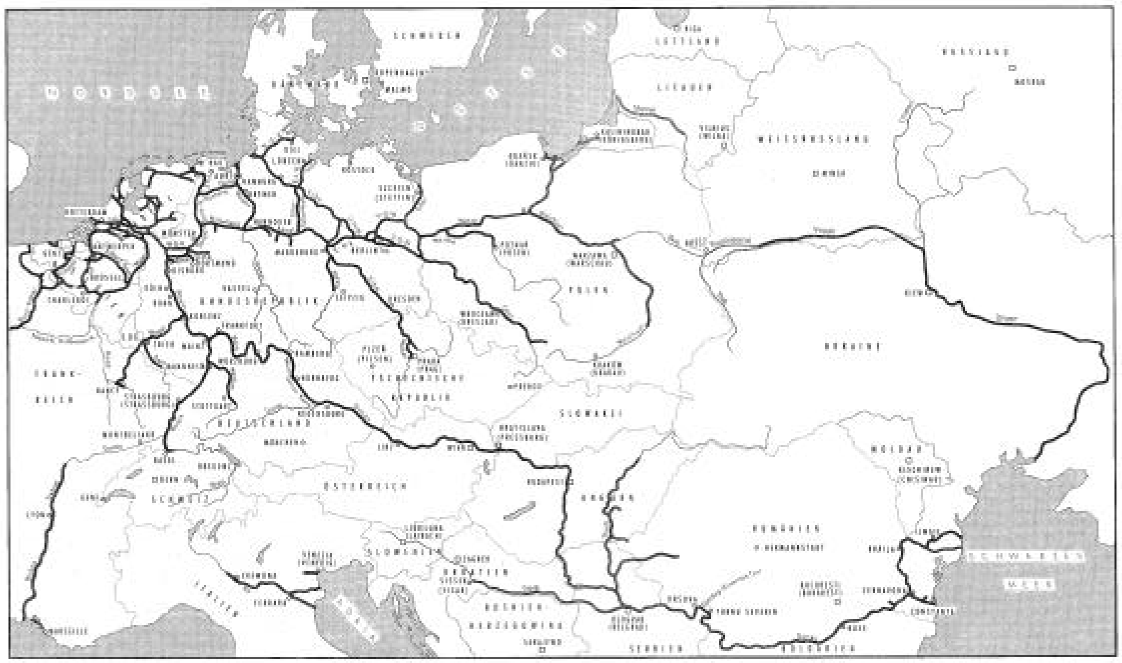

Fig. 4.1.3.2: European Waterway Network

Rhine

The river Rhine is the inland waterway with the highest traffic density in Europe and has a considerable importance for the traffic between the Netherlands and Germany, Switzerland and France. Furthermore there is the possibility to reach Austria, Slovakia, Hungary and the other Balkan States via Main and Main-Danube-Canal without changing means of transport.

The Rhine can be separated into 3 main areas with importance for inland navigation:

?? Upper Rhine (Basle– Frankfurt)

?? Middle Rhine (Frankfurt – Cologne) and

?? Lower Rhine (Cologne – Rotterdam/Antwerp).

The area between Upper Rhine and the confluence in the North Sea has a length of about 800 km.

Main and Main-Danube-Canal

The Main is part of the Rhine-Main-Danube-connection. The Main flows into the Rhine near the city of Mainz. Between Mainz and Bamberg (about 380 km) the Main is regulated by sluices. The Main-Danube-Canal connects Main and Danube between Bamberg and Kehlheim. This artificial waterway was opened in 1992 and has a length of 170 km.

Danube

The Danube is an important waterway for the connection with the Eastern Europe countries. Between Kehlheim an the confluence in the Black Sea it is about 2.400 km in length.

4.1.3.3 Infrastructural Parameters of the Inland Waterways

Classification of Waterways

European inland waterways are divided into specific classes. The specification bases on the measurements of barges such as length, width, draught and height. An important criterion with respect to container transport is the barges height and air draught.

Suitability of Inland Waterways for Container Transport

Standard for the suitability for container transport is the maximal amount of container layers on board of the barge which is affected by the clearance height of bridges:

?? 5,25 m for ships with 2 layers

?? 7,00 m for ships with 3 layers

?? 9,10 m for ships with 4 layers

These specifications are basing on a mix of loaded and empty containers from 50 %.

On the Rhine from Strasbourg to Rotterdam containers can be shipped with 4 layers. Between Strasbourg and Basle the layers are reduced to a maximum number of 3.

The Main and the Main-Danube-Canal are continuous passable only with 2 layers. In consequence there are substantial restrictions regarding the utilisation of capacity of the ships and as a result of this fact corresponding higher costs per container.

On the Danube in the range between Regensburg and Budapest there is a limitation to 3 layers. Most of the ships operating on the upper Danube are carrying 2 layers.

Low Water

Low water causes a reduction of the possible payload of vessels. As a result the transport cost per units are rising (low water surcharge). On the Lower Rhine section there are in principle no restrictions concerning low water. Bottleneck is the range between St. Goar and Mainz where the fairway has the lowest depth. Standard for the calculation of low water surcharge is the Kauber Pegel with an altitude of 1,41 mStandard on the Danube for the calculation of low water surcharges is the Pfellinger Pegel with an altitude of 3,26 m.

Ice-Drift

The risk of ice-drift during winter and possible complete inhibition of the waterway is of importance mainly for the Main-Danube-canal. During the winter period 1995/1996 and 1996/1997 this waterway was completely closed for navigation 47 respectively 42 days.

Sluices

On the Lower Rhine and Middle Rhine navigation is not obstructed by sluices. The Upper Rhine between Basle and Iffezheim (south of Karlsruhe) is regulated by 10 sluices.

On the Main and Main-Danube-Canal from Rhine to Regensburg a barge has to pass through 52 sluices, thereof 16 on the Main-Danube-Canal between Bamberg and Kehlheim.

The Danube between Regensburg and Budapest is regulated by 13 sluices

Charges for Inland Navigation

Inland navigation on the Rhine between Basle and the North See is free of charges as a result of multi-national agreements settled in the „Mannheimer Akte".

For sailing on the Main and the Main-Danube-Canal shippers have to pay charges for the use of the waterway and the use of sluices. The charge is 0,1 DM per TEU-km (0,05 ECU per TEU-km) for **loaded** containers.

Sailing on the Danube is in principle free of charges with the exception of the crossing of borders to outside EU-countries (for example Austria and Slovakia and Slovakia and Hungary). For the clearing formalities the vessel has to make a stop on a berth. The charge for using the berth is about 60 DM (30 ECU).

Inland Navigation Distance and Journey Time

The average distances on inland waterways between inland ports are shown in table 4.1.3.3/1. The determination was made between Rotterdam and chosen inland ports in Germany and respectively in the corridors.

Rhine	Duisburg	Cologne	Koblenz	Mainz	Mannheim Ludwigshafen
Distance in km Sluices	195 -	290 -	410 -	500 -	570 -
Main Main-Danube-Canal	Frankfurt	Nuremberg			
Distance in km	540	960			
Sluices	3	41			
Danube	Regensburg	Linz	Vienna	Budapest	
Distance in km	1.090	1.345	1.540	1.815	
Sluices	52	58	64	65	

Tab. 4.1.3.3/1: Distances and resistances between Rotterdam and selected inland ports

The journey times are influenced by different parameters. Of high importance is the flow direction of the rivers. On the Rhine for instance is the average downriver speed is doubly higher than upriver. Furthermore there are influences because of sluicing times for instances on the Main and Main-Danube-Canal, stopovers in ports, limited speed in channels and specific maximum speed of the vessel. In table 4.1.3.3/2 typical journey times between Rotterdam and the inland ports are shown without operational stops.

Rhine	Duisburg	Cologne	Koblenz	Mainz	Mannheim Ludwigshafen
From Rotterdam	24 h	34 h	44 h	52 h	60 h
to Rotterdam	12 h	17 h	22 h	26 h	30 h
Main Main-Danube-Canal	Frankfurt	Nuremberg			
From Rotterdam	56 h	134 h			
to Rotterdam	28 h	99 h			
Danube	Regensburg	Linz	Vienna	Budapest	
From Rotterdam	154 h	169 h	179 h	193 h	
to Rotterdam	120 h	155 h	185 h	232 h	

Tab. 4.1.3.3/2: Non stop journey times

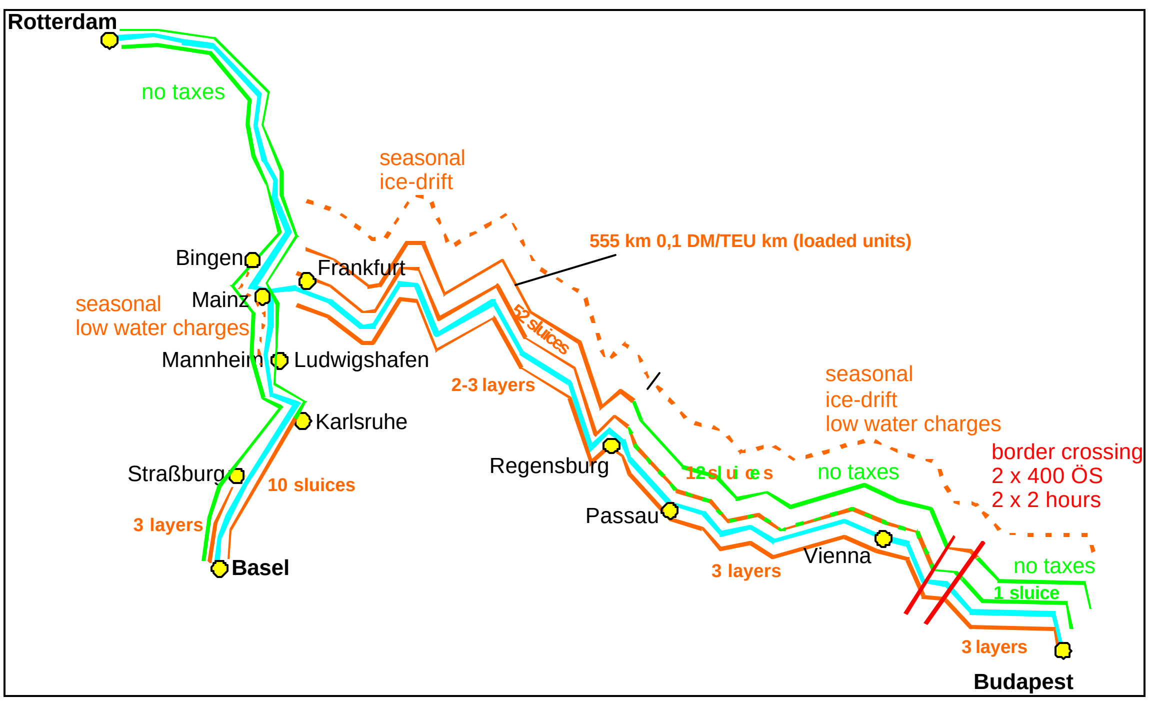

Fig. 4.1.3.3/3: Summary of resistance on inland waterways

Figure 4.1.3.3/3 gives a summary of the general conditions concerning container transport by barges on Rhine, Main, Main-Danube-Canal and Danube. The areas marked in green are inland waterway sections with no or low resistance, the areas marked with red have high resistance.

This analysis shows, that the Rhine - especially the Lower and Middle Rhine - offers optimal conditions for container transport. Nameable resistance through sluices and capacity reduction are existing on the Upper Rhine south of Karlsruhe. Container transport on the Main and Main-Danube-Canal has relatively high resistance because of journey time, capacity reduction, reliability and resulting transport costs.

For these reasons for building up of competitive trimodal transport chains in the corridors inland navigation should be taken into consideration only on the Rhine!

4.1.3.4 Structural Parameters of Transport Means

Rail Transport

In intermodal transport road rail basically there are restrictions in transport through the alpine countries Switzerland and Austria to Italy. These restrictions are results of reductions in train length, train weight and reduction in height of the units because of tunnels.

In combined transport the maximum length of regular trains is 700 m, the maximum total weight is 1.600 t. On the assumption that the average

?? length of a wagon is 17 to 18 m

?? capacity of a wagon is 1 FEU (40`)

?? payload of a FEU is 16 – 20 t

?? dead weight is 20 t (wagon and container)

the whole train capacity is 38 to 40 FEU.

The of conditions (reductions) in alpine transit through Switzerland and Austria are shown in the following table:

via Switzerland (St. Gotthard)	**via Austria (Brenner)**
max train length 600 m	max. train length 550
max. total weight 1.000 – 1.300 t	max. total weight 1.000 – 1.300 t
resulting average train capacity	
25 – 33 FEU	**25 – 30 FEU**

Tab. 4.1.3.4: Resistance in alpine transit

Through Switzerland (via St. Gotthard) the train length is reduced to about 600 m, the maximum train weight amounts 1.000 to 1.300 t. The resulting train capacity is 25 – 33 FEU per train.

Through Austria (via Brenner) the maximum train length is about 550 m, the total maximum train weight is about 1.300 t. For intermodal trains the capacity is reduced to about 30 FEU.

Road Transport

In road transport essential restrictions are existing in transit through Switzerland and Austria.

Switzerland

Road transit through Switzerland is subject to authorisation. The road freight traffic concerning technical and administrative regulations differs partly extremely from those in the EU. In respect of the vehicle measurements the Swiss regulations are the same as in the EU. As maximum total weight of trucks Switzerland allows only 28 t which means a payload of about 15 t. An exception of this rule are admitted on the axle Basel – St. Gotthard – Chiasso when e.g. the capacity in combined transport is fully occupied. At any rate a special case authorisation is necessary.

Beside the usual driving bans on weekends and holiday in Switzerland has special driving bans during the night:

- in summer (01.04. to 31.10.): 10 p.m. – 4 a.m.
- in winter (01.11. to 31.03.): 9 p.m. – 5 a.m.

In road transit through Switzerland the following costs will be raised

- about 20 sfr per journey
- about 50 sfr for 40 t exception
- about 80 sfr for exceptions from night driving bans

Austria

For the road traffic in Austria the technical regulations concerning vehicle measurements and weight are similar to other EU-countries.

Road transit through Austria requires a license. In this context Austria has special rules. Basis for the allowed number of transit journeys are „Ökopunkte“ which are charged for one trip. This system rests upon on the specific emissions (exhaust fumes and noise) of the trucks. That means that by use of trucks with low emissions more transit journeys are possible than for vehicles with high emissions. When intermodal transport is used, no „Ökopunkte“ will be charged.

The use of the Austrian road network is liable to charges amounting to about 80 Ös. Furthermore depending on the chosen route toll will be charged. For using the Brenner-highway depending on vehicle type and time of day the following costs have to be calculated

?? 1.150 ÖS for a trip between 5 a.m. and 10 p.m.

?? 1.500 ÖS for a trip between 5 a.m. and 10 p.m. with high emission vehicles

?? 2.300 ÖS for a trip between 10 p.m. and 5 a.m.

The use of the Brenner route during the night is only allowed with low emission vehicles, the maximum speed in this period is reduced to 60 km/h.

Besides the described restrictions in alpine transit there are further resistors in road transit through Germany. Because of the central geographic position in Europe Germany has a high share of transit on its highway network. Depending on the traffic relation and the chosen route there are several bottleneck sections on which the risk of traffic congestion is relatively high. For the traffic between the chosen corridors the following bottlenecks on the German highway network are having relevancy:

?? Rhine/Ruhr-area (western Ruhr-area in south direction to Bonn)

?? Rhine/Main-area (Wiesbaden/Mainz/Frankfurt/Mannheim-range)

?? Rhine/Neckar-area(Mannheim/Stuttgart-range)

?? Nuremberg-area

?? Munich-area

Nameable time losses for border crossing inside the European countries and in traffic with Switzerland do not exist. On this account stopovers at the border are only taken into consideration between Austria and Hungary. The time need for this border crossing is on the average about 5 hours.

4.1.3.5 Determination of Average Distances and Resulting Journey Times

Rail Transport

The determination of distances on rail is shown in table 4.1.3.5/1.

	Rotterdam	Duisburg	Cologne	Koblenz	Frankfurt Mainz	Mannheim Ludwigshafen
Basle	850 km	600 km	530 km	450 km	350 km	250 km
Zurich	940 km	710 km	640 km	560 km	440 km	340 km
Salzburg/Linz	1.100 km	850 km	780 km	700 km	570 km	520 km
Vienna	1.400 km	1.150 km	1.080 km	1.000 km	870 km	820 km
Verona/Padua	1.450 km	1.200 km	1.130 km	1.050 km	920 km	870 km
Bologna	1.600 km	1.350 km	1.280 km	1.200 km	1.070 km	1.020 km
Milano	1.250 km	1.000 km	930 km	850 km	750 km	650 km
Sopron	1.450 km	1.200 km	1.130 km	1.050 km	920 km	870 km
Budapest	1.650 km	1.400 km	1.330 km	1.250 km	1.120 km	1.070 km

Tab. 4.1.3.5/1: Determination of distances on rail

The determination of the rail distance to Bologna has been made for the Brenner route via Austria, for the other Italian destinations a rail connection via the Gotthard-route has been assumed.

Road Transport

The determination of the road distances shown in table 4.1.3.5/2 has been made under consideration of using the possible fastest highways and roads.

	Rotterdam	Duisburg	Cologne	Koblenz	Frankfurt Mainz	Mannheim Ludwigshafen
Basle	720 km	550 km	490 km	410 km	330 km	260 km
Zurich	810 km	620 km	560 km	480 km	400 km	330 km
Salzburg	990 km	780 km	720 km	660 km	540 km	490 km
Linz	1.000 km	790 km	730 km	670 km	550 km	550 km
Vienna	1.155 km	950 km	950 km	830 km	710 km	720 km
Verona	1.190 km	1.030 km	970 km	890 km	820 km	740 km
Padua	1.270 km	1.110 km	1.050 km	970 km	890 km	820 km
Bologna	1.260 km	1.100 km	1.040 km	960 km	880 km	810 km
Milan	1.040 km	880 km	820 km	740 km	660 km	590 km
Sopron	1.230 km	1.020 km	960 km	900 km	780 km	790 km
Budapest	1.430 km	1.220 km	1.160 km	1.100 km	980 km	990 km

Tab. 4.1.3.5/2: Determination of distances on road

The resulting average journey times are shown in table 4.1.3.5/3. The calculation of journey times was made on the basis of

?? an average speed of 70 km/h

?? the compliance of the regulations concerning steering and pause times

?? one driver on the vehicle.

Time losses for border crossing are only relevant between Austria and Hungary in a magnitude of 5 hours. The shown time figures were tuned with an international forwarder and judged as closed to practise.

	Rotterdam	Duisburg	Cologne	Koblenz	Frankfurt Mainz	Mannheim Ludwigshafen
Basle	14 hours	9 hours	8 hours	7 hours	6 hours	4 hours
Zurich	20 hours	10 hours	9 hours	8 hours	7 hours	6 hours
Salzburg	26 hours	21 hours	20 hours	19 hours	9 hours	8 hours
Linz	26 hours	21 hours	20 hours	19 hours	9 hours	9 hours
Vienna	28 hours	25 hours	25 hours	22 hours	20 hours	20 hours
Verona	36 hours	26 hours	25 hours	24 hours	22 hours	21 hours
Padua	37 hours	27 hours	26 hours	25 hours	23 hours	22 hours
Bologna	37 hours	27 hours	26 hours	25 hours	23 hours	22 hours
Milan	26 hours	23 hours	22 hours	21 hours	19 hours	9 hours
Sopron	40 hours	30 hours	29 hours	27 hours	24 hours	24 hours
Budapest	44 hours	40 hours	32 hours	31 hours	29 hours	29 hours

Tab. 4.1.3.5/3: Determination of road journey times

4.1.4 Requirement Profiles

The feasibility of trimodal transport towards the South and Southeast of Europe depends on several factors. Two of them ? transport volume[1] (number of containers) and infrastructural capacity ? are described in previous chapters. In this section attention will be paid to crucial factors concerning market share such as price and transit time. Trimodal transport chains are compared on price and transit times to alternative transport chains, uni-modal (by truck) and bi-modal (train and truck).

The outline of this chapter is as follows. First the alternative transport chains towards South-European destinations are described. Then the alternative chains are compared on price and transit time, specified for three important destinations: Vienna, Budapest and Verona. Subsequently the market shares for each transport chain are estimated. Finally some conclusions are made.

4.1.4.1 Different Transport Chains

At present two different container transport chains from Rotterdam towards Southeast Europe can be distinguished. An estimated 10-20% is transported by truck, the other 80-

[1] In 1995 2,3 million containers where transported from and to Rotterdam. This will increase to 3,6-4,6 million in 2010 and to 5,2-8,0 million in 2020 (source: 2020 Intergrale verkenningen voor havens en industrie, Port of Rotterdam, 1998).

90% is transported by train towards a terminal in Southeast Europe, where the load is transferred to a truck, that brings the load to its final destination (source [AVV, 1995]). Between 2 and 6% of the containers handled in Rotterdam is transported from and to the Southeast of Europe.

An alternative way to transport containers to destinations in Southern Europe consists of 3 modalities, barge, train and truck and is called trimodal transport. This logistic concept is expected to compete with bimodal transport.

Firstly containers are shipped from Rotterdam on the Rhine by barge, then transferred at an inland harbour to the train and to the final destination by truck. The price, and therewith the economic feasibility, of trimodal transport depends strongly on the location of the inland harbour.

Besides different inland harbours possible locations are Duisburg, Koblenz, Mainz and Mannheim/ Ludwigshafen. Besides the function as transfer location for the cargo flow towards Southeast Europe, the inland harbour can also function as transfer terminal for freight that has Germany as his end destination (35% of the containers handled in Rotterdam are transported from and to Germany).

4.1.4.2 Comparing Transit Times and Prices of Different Transport Chains

The location of the inland harbours depends on several variables such as existing (transfer and transport) infrastructure, origin and destination of cargo volumes, etcetera. Furthermore, the location of the inland harbour influences the costs and transit times of trimodal transport chains. In general it can be said that the further the inland harbour is located from Rotterdam the cheaper the trimodal transport chain will be, but even though the longer the total transit time. In this paragraph the costs and transit times of the three different transport chains (uni, bi and tri-modal) from Rotterdam to three destinations (Vienna, Verona and Budapest) are being compared. In this comparison also three alternative locations of the inland harbour are being evaluated (Duisburg, Koblenz and Mannheim/Ludwigshafen). Tab. 4.1.4.2 shows the variable costs of different transport modes and handling costs of transhipment. These costs heavily depend on the concerning contractvolume and -term and therefore for each cost a bottom and upper limit has been estimated.

		DM/FEU p.km	DM/FEU handling R'dam[2]
Truck	Min[3]	1,60	82
	Max	1,90	82
Rail	Min[4]	0,72	82+90[5]
	Max	1,50	82+191
Barge	Min[6]	0,31	82
	Max	0,49	110

Tab. 4.1.4.2: Handling costs in the Rotterdam harbour per modality

The transfer costs at the inland (rail-truck versus barge-rail) differ between 50 and 80 DM.

The price per driven distance of rail transport from the inland harbour to a destination in South East Europe and vice versa is not equal to the price of railtransport from Rotterdam to the same destinations (and vice versa). For instance the charges for railtransport to Verona from Rotterdam are equal to the charges from any inland harbour in Germany. These charges do not represent the real costs but contain a significant „political" factor or business strategies.

In the examples below, the costs are calculated with the real charges. This starting point is legitimate when the recent white paper concerning calculation of real costs of transport of the European Commission is taken into account [EC, 1998].

4.1.4.3 The Market for Trimodal Transport Chains

The previous paragraph showed that the costs of tri-modal transport is under certain circumstances lower than both uni and bi-modal transport. On the other side tri-modal transport is significant slower than the other transport chains.

To calibrate the decision made by shippers and shipping agents for a certain logistic concept, a small survey is done. The question is whether the market will use tri-modal transport if costs are reduced (compared to bi-modal transport) with 15-30% and the transit time is 2 to 4 days longer than bi-modal transport? A rough estimation (deducted from figures of the Dutch ministry of transport and a limited number of interviews) of the trimodal market share is shown in table 4.1.4.3.

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[2] Different sources in Rotterdam.

[3] Different truck companies.

[4] Trail (rail transport company), depends on weight of container.

[5] Depends on location in Rotterdam (handling costs plus transport costs towards terminal).

[6] CCS (barge transport company).

	Uni-modal	Bi-modal	Tri-modal
Market share	5-15	50-70	20-40

Tab. 4.1.4.3: Estimated market share for different transport chains

It is obvious that when the costs of trimodal transport are lowered more shippers will choose this form of transport. In the same way when the transit times for trimodal transport are reduced with costs remaining at the same level, more shippers will choose for trimodal transport. In a follow up the implications for the modal split should be thoroughly examined.

4.1.4.4 Conclusions

1. Trimodal transport primarily competes with bimodal transport, which is the main way to transport containers towards destinations in the Southeast of Europa (approximately 85%) from and to Rotterdam.
2. Trimodal transport requires an inland harbour somewhere in Germany to transfer containers to the train. This inland harbour can also be used for bimodal transport to Germany, using barge as first transport mode. Three possible locations for this inland harbours are Duisburg, Koblenz and Ludwigshafen.
3. The three examples of destinations across Southeast Europe show that:
   - The transit time of trimodal transport is 2-3 days longer than of bimodal transport, depending on the direction of the transport (from or to Rotterdam) and the location of the inland harbour.
   - At present trimodal transport is not cheaper because the costs of transport by rail for the second part of the tri-modal chain are very high (political price).
   - If variable charges of rail transport in trimodal chains would be equal to those in bimodal chains, tri-modal transport is up to 36% cheaper than bi-modal transport.
   - Using the inland harbour located in Duisburg the cost savings of trimodal transport are minimal compared to bimodal transport. Only when the inland harbour is located in Koblenz or Ludwigshafen the savings are significant.

