Development of New Technologies for Integrated Transport Chains in Europe

Lic. Eng. Johan Woxenius[1]

1. INTRODUCTION

Transport systems are designed according to geographical and infrastructural conditions as well as the demand for transport services in terms of goods flow and desired transport quality. Thorough knowledge about these factors is especially important for developers of integrated transport chains that must consider the preconditions for all links and nodes in the transport chain.

Due to the additional costs of terminal handling and local road haulage, transport relations must exceed a certain minimum distance to allow CT to compete with pure road transport. This implies that international CT is of greater importance than domestic CT for most European countries and compatibility between national networks is of utmost importance. Contrary to this fact, transfer technology development is by many still considered to be governed by national policies and preconditions.

This paper aims at describing the national features that logically should guide the development of combined transport transshipment technology, national and EU research and development support measures and, finally, to analyse whether national or international conditions are prevailing for a number of current development projects.

The presentation is focused on the transshipment function, as shown in the simple system model presented in figure 1, regardless of whether it is terminal-based or integrated with a vehicle or a load carrier.

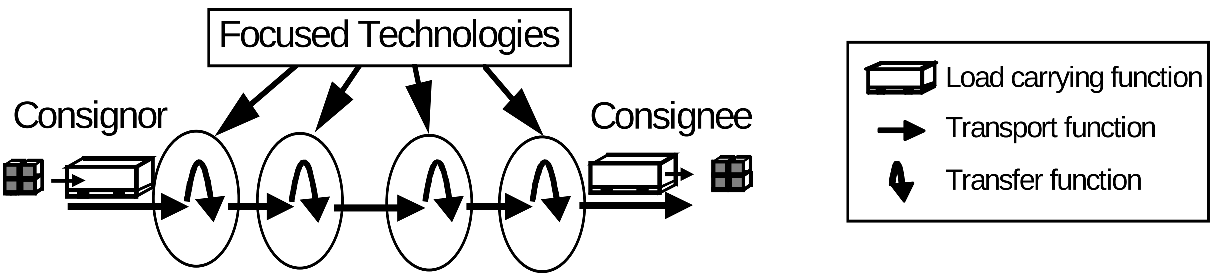

Figure 1. The transfer function in a combined transport context.

[1] Department of Transportation and Logistics, Chalmers University of Technology, S-412 96 Göteborg, Sweden.
Tel: +46-31-772 13 39, Fax: +46-31-772 13 37, E-mail: jwox@mot.chalmers.se

The preconditions vary remarkably between continents and even between countries and the study is demarcated to the EU countries, excluding Eire, Greece, Portugal and Spain but including Switzerland due to its significance for integrated transport chains crossing the Alps. For each country, current development projects are checked against the prevailing conditions and policy. The different countries are treated based upon the normal conditions and procedures, i.e., only special features are mentioned.

The terms integrated transport chain, intermodal transport and combined transport (CT) are used somewhat synonymously.

The paper is prepared using a set of complex data gathered through studies of numerous product brochures, academic papers, industry journals and through attendance to conferences and exhibitions, all during a long time of accumulated research. The topography and demography is studied in various geography books and atlases. This wide variety of informal sources imply that literature references are only given in specific cases and then primarily for the readers' convenience. Describing different technologies is not a particular aim of this paper, so for facts about the systems mentioned it is recommended to search other sources, e.g., EURET (1994, 1995), Rutten (1995), Schreyer (1996) and Woxenius and Lumsden (1994), or to contact the author.

The rendering is a worked up and updated version of an earlier paper (Woxenius *et al.*, 1995). I thank the co-authors of that paper - Johan Hellgren, Ola Hultkrantz (former Karlsson) and Lars Sjöstedt - for their contribution although the thoughts presented here are mainly my own.

2. THE REFERENCE MODEL

Mother nature stipulates the basic conditions for all human activities, transportation certainly not excluded. The pattern of mountains, marshes, seas, lakes and rivers influences the choice of transport mode and the cost of establishing the infrastructure and transport networks. The topography and demography of a country affect the terminals both by stipulating possible rail links, i.e., the configuration of the network and the competitiveness of CT services giving the total goods flow for the terminals to handle. The theoretical base for the network configuration and its implication on terminal technology were defined in earlier research (Woxenius *et al.* 1994).