Transit costs (overview)		Min			Max		
		Uni	Bi	Tri	Uni	Bi	Tri
Verona	Duisburg	1850	1400	1330	2275	2025	1975
	Koblenz	1850	1400	1305	2275	2025	1815
	Ludwigshafen	1850	1400	1290	2275	2025	1770
Budapest	Duisburg	2200	1875	1775	2775	2475	2375
	Koblenz	2200	1875	1700	2775	2475	2200
	Ludwigshafen	2200	1875	1675	2775	2475	2150
Vienna	Duisburg	1925	1875	1725	2425	2175	2100
	Koblenz	1925	1875	1650	2425	2175	1935
	Ludwigshafen	1925	1875	1575	2425	2175	1880

Tab. 4.1.4.4: Overview of transport costs (DM) (Sources: Trail, Port of Rotterdam, CCS, truck companies and different other sources).

The innovative aspect of the APRICOT project is the systematic integration of the inland waterway system in optimal logistic chains door-to-door outside the narrow scheme of the river Rhine area by linking the benefits of inland navigation to the merits of rail transport to the destination areas in South and Southeast Europe and road service for the final distribution in the local areas.

4.2 TECHNICAL-ORGANISATIONAL STRUCTURING OF ADVANCED TRIMODAL TRANSPORT CHAINS [WP 2]

4.2.1 Transhipment Points (Ports and Terminals)

At principle changing points different transhipment installations will be analysed to make the change-over possible and more easy. Layout characteristics of the handling points - under consideration of the capacities for peak and average load - will be compared regarding its suitability.
With this results it will be possible to realise an improvement of terminals and terminal operations by characteristics of an innovative transhipment.

4.2.1.1 Requirements

Trimodal Terminals combines barges, trains and lorries within trimodal transport chains. The requirements for a better functionality there are:

- Maximum transhipment capacity, because the size of ships and barges is growing up and the meantime for a stop has to decrease
- Daily/weekly schedule for barges, trains and lorries, to give a good service to the clients
- Optimal type of port design: Landing place or basin; for a short stop a landing-stage seems be more efficient than a basin
- Optimal local conditions: Length of quay, length of rail track; it makes no sense to share a train for loading or unloading in several parts, so it is better to cut the train only in two parts or to realise the "Rendezvous"-Technique (unloading and loading during the train is passing the terminal) without sharing
- High capacity of barges and trains; optimised by consideration the situation on inland waterways (for example: JOVI with 400 TEU)
- Optimal accessibility for barge, rail and road
- Available area conditions, possible capacity of buffer and storage; huge storage capacities for empty containers can be realised by using a special type of fork lifter, which can stack till eight or more levels, but the control of that storage should be included in the terminal operation system.

4.2.1.2 Influence of Trimodality

Since several years modal split of goods traffic national in Germany or international always is changing in favour of road traffic. This gives the intention that road traffic will be especially cost efficient and works with acceptable quality. Transport means which will compete in that field of transport have to be more attractive than road transport.

This time many people are thinking about the best layout and localisation of terminals for commercial and logistic objectives. There is need for agglomerations and good access to all means of traffic.
Trimodal chains can have trimodal terminals. New in trimodal terminals is the role of inland waterways in an important collaboration with rail operation.
The dimensions of complete trains in relation to barges are not congruent (train 700 m length, barge 150 m length), longitudinal transport is unavoidable.
Solution 1, conventional terminal: Longitudinal transport with straddle carrier or terminal-owned lorries.
Solution 2, innovative fast handling terminal: For example the Krupp fast handling device allows automatic loading and unloading during the slowly passing of the train through the plant (the train itself is a longitudinal conveyor to the storage).
There are different types of compromises possible, at first a combination of a small fast handling plant area and a conventional crane for barge operation and the storage service.

4.2.1.3 Criteria and Changed Aspects for Trimodal Terminals

For a judgement about preferences of transport modes beside volume, network and modal split and the utilisation of inland waterways for trimodal chains it is also necessary to look for the reasons why such transport chains may be chosen by the clients and operators. Trimodal traffic is less expensive and has a better environmental standing by publicity. But trimodal traffic needs more time and is not suitable for all type of goods, especially for goods with high value and time restrictions.

4.2.1.4 Conventional Terminal Layout, Problems and Advantages

The comparison of different types of terminal layouts is starting at conventional structures as a basis scenario.

The usual characteristics of those layouts are

?? 1 - 2 gantry cranes with a working span of nearly 100m
?? 200 - 400 m length of the transhipment area
?? high storage capacity
?? only 1 transhipment track
?? low transhipment capacity (20 LU/h*crane)

These characteristics are important for the logistic flows by trimodal utilisation. The relation between the requirements of a good service for the clients of a port and the possibilities of a conventional terminal gives an impression, if this layout is a good answer.

Following the aspects of advantages and disadvantages of conventional terminals in inland ports it seems that the crucial aspect is the connection and access of train operation. Train operation is in an inland port not an increasing part of the business. Most of the conventional terminals are including train connection with a transhipment track directly beside the quay or as the last lane on the land side. Today the use of train operation as a form of pre- and posthaulage is seldom.

Alternatives for the design of conventional trimodal terminals

For the future of trimodal terminals different solutions are possible. This solutions are oriented on different maximum volumes. The starting layout shows a special reach stacker which can unload and load one ship per day with a capacity of nearly 100 ITU. For smaller ports with low capacity the reach stacker is a good starting solution. But problems with low and high water are possible.

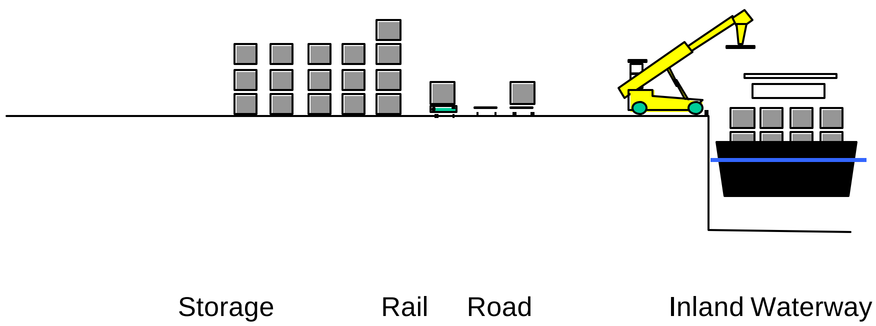


Fig. 4.2.1.4/1: Cross Section of a Conventional Terminal with Reach Stacker

The layout of this terminal looks like a more compact one with a short length and more width. The most difficult thing there will be the service of the storage and the lorries and for a second the handling with the barges in the right time-volume relation in extreme environmental situations.

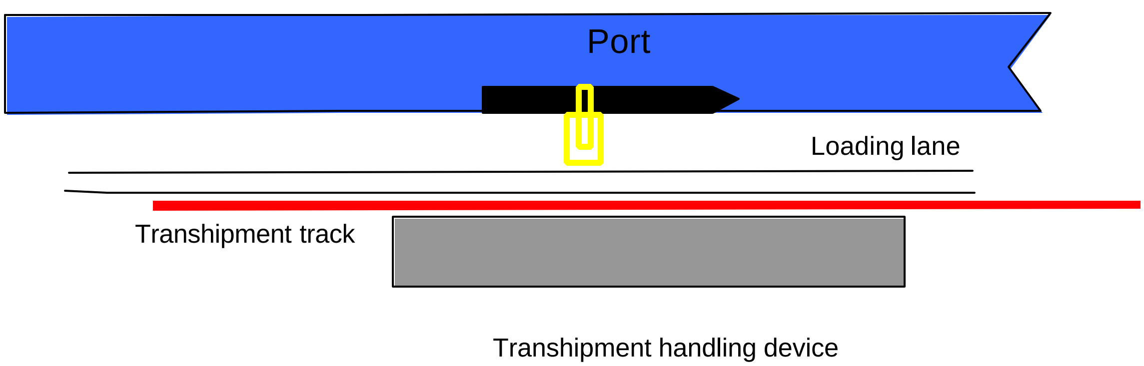


Fig. 4.2.1.4/2: Layout of a Conventional Terminal with Reach Stacker

The next solution is the usual configuration in inland ports at the river Rhine for medium capacities and is designed with great gantry cranes. This cranes have a span of more than 100 m and works as an universal handling device.

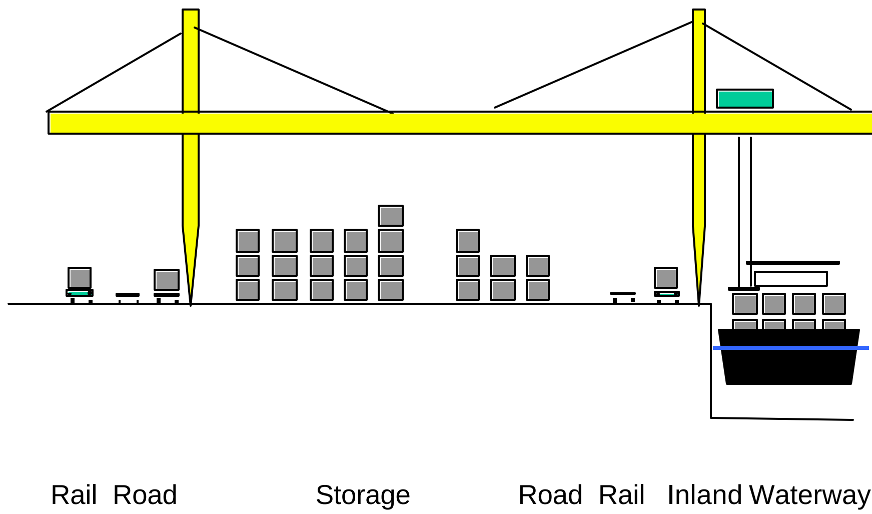


Fig. 4.2.1.4/3: Cross Section of a Conventional Terminal with Gantry Crane

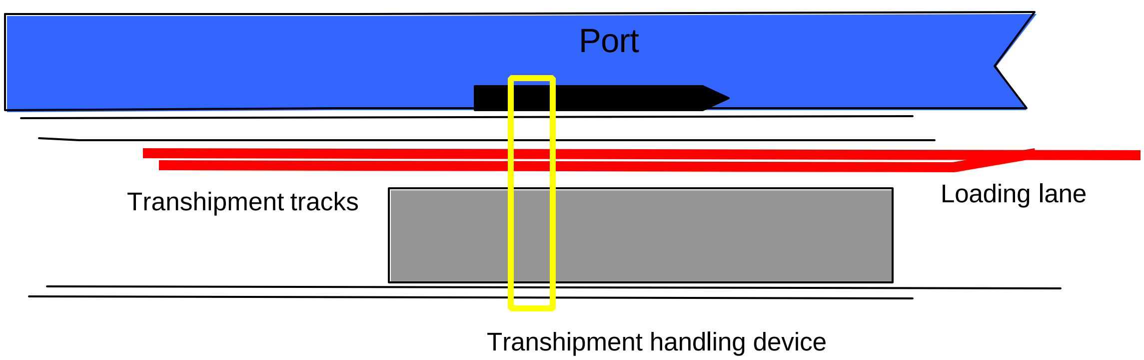


Fig. 4.2.1.4/4: Layout of a Conventional Terminal with Gantry Crane

This layout is oriented in the length direction and in relation to one or two berth places. Usual the terminal is shorter than a train length and needs for trimodal functions more than one loading track to serve a whole train.

4.2.1.5 Semi-innovative Terminal Layout

Many possible locations in the Rhine and Danube area are provided with conventional transhipment devices and conventional ”handmade” terminal operation systems. To improve the terminal it makes sense to install an external advanced train serving terminal, which can serve the train without shunting. Quayside and storage are unchanged, but for the connection to the rail terminal they serve terminal owned trucks or AGV´s.

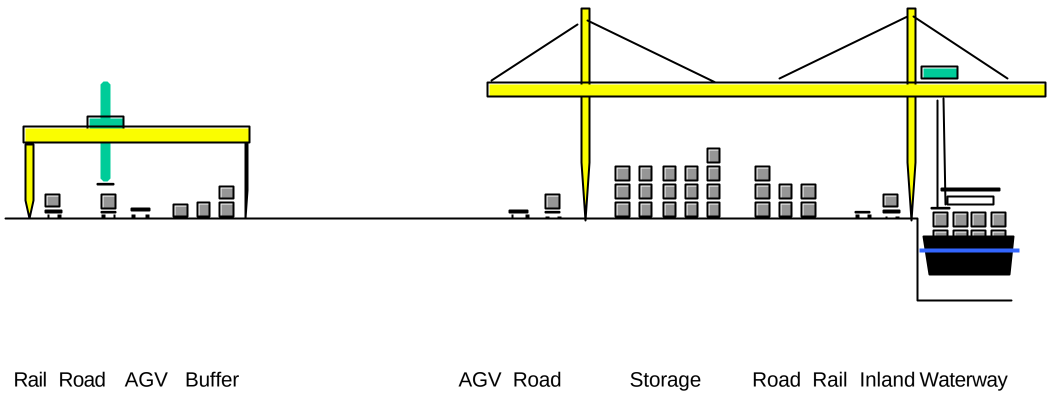


Fig. 4.2.1.5/1: Cross Section of a Semi-innovative Terminal

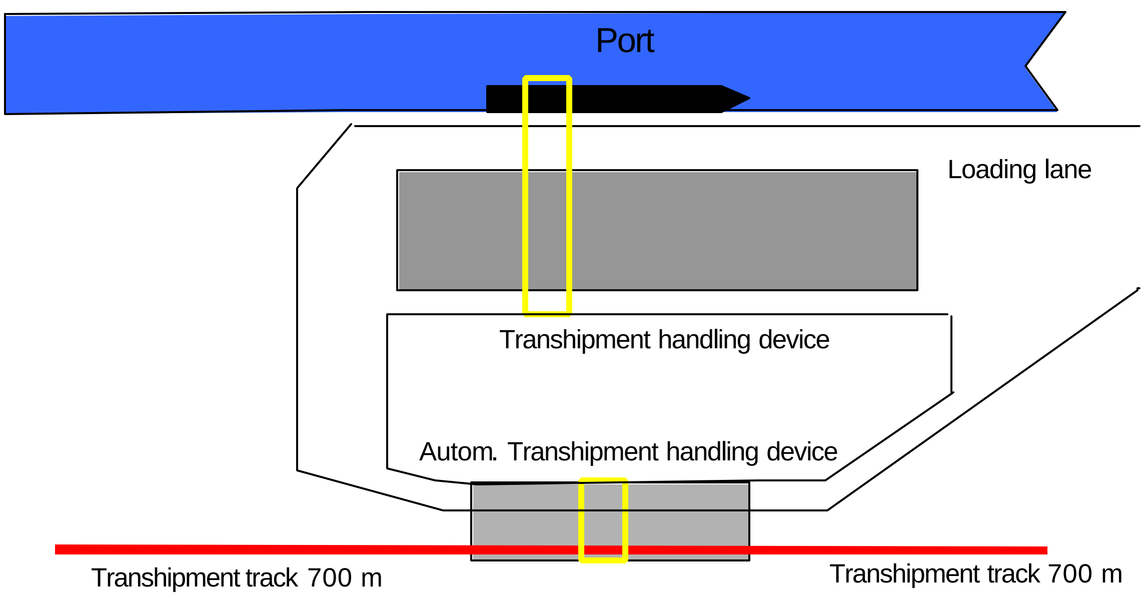


Fig. 4.2.1.5/2: Layout Section of a Semi-innovative Terminal

This layout configuration seems like a bad compromise, but for our opinion it can be a good real solution for all cases where an old handling device just is working without technical problems in a port. The solution will grow important, if there is need for an undisturbed handling at the quayside and on the railside.

4.2.1.6 Innovated Integrated Terminal Layout

The characteristics of innovated and integrated terminals are very different to conventional types of terminals. Without a direct validation it is clear, that there will be some additional advantages for a better service to the client. The system features of integrated trimodal terminals are the following:

?? Optimal transport distances between the different transport means
?? Reducing of longitudinal transportation with "Rendezvous"-Technique
?? Automated handling by storing and transhipment in between
?? Service of lorries really in time
?? Flexible layout for different capacities
?? Integrated terminal operation system
?? Lower land occupation

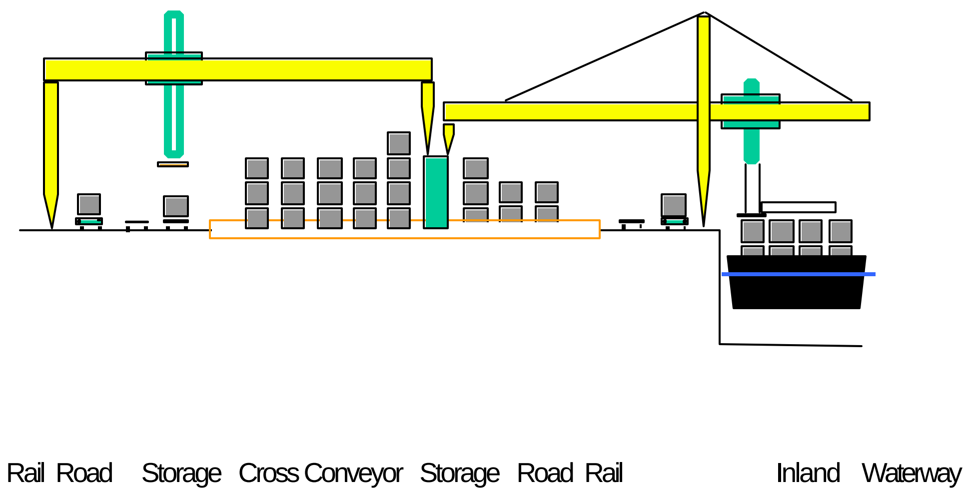


Fig. 4.2.1.6/1: Cross Section of an Integrated Trimodal Terminal

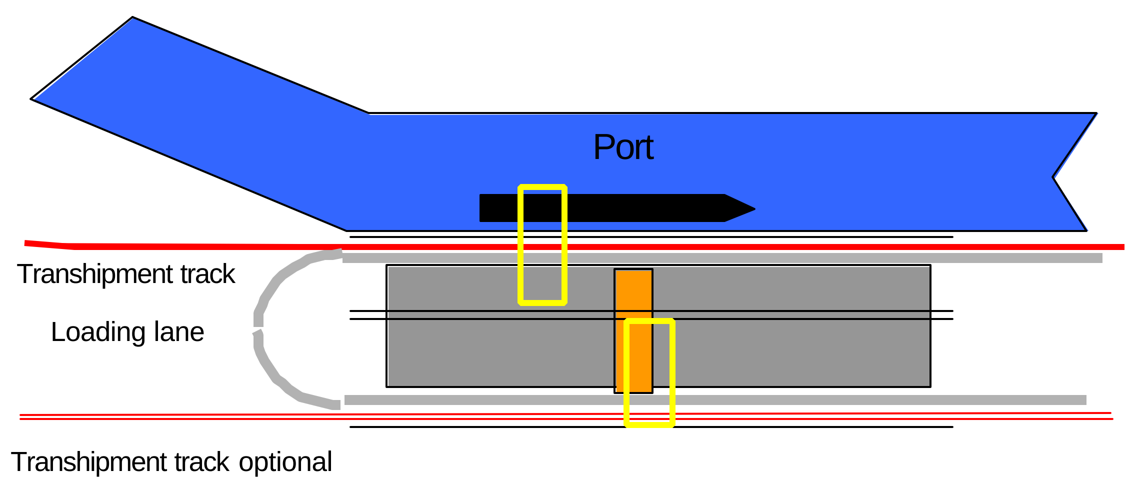


Fig. 4.2.1.6/2: Layout of an Integrated Trimodal Terminal

Cross section and layout of this terminal give the impression that such a compact plant in combination with an integrated control system can be the solution for the future.

4.2.1.7 Evaluation

In the field of evaluating a layout for future trimodal terminals, results are dependent on the today situation in the chosen port. Parameters are the installed handling device, the total and peak load volume -daily and per year-, the accessibility of the terminal for the means of transport and the figure of the concerned area.

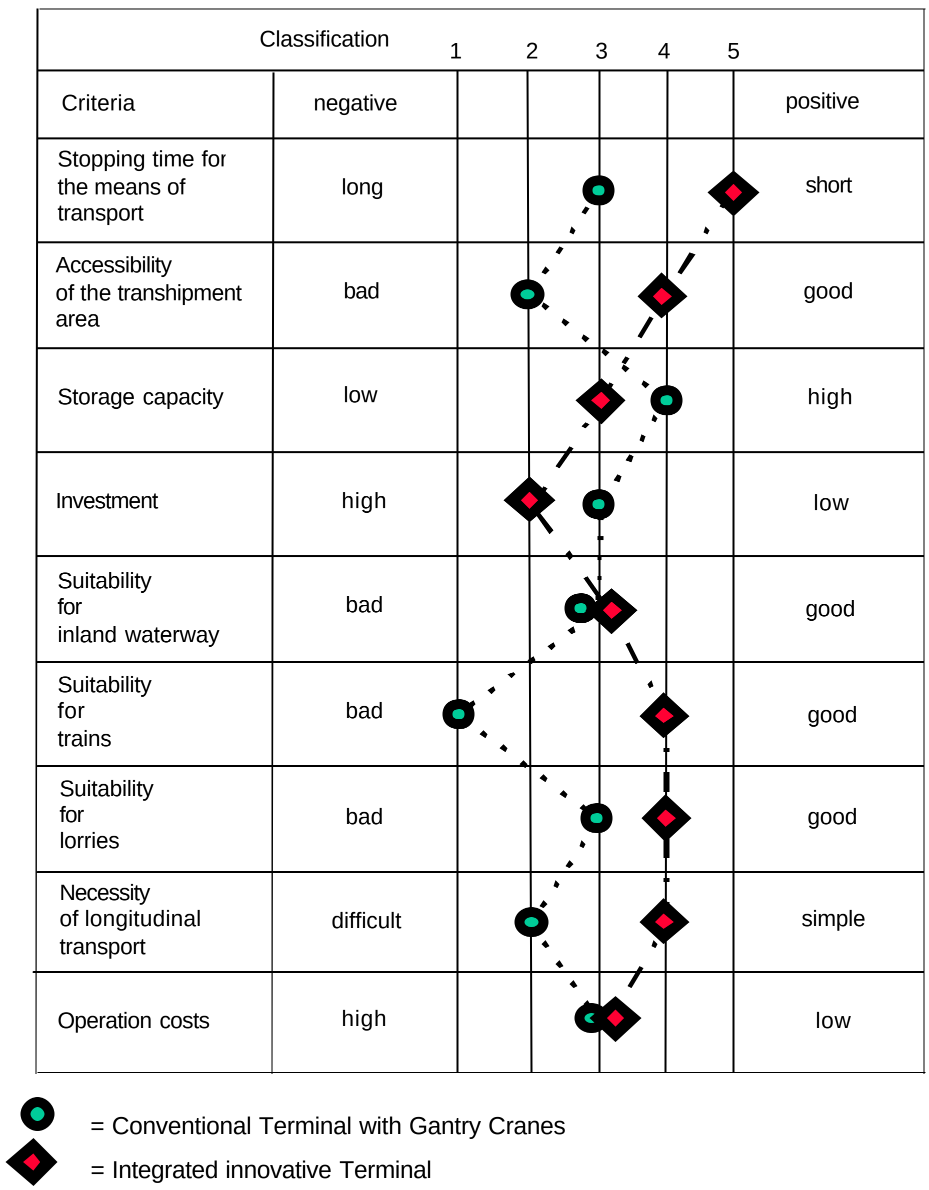


Fig. 4.2.1.7/1: Comparison of the Suitability of Conventional Terminal with Gantry Cranes and Integrated Innovative Terminal

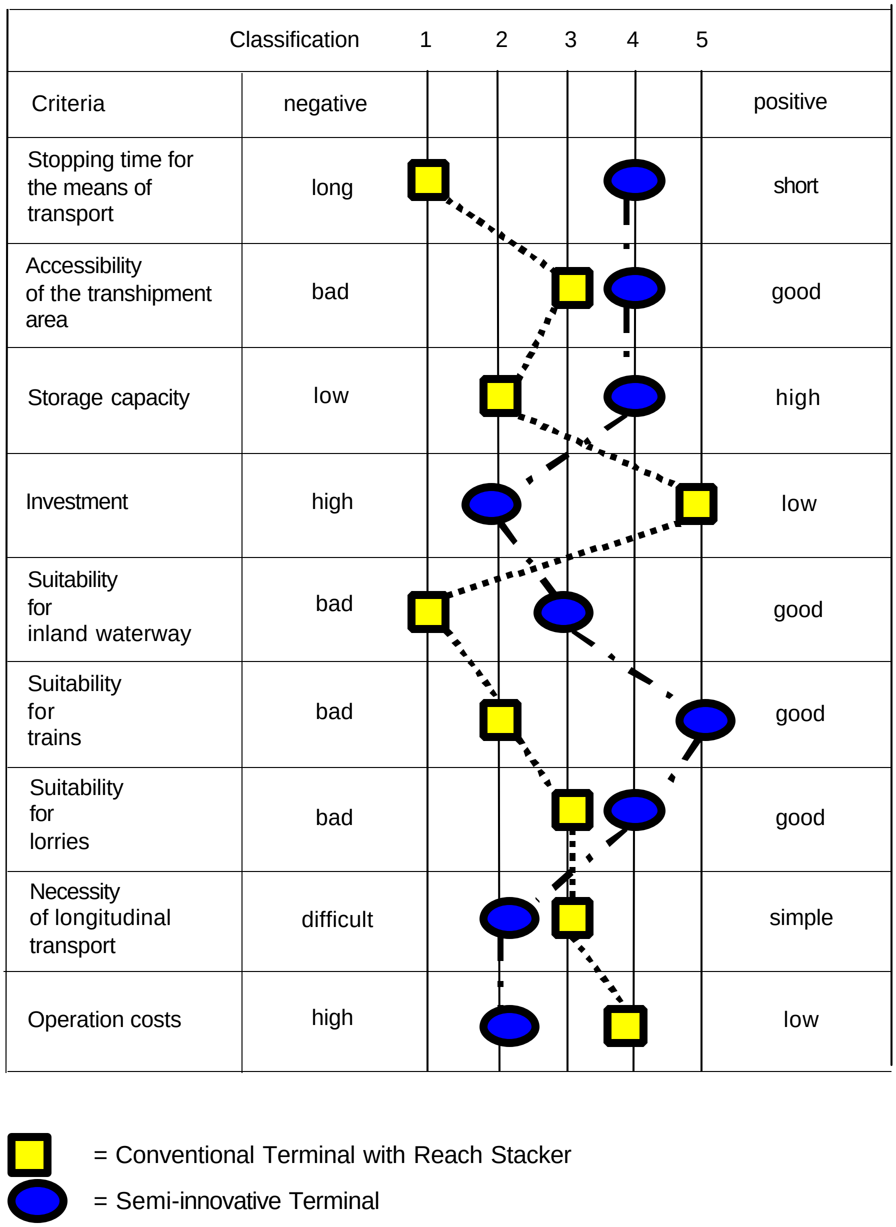


Fig. 4.2.1.7/2: Comparison of the Suitability of Conventional Terminal with Reach Stacker and the Semi-innovative Terminal

The characteristics, advantages and disadvantages of the shown solutions can be compared without any concrete local requirements. The figures above give an impression of this aspects. It seems, that positive characteristics of service and suitability are realised with innovative and semi-innovative terminals. But conventional terminals with reach stackers and gantry cranes have lower investment costs. Both types are possible for usual connections between inland waterway and road. If the special requirements of rail connection is important, than new solutions become more suitable and attractive.

4.2.2 Transport System Specific Operation Concepts

The previous analysis and determinations concerning conditions and requirements in the corridors had shown that trimodal transport chains have particularly advantages on the Rhine – especially on the Rhine section up to Karlsruhe. Beside the optimal infrastructural conditions

- no time-losses caused of sluicing
- no taxes or fees for using the waterway
- no restriction in bridge height

the Rhine offers the possibility to transport or bundle the potential volume of traffic between Rotterdam and the corridors on this waterway and allows the concentration on one trimodal terminal location.

The Main-Danube-Canal shall not be taken into consideration for the traffic from and to Rotterdam because of the specific restrictions concerning ship-capacity, speed reductions in the canal and resulting journey time.

Important basis for the acquisition, the transfer of existing traffic and the implementation of trimodal chains are the economic competitiveness, the technical compatibility and the reliability. Which means that not only the journey time is the most important factor but the keeping of time schedules in the destination terminal too. In this context the trimodal terminals are of very high importance because the handling and the operation causes time losses and costs.

One deciding factor is the optimal synchronisation of the involved transport modes inland navigation, rail and truck under consideration of the different system-technical parameters (speed, network, capacity ...). In particular the different capacities of barge and rail are leading to specific problems in the terminals regarding to handling and storing of loading units.

4.2.2.1 Basic Requirements on Trimodal Operation Concepts

One important deciding factor for the working of trimodal chains is the interoperability between the different transport modes. The interoperability must be guaranteed for the whole transport chain between starting and destination terminals or consignor and consignee to ensure a frictionless transport flow.

- **technical interoperability**

The technical interoperability is guaranteed through the use of standardised loading units which are suitable for all used transport modes in the trimodal chain. Trimodal terminals must be equipped with corresponding handling techniques.

For the use of standard ISO-containers there are no problems existing concerning compatibility because of the international standardisation of this units. Difficulties in trimodal transport chains are existing concerning loading units which do not fit into the ISO-measurements. These loading units are swap bodies and semi-trailers and special inland containers (e.g. used by Transfracht). The width of these ITU is 2,5 m up to 2,6 m and they have various length. Semi-trailers are not even very standardised for the intermodal traffic road/rail and they are needing special pocket wagons.

Particularly swap-bodies and semi-trailers which are very common in intermodal transport road/rail can not be operated without restrictions in barge-transport because the cargo hold of barges is constructed regarding the sizes of ISO-containers. Swap bodies are normally not stackable and have a bigger width. In this respect – from the recent point of view – the only feasible possibility of carrying swap bodies on barges is the stowage on the top layer (on top of ISO-containers). There is the same alternative for the carrying of semi-trailers. Exception for the use of semi-trailers is the transportation on RoRo-barges.

- **functional interoperability**

Particular in trimodal terminals there are strong requirements concerning the continuous transport flow. The different parameters

- barge size, barge frequency and capacity utilisation
- terminal (location, capacity and performance)
- train capacity, frequency and capacity utilisation

have to be taken into consideration. The optimum form under respect of economy and journey time is the direct handling from barge to intermodal train or vice versa. This cannot be guaranteed because of the different capacities of both transport modes.

A comparison of barge and train capacities is shown in figure 4.2.2.1.

Barge			Intermodal Train	
Typ	Layers	Capacity	Alpine Transit (60 TEU)	"Regular" (78 TEU)
JOWI	4	398 TEU	**6,5**	**5,1**
	3	298 TEU	**5,0**	**3,8**
	2	199 TEU	**3,3**	**2,6**
GMS	4	192 TEU	**3,2**	**2,5**
	3	144 TEU	**2,4**	**1,8**
	2	96 TEU	**1,6**	**1,2**
Europa	4	108 TEU	**1,8**	**1,4**
	3	81 TEU	**1,4**	**1,1**
	2	54 TEU	**0,9**	**0,7**

Fig. 4.2.2.1: Comparison of barge and train capacity

The barge Jowi shown in figure 4.2.2.1 is an exception concerning the measurements and has special requirements regarding the handling equipment in inland ports.

- **market interoperability**

Important criterion for the success of trimodal chains is the customer sufficient conception. The functional and the technical concept must fit closely to the users and goods requirements. That means that journey time, costs/prices for the whole transport chain and the frequency of trimodal chains in the relations between the corridors have to satisfy the potential users or clients to be a competitive alternative to unimodal transport or bimodal transport chains.

4.2.2.2 Operation Concepts of Inland Navigation

For the regular operation of barges – the connection between harbours according timetable – are two different types existing: liner service and shuttle service.

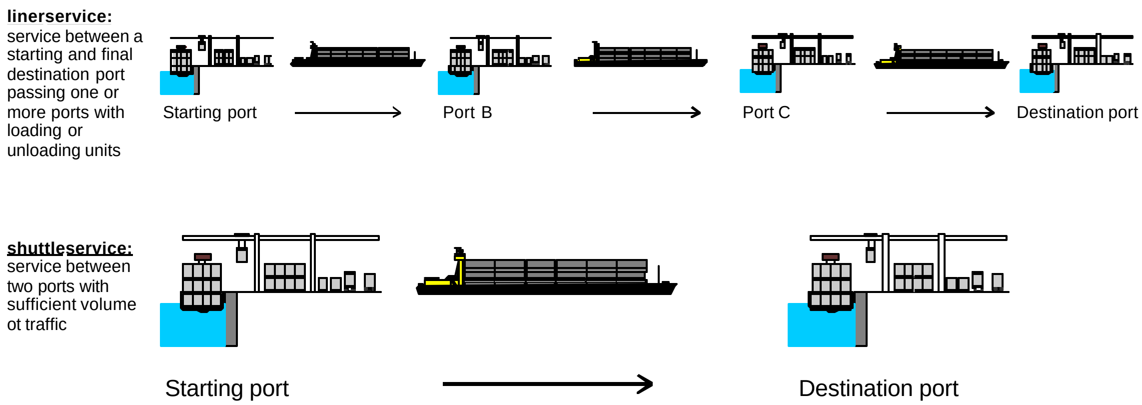


Fig. 4.2.2.2: Operation concepts – inland navigation

The liner service is running between a starting harbour and a destination harbour with passing one or more harbours for the loading and unloading of units. This kind of service is useful for relations in connection between harbours which do not have a sufficient volume of traffic to fill the whole capacity of one barge. In this case in the whole traffic volume is collected in one barge and distributed during the journey.

The shuttle service is a service between two harbours. Basis is a sufficient volume of traffic which is high enough for an economic barge operation. One example for this kind of service is an existing connection between Rotterdam and Duisburg.

For the use of the loading capacity of barges there are in principle two alternative concepts possible. The first one is the exclusive operation of barges for trimodal chains. The other alternative is the use of part capacity of a barge (slots) in connection with existing services along the Rhine.

The choice of the specific optimal operation concept is depending on the respective volume of traffic. If there is a high enough volume in certain relations it is possible to operate complete barges for each relation in the corridor. Another alternative could be the integration of two or more destinations in one barge. If the volume of traffic is not high enough to fill one barge with trimodal volume of traffic has to be integrated into existing barge services.

4.2.2.3 Operation Concepts of Intermodal Rail Transport

The different possibilities of operation concept for intermodal trains are described in figure 4.2.2.3.

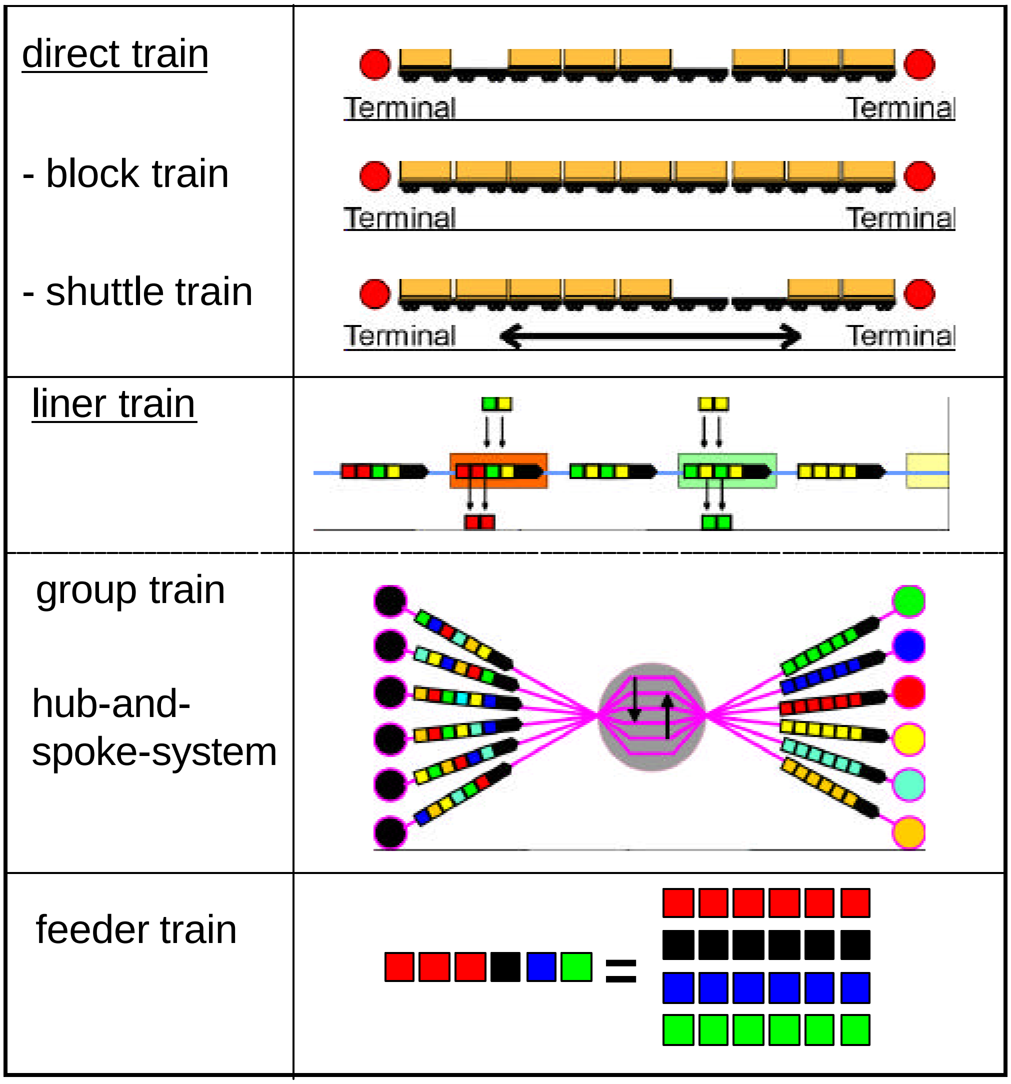


Fig. 4.2.2.3: Operation concepts - intermodal trains

- **direct trains**

The most economic operation concept for intermodal trains are direct trains. They are running between two terminals without intermediate marshalling. There are different forms of direct train connections possible:

- block trains: They are arranged according to the actual volume of traffic which means that the number of wagons can change every day. This causes additional work and expenditure for the assembling.
- shuttle trains: They are operating with a fixed number of wagons between two terminals. Normally there is no change of sequence and number of wagons. The

operating of shuttle trains is the most effective production form in intermodal rail service.

- liner trains: Liner trains are connecting a starting and a final destination terminal with passing one or more terminals to load and unload units.

- **group trains**

Relations with a volume of traffic which is not high enough to fill the capacity of a complete train can be connected economically with a group train system. In this system the volume of traffic for different destinations is loaded on one train. The train has to be shunted in an intermediate marshalling yard and reassembled with wagons for one destination.

An alternative to the group train is the interconnection between terminals in a hub and spoke train system. The trains between the terminals and the hub are operated as shuttle trains. In the hub they have to be reassembled by means of marshalling or changing the intermodal loading units between the trains.

- **feeder trains**

The operation of feeder trains is an alternative for the integration of terminals with a low volume of traffic into the intermodal rail network. These trains can be operated between an intermodal hub or a small terminal and a big intermodal terminal with a good network integration.

4.2.2.4 Operation Concepts of Terminals

One important module for the efficiency of trimodal transport chains are the interfaces or the terminals. Precondition for a trimodal terminal is the integration into the waterway network and a rail connection in the surroundings. Regarding rail connection two variants are possible:

A trimodal terminal with a direct connection to the rail network allows in principle the direct handling of the units between barge and rail wagon or vice versa. If the units are buffered in a store they can be loaded on the train inside the terminal ("on dock").

If the trimodal terminal has no rail connection transhipment (e.g. by truck) to an intermodal terminal road/rail is necessary. This causes additional handling expenditure and time losses. Direct handling between the transport modes is not possible.

To ensure efficient and economic handling of the loading units the terminal should have a direct rail connection. The cartage between water and rail terminal causes higher requirements concerning managing and controlling the transport chain.

If it is in practice possible to handle the loading units directly between the transport modes in principle depends on the harmonisation or the construction of the time tables of barge and rail. Direct handling requires reliable barge arrivals. This fact has to be judged critically. Inland navigation can be imponderable because of e.g. weather conditions, possible delays in the harbour – especially Rotterdam. Moreover direct handling causes access to the loading units on board without restrictions. In this case stowage plans and trimming instructions have to be followed.

4.2.2.5 Dependencies and Influence in Operation Concepts

The consequences concerning barge capacity and barge operation frequency are shown in figure 4.2.2.5 for a dedicated barge service under consideration of identical volume of traffic.

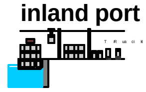
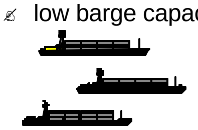
	Requirements/Consequenses on the Transport Chain			
Frequence of barge service	**Terminal inland port** 	**Rail service/ Train rotation**	**Cost effects**	**Journey time**
low frequence ✍ high barge capacity 	transshipment capacity ✍ gantry crane ✍ big storage capacity required	good basis for use of shuttle or direct trains (dedicated train system)	comparetively high cost degressing because of capacity utilization on barge ✍ possibility to connect price and journey time	high (depending on loading sequence on the train)
high frequence ✍ low barge capacity 	low requirements on transshipment capacity	depending on traffic volume - use of existing train connections - direct/shuttle trains	lower cost degressing effects because of higher TEU-costs on the barge	comparetively low

Fig. 4.2.2.5: Operation concepts - consequences

A low frequency in barge operation requires a higher barge capacity. From this corresponding requirements concerning handling capacity and storage capacity in the terminal are resulting. For the intermodal rail transport the concentration of higher traffic volume offers the possibility to build up direct train or shuttle train connections to various destinations in the corridors. Regarding transport costs this concept offers the advantage to operate big barges with high capacity utilisation. Disadvantage is a comparatively long journey time for the units.

With a higher barge frequency the requirements concerning barge capacity are getting lower. The number of loading units for each barge arrival and the necessary storage capacity are corresponding. With the use of smaller barges – in spite of good capacity utilisation – the specific costs of units are higher compared to barges with higher loading capacity. For the intermodal rail transport the possibility to fill dedicated (direct) trains is lower. The journey time for the whole transport is getting smaller with a higher barge frequency.

4.2.2.6 Exemplary Trimodal Operation Concepts

Potential Volume of Traffic

The basis for the developing of requirement profiles concerning operation concept is the goods flow analysis (flows in combined traffic between Rotterdam and the corridors in 1994) under consideration of a 30 %-surcharge. Potential market shares for trimodal chains were assumed (10 %, 20 % and 30 %).

Origin	Destination	ITU[1)]				
		p.a.	p.w.	10%	20%	30%
Rotterdam	Wien	2.647	51	5	10	15
Rotterdam	Linz	1.086	21	2	4	6
Rotterdam	Salzburg	806	16	2	3	5
Rotterdam	Budapest	181	3	0	1	1
Rotterdam	Sopron	350	7	1	1	2
Rotterdam	Milan (Busto)	37.426	720	72	144	216
Rotterdam	Verona/Padova	1.039	20	2	4	6
Rotterdam	Udine/Trieste	207	4	0	1	1
Rotterdam	Bologna	666	13	1	3	4
Rotterdam	Basel	809	16	2	3	5
Rotterdam	Zurich	530	10	1	2	3
Total export traffic to areas		**45.744**	**880**	**88**	**176**	**264**

Origin	Destination	ITU[1)]				
		p.a.[2)]	p.w.	10%	20%	30%
Wien	Rotterdam	1.382	27	3	5	8
Linz	Rotterdam	1.680	32	3	6	10
Salzburg	Rotterdam	298	6	1	1	2
Budapest	Rotterdam	412	8	1	2	2
Sopron	Rotterdam	764	15	1	3	4
Milan (Busto)	Rotterdam	39.293	756	76	151	227
Verona/Padov	Rotterdam	4.195	81	8	16	24
Udine/Trieste	Rotterdam	117	2	0	0	1
Bologna	Rotterdam	2.877	55	6	11	17
Basel	Rotterdam	217	4	0	1	1
Zurich	Rotterdam	332	6	1	1	2
Total import traffic from areas		**51.566**	**992**	**99**	**199**	**298**

[1)] Import and export CT flows from the area of Rotterdam to the areas of analysis.

Year 1994 - Container + Combined Traffics - Source: Dutch Railways

[2)] 1994 + 30 % for 2000

Tab. 4.2.2.6/1: Potential trimodal volume Rotterdam – selected corridors

For the barge service three operation frequencies were assumed:

1 sailing per week

3 sailings per week (Monday/Wednesday/Friday)

5 sailings per week (Monday to Friday)

The consequences of the goods flow analysis under consideration of potential market shares, barge frequencies and possible barge size are shown in table 4.2.2.6/2.

	North – South								
Sailing frequency	**weekly**			**Mon./Wednesday/Fri.**			**daily (Mon. - Saturd.)**		
Market penetration	**10%**	**20%**	**30%**	**10%**	**20%**	**30%**	**10%**	**20%**	**30%**
Potential Volume [TEU]	134	268	402	45	89	134	27	54	80
Barge type									
Dedicated	GMS-s.	JOWI	JOWI	-	Europe	GMS-s	-	-	-
(capacity utilisation)	76%	67%	100%	-	82%	76%	-	-	-
	South – North								
Sailing frequency	**weekly**			**Mon./Wednesday/Fri.**			**daily (Mon. - Saturd.)**		
Market penetration	**10%**	**20%**	**30%**	**10%**	**20%**	**30%**	**10%**	**20%**	**30%**
Potential Volume [TEU]	108	216	324	36	72	108	22	43	65
Barge type									
Dedicated	Europe	GMS-s	JOWI	-	Europe	Europe	-	-	-
(capacity utilisation)	100%	100%	81%	-	76%	100%	-	-	-

Tab. 4.2.2.6/2: Necessary barge capacity

Rail transport

Concerning the integration into intermodal rail network different variants are possible. Depending on the volume of traffic in the relations between the trimodal terminal and the corresponding corridors existing intermodal or a dedicated trimodal train systems can be used. Fig. 4.2.2.6 shows an example of a possible operation concept for an intermodal train system in between the trimodal terminal and the corridors.

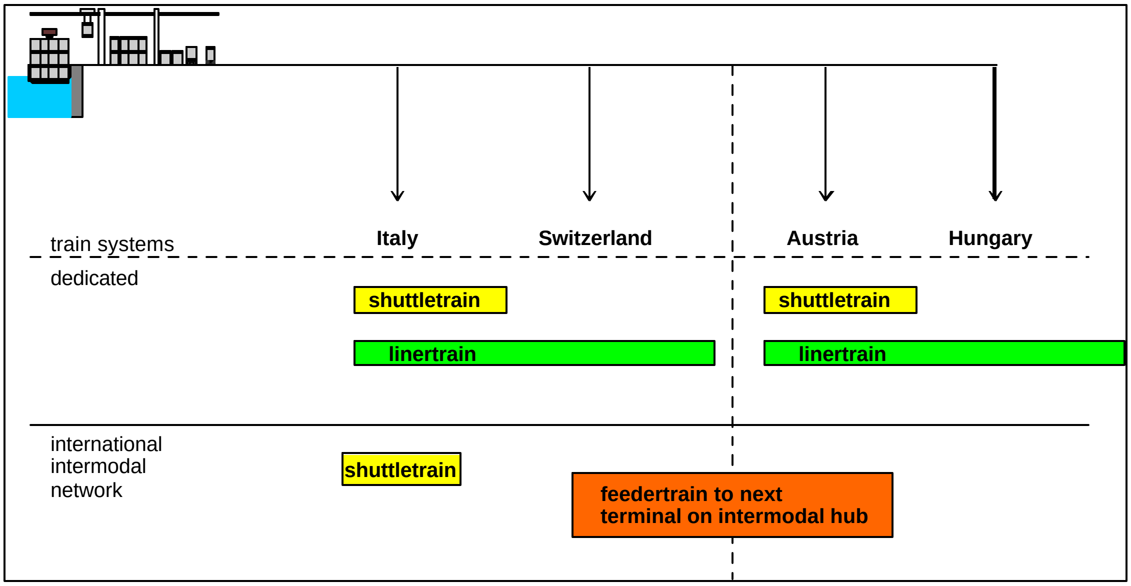


Fig. 4.2.2.6: Operation concepts – possible integration into intermodal train system

4.2.3 Communication Systems (Ports and Terminals)

In the field of integrated transport chains various intermodal operators, truckers, shipowners, railways, forwarders and agents have to collaborate. It is the aim, that although the intermodal transport units (ITU) are changing the modes of traffic, the information accompanying the consignments are floating between the operators control system, allowing a smooth and reliable transport.

Like an umbrella, communication and data interchange in relation with tracking and tracing and consignment follow-up is covering the whole chain and linking the various partners in the chain.

The compatibility of the information and communication system (EDI) will be examined and suitable strategies for the adaptation of these systems will be developed.

4.2.3.1 Requirements

Trimodal transport chains includes the operating of barges, trains and lorries. The requirements for a better communication are

?? Compatible database for ships, trains, lorries and the terminals

?? Knowledge of the daily/weekly schedule for barges, trains and lorries for all expected clients, to give the clients an optimal service

?? Optimal type of port design with optimal control points

?? Optimal local conditions for control and communication

?? Optimal dataflow between the operators of terminals, barges, trains and lorries.

4.2.3.2 Possible Alternatives

Organisation of a logistic system like an inland port could be done by different ways. The usual way is only oriented on information and not more. Control systems are more internal networks inside individual companies like traffic organisations, terminals for transhipment, companies for container services and other logistic elements like storages.

All types of traffic have their own organisation, it is not easy to change this and it is a discussion, if traffic grows better including integrated control systems.

This systems could be more instabile than a loose connection and information system.

4.2.3.3 Compatibility of Alternative EDI-Systems

The compatibility of possible and existing EDI-Systems will not be a great problem. Normally more new logistic control systems consider the possibility to communicate with the EDIFACT protocol and include standardised connecting possibilities.

4.2.3.4 Suitability of EDI-Systems for Trimodal Transport Chains

The comparison of different types of communication systems is necessary under the discussion of different types of terminal layouts and different means of transport in the logistic chain. The characteristics of communication systems and the system layouts depend on several parts of control:

?? entry control at the gate for all lorries and load units

?? entry control for trains and wagon groups at incoming rail tracks after the switch from the main track

?? entry control of the ships and barges and control of their load

?? control of handling devices

?? database for buffer and storage

?? outgoing control for all means of transport.

All functional elements should be controlled by different communication systems. The relation between the requirements of a good service for the clients of a port and the possibilities of control in a conventional terminal gives an impression, if such a layout is a good answer for the searching for a good service.

4.2.3.5 Suitability of EDI-Systems for Corridor Specific Applications

The different terminal organisations have special information-, communication- and control systems. For the transport chain this in-house systems are not suitable for a communication between railway organisations and inland ports. On the other side the ongoing privatisation of the state-owned railway organisations reduce the possibility, to realise a railway-owned standard software for data connection from the different systems of trimodal terminals inside a trimodal chain.

But it would be helpful for the development of trimodal chains that all partners of the logistic chain have the possibility to use a common database for their optimisation of the logistic elements and the whole transport chain.

4.2.3.6 Results

The most effective organisation to combine the control systems of all partners in a transport chain cannot reached realistic, because the partners are more interested in optimisation of their specific logistic courses. But the development of electronic communication and data change allows new constellations by using the standards of EDIFACT and other possibilities of the INTERNET.

More effective communication systems can be reached by using bilateral agreements. The basic systems made be available by the telecommunication companies in Europe. There are solutions possible beginning with radio telecommunication and ending with integrated control systems for whole transport chains.

4.3 FUNCTIONAL DEMONSTRATION OF ADVANCED TRIMODAL TRANSPORT CHAINS [WP 3]

4.3.1 Comparative Analysis of Existing Transport Chains in the Corridors

The proposed innovative integrated transport chain emerging from previous work can be schematised as in the figure below. The preliminary market analysis showed that, to take full advantage of the barge and train capacity along the corridor, the real tri-modal traffic covering all the path from the port of Rotterdam to its final destination in Italy or Hungary should be integrated with traffic over shorter routes, using only part of the chain (e.g. from Rotterdam to a location in the area of attraction of an inland port).