Nature has also influenced the geographical pattern of other human activities. Location of natural resources, the climate and the soil all influence where humans have decided to settle and thus indirectly the demand for transport services. Consequently, transfer technology developers must take possibilities for different transport modes as well as the potential size of the transport market into account.

According to Manheim's basic relations model (Manheim, 1979), the performance of the transport system in the long term influences localisation of manufacturing and other human activities. However, this long time interdependence is ignored in this paper since CT is only a part, and so far only a marginal part, of the total transport system serving Europe.

Another factor that influences transshipment technology development is the CT industry and the structure of its market. The focus of the analysis is on significant differences from what can be considered as ”average” European conditions. The competition with road transport is especially emphasised.

Up to today CT has generally proven to be unprofitable for the companies involved while the society as a whole has benefited from the transport system’s environmental friendliness. The European national railways are now transformed into organisations with strict business economic profitability goals. Hence, until the external costs have been internalised, publicly funded R&D will play an increasingly important role in the design of CT systems, and particularly the interface between the relatively mature road and rail transport modes. Most notable of these programs is arguably the EU Commission’s fourth framework programme, but the issue is also addressed by smaller programs run by the Commission.

A reference model can thus be outlined. Factors that are included are: (1) the general preconditions, e.g., topography and demography; (2) the current CT system regarding infrastructure, production system and competition and; (3) governmental and EU policies for financial support for R&D, investments and transport service operation. These factors all affect the general lists of functional specifications for new terminal technologies that apply to each country or the EU as a whole. Of course, the lists lined out here are restricted to a logical analysis, the lists actually guiding technology development might be quite different from company to company. Finally, country by country, a number of development projects are compared to the special features expected to guide the development. The model is graphically presented in figure 2.

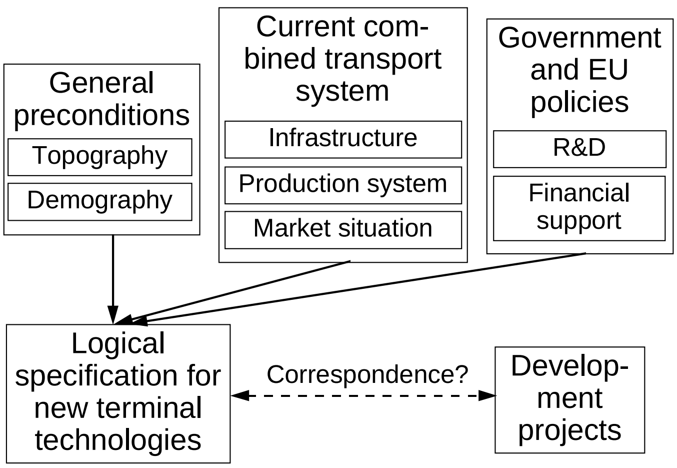

Figure 2. The reference model guiding the analysis.

3. PRECONDITIONS AND DEVELOPMENT PROJECTS

In this section the reference model is applied to a number of European countries that are listed in a purely geographical order, starting from the north.

3.1. NORWAY

Norway is largely mountainous with a large number of fjords and inlets that cut inland from the coast and the winter climate is extremely harsh. Transport to the northern parts go through Sweden because the Norwegian national rail network misses a link to the far North. This means that nature dictates a hub-and-spoke structure or a corridor with rather long feeder links to be employed. The topography also implies the competitiveness of coastal shipping. In addition to the barren topography, the scarcity of population means that CT is only feasible in some areas. No substantial CT funding programme has been employed in Norway. In short, the preconditions in Norway does not favour CT.

Any concept dedicated to the Norwegian CT system must facilitate small scale handling and a low fixed to variable cost ratio. Coastal shipping and the harsh climate must also be taken into account in the design process. These problematic conditions together with the small domestic market are constraints leading to the fact that the Norwegians have not come up with any important CT technologies. However, the Norwegians are not technology unfriendly and some systems from other countries have been tested, e.g., a bimodal system and a small-box concept. Moreover, during the autumn of 1996 Swedish State Railways (SJ) has run commercial tests with a rolling highway service aiming at Norwegian transiting lorries but it has not proven to be particularly successful.

3.2. FINLAND

Finland is situated on the eastern side of the Gulf of Bothnia, which means that most connections to and from Western Europe comprise a sea leg. Therefore, a trimodal system (road/rail/sea) is often required. On the infrastructural side, the wider gauge of Finnish railways means that there is no use transporting CT wagons between Finland and Western Europe. A large part of the Finland -Continental Europe flow goes through Sweden even strengthening the importance of trimodal adaptation.