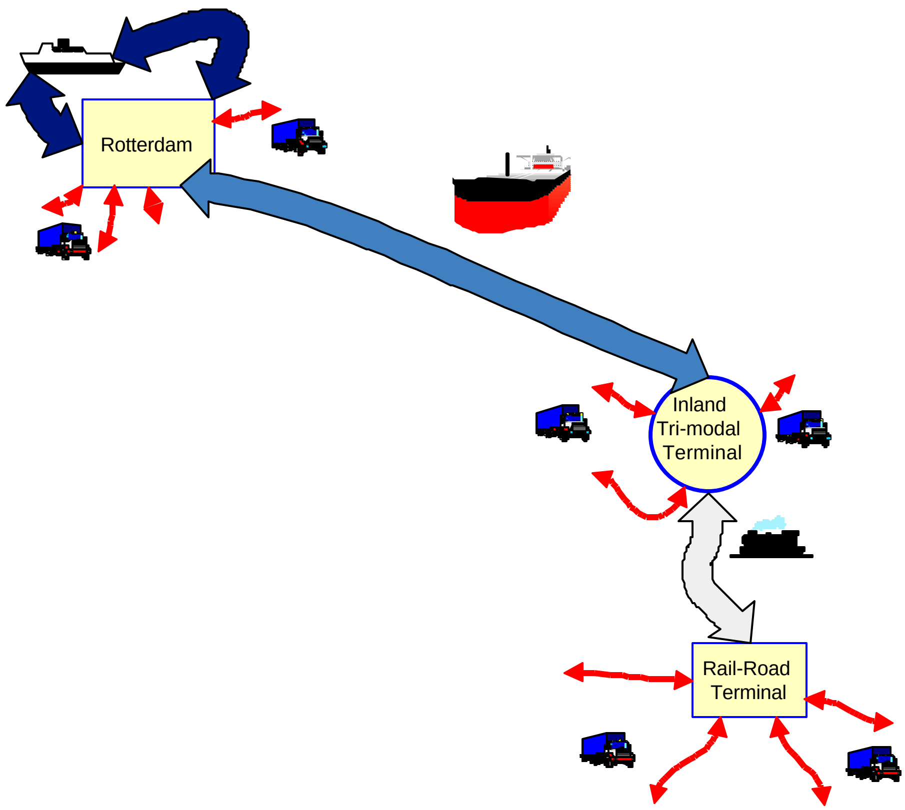


Fig. 4.3.1: The Trimodal Chain

The objective of this task is to provide the elements for a comparative analysis of existing transport chains in the corridors.

Five alternative integrated transport chains were taken into consideration as reasonable hypotheses for comparison:

?? Unimodal chain Road

?? Intermodal chain Rail + Road

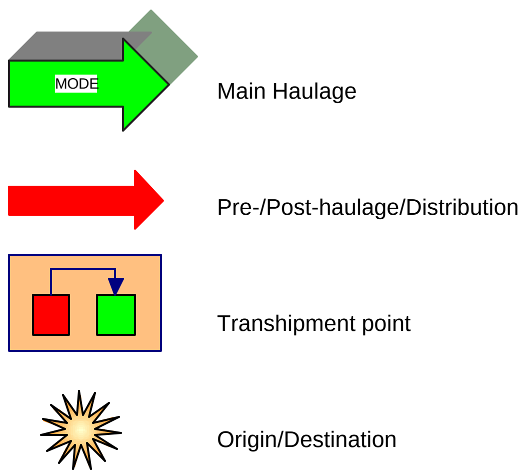
- Intermodal chain IWT + Road
- Tri-modal chain IWT + Rail +Road
- Tri-modal chain Rail + IWT (+ Rail) +Road

The functional elements of the chain were then identified grouping them in two sets: haulage elements and terminal/transhipment elements. The different elements where then analysed separately, and information about cost/price, time and quality parameters were investigated.

4.3.1.1 Identification of Alternative Transportation Chains

The five different chains presented hereafter are the resultant feasible solutions that were pre-selected among a larger number of alternatives. The choice of origin, destinations and location for modal shift was undertaken considering the preliminary result of previous tasks of the project.

Fig. 4.3.1.1/1: Symbols Used for the Schematisation of the Chains



We used the convention of describing all the chains in the direction going from the Port of Rotterdam to the final destination. This is of course a simplification introduced for the representation only, since both directions have been taken into account in the analyses, and in most of the cases conditions of symmetry apply.

4.3.1.1.1 Unimodal Chain Road

The advantages of these mode of transport has been widely recognised and are mainly:

- *Flexibility*
- *Monitoring*
- *Simple chain management*

?? *Reliability*

?? *Safety of cargo*

?? *Speed*

?? *Price*

The disadvantages are mainly on the side of the external impact of the heavy road transport, but they are scarcely reflected on the price that one has to pay for the service, since externalities are in most cases still not charged to their producer.

The main disadvantages identified are the following:

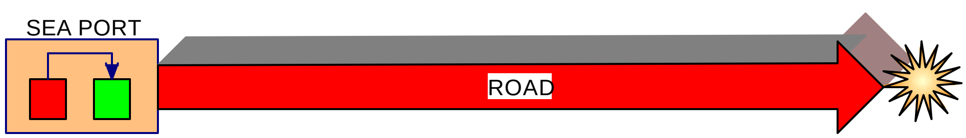
?? *Energy consumption*

?? *Pollution*

?? *Infrastructure saturation*

?? *Road Safety*

Fig. 4.3.1.1/2: Schematisation of the Unimodal Transportation Chain on Road



Identification of the Chains to be Investigated

In the case of unimodal road transport there is not the need of sharing the capacity with traffic attracted or originated in intermediate locations along the route, so the only cases to be taken into account for successive evaluations are the chains directly connecting the port of Rotterdam with the south and south-east selected destinations:

Rotterdam ✍ Milan/ Verona

Rotterdam ✍ Zurich/Basle

Rotterdam ✍ Vienna

Rotterdam ✍ Sopron/Budapest

4.3.1.1.2 Intermodal Chain Rail + Road

As stated before this is the real term of reference for containerised traffics from Rotterdam to Switzerland/Italy. This is made possible by a series of factor:

First of all the goods are already containerised, being directed or coming from a deep sea haul; this made it more attractive the rail service. Second factor are the difficulties encountered by road transport in the alpine crossing. Third, it is a relation connecting major point of generation and attraction of goods.

The advantages of intermodal rail-road transport have been widely investigated by a number of research project, among which the SIMET and IMPULSE ones. We recall here the main points:

?? *Reduced energy consumption*

?? *Optimisation of the usage of the main strength of different modes*

?? *Reduction of congestion on road network*

?? *Low environmental impact*

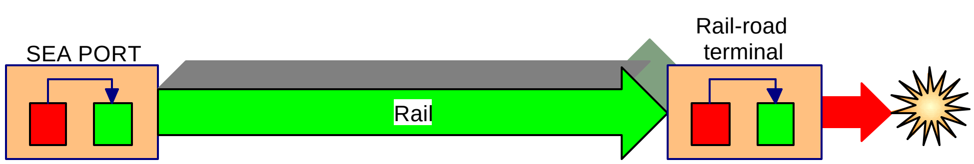
The main disadvantages include:

?? *Monitoring*

?? *Reliability*

?? *Complexity of the chain*

Fig. 4.3.1.1/3: Schematisation of the Intermodal Rail-Road Transportation Chain



Identification of the Chains to be Investigated

As in the case of unimodal road transport there is not the need of sharing the capacity with traffic attracted or originated in intermediate locations along the route, so the only cases to be taken into account for successive evaluations are the chains directly connecting the port of Rotterdam with the south and south-east selected destinations:

Rotterdam ✍ Milan/ Verona

Rotterdam ✍ Zurich/Basle

Rotterdam ✍ Vienna

Rotterdam ✍ Sopron/Budapest

4.3.1.1.3 Intermodal Chain IWT + Road

The one we propose here is a variation of a transportation chain already in use on the relations Rotterdam - Germany and Rotterdam - Switzerland. For these chains in fact the barge is used as the main transportation mode for the trunk haul, while the road serves the role of pre- or post- haulage for distribution over short distanced in the area of influence of the inland terminal.

The alternative investigated here, however, differ from the one mentioned above because the road transport is used for a long distance haulage going from an inland port to a far final destination.

The importance of this sort of chain is highlighted by the need of the port of Rotterdam of decongesting the road and rail network around the port area, thus favouring the transhipment to barges up to an inland port.

ECT, the Port of Rotterdam main container terminal operator has already invested for the creation of an inland terminal in Duisburg to be used as a sort of Gateway to the sea port. The location of a port far upstream could take advantage of the reduced costs of inland waterways for a longer part of the chain, having comparable handling costs. The disadvantage being of course an increased delivery time.

The advantages of this kind of chain are of course:

?? *better utilisation of the Rhine capacity*

?? *reduced environmental impact in the upper part of the chain,*

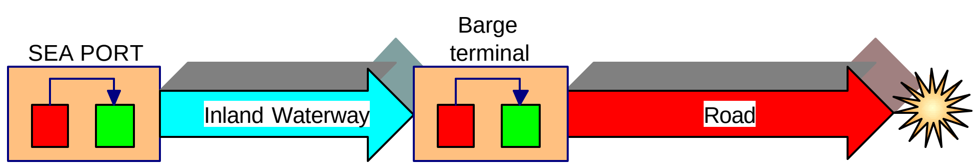
?? *possible reduced overall chain cost.*

The main disadvantages are:

?? *increased complexity of the chain compared to pure road transport,*

?? *negative impact on the alpine environment, which is the same as for the pure road chain.*

Fig. 4.3.1.1/4: Schematisation of the Intermodal IWT-Road Transportation Chain



Identification of the Chains to be Investigated

The chain to be investigated are those connecting the port of Rotterdam with an inland port in Germany. The pre-selection of possible port locations respects the finding of WP1. In this case the intermediate location of transhipment can be profitably used also by traffics having origin/destination within the terminal area of influence (i.e. this is the case of the traditional chains based on IWT already in use). The selected chains are indicated hereafter, where the alternative locations of the intermediate terminals indicated in brackets and separated by th e symbol |.

Rotterdam ✍ (Duisburg | Mainz | Mannheim | Basle)✍ Milan/ Verona

Rotterdam ✍ (Duisburg | Mainz | Mannheim)✍ Zurich/Basle

Rotterdam ✍ (Duisburg | Mainz | Mannheim) ✍ Vienna

Rotterdam ✍ (Duisburg | Mainz | Mannheim)✍ Sopron/Budapest

4.3.1.1.4 Tri-modal Chain IWT + Rail +Road

This is the real object of all our investigations. It was a brand new concept when the Apricot Project was first initiated, but has become a reality, at lest at an experimental level, when the new "ROMI Shuttle" service connecting Rotterdam to Milan via the inland port of Basle was launched last spring.

The basic concept behind this innovative chain is to take the best out of the different modes of transport, thus using the inland waterway for a first trunk haul, the railways to connect the inland port with a final terminal, avoiding the negative impact of road transport over the alpine environment, and the road for the final.

The possible advantages, disadvantages and operational concepts have already been presented in the previous Apricot project deliverable D2.

The main advantages are:

?? *Reduced environmental impact*

?? *Reduced energy consumption;*

?? *Low costs*

The main disadvantages are:

?? *Increased complexity of the chain*

?? *Difficulties in monitoring the whole chain*

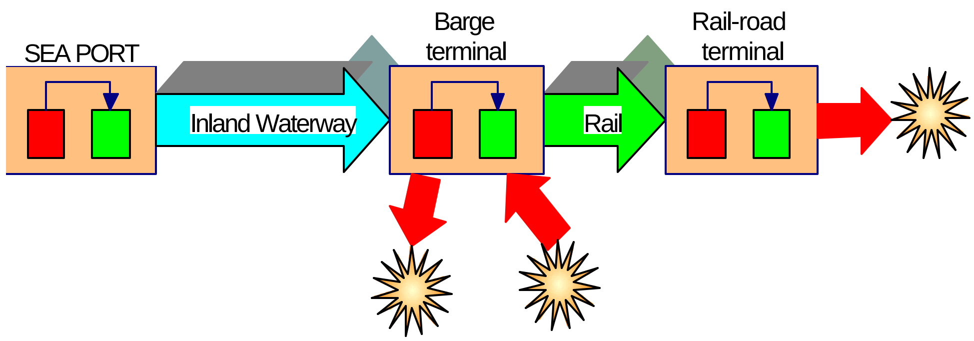
?? *Increased handling operations and costs*

?? *Reduce speed of the chain*

?? *Possible reduction of reliability due to the number of connecti ons*

It is clear that a key role for the reduction of a series of negative factors is played by the tri-modal terminal, which can not be managed in a conventional way, but requires an increased efficiency and quality of service to cope with the more sophisticated and complex chain.

Fig. 4.3.1.1/5: Schematisation of the Tri-modal IWT-Rail - Road Transportation Chain



Identification of the Chains to be Investigated

As in the previous case, the chains to be investigated are those connecting the port of Rotterdam via an inland port in Germany, to the final destinations.

The chain can be profitably used also by traffics having origin/destination within the terminal area of influence (i.e. this is the case of the traditional chains based on IWT already in use).

In addition, the rail capacity can also be used by those traffics between the area of influence of the inland port and the final destinations in Switzerland, Italy, Austria and Hungary.

The selected chains are indicated hereafter, where the alternative locations of the intermediate terminals are indicated in brackets and separated by the symbol |.

Rotterdam ✍ (Duisburg | Mainz | Mannheim | Basle)✍ Milan/ Verona

Rotterdam ✍(Duisburg | Mainz | Mannheim)✍ Zurich/Basle

Rotterdam ✍(Duisburg | Mainz | Mannheim) ✍ Vienna

Rotterdam ✍(Duisburg | Mainz | Mannheim)✍ Sopron/Budapest

4.3.1.1.5 Trimodal Chain Rail + IWT (+ Rail) +Road

This is a special case of tri-modal chain where the first leg is represented by the rail transport. The rest of the chain is similar to the IWT + Road chain proposed before. We also examined the possibility of adding a second rail leg at the end of the chain, but the resulting complexity make it an unreasonable solution.

The proposed chain is based on an innovative train service concept named *Shuttle²* or *double shuttle*, developed in the framework of the IMPULSE project.

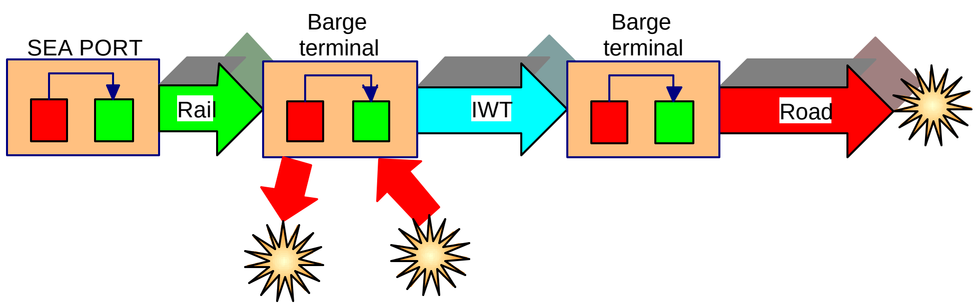
It consists a train composing of a fixed number of wagon (Shuttle) which is running between two terminal twice a night ("Shuttle²"). The aim is to exchange the same number of ITU as with two block trains with only one composition of wagon, thus achieving consistent saving due to a better utilisation of rolling stock and rail capacity. This kind of service is possible between terminals with a distance of about 200-300 km, leading to a total travel distance of 400 to 600 km which the train has to perform per night. Considerable high cost savings could be obtained by the adoption of highly automated equipment in the terminals served by the *Shuttle²* train.

The following are some details of the proposed service::

- Standard intermodal wagon, ability to running at 120 km/h, 100 km/h loaded
- All Intermodal Transport Units, since no structure gauge problems on selected routes (except left Rhine track – which is therefore excluded)
- 700 m train length at 1.500 t
- Electric propulsion on main line, Diesel traction, if necessary and for shunting operations inside terminals
- Mixture with passenger and wagon load trains
- Maximum Speed 100 (120) km/h
- Average Operation Speed 70 (80) km/h considering already necessities of operation (despite terminals, breaking points of transport, frontiers and change of loco drivers).
- Stop to leave group of wagon: 10 min
- Stop to accept group of wagon: 30 min
- Change engine driver: 2 minutes

Given the characteristics of the service, the only possible location of the tri-modal terminal featuring automated facilities to cope with the *Sthuttle²* service is Duisburg, being the other selected location too far from Rotterdam.

Fig. 4.3.1.1/6: Schematisation of the Tri-modal Rail-IWT- Road Transportation Chain



Identification of the Chains to be Investigated

As in the previous case, the chains to be investigated are those connecting the port of Rotterdam with the tri-.modal terminal in Duisburg, then via an inland port in Germany, to the final destinations.

The chain can be profitably used also by traffics having origin/destination within the Duisburg terminal area of influence

The selected chains are indicated hereafter, where the alternative locations of the intermediate terminals are indicated in brackets and separated by the symbol |. As one can notice the possible locations of intermediate terminals serving all the final destinations are limited to Mainz and Mannheim.

Rotterdam ✍ Duisburg ✍ (Mainz | Mannheim | Basle) ✍ Milan/ Verona

Rotterdam ✍ Duisburg ✍ (Mainz | Mannheim) ✍ Zurich/Basle

Rotterdam ✍ Duisburg ✍ (Mainz | Mannheim) ✍ Vienna

Rotterdam ✍ Duisburg ✍ (Mainz | Mannheim) ✍ Sopron/Budapest

4.3.1.2 Elements for the Analysis of the Selected Chains

We present here some synthetic results of the investigation carried out for the determination of terminal and haulage costs and delays. More detailed elements were used for the calculation of average parameters to be used in the analysis. The average cost/prices indicated will be used as reference values to be introduced in the cost evaluation model for the formulation of the base cases of analysis.

4.3.1.2.1 Terminals Costs and Delays

Maritime Ports, Port of Rotterdam

The port of Rotterdam has been chosen as the end point of the inland transportation chains investigated in the Apricot Project.

Our main goal is the comparison of these alternative chains, which usually form part of a longer and more complex intermodal traffic relation involving deep-sea haulage. We therefore mainly focused our attention on the differences existing in operations, costs and delays for the transhipment from the deep-sea side to the three inland modes.

Presently about 70 % of the maritime containers land at the Maasvlakte (Delta Terminal), the other 30 % is sailed more inland (35 km) towards the Terminals such as Waalhaven.

The result of our investigation showed that direct transhipment from sea to inland modes does never take place, all transhipment is via an intermediate storage (buffer). For the comparison of costs and delays we can then consider the starting point of our chains to be the storage lot at the port.

The modal split in 1998 of container transhipped at the port of Rotterdam to/from inland modes is about: 10 % rail, 30 % barge, 60 % truck.

The average stacking time is 2,5 day's.

Rotterdam has only 2 railway terminals: RSC Maasvlakte and RSC Waalhaven.

About 20 trains/week are leaving Rotterdam for the major European transport chains.

Barges that start at the Maasvlakte will normally visit another 5 to 7 terminals in the Rotterdam area before sailing of to Germany.

These barge-terminals are used for continental loads mainly represent an increasing market, which should be taken into account for the evaluation of potential benefits generated by the introduction of the new intermodal chain. Not only container flows from the Port of Rotterdam should be considered as potential market for the tri-modal chain to Italy, Austria, Switzerland and Hungary, but also other inland traffics originated or attracted by the Rotterdam region.

The big Carriers (Maersk etc.) are regularly making a full contract with the stevedores, including all the terminal handling , transhipment into the barge or train.

The full costs at Maasvlakte including all charges for documents, are 135 EURO for a 40'.container.

The pure transhipment costs are 40 EURO for 2 moves (truck✍ stack, stack✍ barge).

For policy reasons justified by the idea of neutrality in front of the different mode of transport, and favouring the competition, the price for the handling of a container is the same for all modes.

For the proceeding of the project we can assume as parameters for our evaluation the following prices:

Charge for transhipment and handling Sea-Road	40 EURO /ITU
Charge for transhipment and handling Sea-Rail	40 EURO /ITU
Charge for transhipment and handling Sea-IWT	40 EURO /ITU

Rail - Road Terminals

The operations performed in rail-road intermodal terminal has been the subject of many EC-funded projects, among which the SIMET and IMPULSE ones, and therefore were not further investigated in the framework of the APRICOT Project.

We concentrate our effort in the collection of pieces of information regarding pricing of intermodal transhipment and storage within terminals.

As far as waiting time at terminals and availability of ITUs after the train arrival is concerned, we observed that generally the waiting time of trucks outside a terminal is limited to a maximum of 1 hour, with an average of 20 - 40 minutes.

Generally we consider that the totality of ITUs carried by a train are made available within 1 hour from arrival. For closing time of trains before departure, this depends on the terminal and on the relations, but we must consider a minimum time of 1 hour.

As far as cost/price for transhipment is concerned we have collected the following information:

Terminal handling in Hungary

The following information was collected at the Budapest (Józsefváros) Rail/Road Terminal.

One “handling” includes two lifting (one between the train and the storage place and one between the truck and the storage place); the price applied for one lifting is 23 EURO for a 40' container.

If forwarding is done by one of the Hungarian Railways subsidiaries then one lifting is free of charge.

Storage costs for a 40' container is:

?? up to the second day from arrival: free

?? from the 3rd day to the 11th day: 14 EURO /day

?? from the 12th day: 24 EURO /day

Terminal handling in Italy

The normal price for handling is about 45-50000 ITL/ITU (23-25 EURO /ITU).

Fare for storage are dependent on various factors, but the following indications covers most of the situations:

Loaded containers:

?? first 2-4 days: free of charge

?? additional days: each ITU 2-4 EURO /day

Empty containers:

?? first 7-10 days: free of charge

?? additional days: each ITU 2-4 EURO /day

Swap-bodies and semi-trailers:

?? day of arrival+1day: free of charge

?? additional days: each ITU 2-4 EURO /day

Terminal handling in Germany

The official price for handling a 40' container in terminals owned by the DB is 40 DM (about 20 EURO)

The information collected from different sources regarding private operators indicate lower limits of about 15 EURO /ITU

For the purposes of the Apricot Project we can assume an average price of 18 EURO per shift to be appropriate.

IWT Ports

Specific elements for the inland ports were collected. We present here only some elements useful for the definition of costs.

The present operations normally serves both the rail and road modes of transport via a storage. There are, however, some cases of direct transhipment from barge to rail.

Usually the containers are transhipped with a crane from the barge to the storage. The same crane is used also for the transhipment from the storage to the inland modes.

We call this kind of operations "on-dock", and for barge-rail transhipment is possible only when there is a direct rail connection to the transhipment area.

This operations procedure:

Barge ✍ Gantry ✍ Storage ✍ Gantry ✍ Rail or Road

is for example used in the port of Basle.

More complex operations take place in other cases, for example in Duisburg, where the gantry serving the barge is not involved in the storage operations. The storage area is in a separate place and an intermediate movement is necessary between the transhipment area and the storage area. We refer to this kind of operations as "off-dock".

The sequence of operations in Duisburg is the following:

Barge ✍ Gantry ✍ multitrailer ✍ gantry ✍ store ✍ gantry ✍ rail

As far as time/delay elements are concerned, it is not simple to collect unambiguous figures valid for all situation.

For the intermodal chains presently in operation it seems that there is never a short time connection between barge and train departure/arrival, but a buffer time of about 1 day is always included, to take into account delays along the chain and problems of synchronisation between the two modes.

Significant improvements in the today situation can derive from the introduction of automation in inland ports, together with an improved chain management and information system for the co-ordination of rail and IWT.

For road transport we can consider an average time of 2-3 hours after the barge arrival for the availability of a loading unit.

As far as costs elements are concerned, we can consider an average cost of 18-20 € per shift. Consequently the price for a common "on-dock" transhipment consisting on 2 ship is about 35-40 EURO.

The cost of an "off-dock" transhipment is higher, especially when the rail terminal is not within short distance from the barge transhipment area, and can be estimated in about 60-65 EURO.

4.3.1.2.2 Haulage Costs and Times

Road

Long distance road haulage

Long distance Road haulage is important in our analysis not only as a term of reference for the complete chain from Rotterdam to the final destinations, but also as a component of several alternative intermodal chains. Therefore our investigation were focused on the relations between Rotterdam and the extremities of the selected corridors, and between the candidate terminal locations and the above mentioned locations.

Costs/Prices

For the sake of comparison with alternative chains we can take an average price of 0.9 EURO/km for the haulage of a 40' container, with minimum values at around 0.8 EURO/km. Some sensitivity analysis should be carried out on the results, because road prices are heavily conditioned by regulations and taxes, which can vary in the future to take into account the external effects produced by the road transport on the environment.

The carriage of a 40' container between Rotterdam and the North of Italy is priced around 1000 EURO for single trip, calculated on the base of a Round trip carrying a container to and a container from the port of Rotterdam for about 2000 EURO.

As far as Hungary is concerned, the price for a single trip from Rotterdam is about 1125 EURO to Budapest and 1000 EURO to Sopron.

The prices to/from different port locations in Germany are presented in the table below. The prices were collected from different sources and independently by Apricot partners, and then compared, showing some ranges of variation presented in the table.

Tab. 4.3.1.2/1: Road transport market prices for a single trip from an inland port location to a final destinations on the selected corridors

From	To	Min. price (EURO/trip)	MAX. price (EURO/trip)
Duisburg	Budapest	980	1.110
	Sopron	830	940
	Busto/Milan	720	900
	Verona	840	1000
	Vienna	780	880
Mannheim	Budapest	790	890
	Sopron	790	890
	Busto/Milan	480	600
	Verona	600	700
	Vienna	590	660
Mainz	Budapest	780	880
	Sopron	640	720
	Busto/Milan	540	650
	Verona	670	800
	Vienna	580	650
Basle	Budapest	900	1.000
	Sopron	750	850
	Busto/Milan	270	350
	Verona	400	500
	Vienna	690	780

New elements for the evaluation of the chains to Italy is the re-opening of Switzerland to 40t traffics starting from the year 2001, but subject to a new tax based on total weight and kilometers driven.

Nowadays the vehicle dimensions limits are the same as in the EU, but the maximum total weight of trucks is 28 t which means a payload of about 15 t.

New regulations will raise the total weight allowed to 40 t by the year 2005, with an intermediate step at 34 t from 2001.

There will be an initial limited number of authorisation for 40 t vehicles since 2000 The new policy will be introduced gradually, and only in 2005 the transit of 40t trucks will be completely granted.

The amount of the transit tax from Basle to Lugano will be of about 200 EURO for a 40 t truck.

Travel Time

Travel time over long distances is dependent not only on the distance, but also on the time spent in breaks during the trip.

The working conditions for transport within EU member states are regulated by the Council Regulation (EEC) No 3820/85 of 20 December 1985. Some basic rules are herewith synthesized (source: EC-DGVII, 1999 - *Guide to the transport acquis*)

Daily driving period shall not exceed nine hours, it may be extended twice in any one week to10 hours, so for our calculation we can consider 10 hours driving time

A **weekly rest period** is prescribed after six daily driving periods.

Breaks: after four-and-a-half hours' driving, unless a daily or weekly rest commences, a break of at least 45 minutes is prescribed, which can be split.

Daily rest period in each period of 24 hours at least 11 consecutive hours, which may be reduced to a minimum of nine consecutive hours not more than 3 times in any one week; alternatively, it may be taken in two or three separate periods during the 24-hour period, in which case the minimum rest time is 12 hours, with the minimum period of one segment of the rest period being 8 hours. There are special rules for vehicles transported by train or ferryboat. Reduced rest must be subsequently compensated in rest hours before the end of the following week.

Given this regulatory framework and considering an average speed speeds of 90 km/h on Motorways, 70 km/h on other major roads and 40 km/h in secondary roads, we have made some calculations of running times along the selected routes.

As an example we present here results for the route Rotterdam-Milan: Using the transit through Switzerland we need via Gotthard tunnel a travel time of 22 hours and via Frejus tunnel 26,5 hours for the relation Rotterdam-Milan for 1072/1337km.

The transit times for the relations to Hungary must take into account some additional delays at the borders. Investigations among Hungarian carriers showed that a guaranteed performance for a round trip to Rotterdam of any of the inland ports considered by the APRICOT Project is of 5 days.

Short distance Pre- and Post-Haulage

For the Pre- and Post- haulage we tried to collect information leading to some clear indication about unitary costs per kilometre and per hour.

For Hungary, the following prices were collected from a forwarder: 157 – 180 EURO/round trip with normal truck for 0 – 50 km.

For Italy several ambiguous indications were collected, leading to very different prices dependent on a variety of conditions.

The official fare applicable to a 40' container within a distance of 75 km from a terminal (150 km round trip) is about 160 EURO, but high discounts can be made on special agreements with the hauliers.

Rail

The matter of establishing the right costs for a rail service is a matter discussed over the whole history of transportation economics, and is still difficult to determine the exact costs to be charged over single services. For this reason we have investigated mainly the prices at which the rail service is offered.

An average price to be used in the framework of the Apricot project could be considered about 0.5 EURO/FEU-km. Even though the prices found in the market are some times only partially depending on the distance (almost the same price in for example offered for the services Rotterdam-Milan and Duisburg-Milan).

The prices collected for different relations to/from German terminals is presented in table 4.3.1.2/2 (Source: HaCon, 1999).

Tab. 4.3.1.2/2: Intermodal Transport on Rail. Prices for a single trip from an inland port location to a final destinations on the selected corridors for a 40' container

		Min. price (EURO/trip)	MAX. price (EURO/trip)
Duisburg	Budapest	895	920
	Sopron	741	767
	Busto/Milan	665	690
	Verona	792	818
	Vienna	665	690
Mannheim	Budapest	690	716
	Sopron	562	588
	Busto/Milan	486	511
	Verona	588	613
	Vienna	486	511
Mainz	Budapest	665	690
	Sopron	537	562
	Busto/Milan	486	511
	Verona	639	665
	Vienna	460	486

The prices indicated in the table doesn't include any handling fee, nor pre-end haulage.

The following data were obtained from a forwarding company owned indirectly by the Hungarian State Railways and Györ-Sopron-Ebenfuhrt Railways (GySEV), which is called Hungarokombi). Prices are given in EURO for 20' and 40' units and five different gross weight category.

Tab. 4.3.1.2/3: Intermodal Transport on Rail. Prices for a single trip from terminals in Hungary to Rotterdam and inland port locations (Source: Transman, 1999)

T/F Rotterdam		<8 tons	<16.5 tons	<22 tons	<34 tons	>34 tons
Budapest	'20	386	452	535	740	822
	'40	714	755	961	961	961
Sopron	'20	339	395	465	645	714
	'40	625	660	834	834	834
T/F Duisburg						
Budapest	'20	432	499	582	750	833
	'40	708	750	959	959	959
Sopron	'20	375	434	506	652	724
	'40	616	652	833	833	833
T/F Mainz						
Budapest	'20	There is no direct connection (shuttle or fast service) between Hungarian terminals and Mainz therefore prices obtained for Mainz are not realistic. These should be estimated.				
	'40					
Sopron	'20					
	'40					
T/F Mannheim						
Budapest	'20	382	441	515	662	736
	'40	625	662	846	846	846
Sopron	'20	332	383	448	576	640
	'40	543	576	736	736	736
T/F Basle						
Budapest	'20	438	505	589	756	839
	'40	714	756	965	965	965
Sopron	'20	381	439	512	657	730
	'40	621	657	839	839	839

These prices include:

?? the rail transport;

?? one lifting at Budapest (see terminal handling cost data) and one lifting in the other station;

?? the forwarder's margin.

The following data is related to some relations between Italian terminals and Rotterdam. The prices are only indicative and are valid for both directions.

The prices includes handling at terminal but not pre and post haulage.

Tab.4.3.1.2/4: Intermodal Transport on Rail. Prices for a single trip from terminals in Italy to Rotterdam in EURO (Source: Euretitalia, 1999)

T/F Rotterdam		<8 tons	<16.5 tons	<22 tons	<34 tons	>34 tons
Milano	'20	292	342	405	532	-
	'40	500	532	689	689	689
Padova	'20	381	451	539	714	-
	'40	670	714	933	933	933
Bologna	'20	375	444	529	701	787
	'40	658	701	916	916	916

As far as travel time is concerned, we have noted a great variety of services and therefore it is difficult to take an average time. For the sake of chain comparison it was decided to consider only shuttle services during the subsequent tasks of the project.

A typical travel time from Rotterdam to the North of Italy for such a service is about 36-40 hours.

Inland Waterway

Extensive information about sailing times and framework conditions for barge sailing along the Rhine have already been presented in the final reports of previous tasks.

Here we present only some general information about here are ship costs (fix) per day in continue operation for different barge categories:

Europaschiff (100 TEU): 5.500 DM per day

GMS (200 TEU): 8100 DM per day

Jowi (400 TEU): 10.600 DM per day

Variable operating costs (e.g. fuel) have to be added.

Investigation by consortium members have shown a reasonable range of cost for Inland Waterway haulage of a 40' container to be between 0.27 EURO/FEU-km (400 TEU barge) and 0,30 EURO/FEU-km (200 TEU barge)

4.3.2 Comparative Analysis of Transfer Systems in Ports and Terminals

The statistical consideration of only special ports are explained with the search for the best useful ports for trimodal chains. The most attention is given to the special situation of the different inland ports.

Ports, which will be considered, are visited, to get a view to the real working conditions for trimodal functions. Data of the inland ports could not be completed by reason of different sources of information and the voluntariness of reaction, because the port organisations fear competition of other inland ports. For the assessment of the practicability of trimodal transport chains the data always are sufficient. The special information about the accessibility for trains and trucks are more important than exactly data of volume and transhipment.

We take in consideration only inland ports, which have a special utility for traffic from and to agglomerations or are situated in the surrounding of an agglomeration. The focal point we have seen along the Middle Rhine with several locations. Another point for the selection was the possibility to made early tests for the developed calculation software for the analysis of inland ports. For a real decision additional individual aspects and trends can be helpful.

List of criteria for best suitability for trimodal transport chains at the inland waterway Rhine:

?? Short stopping time for the means of transport

?? Good accessibility of the transhipment area for all means of transport

?? High storage capacity

?? Typical suitability for inland waterway, trains and lorries

?? Reduced necessity for longitudinal transport

?? Low investment and low operational costs

4.3.2.1 Analysis of Exemplary Inland Ports at the River Rhine

4.3.2.1.1 Inland Port: Duisburg

The region of Duisburg is growing up in the field of logistics and transport. For this their are effective designed terminals for Combined Transport Rail/Road/Inland Waterway necessary. The special situation of Duisburg gives the impression, that the future of the barge-side transhipment will be in different special “private” terminals with their own logistic for one ship-owner or operator. The partners inside such a co-operation serves only the own barges or terminals but very efficient. For the ARA ports Duisburg is a good located for a hinterland terminal without the expensive costs for personnel in the seaports.

Duisburg is located close to the Ruhr region and the city of Düsseldorf. There are more than 5 Mio. people inside the agglomeration. As a hub Duisburg serves the whole East Germany with Berlin and East Europe with Poland and other countries. To the South-East to Nuremberg / Munich and to the South to Swiss and Italy. The East- and South-East-relations normally be served with rail, the South be served with inland shipping in addition with road and rail. The evolution of Duisburg from the leading inland bulk goods port to one of the greatest inland container port is still running.

The attractions of the port of Duisburg are the different transhipment possibilities including the transhipment from barge to train for a second main haulage. In Duisburg it seems clear that trimodal transport chains can be promoted from:

- Low costs for personnel and equipment in the inland ports
- Punctuality and reliability of the short and efficient inland waterway Rhine
- Railway access of high quality for all relevant destinations.

Fig. 4.3.2.1/1: Container Terminal DeCeTe, Duisburg

4.3.2.1.2 Inland Port: Mainz

The inland port of Mainz is dominated from the activities of the container terminal Frankenbach. The configuration of berth and storage area are not very favourable but very efficient used. The location close to the city of Mainz is not fortunate for the development of the port in the future. Area for expanding and low-priced development for infrastructure is missing. It is not the aim of the government to collect the logistic functions in the near of the city.

But the great catchment area at Rhine and Main is very good for trimodal utilisation.

Fig. 4.3.2.1/2: Container Terminal Frankenbach, Mainz

4.3.2.1.3 Inland Port: Mannheim

The inland port of Mannheim looks back at a very long tradition. Located at the confluence of the rivers Rhine and Neckar there exists a collecting and distributing function for the goods flow from the North to Stuttgart and Basle and back. Container handling is existing nearly since the beginning of combined traffic in Europe. On the opposite bank of the river Rhine in the city of Ludwigshafen there exists an additional container terminal in this region. A second terminal of Mannheim is just built up at the river Neckar. Last but not least includes the port of Mannheim the DUSS-Terminal for combined transport rail – road. In total shows the port of Mannheim best conditions for trimodal activities.

Fig. 4.3.2.1/3: Container Terminal Rhenania, Mannheim

4.3.2.1.4 Inland Port: Basle

The port of Basle is the most south end of the important Rhine shipping. Trimodal transport chains, which using Basle for transhipment from barge to rail, can have an attractive price but need 4 days for travel. Basle as a destination itself provides the Northern and Western Swiss , the region South-Baden and Southeast France. One trimodal chain from Rotterdam to Busto Arsizio is already existing (The ROMI-Shuttle). In competition to this the ART-Shuttle will start soon.

Fig. 4.3.2.1/4: Container Terminal SRN-Alpina, Basle

4.3.2.2 Exemplary Layout of Trimodal Terminals with New Logistic Concepts

The different locations of inland ports make difficult to choose an representative example of terminal layout. With the installation of a new logistic concept the layout of an inland port will be changed.

A new logistic concept will be necessary if a container terminal starts trimodal functions. The new element inside the terminal, the train, is oriented at the rules and operation necessity of train operation. This rules are strange in an inland port and not easy to realise. It may be helpful if new terminal layouts with innovative components bridge the missing compatibility.

The technical components which need an improvement are

- ?? Handling devices
- ?? Railway access
- ?? Barge unloading and loading system

An important aspect should be the different length of train and barge. This creates additional traffic, handling facilities and additional personnel cost. The usual way to avoid this traffic is the shunting of the trains into several wagon groups and the working parallel or one after another. Alternative to this traditional way it is possible, to use an innovative fast handling system with automatically transhipment along the moving train. Unloading and loading procedures of the trains take place directly beside the barge without additional longitudinal transport. This technique needs inside the port area one length of a train always before and behind the berth.

The following figure shows for the example of Mannheim the new configuration with a transhipment plant integrated into the existing port area.

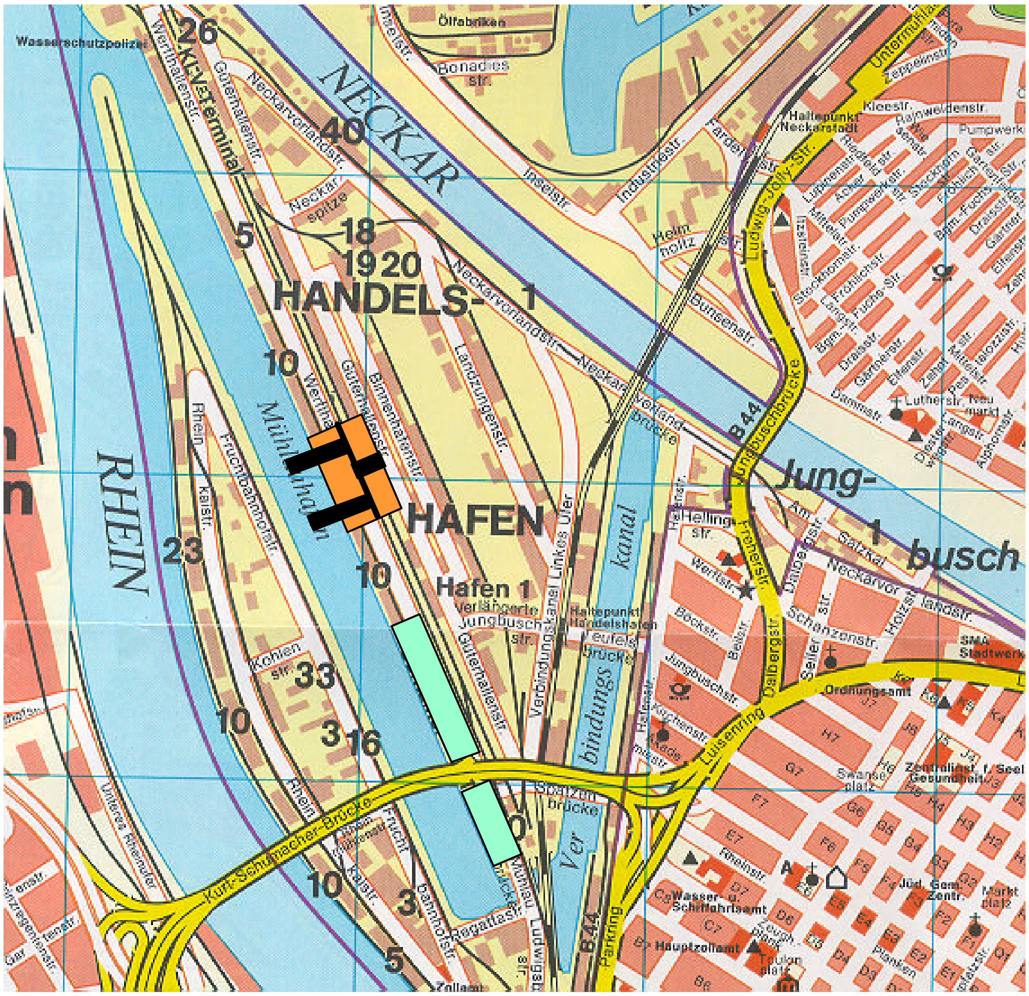


Fig. 4.3.2.2/1: Innovative Trimodal Transfer System (Example Inland Port Mannheim)

The figure makes clear, how longitudinal transport proceedings can be reduced. This reduction results in reduced operation costs and reduced expenditure of marshalling and at least in reduced costs for the whole transport chain. In addition the travel from and to the South grows more attractive and faster.

Along the river Rhine there exists already a number of container terminals. For this terminals it is better to search for an integration of old and new technique by using the existing equipment for unloading and loading the barges. The operation in relation to the trains should be realised by new compact terminal concepts. For the alternative concept also designed for Mannheim the effects could be shown in the following figure.

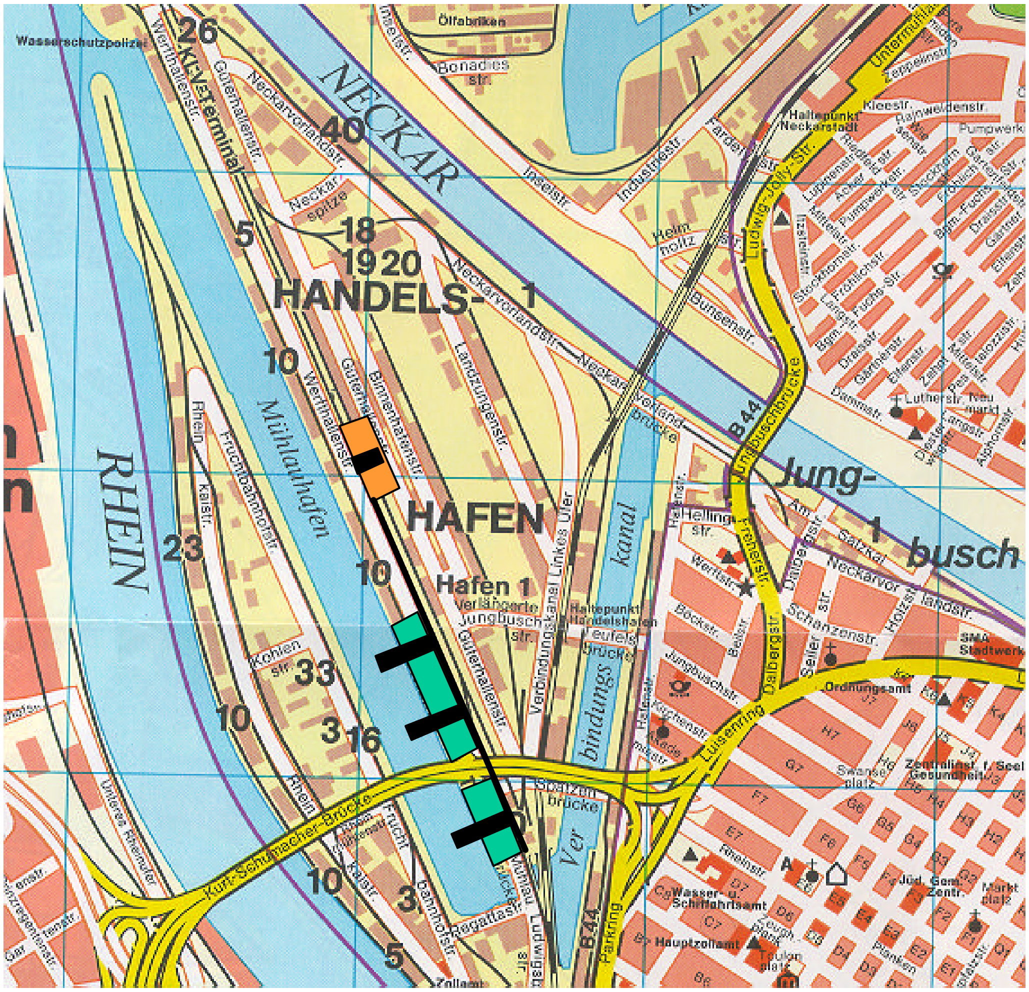


Fig. 4.3.2.2/2: Semi-innovative Transfer System (Example Inland Port Mannheim)

4.3.2.3 Conclusion for Trimodal Terminal Operation

The trimodal usage of terminals in inland ports needs the peculiarities of all involved traffic means inland shipping, rail and road. The existing container terminals along the river Rhine normally are designed for a good function of the connection between road and barge with an profitable operation.

As an complete new type of traffic the rail transport add to this. Transport on rail distinguishes special aspects:

- The schedule in the DB-Network with time-slots

- The extraordinary length of the trains
- The high investment for engine and wagons
- The fixing on rails practically without a possibility for overtaking.

For the attractiveness of an inland port and his container terminal in respect of trimodal functions may be the buffer time between unloading the barge and loading the train important and a commercial factor.

But the question for required buffer times could not be answered finally, because the situation is not homogeneous. On the one hand barges sails very punctually, the same from Rotterdam to Duisburg and to Basle, on the other hand the containers usual use only the train departure at the next evening and lose half a day. For this important aspect additional practical and theoretical analysis are necessary.

Today very urgent goods are transported directly from the berth by road.

The trimodal terminals along the river Rhine needs fast handling systems with low costs for transhipment.

4.3.3 Modelling of Transport Corridors

The working on the previous work-packages was focussed on the analyses of innovative tri-modal transport chains under various aspects. This work shall be expanded by a computer simulation program for calculation of transport chains in the corridors. Aim of the program is the presentation of different chosen or defined transport chains between the corridors by means of simulation and calculation on basis of various parameters.

During the previous duration of this project particularly the tri-modal transport chain was discussed and examined in some different practical orientated projects with concentration of the Northern-Italy-range. One already running project is the "Romi-Shuttle" between **Ro**tterdam and **Mi**lan.

The collected data and the results of this work will become influence parameters for the model or will be taken into account for the design of the transport chains.

Substantial contents is the description of the

- program
- main structure of the transport chains
- possibilities of evaluation and analysis of the results.

4.3.3.1 Basic Requirements

In general the program should meet the following demands:

- **Development on basis of standard software MS EXCEL**

Nowadays excel has become a standard software with a very wide distribution. Excel is installed on most of the personal computers. Herewith a problem-free installation and running is guaranteed.

- **User friendly system interface**

  A user friendly system interface ensures that the training period can be very short and the work with the program and the integrated specific features in principle is so easy that no user's handbook is necessary. It is designed with short on-line descriptions and explanations which makes an unlimited use possible.

- **Presentation of the results in suitable and clearly charts or maps or combination of both**

  A concise and clearly laid out presentation of the results helps to ensure fast and easy analysis.

- **Opportunity to change or modify basic-parameters for the calculation**

  The calculation parameters (prices) are integrated into the program with standard values (based on current surveys). Particularly the price development depends on various influences (e.g. competition situation, prices of competitors, fiscal politics etc.). Because of that the program offers the opportunity to adapt the standard price parameters to the recent market situation.

4.3.3.2 Basis of the Program

For the building up of a theoretical test model different parameters with their specific influences - depending on the chosen mode of transport - have to be taken into consideration.

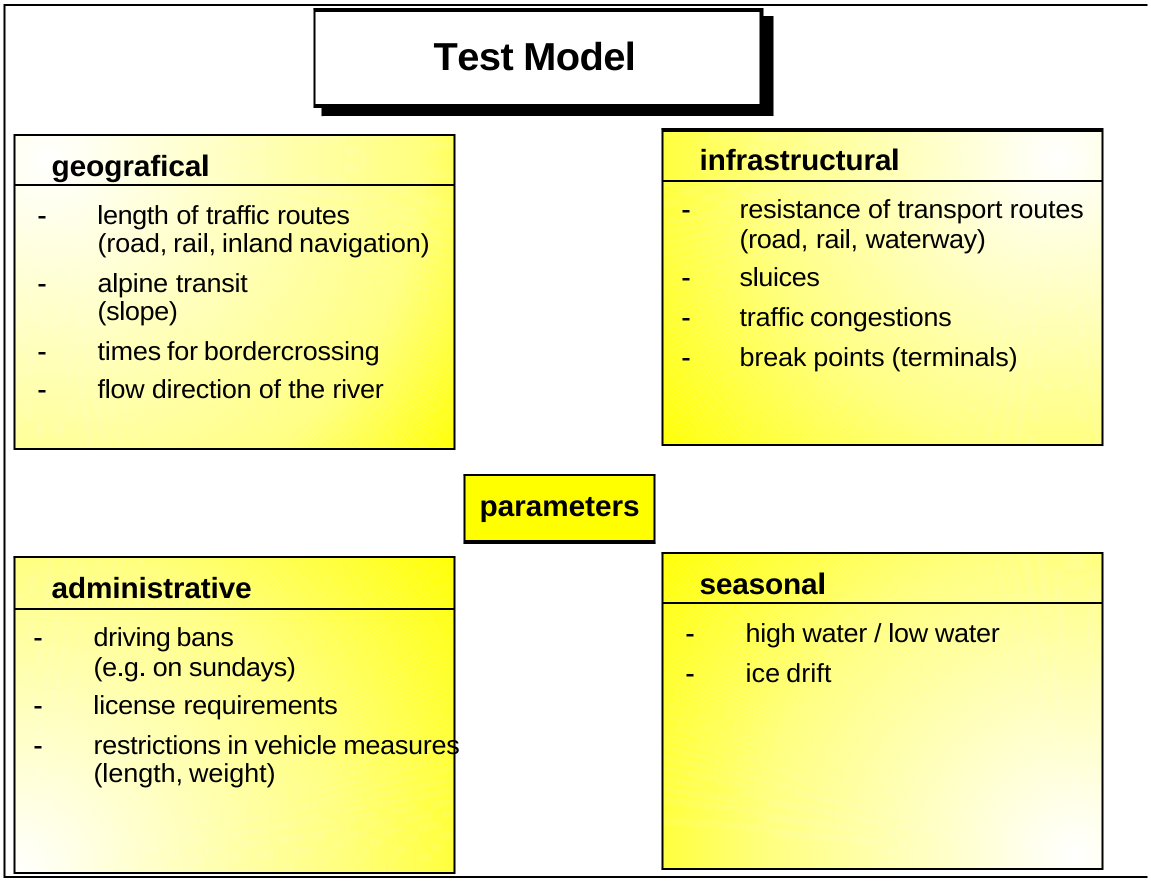


Fig. 4.3.3.2/1: Parameters of a test model

Geographical Parameters

One important geographical parameter is the length of the transport route which can be considerable different depending on the mode of transport. The road network in Europe has compared to rail and inland waterways a very good density. Because of this, in many cases road transport has the shortest length of traffic routes and has benefits especially compared to inland navigation which can use only a restricted amount of waterways (low density, less integration).

For rail transport the Alps with their specific topography (slopes) have influences on the train capacity. For road transport alpine transit has to be seen in connection with special administrative regulations.

Especially crossing of borders is a problem for rail transport because the European railway systems are often not compatible (traction, control, signalling, gauge).

The flow direction of natural waterways has a strong influence on journey time (see above).

Infrastructural Parameters

These parameters are dealing with the specific resistance of transport routes. For instance the passing of sluices has a negative influence on the journey time. In road transport the risk of traffic congestion is getting higher continuous. For bimodal and trimodal transport chains the location (network integration, access) and the capacity of terminals are having a very high importance.

Administrative Parameters

Above all administrative regulations are influencing mainly the road transport.

Seasonal Parameters

Particularly inland navigation is dependent from weather conditions and other seasonal parameters (low water, ice drift).

4.3.3.2.1 Transport Chains

The transport chains which are basis for the calculation and modelling of the corridors are shown in Fig. 4.3.3.2/2. They can be separated into unimodal, bimodal and tri-modal transport chains.

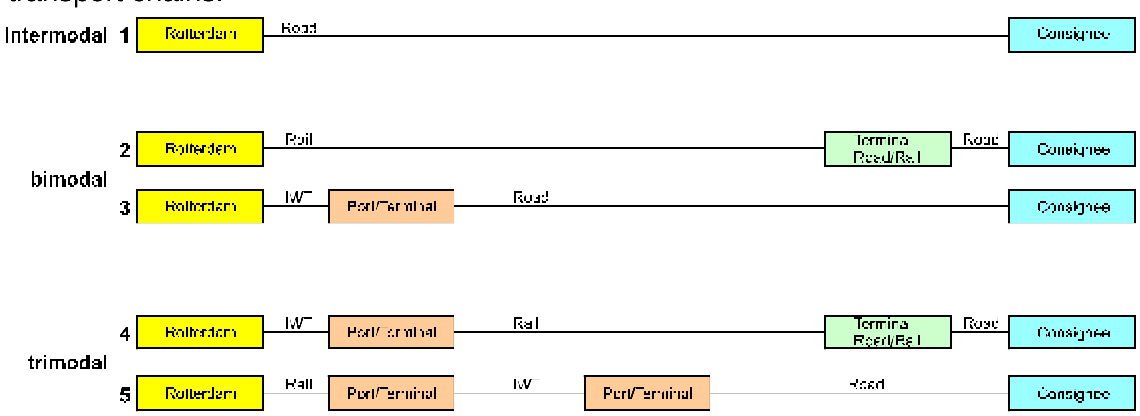


Fig. 4.3.3.2/2: Transport Chains

First chain shows the direct long haul road traffic between Rotterdam and the corridors from place of dispatch to receiving point.

The second chain shows the “classic” connection in intermodal transport road-rail. These are the main transport chains for goods traffic between the corridors.

The other chains described in Fig. 4.3.3.2/2 are including the use of inland waterway transport (IWT). Chain 3 is bimodal in combination with waterway- and road-transport but included into the program because this chain is common especially in the connection between Rotterdam and Duisburg (IWT).

Transport Chain 4 shows a “typical” tri-modal chain. Starting point is Rotterdam with an inland waterway transport to an inland port along the Rhine. In the port the units have to be transferred between barge and rail and transported to destination terminal. The final end-haulage is done by truck.

Transport Chain 5 is a second variant of a possible tri-modal connection. In difference to Chain 4 the transport between Rotterdam and a terminal is done by intermodal train which ends in a terminal location of a port along the Northern Rhine. There it is connected with inland waterway transport to a port in the Southern Rhine-area.

In this case the number of terminals and the combination of both is restricted. The further transport is made on the road by truck.

4.3.3.2.2 Relations

Basis for modelling of corridors is the definition or fixing of the relations which shall be analysed and compared. During a meeting of the apricot working group it was fixed to examine the following relations:

Netherlands – Northern Italy

- Rotterdam – Verona
- Rotterdam – Milan

Netherlands – Switzerland

- Rotterdam – Basle

Netherlands – Hungary

- Rotterdam – Sopron
- Rotterdam – Budapest

Netherlands – Austria

- Rotterdam – Vienna

In the program the mentioned relations and the possible variants (unimodal, bimodal and tri-modal) will be calculated and valued under consideration of the relevant parameters.

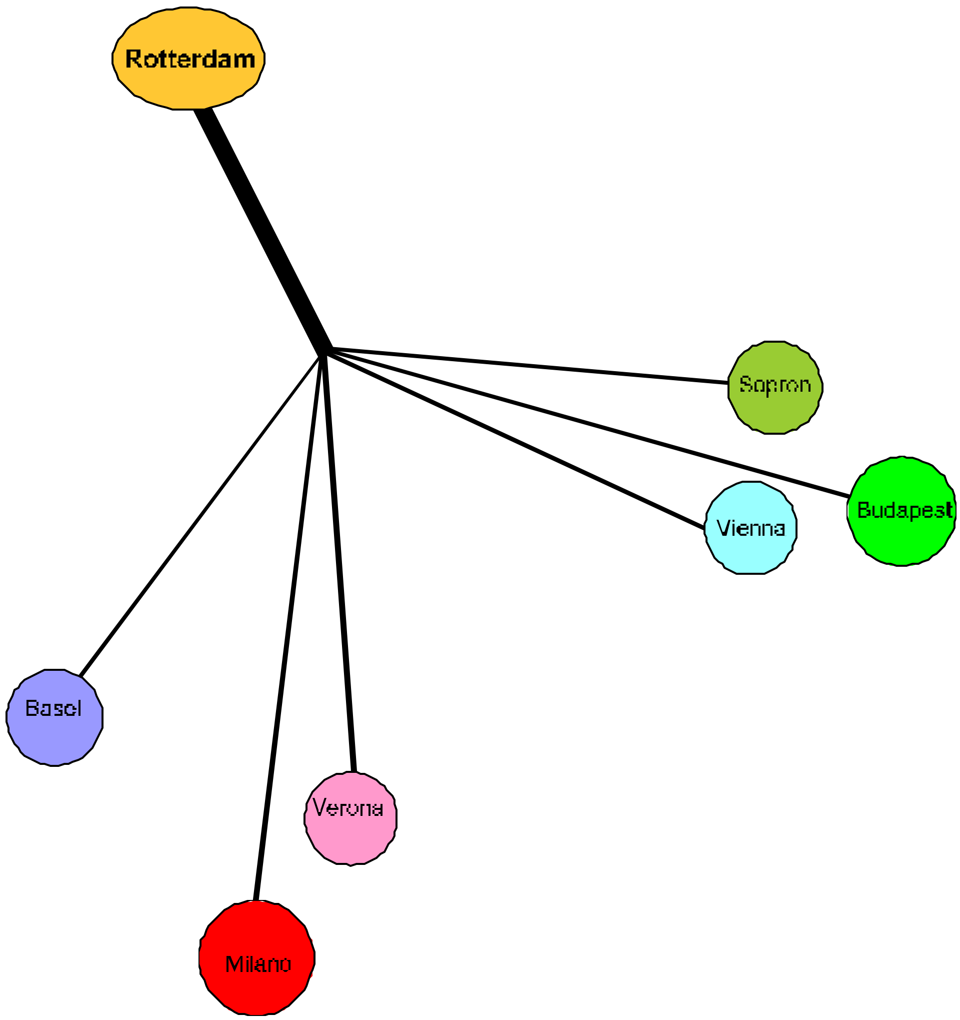


Fig. 4.3.3.2/3: Relations

4.3.3.2.3 Locations for Tri-modal Terminals

As locations for tri-modal terminals the following inland waterway terminals along the Rhine are integrated into the calculation:

- Duisburg
- Mainz
- Mannheim
- Basle

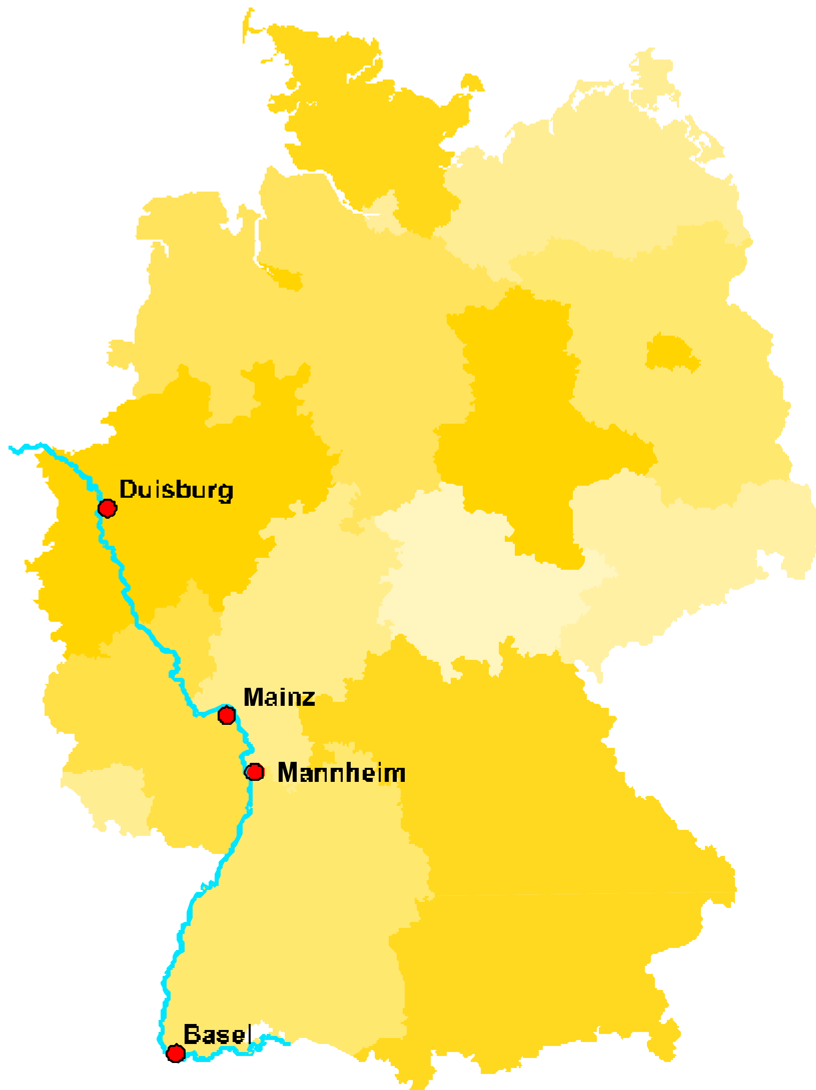


Fig. 4.3.3.2/4: Terminal locations along the Rhine

The reduction to locations along the Rhine is a result of the previous work which has shown that the use of the Main-Danube-Channel for container transport is not optimal under economic aspects because of the specific disadvantages (restricted capacity utilisation, low speed, etc.) compared to the Rhine.

4.3.3.3 Modelling of Corridors

Figure 4.3.3.3/1 shows the principle mode of operation and features – portrayed in simplified terms.

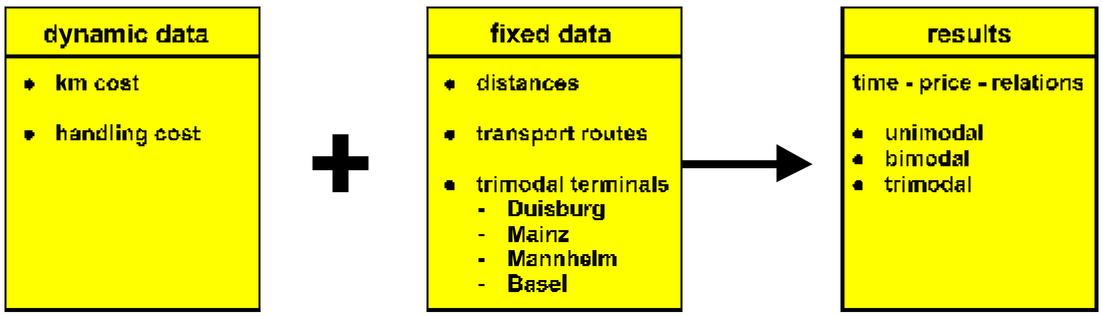


Fig. 4.3.3.3/1: Principle Mode of Operation

Starting point is the input or selection of the relation which shall be analysed. After this selection the destination bcation in the relation has to be chosen in connection with an inland waterway transport chain.

After the running of the calculation the program offers a comparison between the basis chains unimodal with road and bimodal with rail-road and the selected transport chain with included use of inland waterway transport. For these three chains the relevant results are presented: Price (handling in terminals, transport prices, pre- and –end-haulage) for the whole chain from Rotterdam to destination and journey time (terminal times, buffer times, journey times e.g.) for the whole chain.

Chosen Parameters	
Iwt	200 TEU
Service	shuttle service
Duisburg	conventional handling
Dock	off dock
Container	FEU

Results - Price [€]	Ro'dam Handling	Iwt	Duisburg	Rail	Road	Milano	Pre - and End-haulage	Sum	
Chain 1: Road	40				936			976	€
Chain 2: Rail - Road	40			625		28	150	843	€
Chain 4: Trimodal	40	60	63	500		28	150	841	€
Results - Time [h]	**Ro'dam Handling**	**Iwt**	**Duisburg**	**Rail**	**Road**	**Milano**	**Pre - and End-haulage**	**Sum**	
Chain 1: Road	0,5				26,0			26,5	h
Chain 2: Rail - Road	3,0			24,0		3,5	3,0	33,5	h
Chain 4: Trimodal - upstream	13,5	24,0	18,0	20,0		3,5	3,0	82,0	h
Chain 4: Trimodal - downstream	13,5	12,0	18,0	20,0		3,5	3,0	70,0	h

Fig 4.3.3.3/2: Prices for the Whole Chain Rotterdam – Duisburg - Milan

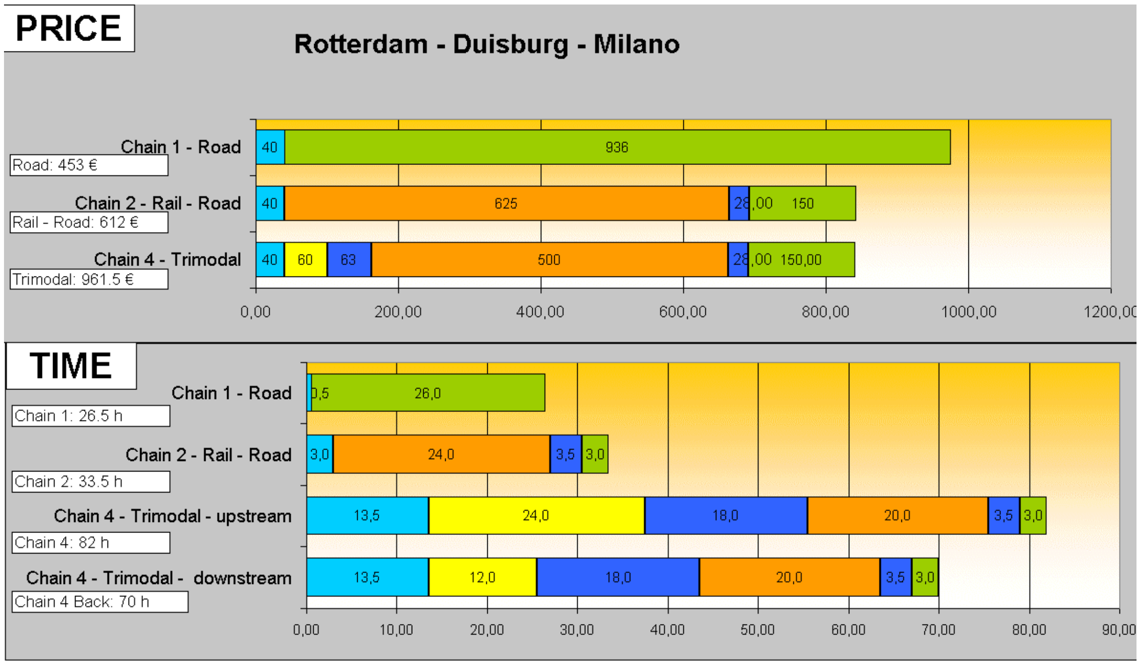


Fig 4.3.3.3/3: Journay Time Selection for the Chain Rotterdam – Duisburg - Milan

4.3.3.3.1 Parameters

For the calculation two sorts of calculating parameters are going to be used:

- fixed parameters: the user has no possibility to change or modify the numbers or values
- variable parameters: the user is allowed to update and modify if necessary

Journey Times

The specific journey times have been integrated as fixed parameters.

Road

The distances between the starting and destination point are basis for the determination of journey times. In the data base for each relation the specific convenient distance was determined.

On this basis and under consideration of the regulations concerning resting an driving times. The journey times have been tuned with an international forwarder and judged as close to the practise.

Rail

The journey times for rail transport have been fixed under consideration of using direct or shuttle trains. Basis for the determination of journey times are existing train connections. In relations where no connections are existing today the journey times were estimated.

Inland waterway transport

The journey times for barges were estimated on basis of different sources and under consideration of the flow direction of the river.

Handling

Seaport Rotterdam

The handling in Rotterdam is calculated under consideration of the different chains:

seaport – road

seaport – rail

seaport – IWT

For each handling chain specific average prices will be integrated in the calculation.

Tri-modal ports

In tri-modal ports are several different handling alternatives to choose:

fast handling

Assumes the use of a fast handling plant.

conventional handling

In this case the handling will be made by conventional gantry cranes.

direct transhipment

Assumes direct handling between barge and rail wagon or truck indirect transhipment

Assumes an intermediate storing between barge and rail transhipment.

on dock terminal handling

Assumes that handling between barge and rail is made in one terminal which means that a rail connection with a loading track is existing inside the terminal (also precondition for direct transhipment).

off dock terminal handling

Here a cartage between barge and rail terminal is necessary. Direct transhipment is excluded (not possible).

Destination terminals

The handling in the destination terminals is calculated under consideration of an specific average time.

Barge Size

Concerning the barge size 3 alternatives can be chosen:

100 TEU (Europaschiff)

200 TEU (GMS)

400 TEU (Jowi)

From the possible capacity of the barge different port laying times are resulting. When using an Europaschiff or a GMS it is assumed that the loading and unloading of the barge will be done by one gantry crane. Ships with a capacity of 400 FEU are served with two gantries. Therefor the choice of ship size influences the port laying time. There is no influence concerning the driving ti me on the river or canal.

Ship Operation Service

Concerning barge operation there are two different possibilities:

- liner service assumes 2 stopovers between starting and destination terminal
- shuttle service assumes a direct connection between two ports without intermediate stopover to load and unload.

Rail Operation

Concerning rail operation there are two alternatives possible:

- conventional shuttle

Assumes a shuttle train connection with one journey per day for a shuttle-configuration or equipment.

- double shuttle

Assumes more than one journey per day for a shuttle train equipment (dependent on distance).

4.3.3.4 Program Description

Selection of Corridor

The start screen shows the possibilities of selecting corridors. Starting point is Rotterdam, destination terminals / consignees are located in Switzerland, Hungary, Italy and Austria.

The user has to select one of the following relations:

- Rotterdam – Basel
- Rotterdam - Vienna
- Rotterdam - Verona
- Rotterdam - Milano
- Rotterdam - Budapest
- Rotterdam - Sopron

Transport Chains

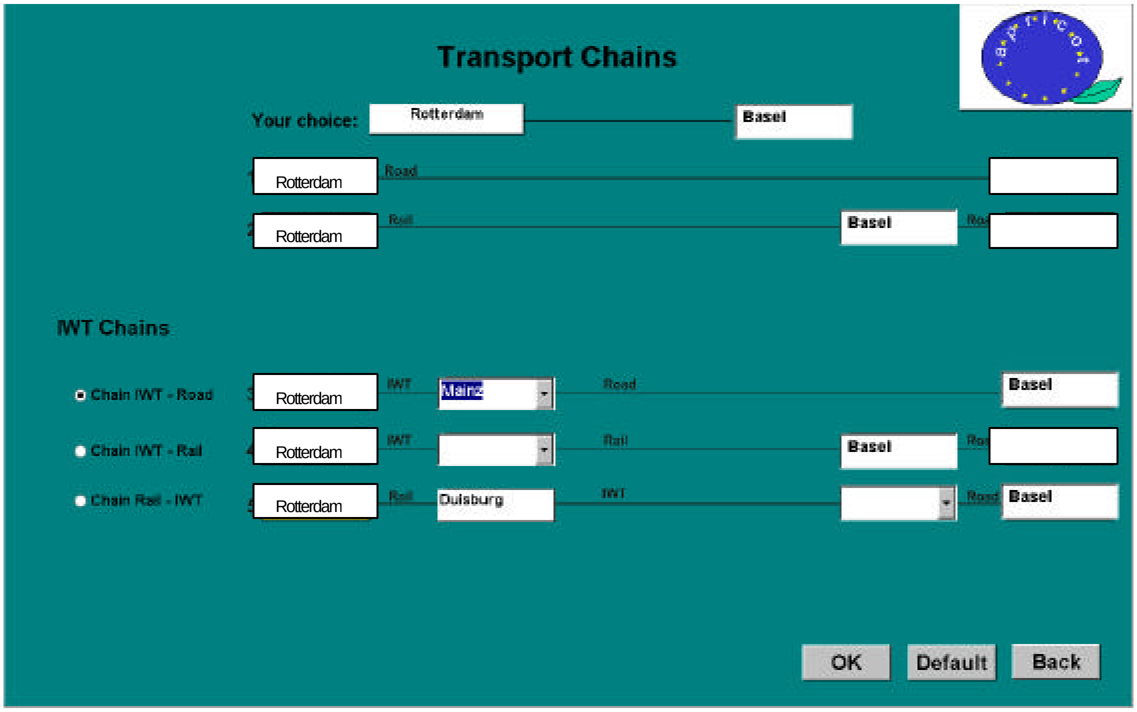


Fig. 4.3.3.4: Transport Chains

After selecting the relation the user has to choose one of three given transport chains (Chain 3 to 5). Chain 1 and 2 are always calculated by the program as reference relations.

Chain 1: unimodal, road

Chain 2: bimodal, road – rail

Chain 3: bimodal, IWT – road

Chain 4: trimodal, IWT – rail – road

Chain 5: trimodal, rail – IWT – road

Furthermore the user has to select one of the following given tri-modal terminals:

Chain 3: Duisburg

Mannheim

Mainz

Basle

Chain 4: Duisburg

Mannheim

Mainz

Basle

Chain 5: Duisburg (this terminal is fixed inside the program)

2nd terminal: Mainz

Mannheim

Defining Chosen Chain 3

Chain 3 includes IWT inland waterway transport) and terminal handling in Duisburg, Mainz, Mannheim or Basle. The parameters which have been selected for IWT and terminal handling are necessary for the calculation of results (prices, time and modal split).

IWT:

- selection of ship size
- selection of service (liner or shuttle)

Terminal handling:

- selection of handling (fast or conventional)

Setting Price Parameter - Chain 3

Every input field on this page has to be filled with a price. One alternative is the selection of a price out of the list which is shown by clicking at the arrow of the boxes, the other way is to fill in own specific prices into the input fields.

The following table shows the prices which have to be selected:

Rotterdam Handling	sea – road – price (EURO per container, FEU) sea – rail – price (EURO per container, FEU) sea – IWT – price (EURO per container, FEU)
Terminal 1 (handling IWT – road)	handling price (EURO per container, FEU)
Road price	price long distance (EURO per container (FEU), per km) pre- and end-haulage price (EURO for one FEU, fixed distance)
Rail	Rail price (EURO per container (FEU), per km)
IWT	IWT price (EURO per container (FEU), per km)
Destination terminal (handling rail – road)	handling price (EURO per container, FEU)

Tab. 4.3.3.4/1: Selection of Prices – Chain 3

Remark: "Road price for long distance" is presented two times at this form but it is only possible to select or fill in the price in the input field of Chain 1, this price is automatically filled into in the second field.

Defining Chosen Chain 4

Chain 4 includes IWT (inland waterway transport), terminal handling in Duisburg, Mainz, Mannheim or Basle and rail - transport. The parameters which are selected for IWT, terminal handling and rail – transport are necessary for the calculation of results (prices, time and modal split).

IWT:

?? selection of ship size

?? selection of service (liner or shuttle)

Terminal handling:

?? selection of handling (fast or conventional)

?? selection on dock (direct transhipment, transhipment via store), off dock

Rail:

- ?? selection conventional shuttle or double shuttle

Setting Price Parameter - Chain 4

The following table shows the types of prices which have to be selected:

Rotterdam handling	Sea – road – price (EURO per container, FEU) Sea – rail – price (EURO per container, FEU) Sea – IWT – price (EURO per container, FEU)
Terminal 1 (handling IWT – rail)	Handling price **“on dock”** or **“off dock”** (EURO per container, FEU)
Road price	Price long distance (EURO per container (FEU), per km) Pre- and end-haulage price (EURO for one FEU, fixed distance)
Rail	Rail price (EURO per container (FEU), per km)
IWT	IWT price (EURO per container (FEU), per km)
Destination terminal (handling rail – road)	Handling price (EURO per container, FEU)

Tab. 4.3.3.4/2: Selection of Prices – Chain 4

Remark: **“Destination terminal”** is presented two times at this page but it is only possible to select or write the price into the input field of Chain 1, this price is automatically filled into the input field. The calculation uses one price for both chains.

Defining Chosen Chain 5

Chain 5 includes rail transportation, first terminal handling in Duisburg, second terminal handling in Mainz or Mannheim, IWT – transportation and road transportation. The parameters which are selected for IWT, terminal handling, rail - and road – transportation are necessary to calculate the results (prices, time and modal split).

Rail:

- ?? Selection conventional shuttle or double shuttle

Terminal handling in Duisburg:

- ?? Selection of handling (fast or conventional)
- ?? Selection **"on dock"** (direct transhipment, transhipment via store) or handling **"off dock"**

IWT:

- ?? Selection of barge size (100, 200 or 400 TEU)
- ?? Selection of barge service (liner or shuttle)

Terminal handling second terminal:

- ?? Selection **"on dock"** (direct transhipment or transhipment via store)

Setting Price Parameter - Chain 5

The following table shows the prices which have to be selected:

Rotterdam handling	Sea – road – price (EURO per container, FEU) Sea – rail – price (EURO per container, FEU) Sea – IWT – price (EURO per container, FEU)
Terminal Duisburg (handling rail – IWT)	Handling price **"on dock"** or **"off dock"** (EURO per container, FEU)
Road price	Price long distance (EURO per container (FEU), per km) Pre- and end-haulage price (EURO for one FEU, fixed distance)
Rail	Rail price (EURO per container (FEU), per km)
IWT	IWT price (EURO per container (FEU), per km)
Destination terminal (handling rail – road)	Handling price (EURO per container, FEU)
Terminal 2 (Mainz or Mannheim) (handling iwt – road)	Handling price **"on dock"** (EURO per container, FEU)

Tab. 4.3.3.4/3: Selection of Prices – Chain 5

Remark: **“Road price long distance”** is presented two times at this page. It is only possible to select or fill in the price into Chain 1. This price is automatically taken over into the second input field. The calculation uses the same price for both chains.

4.3.3.5 Price Scenarios

For a first use and testing of the program two relations have been examined and analysed:

- Rotterdam – Milan
- Rotterdam – Sopron

The calculation has been made for all trimodal inland ports which are integrated in the program for the examination of the optimal location under consideration of different price scenarios for the competitors road and road-rail.

The basic parameters for the calculation are defined as follows:

? ? **price scenarios for the basis chains:**

SCENARIO	**pure road**		**intermodal road-rail**	
	comment	**price**	**comment**	**price**
1	basic price	0,9 EURO	basic price	O,5 EURO
2	basic price	0,9 EURO	+ 20 %	0,6 EURO
3	basic price	0,9 EURO	- 20 %	0,4 EURO
4	+ 20 %	1,1 EURO	basic price	O,5 EURO
5	+ 20 %	1,1 EURO	+ 20 %	0,6 EURO
6	+ 20 %	1,1 EURO	- 20 %	0,4 EURO

Tab. 4.3.3.5: Price Scenarios [EURO / km]

? ? **price for inland waterway transport:**

- 0,30 EURO /FEU-km for a barge with a capacity of 200 TEU
- 0,27 EURO /FEU-km for a barge with a capacity of 400 TEU (consideration of cost-digression effects)

? ? **barge-operation:** shuttle-service

? ? **transshipment alternatives:**

?? **Duisburg ("off dock")**

cartage between barge terminal and terminal road rail and intermediate storage

?? **Mainz ("on dock")**

a) direct transhipment

b) indirect transhipment (via store)

?? **Mannheim ("off dock")**

cartage between barge terminal and terminal road rail and intermediate storage

?? **Basel (on dock")**

a) direct transhipment

b) indirect transhipment (via store)

? ? **transshipment prices**

?? **Rotterdam:** 40 EURO /unit for all modes

?? **trimodal ports (Duisburg, Mainz, Mannheim, Basle)**

- transhipment "on dock": 35 EURO /unit
- transhipment "off dock": 63 EURO /unit

?? **destination terminals**

- Milan: 28 EURO /unit
- Sopron: 15 EURO /unit

?? **pre- and –end-haulage**

- Milan: 150 EURO /unit
- Sopron: 80 EURO /unit

On basis of the results it is possible to determine - under consideration of the given parameters (prices and design of transport chain) - all relevant data:

- cheapest transport chain
- price differences between the transport chains
- fastest/slowest transport chain
- optimal trimodal inland port location under consideration of price and journey time

for the selected relation.

4.4 EVALUATION AND RECOMMENDATION [WP 4]

4.4.1 Economic and Ecological Evaluation

The final Work package of the Apricot project had the overall objective of summing up the results achieved in the previous work done, preparing the contents for a discussion with external experts (the User's group) for a verification of the main findings of the work carried out, and drawing the final conclusions.

The Project team has selected, evaluated and presented some proposal for possible location of tri-modal terminals along the Rhine and evaluated the structure of possible tri-modal chains along the selected corridor.

This task has investigated in detail the possible costs for the proposed tri-modal chains, and evaluated the suitability of the different modes of transport and of the selected routes for the implementation of tri-modal services.

Some of crucial questions faced during this last part of the Project, and discussed with the external experts were:

?? Can tri-modal chain efficiently compete against existing single-modal or bimodal ones in terms of prices and of level of service required by the users?

?? Which could be the most suitable locations for a tri-modal terminal along the river Rhine?

?? Is there enough potential traffic to start promoting this kind of innovative integrated transport chain?

More technical questions about the organisation of tri-modal terminal had already been discussed in previous work packages; the results achieved were used in the framework of this part of the work mainly as input parameters for the evaluation of the global cost and performance of the tri-modal transport chain.

When the Apricot Project was launched, the idea of tri-modal integrated transport chain connecting Rotterdam to the south - south east Europe was rather new, and seen by some observers outside the Apricot consortium as a very difficult and unrealistic alternative to set up.

Our work found out that indeed there are some possibilities for a successful establishment of such complex integrated transport chains.

We however evaluated that only one of the selected axes (Rotterdam-Italy) has a potential market that justifies the required investments and organisational effort, while over the other corridor (Rotterdam-Hungary) the market seem not so expanded nowadays to promote an efficient competition of the tri-modal chain against road transport. In fact, the successful utilisation of the combination of rail and barges requires an amount of regular traffic that is not foreseen at the moment over this route.

A validation of our initial hypotheses and of the first outcome of our work came from the launch of new service along the route Rotterdam-Milan, called ROMI, which involves the companies SBB-CARGO (rail operator), Sauer Bevrachtingen (traffic acquisition), Haeger & Schmidt (capacity - management and barge transport) and Ultra-Brag (terminal handling).

Some information about the service had already been included in our previous reports, and served as a reference for our evaluations, which, however used mainly other sources of information for the estimation of costs, prices and levels of service.

This report presents in a short and compact way the main findings of the work carried out, whose primary aim was to support the preparation of final recommendations for potential users, operators and transport policy.

4.4.1.1 Comparison of Existing and Innovative Transport Chains

The main aspect for a successful establishment of an alternative mode of transport is its ability to compete against the existing transportation chains, and in particular mode against road haulage.

From the customer's point of view, the competition involves several aspects, which can be synthesises under two headings: cost and quality of service.

The latter includes several components, among which one of the most important for the modal choice is time.

In this chapter we briefly discuss the results of our investigations: in the case of costs the elements collected allow us to present some quantitative facts, which can support any subsequent evaluation. As far as quality of service is concerned our work was mainly concentrated on time aspects. Other factors which are important for the modal choice were identified and treated in a qualitative way, drawing our conclusions from observation of the market, from the results of interviews and discussion with external experts and operators met during Apricot Users Groups and technical visits, and from literature surveying.

The importance of the tri-modal chain, however, is not confined to the possible advantages for the users. The main advantages come to a larger extent from the reduced impact of the externalities produced by the modes of transport used. These aspects were briefly addressed by our project, and an outline of our finding has been reported here for completeness of the analysis.

4.4.1.1.1 Cost/Price Aspects

We present here a summary of some calculations carried out in the framework of Work Package 4 using the cost model developed by HaCon during earlier steps of the project.

When discussing about costs/prices the question that always arises is: do we take into consideration the costs of production of the service or the price paid by the users in comparing alternative chains?

During the project our investigations tried to gather as much information as available about both aspects. When considering the user's point of view, however, we decided to take into consideration the market prices. Only for Inland waterway haulage we considered the cost as a base estimation of a market price.

The analysis considered different scenarios in order to compare the innovative tri-modal integrated transport chain with possible evolutions of the present market conditions, and evaluate therefore the sensitiveness of the results to these possible variations.

The following table presents the base parameters used for the long-distance road haulage and for rail-road combined transport in the framework of our analysis.

Tab. 4.4.1.1/1: Price scenarios [EURO/km] for Road and combined transport

Scenario	**Pure Road**		**Intermodal Road-Rail**	
	Comment	**Price**	**Comment**	**Price**
1	Basic price	0,9 EURO	Basic price	O,5 EURO
2	Basic price	0,9 EURO	+ 20 %	0,6 EURO
3	Basic price	0,9 EURO	- 20 %	0,4 EURO
4	+ 20 %	1,1 EURO	Basic price	O,5 EURO
5	+ 20 %	1,1 EURO	+ 20 %	0,6 EURO
6	+ 20 %	1,1 EURO	- 20 %	0,4 EURO

As far as inland waterway transport is concerned, our investigations concentrated in the possible usage of large barges of the types GSM (capacity up to about 200 TEUs over 4 layers) and JOWI (about 400 TEUs over 4 layers).

Our investigation considered the barges operating a shuttle service, with direct connection of the Rotterdam area to only one inland port, without intermediate stops and came out with the estimation of the following prices:

?? 0,30 EURO/FEU-km (200 TEU-barge)

?? 0,27 EURO/FEU-km (400 TEU-barge)

The outcome of the preliminary investigations directed us to restrict the investigation of alternative location of a tri-modal chain to the areas of Duisburg, Mainz, Mannheim and Basle.

?? Duisburg: this location is the one presently favoured by the port of Rotterdam, with the main aim of de-congesting the port area from rail and road traffic, and of attracting local traffic from the industrial Rhine-Ruhr area.

The transhipment technique considered for this terminal, given the present and foreseen situation at terminal locations is of the kind that we called "off dock", with cartage between barge terminal and road-rail terminal or intermediate storage.

?? Mainz: this port is located favourable position along the Rhine, where the full capacity of barges can be used all year round, and sufficiently downstream to take full advantage of the cost saving guaranteed by the barge transport.

The transhipment techniques considered for this port is of the kind "on dock". Both direct transhipment and indirect transhipment (via store) were taken into account during analysis.

?? Mannheim: this location was one of the favoured by our investigations. It has the same advantages of Mainz as far as location along the Rhine is concerned; moreover, it is located in an area where good intermodal services to/from Italy already exist, so the complete tri-modal chain could take advantage of the synergy with existing organised traffic relations to provide a successful alternative to road transport.

The transhipment technique taken into account here, was of the kind "off dock", with cartage between barge terminal and road-rail terminal.

?? Basle: this location is the one that takes the full advantage of the cost savings produced by barge transport. The disadvantage is that the full capacity of barges cannot be used due to some constraints along the river, already discussed in previous reports. This is the location chosen by the ROMI service to operate. The transhipment techniques considered for this port is of the kind "on dock". Both direct transhipment and indirect transhipment (via store) were taken into account during analysis.

The determination of the price to apply for transhipment between different modes was one of the more discussed and investigated issues during the whole project. Several estimation were produced, taking into account different factors (terminal owned and paid by the operators or provided by the local or national authorities, equipment partially founded with public money for the development of intermodality, etc.). For the purpose of comparing the different chains, however, we decided to apply some fixed factors that came out from the comparison of some more theoretical calculations with a survey among operators of the various modes of transport.

The transhipment prices considered were thus the following:

?? Rotterdam:
40 EURO/unit for all modes

?? Tri-modal Ports (Duisburg, Mainz, Mannheim, Basle)

Transhipment "on dock": 35 EURO/unit

Transhipment "off dock": 63 EURO/unit

We haven't taken into account any variation in handling prices depending on the fact that the unit could pass via an intermediate storage.

?? Destination Terminals

Milan: 28 EURO/unit

Sopron:15 EURO/unit

As far as the pre-/end-haulage is concerned, our analysis considered locations within a restricted area around the two terminals of origin/destination that we have selected: Milan and Sopron. Given the overall approximation adopted for the whole chain, we decided to adopt fixed costs also for this initial or final section of the chain, with the prices given by some average values gathered from road and intermodal operators:

?? Milan: 50 EURO/unit

?? Sopron: 70EURO/unit

Given the above assumptions, we employed the HaCon model for comparing the alternative chains along the two selected routes Rotterdam-Milan and Rotterdam-Sopron.

Rotterdam to Milano via	transshipment alternative	barge capacity [TEU]	distance total [km]	distance from Rotterdam to harbour [km]	total journey time [hour]	transshipment alternatives [€]					
						variant 1 road: 0,9 € rail: 0,5 €	variant 2 road: 0,9 € rail: 0,6 €	variant 3 road: 0,9 € rail: 0,4 €	variant 4 road: 1,1 € rail: 0,5 €	variant 5 road: 1,1 € rail: 0,6 €	variant 6 road: 1,1 € rail: 0,4 €
						price 1 EURO	price 2 EURO	price 3 EURO	price 4 EURO	price 5 EURO	price 6 EURO
Road			1.040		20,5	976	976	976	1.184	1.184	1.184
Rail			1.260		33,5	843	868	718	843	968	718
Duisburg	off dock	200 TEU	1.200	200	upstream: 82,0 h downstream: 70,0 h	841 (green)	941 (red)	741 (red)	841 (green)	941 (red)	741 (red)
		400 TEU			up: 89,0 h down: 77,0 h	835 (green)	835 (red)	835 (red)	835 (green)	835 (red)	735 (red)
Mainz	direct transshipment	200 TEU	1.260	500	up: 95,3 h down: 68,3 h	778 (green)	853 (green)	973 (green)	778 (green)	853 (green)	703 (green)
		400 TEU			up: 120,1 h down: 78,1 h	763 (green)	838 (green)	688 (green)	763 (green)	838 (green)	688 (green)
	via store	200 TEU			up: 103,0 h down: 77,0 h	778 (green)	853 (green)	703 (green)	778 (green)	853 (green)	703 (green)
		400 TEU			up: 110,0 h down: 84,0 h	763 (green)	838 (green)	688 (green)	763 (green)	838 (green)	688 (green)
Mannheim	off dock	200 TEU	1.220	570	up: 112,0 h down: 82,0 h	777 (green)	842 (green)	712 (green)	777 (green)	842 (green)	712 (green)
		400 TEU			up: 119,0 h down: 89,0 h	760 (green)	825 (green)	695 (green)	760 (green)	825 (green)	695 (green)
Basel	direct transshipment	200 TEU	1.220	810	up: 111,6 h down: 72,1 h	701 (green, grey)	742 (green, grey)	660 (green, grey)	701 (green, grey)	742 (green, grey)	660 (green, grey)
	via store	200 TEU			up: 121,0 h down: 81,5 h	701 (green, grey)	742 (green, grey)	660 (green, grey)	701 (green, grey)	742 (green, grey)	660 (green, grey)

100 (red) trimodal chain is more expensive than road-rail

100 (green) trimodal chains cheaper than road-rail

(grey) cheapest transport chain

Tab. 4.4.1.1/2: Results of the comparison of the cost of different transportation chains over the route Rotterdam-Milan under several scenarios using the HaCon model.

The summary of the results for the more important scenario we have tested are presented in table 4.4.1.1/2 for the route Rotterdam-Milan and in table 4.4.1.1/3 for the route Rotterdam-Sopron.

The route to Milan shows a clear advantage on the cost side to use the barge as far as possible along the Rhine. Using the barge up to Basle the possible cost saving is around the 30% compared to the pure-road haulage. Clearly the price to be paid is in term of lower performance on delivery time. The savings in transport costs are of 142 EURO related to rail and 275 EURO to road transport; the more time needed for trimodal transport is 78 hours related to rail and 86 hours to road transport.

A good price performance is obtained placing the intermediate transhipment barge-rail in Mainz or Mannheim (about 20% lower than road), but with better performance.

According to the model, however, the time performance not only is associated to the distance, but also to the transhipment technique used. As one can observe, the usage of direct transhipment techniques can save a great deal of time (up to the 10% of the whole sail time), with only a little additional expenditure. We highlight here the fact that the Mannheim terminal, given the assumptions of the analysis, suffers on the cost side from the fact that only off dock operations are performed for transhipment.

Rotterdam to Sopron via	transhipment alternative	barge capacity [TEU]	distance total [km]	distance from Ro'dam to harbour [km]	total journey time [hour]	transhipment alternatives [€]					
						variant 1 road: 0,9 € rail: 0,5 €	variant 2 road: 0,9 € rail: 0,6 €	variant 3 road: 0,9 € rail: 0,4 €	variant 4 road: 1,1 € rail: 0,5 €	variant 5 road: 1,1 € rail: 0,6 €	variant 6 road: 1,1 € rail: 0,4 €
						price 1 EURO	price 2 EURO	price 3 EURO	price 4 EURO	price 5 EURO	price 6 EURO
Road			1.230		40,5	1.147	1.147	1.147	1.393	1.393	1.393
Rail			1.450		45,5	860	1.005	715	860	1.005	715
Duisburg	off dock	200 TEU	1.400	200	upstream: 94,0 h downstream: 92,0 h	858	978	738	858	978	738
		400 TEU			up.: 101,0 h down.: 89,0 h	852	972	732	852	972	732
Mainz	direct transshipment	200 TEU	1.420	500	up.: 107,3 h down.: 81,3 h	780	872	688	780	872	688
		400 TEU			up.: 114,1 h down.: 88,1 h	765	857	673	765	857	673
	via store	200 TEU			up.: 116,0 h down.: 89,0 h	780	872	688	780	872	688
		400 TEU			up.: 122,0 h down.: 96,0 h	765	857	673	765	857	673
Mannheim	off dock	200 TEU	1.440	570	up.: 124,0 h down.: 94,0 h	804	891	717	804	891	717
		400 TEU			up.: 131,0 h down.: 101,0 h	787	874	700	787	874	700

100 trimodal chain is more expensive than road-rail

100 trimodal chain is cheaper than road-rail

cheapest transport chain

Tab. 4.4.1.1/3: Results of the comparison of the cost of different transportation chains over the route Rotterdam-Sopron under several scenarios using the HaCon model.

From the table above we can therefore draw these conclusions:

If time were immaterial (see comments on the subsequent sections of this report), the terminal located in Basle would be the preferred location. The Mainz terminal, given the assumption stated above about the transhipment techniques used, gives a good time/cost performance.

On the Sopron route, to proceed along the Rhine further than Mainz/Mannheim doesn't produce any advantage and therefore these central locations should be taken into account for a potentially attractive location for a tri-modal terminal.

4.4.1.1.2 Quality of Service Aspects

Monetary cost is not the only factor taken into account for the choice among alternative modes of transport. Several attempts have been made in order to identify the criteria by which the final decision of mode choice is taken. During the Impulse project (see IMPULSE, Deliverable D2, 11/97) the transport criteria entering in this procedure were summarised in the following seven groups:

1. Time.
2. Reliability
3. Flexibility
4. Monitoring
5. Security (Avoidance of cargo loss or damage)
6. Accessibility (or Availability) and
7. Qualifications

Each of these components was further decomposed, and a survey was carried out in order to evaluate the possible impact of them over the modal choice.

The most important criteria resulted from the survey, in order of importance, were:

?? **security** , intended as the "probability of load unit and/or cargo loss"

?? **monitoring,** and in particular the ability to determine the "positioning within chain"

?? **reliability:** considered as "the unforeseen deviation in time and in qualification as well as the accuracy of the information system advice"

?? **time**, and more specifically the "travel time between initial and final terminal"

The investigations carried out during the Apricot project confirmed these findings, and in particular the fact that time is not always the primary factor of choice. This is especially true for the maritime container traffic, which usually is less time sensitive than the inland road-rail combined transport.

Indeed, from the above list we must say that for the development of tri-modal chains along the Rhine the most critical aspect is reliability. We observed in fact in previous deliverables that many factors such as ice drift, low and high water and other meteorological factors can produce unforeseen effects over the Rhine navigation, especially far upstream. For this reason a location not too far from Rotterdam could be favoured.

As far as monitoring and security is concerned, our investigation showed positive answers regarding the ability of IWT to satisfy the standard requirements from customers.

4.4.1.1.3 Environmental Aspects

The limited resources available for the project was not intended to support a full scale detailed investigation of the possible impact of the different modes along the corridor, so the evaluations we carried out were mainly of qualitative nature.

In the deliverable D1 some issues concerning external costs produced by different means of transport were presented.

Tab. 4.4.1.1/4: Comparison of external costs produced by the flows initially shiftable to tri-modal chain using different chain organisations.

Chain	***Mode***	***km***	***t***	***1000tkm***	***€/1000tkm***	***Ext Cost***
Unimodal Road	Road	1.040	350.000	364.000	21,89	€. 7.967.960
CT RailRoad	Rail	1.250	350.000	437.500	4,88	€. 2.135.000
	Road	50	350.000	17.500	21,89	€. 383.075
	TOTAL					**€. 2.518.075**
IWT Duisburg	IWT	200	350.000	70.000	1,17	€. 81.900
	Rail	1.000	350.000	350.000	4,88	€. 1.708.000
	Road	50	350.000	17.500	21,89	€. 383.075
	TOTAL					**€. 2.172.975**
IWT Mainz	IWT	500	350.000	175.000	1,17	€. 204.750
	Rail	750	350.000	262.500	4,88	€. 1.281.000
	Road	50	350.000	17.500	21,89	€. 383.075
	TOTAL					**€. 1.868.825**
IWT Mannheim	IWT	570	350.000	199.500	1,17	€. 233.415
	Rail	650	350.000	227.500	4,88	€. 1.110.200
	Road	50	350.000	17.500	21,89	€. 383.075
	TOTAL					**€. 1.726.690**
IWT Basel	IWT	810	350.000	283.500	1,17	€. 331.695
	Rail	410	350.000	143.500	4,88	€. 700.280
	Road	50	350.000	17.500	21,89	€. 383.075
	TOTAL					**€. 1.415.050**
CT IWT-road Basel	IWT	810	350.000	283.500	4,88	€. 1.383.480
	Road	450	350.000	157.500	21,89	€. 3.447.675
	TOTAL					**€. 4.831.155**

On the basis of the parameters presented before we performed some comparison of the possible impact produced by a modal shift from existing chains to alternative chains using barges.

The table above presents the comparison of the external costs produced by an amount of 350.000 t using different alternative transportation chains.

The calculation presented here corresponds to the possible scenario of an initial shifting of some 15.000 TEU/ direction from traditional chains (Road or rail-road CT) to innovative ones using IWT.

In summary, the main findings of our work were the following:

?? Only the tri-modal chain is besides rail+road a good choice to have a real reduction of the impact on the environment. The bimodal chain barge+road, in fact, leaves unaltered the heavy impact of the road transport on the alpine environment, which is the most sensitive area along the chain. So the shift of present CT traffic to IWT is to be favoured only if rail is used in conjunction. The other way round will only produce benefits in the northern part of the chain, raising the impact on the southern (and more environmental-sensitive) section.

?? The most effective location of a tri-modal terminal in terms of reduction of external costs produced by the transport modes is Basle, with a reduction of the external costs of about 44% in comparison to CT, which is the present terms of reference.

?? The positive impact is, however, limited to the northern section of the corridor, leaving almost unaltered the present situation across the Alps, since most of the traffic considered is already on rail.

?? A more accurate environmental impact assessment would, however, take into account also other side effect of a location of terminal in the middle part of the Rhine course (Mainz, Mannheim), i.e. the shift of present road transport from that regions to Italy/Switzerland due to an increased supply of CT services set-up to complete the tri-modal chain.

4.4.1.2 Impact of a Trimodal Transport Chain on the Market

We state here briefly some of the main findings of our investigation about the potential market of a tri-modal integrated transport chain along the selected corridors.

Trimodal chain to Italy is possible, but in order to make it a valuable alternative to the existing transportation modes it must be combined to other traffics from Rotterdam to Germany (and return). This would guarantee the necessary economy of scale on the IWT section of the chain, which makes it more attractive to potential users.

The amount of direct traffic on the axis Rotterdam<->Switzerland and Italy is presently limited to less than 50.000 ITU/year in each direction on Combined transport. According to the estimation we have gathered during our study it is about the 70% of the whole Rotterdam port traffic over this route. So this market is rather poor for establishing such a high capacity chain as the tri-modal one using dedicated services of large barges along the Rhine.

The information we gathered make it reasonable to consider that the time-sensitiveness of almost the 50% of the containerised traffic over the corridor is compatible with the service times expected for the tri-modal chain.

We think that a reasonable expectation for an initial tri-modal service operating over the chain would be one based on a regular service of a couple of shuttle trains per day (one in each direction) from the tri-modal terminal. This could be combined with a dedicated bi-weekly service operated with a GMS barge to/from Rotterdam.

Combining a component of traffic Rotterdam<->Inland port hinterland, we can have a daily service also on barge, thus guaranteeing the necessary regularity and continuity requested by a modern and efficient transportation service.

If we take into account all the Road traffic from the Rotterdam region (not only the port) the amount of freight flows along the corridor (to Switzerland-Italy) could be estimated in about 700.000- 800.000 Tons/year. The reverse way is only limited to some 300.000.

If the tri-modal chain could catch the 10% of this market we would expect a yearly traffic of about 7000 TEU/year in one direction, the half on the opposite direction. This could be considered as an additional market that would allow increasing the frequency of the basic service outlined above.

The main problem with this sort of traffic, is that, being mainly pure road traffic, it is not containerised. The most suitable sort of ITU to favour the modal shift would be the swap body, which can not be used in our chain. The promotion of the usage of stackable swap-bodies, accommodated in the upper level or on dedicated sections of the barge could be a solution worth investigating further and experimenting.

Market from Rotterdam to Hungary and the Central-East Europe is very low today.

Even if it increases at a good pace it is likely to be served by road, or, alternatively, combined rail-road services.

Dedicated tri-modal chains providing complete services from Rotterdam to Hungary seems not foreseeable at the moment. Only the combination of these traffics with other freight flows serving the Germany-Hungary relation could result in the supply of some tri-modal service. The impact of this sort of traffic on the overall system is, however, limited, and it would hardly justify any further effort of investigation and experimentation. Other kind of barge or tri-modal services connecting North European ports to Central Europe have been investigated in the course of the Apricot project and were presented in previous deliverables.

The only valuable note here is that the location of the tri-modal terminal in the Mainz or Mannheim areas would leave some possibilities of serving also Central-European areas using tri-modal chains in combination to other traffics.

4.4.1.3 Results

The analyses carried out in the framework of the whole Apricot project together with the response of the expert contacted during the Second User Group Workshop consolidated the consortium's view about the feasibility of an integrated transport chain including inland waterway services along the routes from Rotterdam to the North of Italy.

The work carried out has verified the suitability of the tri-modal chain for the competition in the market from Rotterdam to Milan. Many doubts emerged about the feasibility of the other corridor initially foreseen as potential for this kind of traffic: the one connecting Rotterdam to Budapest.

The main advantage of the intermodal chain is the low cost and the possible increase of capacity for the whole corridor in the first (and heavily congested) part of it, from Rotterdam to Germany.

The environmental positive benefits are in larger part confined to the northern section of the chain (Netherlands and Germany). The expected impact on the Alpine area is limited – given the small amount of freight flows involved and the possibility of the usage of road transport for the whole final part of the chain (bimodal transport IWT-Road without the usage of rail)

The results of this study should be extended to the investigation of the possible usage of this innovative transport chain to serve also some German internal market

The experimentation and usage of stackable swap bodies on barges could be particularly favourable for the attraction of intra-European traffic which presently use the pure road haulage.

The intermediate tri-modal terminal is to be organised and equipped in an optimised way, since the impact on time-savings could be high if direct transhipment is adopted.

Only if an effective chain management system will be adopted the usage of tri-modal barge-rail-road combination will be feasible, and the positive effects on the environment will be observed in the southern section of the chain as well.

4.4.2 Resulting Recommendation

Inland waterway transport (IWT) has specific advantages. Beside the ability of mass transportation IWT has - compared to road (and rail too) - the lowest prices and is provable the mode which is most environmentally friendly. Moreover inland waterways do have considerable capacity reserves today (for instance on the Rhine they are assumed in magnitude of more than 50 %).

Fundamental disadvantages of IWT are the relatively low speed, occasionally incalculable transport reliability depending on weather conditions such as ice drift, high and low water as well as the restricted ability of integration because precondition for the use of IWT is an access to the waterway network.

Intermodal carriage of containers gains in importance for European inland waterway transport. This is documented by the increasing traffic volumes during the last years in this market segment. For the year 1999 it is assumed that again more than 1 million TEU will be carried by barges. The main share of this volume (90 %) goes on the Rhine and the confluence areas of his effluents from and to the big seaports of Rotterdam and Antwerp. There are forecasts that e.g. the harbour of Rotterdam will quadruple its container volume by 2020.

In this traffic the countries Germany, Switzerland and France do have a dominant position whereas container transport on the Main-Danube-Canal (e.g. to Austria or Hungary) is not developed well.

Essential reason for the concentration on the Rhine are the good infrastructural conditions which allow a maximum capacity utilisation of the barges with 4 container layers and a relatively high cruising speed (compared to other waterways) because of the non-existence of sluices up to Karlsruhe. It is assumed that in the next years container transport will increase on other inland waterways too.

Transport politics has recognised the possibilities which IWT can achieve for the reduction off road transport and is going to improve the support of intermodal transport chains with integration of both rail and barges.

4.4.2.1 Summary of Main Results

The results of the apricot study have shown that trimodal transport chains offer specific advantages – depending on the surrounding conditions – and can be an economic alternative or amendment to unimodal (truck) and bi-modal transport chains (road-rail).

The range of advantages depends in principle on the following factors:

Efficiency of integration between inland waterway transport and rail in the terminals

Important influencing factor for the economy and competitiveness of trimodal chains are optimal conditions in the trimodal terminals or inland ports. Efficient integration between the modes basically means the guarantee of frictionless interchange of ITU between barge and rail (and vice versa). For this reason terminal planning, terminal organisation and terminal layout have to be adapted to the requirements of trimodal chains.

An optimal integration is realised when ITU are handled between the modes without intermediate storage or additional handling. Pre-condition for direct transhipment is an optimal tuning between barge and rail timetables. Furthermore free access to the loading units has to be ensured.

Another pre-condition for direct transhipment is a physical concentration of the modes in one trimodal terminal. Through this the necessary handling for the change of ITU between the modes can be reduced to a minimum. A physical separation of barge and rail terminal causes time- and cost-intensive additional handling (e.g. cartage between the terminals).

The installation and use of innovative techniques such as fast handling can optimise the handling and allows a better integration of transport modes.

Transport distance and specific share of inland waterway transport

In principle the cost benefit of trimodal transport chains – compared to unimodal road transport or bimodal road-rail - is increasing in combination with growing share of inland waterway transport.

The reason for this effect is the TEU-kilometre price for the inland waterway transport which is noticeable lower than on road and on rail.

The comparison of trimodal chains with different trimodal terminal locations had shown that on the Rhine axis the use of Basle instead of e.g. Duisburg causes cost reductions of more than 15 %.

Against this cost advantage there is a relevant disadvantage concerning transport time. A second relevant disadvantage is the limitation on ISO-containers at the moment.

4.4.2.2 Recommendations

4.4.2.2.1 Interoperability

Interoperability is a basic precondition for the success of trimodal chains.

Important factor for the working of trimodal chains is the interoperability between the different transport modes. Interoperability has to be guaranteed for the whole transport chain between starting and destination terminals or consignor and consignee to ensure a frictionless transport flow.

4.4.2.2.2 Terminals

Infrastructure (and improvement of infrastructure) in trimodal terminals has to correspond to the requirements of both transport modes inland waterway and rail transport.

Competitive intermodal transport using trimodal chains needs efficient and frictionless working terminal infrastructure. The analysis of existing plants in inland ports had shown that several terminals are not designed in an optimal way to the specific requirements of trimodal transport chains.

Particularly the available length of railway sidings is insufficient in many cases. This causes time and cost intensive marshalling procedures and overall a reduction of transport quality.

For this reason beside the improvement of existing terminals infrastructure the installation of new trimodal terminals plants should be taken into consideration to ensure an efficient integration between rail and inland waterway. In this context innovative technologies also have to be taken into consideration as an alternative to conventional transhipment technologies. Innovative technologies can give a solution for the geometric difference between train (till 700 m in length) and barge (100-150 m in length) and the with it entailed operation requirements of

- ?? the longitudinal transport for the connection barge – (storage) – train and
- ?? the timing of rail transport in slots and barge shipping dependent on weather conditions, each with optimised buffer times.

Therefore new plants should be planned under the aspect “trimodality” which means that the requirements and needs of both transport modes have to be considered.

A first step into this direction and important basis for the aimed improvement terminals in inland ports is the terminal masterplan for intermodal transport on inland waterways in Germany.

This study was carried out by order of the German Minister of Transport and published in May 2000. On basis of recent forecasts, conceivable market trends and the analysis of existing transhipment capacities the future infrastructure demand was estimated for several terminal locations in Germany.

Aim of the study was the creation of a base for the evaluation of promotion needs for concrete locations. One aspect was the integration between rail and inland navigation.

4.4.2.2.3 Barges

The improvement of barges (design and technique) can be a key for the success of trimodal chains.

Regarding the conception of trimodal chains the following aspects are determining the conditions of inland waterway transport: transport time and transport costs. Of course the selection of terminal location has substantial effects on transport time and costs (TEU-km compared to rail). Furthermore barge technology can have influences as well. Concerning the recent advancement of barge technology there are two tendencies which shall be mentioned:

- ?? **large barges**: Barge units with higher or large capacity (e.g. Jowi 400 TEU) have noticeable effects concerning reduction of transport costs (TEU-km). Disadvantage is the extension of time for loading and unloading higher amounts of ITU. Furthermore the requirements concerning transport organisation (e.g. terminal operation, integration into rail service) are rising.
- ?? **small (fast) barges**: Example are the “sprinter”-barges operated by CCS (Combined Container Service) since this year. With a relatively low capacity (32 TEU), low requirements concerning waterway (necessary clearance height of bridges 5,3 m) and a comparable high speed they offer high operating flexibility.

Advantage of the "sprinter" is the fast connection between two inland ports in combination with low laying time. In the opinion of the operator these barge can be seen as a serious competitor to rail transport.

The development of innovative or new barges indicates that inland waterway transport is trying to improve efficiency which can have positive effects on trimodal chains too. Particularly the operation of "fast" barges with the chance of noticeable improvement of transport time.

4.4.2.2.4 Intermodal Transport Units (ITU)

Important for the success of trimodal transport chains is the introduction of an European-wide multi-modal ITU (technical interoperability).

The existing technical parameters in inland navigation particularly the useable width of cargo hold of barges are limiting the operation of trimodal chains only to the hinterland transport of maritime ISO-containers. These units do not correspond to the needs of Trans-European freight traffic (road and rail): the offered volume is lower compared to common swap bodies and they do not fit to the dimensions of standard pallets.

On the other side current swap bodies are designed and standardised according to the requirements of road and rail transport. These ITU normally are not stackable and not equipped with top corner fittings.

For the integration of inland waterway transport into multimodal transport chains an intermodal transport unit is required which is suitable for all transport modes (see final report of the RTD study "UTI-Norm" in which this standardised loading unit is described and defined).

4.4.2.2.5 Operation

Organisation, management and control of trimodal transport chains have to be done in a co-operative way (neutral concerning modes).

Important for the success of trimodal transport chains is the optimal co-operation between transport modes - without competition. The participants have to subordinate their individual profit motives to the efficiency and economy of trimodal chains.

Particularly inland waterway transport and rail today are traditional competitors which are combating for improving market shares in intermodal transport especially on the Rhine axis. For the development of integrated trimodal chains this is of course an unfortunate starting point.

The quality of service today is an important criteria for the choice among alternative modes of transport. To guarantee a high quality level of service in trimodal chains and in case of any problems the clients should only have one competent contact for the whole chain.

4.4.2.2.6 Information Technology

Important for success of trimodal chains is the introduction of efficient information systems

Inland waterway transport - especially in trimodal chains - has to be included in the development of integrated communication systems.

Because of the connection and integration of three transport modes the necessity of availability of relevant information along the whole transport chain inclusive the terminals is very high. For this reason an important aspect is the introduction of an information system regarding the requirements of all participants:

- shipping line
- seaport
- barge operator
- trimodal terminal
- railway operator
- terminal road rail
- forwarder
- consignee.

4.4.2.2.7 Market

For the further determination of possibilities for trimodal transport chains specific market studies should be carried out.

A disadvantage of trimodal chains can be seen in the considerable extension of transport time. The relevance of extended transport time for goods or freight market segments has not been examined yet. Assured information about the affinity of certain goods or specific freight market segments is a basis for the aimed acquisition of clients for trimodal chains.

4.4.2.2.8 Policy

During the implementation phase trimodal chains can be supported by policy makers.

In spite of the restricted waterway network trimodal chains can open up new potentials for inland waterway transport the most environmentally friendly way of freight transport.

The combination between barge, rail and road under consideration of the optimal use of their specific benefits allows the construction of a very environmental friendly transport chain with high effects concerning modal shift.

Previous activities to integrate trimodal chains into the market have not been very successful. One precondition for success is the acceptance in the transport market. This can be supported by incentives (e.g. promotion with public money).

4.4.2.2.9 Implementation

For quantity reasons and capacity of inland waterway trimodal chains should mainly be set up on the Rhine axis and in the future also along the Danube

The installation of trimodal transport chains at first should mainly be set up on the Rhine axis for the following reasons:

- introduction of important seaports
- relations with sufficient volumes
- existing strong market for IWT-container transport
- existing terminal infrastructure
- optimal waterway conditions

The concrete selection and evaluation of locations for trimodal terminals has to be done under consideration of clients and goods requirements to find an optimal solution concerning transport cost and transport time. This has to be made for each relation.

The user group meetings during the Apricot Project had shown, that there is in general a big interest from the side of inland ports and terminal operators for the installation of trimodal chains.

In addition to the Rhine area there are several possible other region of interest for the installation of trimodal chains such

- Elbe
- Seine
- Rhône

The transfer possibilities of the results of the apricot project have to be examined.

4.4.3 Publication and Dissemination

The subject of trimodal transport chains is not an important part of the public discussion about solutions for the reduction of the existing transport problems in Europe. For this we look for a simple and understandable way of analysis.

For this declaration it is important to show the difference and the problems which are coming with the installation of trimodal transport chains and to show their solutions.

The investigations are designed as analysis of examples for trimodal chains and possible inland ports for the transhipment points. The selected inland ports are examples for types of ports in the interesting regions. For a real implementation of specific trimodal transhipment there are additional analysis necessary.

As a suitable method for the tuning with relevant groups we organised User Group meetings to make sure the acceptance of the potential later users.

The User Group Meetings in October 1998 and September 1999 are the most important meetings during the project APRICOT.

The 1st User Group Meeting in the Gelredome in Arnhem, NL, in October, 12 and 13 of 1998 was used for becoming acquaintance with the problems of the practice of inland shipping and especially trimodal transport chains.

The 2nd User Group Meeting in the inland port of Mannheim, D, was used for presentation and discussion of thesis and first results.

In addition the presentation of APRICOT during the European Conference for Research and Development in November 1999 was important. The results of APRICOT could be discussed. Contacts and suggestions during the conference could used for the final work of APRICOT.

4.4.3.1 Second User Group Meeting

The second meeting of companies, institutions and federations which are involved in combined transport could be prepared in combination with a visit in an inland port. It takes place inside the port of Mannheim in the rooms of HGM, the port authority in September, 9 and 10 of 1999.

This second meeting of an User Group includes more the presentation of the first results of the project APRICOT and the discussion of this. In connection with the results one times more the expected problems of trimodal chains have been discussed. The in total different participants of the 2nd User Group in relation to the first one creates additional knowledge and ideas concerning the treated problems. For the final work we find new aspects for the improvement of the results.

Fig. 4.4.3.1: The User Group 2

Program of the 2nd User Group Meeting:

Description of structure and objectives of APRICOT and first results

Some of the partners of the project give an overview, to show the methods of analysis and to place the results of the investigations:

Euretitalia shows the difficulty of using the incomplete database. There are not enough data for a sure forecast of the potential for trimodal transport chains in Europe. The main traffic concerning inland shipping is using the river Rhine, therefore trimodal traffic has today a chance only for the relations to the south.

Krupp shows the technical aspects of the terminal configurations, existing in inland ports and gave some examples what is possible by using new technologies. This new technologies works like a Krupp Fast Handling System and reduces the length of the terminal transhipment area from a 700m train to a length of one or two barges (100 to 200 m).

HaCon has an experience for the time and price relation concerning the different means of traffic and their transport chains. The developed calculation program gives the possibility to find a feeling for the right combinations of transport modes to realise optimal time – price relations.

Discussion of Thesis and Results, Moderation K.-U. Sondermann

Thesis for discussion during the 2nd User Group Meeting:

? ? TIME / DELAY

?? Trimodal transport chains using IWW are
- slow, but punctual
- operating 7 / 7, but not 365 / 365

?? 50 – 60 % of this cargoes are not time sensitive

?? Buffer time barge – train of 1 day required

?? Example corridor Rotterdam – Milan:
Trimodal chain 1 – 4 times more

? ? COST / PRICE

?? Trimodal transport chains using IWW are economic on good "Water regimes":
4 layers, 4 – 6 wide

?? Trimodal terminal operations must be efficient

?? IWW can be 33 % cheaper than railways main haulage
(dependent on barge and train type)

?? Example corridor Rotterdam – Milan:
Trimodal chain 5 – 20 % cheaper

? ? ACCESS / LOCATION

?? Interoperability criteria limits
IWW to seaport hinterland and ISO-Container, yet

?? Trimodal chains require:
- good model access
- efficient relation between modes
- buffer capacity
- efficient internal longitudinal transport.

?? Trimodal terminals are not only hubs but should have their own traffic basin

?? Trimodal terminals are using existing rail operation forms, yet.

Discussion with Results

Representatives of operators, industry, inland ports and their federation, carriers and consultants take part in the discussion of the 2nd User Group Meeting.

During the discussion of course many aspects are weighed against one another because the different institu-tions take part from their own point of view. It results following consensual conclu-sions:

Trimodal transport chains cannot wait till there is enough volume for a daily single relation. Trimodal transport chains should start with relations using partly load.

The User Group agreed that for the present the river Rhine will be the only one with enough volume for a daily part load on barges and trains.

From the price side the longer travels on the river Rhine should be competi-tive. Shorter travels are affected from the costs of transhipment in the ports.

For other possible trimodal transport chains are other rules in force:

For the relation Rotterdam – Budapest today there is nearly no traffic flow. A better situation but also with weak flow you can find for the relation from Hamburg to Budapest. In the future trimodal traffic can be installed for the relations on the Danube and on other rivers with big traffic in Europe.

4.4.3.2 European Transport Research Conference

The conference was an excellent possibility, to give the visitors a short introduction into the objectives and results of the projects of the European Commission in the field of transport research under the motto:

“Paving the way for Sustainable Mobility”

The presentation of the APRICOT project was situated in Session 8.1:

Trimodal Transport Chains and Terminals

Fig. 4.4.3.2: European Transport Conference for Research, Lille, Grand Palais

The abstracts of the APRICOT presentati on:

?? Addressed Problem

?? Innovative Objectives

?? Transport Modes Characteristics

?? Interoperability of Transport Chains

?? Example of Trimodal Chains

?? Conventional Terminal (cross section and layout)

?? Semi-innovative Terminal (cross section and layout)

?? Integrated Innovative Terminal (cross section and layout)

?? Suitability of Terminals

?? Corridors and Selection of Terminals

?? Port of Mainz

?? Port of Mannheim

?? Comparison Road / Road-Rail / Trimodal

?? Recommendations

?? Exploitation Possibilities

5 CONCLUSIONS AND RECOMMENDATIONS

The results of the project APRICOT have shown that trimodal transport chains (barge-rail-road) offer specific advantages – depending on the surrounding conditions – and can be an economic alternative or amendment to unimodal road transport and bi-modal transport chains (rail-road).

Important influencing factor for the economy and competitiveness of trimodal chains are optimal conditions in the trimodal terminals or inland ports. Efficient integration between the modes basically means the guarantee of frictionless interchange of ITU between barge and rail (and vice versa). For this reason terminal planning, terminal organisation and terminal layout have to be adapted to the requirements of trimodal chains.

An optimal integration is realised when ITU are handled between the modes without intermediate storage or additional handling. Pre-condition for direct transhipment is an optimal tuning between barge and rail timetables. Furthermore free access to the loading units has to be ensured.

Another pre-condition for direct transhipment is a physical concentration of the modes in one trimodal terminal. Through this the necessary handling for the change of ITU between the modes can be reduced to a minimum. A physical separation of barge and rail terminal causes time- and cost-intensive additional handling (e.g. cartage between the terminals).

The installation and use of innovative techniques such as fast handling can optimise the handling and allows a better integration of transport modes.

In principle the cost benefit of trimodal transport chains – compared to unimodal road transport or bimodal road-rail - is increasing in combination with growing share of inland waterway transport. The reason for this effect is the TEU-kilometre price for the inland waterway transport which is much lower than on road and on rail.

The comparison of trimodal chains with different trimodal terminal locations had shown that on the Rhine axis the use of Basle instead of e.g. Duisburg causes cost reductions of more than 15 %.

Against this cost advantage there is a relevant disadvantage concerning transport time. A second relevant disadvantage is the limitation on ISO-containers at the moment.

From the work carried out in APRICOT and from the above conclusions, the following recommendations can be made:

Interoperability

Interoperability is a basic precondition for the success of trimodal chains.

Important factor for the working of trimodal chains is the interoperability between the different transport modes. Interoperability has to be guaranteed for the whole transport chain between starting and destination terminals or consignor and consignee to ensure a frictionless transport flow.

Terminals

Infrastructure (and improvement of infrastructure) in trimodal terminals has to correspond to the requirements of both transport modes inland waterway and rail transport.

Competitive intermodal transport using trimodal chains needs efficient and frictionless working terminal infrastructure. The analysis of existing plants in inland ports had shown that several terminals are not designed in an optimal way to the specific requirements of trimodal transport chains.

Particularly the available length of railway sidings is insufficient in many cases. This causes time and cost intensive marshalling procedures and overall a reduction of transport quality.

For this reason beside the improvement of existing terminals infrastructure the installation of new trimodal terminals plants should be taken into consideration to ensure an efficient integration between rail and inland waterway. In this context innovative technologies also have to be taken into consideration as an alternative to conventional transhipment technologies. Innovative technologies can give a solution for the geometric difference between train (till 700 m in length) and barge (100-150 m in length) and the with it entailed operation requirements of the longitudinal transport for the connection barge – (storage) – train and the timing of rail transport in slots and barge shipping dependent on weather conditions, each with optimised buffer times.

Therefore new plants should be planned under the aspect “trimodality” which means that the requirements and needs of both transport modes have to be considered.

Barges

The improvement of barges (design and technique) can be a key for the success of trimodal chains.

Regarding the conception of trimodal chains the following aspects are determining the conditions of inland waterway transport: transport time and transport costs. Of course the selection of terminal location has substantial effects on transport time and costs (TEU-km compared to rail). Furthermore barge technology can have influences as well. Large barges (e.g. Jowi 400 TEU) have noticeable effects concerning reduction of transport costs (TEU-km). Disadvantage is the extension of time for loading and unloading higher amounts of ITU. Small (fast) barges have a relatively low capacity (32 TEU), low requirements concerning waterway (necessary clearance height of bridges 5,3 m) and a comparable high speed they offer high operating flexibility. Advantage of the “sprinter” is the fast connection between two inland ports in combination with low laying time.

The development of innovative or new barges indicates that inland waterway transport is trying to improve efficiency which can have positive effects on trimodal chains too.

Intermodal Transport Units (ITU)

Important for the success of trimodal transport chains can be the introduction of a multi-modal ITU (technical interoperability).

The existing technical parameters in inland navigation particularly the useable width of cargo hold of barges are limiting the operation of trimodal chains only to the hinterland transport of maritime ISO-containers. These units do not correspond to the needs of Trans-European freight traffic (road and rail): the offered volume is lower compared to common swap bodies and they do not fit to the dimensions of standard pallets. On the other side current swap bodies are designed and standardised according to the requirements of road and rail transport. These ITU normally are not stackable and not equipped with top corner fittings.

For the integration of inland waterway transport into multimodal transport chains an intermodal transport unit is required which is suitable for all transport modes.

Operation

Organisation, management and control of trimodal transport chains have to be done in a co-operative way.

Important for the success of trimodal transport chains is the optimal co-operation between transport modes.

The quality of service today is an important criteria for the choice among alternative modes of transport. To guarantee a high quality level of service in trimodal chains and in case of any problems the clients should only have one competent contact for the whole chain.

Information Technology

Important for success of trimodal chains is the introduction of efficient information systems.

Because of the connection and integration of three transport modes the necessity of availability of relevant information along the whole transport chain inclusive the terminals is very high. For this reason an important aspect is the introduction of an information system regarding the requirements of all participants.

Market

For the further determination of possibilities for trimodal transport chains specific market studies should be carried out.

A disadvantage of trimodal chains can be seen in the considerable extension of transport time. The relevance of extended transport time for goods or freight market segments has not been examined yet. Assured information about the affinity of certain goods or specific freight market segments is a basis for the aimed acquisition of clients for trimodal chains.

Policy

During the implementation phase trimodal chains can be supported by policy makers.

The combination between barge, rail and road under consideration of the optimal use of their specific benefits allows the construction of a very environmental friendly transport chain with high effects concerning modal shift.

Previous activities to integrate trimodal chains into the market have not been very successful. One precondition for success is the acceptance in the transport market. This can be supported by incentives (e.g. promotion with public money).

Implementation

For quantity reasons and capacity of inland waterway trimodal chains should mainly be set up on the Rhine axis and in the future also along the Danube

The concrete selection and evaluation of locations for trimodal terminals has to be done under consideration of clients and goods requirements to find an optimal solution concerning transport cost and transport time. This has to be made for each relation.

The user group meetings during the APRICOT project had shown, that there is in general a big interest from the side of inland ports and terminal operators for the installation of trimodal chains.

In addition to the Rhine area there are several possible other region of interest for the installation of trimodal chains such Elbe, Seine, Rhône.

The transfer possibilities of the results of the APRICOT project have to be examined.

6 ANNEXES

6.1 Publications

List of Deliverables:

D1	**Foundation of Potential Corridors for Trimodal Transport Chains (WP 1)**
Responsible:	**KRUPP**
Reference:	**0101 TN 0031**
D2	**Technical-Organisational Structuring of Advanced Trimodal Transport Chains (WP 2)**
Responsible:	**KRUPP**
Reference:	**0101 TN 0057**
D3	**Functional Demonstration of Advanced Trimodal Transport Chains (WP 3)**
Responsible:	**HACON**
Reference:	**0101 PR 0068**
D4	**Evaluation and Recommendation (WP 4)**
Responsible:	**KRUPP**
Reference:	**0101 PR 0077**

Newsletter:

Trimodal System: The European RTD Project APRICOT

August 1998

6.2 Presentation and Conferences

Publication and Dissemination Activities of APRICOT

Date	Company/ Institution	Subject
07.04.98	Ministry of Transport, NL	National Study Conference
08.05.98	Leipzig	Contacts Logistic Fair
19.05.98	LCS	Multimodal Initiative
07.08.98	CTN/MTC	Discussion of Studies
01.09.98	Port of Antwerp	Techn. Discussion
12.-13.10.98	Nijmegen	1st User Group Workshop
02.12.98	Rotterdam	Contacts Intermodal 98
09.03.99	Rhine Forward.	Barge Meeting
13.04.99 14.04.99	Port of Mainz Port of Mannheim	Interview, Discussion Interview, Discussion
14.04.99	Port of Germersheim	Interview, Discussion
20.04.99	5 MDN	Modal Shift Meeting
28.05.99	ECT Duisburg	Interview, Discussion
12.08.99	RSC Rotterdam	Discussion of Results
09.-10.09.99	Mannheim	2nd User Group Workshop
28.09.99	5 MDN	Modal Shift Meeting
28.10.99	Hafag	Interview, Discussion
08.-09.11.99	Lille	EU Transport Research Conference APRICOT Presentation

		– **APRICOT Presentation**

7 REFERENCES

All references from which ideas, contributions or quotations are picked up have not been reported in the document. Any reference is given in the respective Deliverable corresponding to the Workpackage.