Due to the paucity of population, CT only exists in some regions in Finland. In addition, the large size of lorries - 22 m and 56 metric tonnes - further reduces the competitiveness of CT and yield lorries that are not adapted for carrying unit loads. However, after entering the EU, Finland and Sweden have agreed to increase the permissible vehicle length to 25,25 m in 2003 in order to make it easier for foreign hauliers to compete domestically in Scandinavia. By use of different combinations of swap bodies and trailers, the foreign haulier can reconfigure three continental vehicles of 18,75 m into two 25,25 m units. Consequently, the Finnish and Swedish domestic road transport now see reasons for using unit loads instead of fixed road vehicles.

Furthermore, Finland is aggressive in its intention to serve as the main gateway to Russia and the Far East by the Trans-Siberian railway. The long experience of trading with the Russians makes the transport route via St Petersburg and the Port of Kotka very interesting until new and efficient rail links has been built directly between Russia and Western Europe. The gateway function has led to a concentration to ISO-containers that are suitable for transportation in Russia and can be used for sea transport directly to Germany.

Finland's geography calls for transfer technologies that are suited for transshipment between road, rail and sea vehicles and vessels. The focus on ISO-containers calls for equipment that is specially adapted to that load carrier. The modest population in Finland, however, means that there is no demand for high-capacity equipment.

Technologies that have been developed in Finland include the port-to-port cassette system Rolux, the trimodal Wheelless system and a road-to-ground container handling device that uses an inclined plane. Both these technologies are low-capacity systems that are suited to all transport modes and ISO-containers. They can therefore be said to match the established specification.

3.3. SWEDEN

As is true for all Nordic countries, Sweden's small population dictates that CT is not feasible in all areas. Road vehicles are even larger than in Finland - 24 metres and 60 metric tonnes is allowed - which further reduces the competitiveness of CT. Swedish domestic road transport is today dominated by articulated lorries but as mentioned in the section above, Sweden and Finland have agreed to change the road regulation favouring road vehicle combinations using unit loads.

Swedish national R&D policy aims at stimulating development of technologies suitable for low density demand and for short sea shipping. This is in line with Sweden's limited population and peninsular lie, even though the importance of the latter fact will be diminished once the Öresund bridge is finished. A parliamentary committee for analysis of the future of Swedish transportation in a wide context has recently come with its first proposals, however very badly received by virtually all bodies to which it was referred for consideration. The directive to the committee revealed a desire for stronger governmental involvement and the establishment of further integration between the transport modes as well as increased environmental concern.

The most notable factors that influence the development of transfer technologies in Sweden are the limited population density, which means that technologies for low-density flows are needed, and the peninsular position, which means that short sea shipping needs to be integrated into the operations. The first factor is more generally prevailing than the second and therefore most development projects have been aimed in that direction.

Examples of Swedish low-capacity technologies are several versions of counter-balanced trucks, Kombiflex, CarConTrain, the Stenhagen System and a special container technology for dry bulk material transportation. Other, now abolished examples are the C-sam small box system and Supertrans. The Hipernet trimodal cassette system addresses both small scale transportation and the peninsular lie, while side-loaders focus on serving the short and deep sea shipping markets with hinterland distribution. Arctic Trailer - a twisting rolling highway wagon designed for the coming 25,25 m vehicles and Berglund's intermodal wagon are new developments of rolling stock with internal handling.

Despite the fact that development of CT technology has been governmentally sponsored through the general programme for technology development, SJ's CT company Rail Combi insist in investing largely in existing, very conventional terminal technology - by SJ referred to as heavy-combi. At the staff level, however, SJ runs a development project lining up the schemes for a light-combi system for geographical outreach and as a complement to the heavier system (Lundberg, 1996). The preliminary plans comprise 30-40 terminals covering most parts of Sweden with international connections available through a gateway in Scania. Previously SJ have presented ideas for a small scale CT system including the use of counter balanced trucks and new domestic containers (Nelldal, 1994).

In general, the Swedish inventions contribute to solving the special needs for the Swedish market but have also attracted attention from foreign markets.

3.4. DENMARK

The dominant geographical feature of Denmark is its position as a gateway between the rest of the Nordic countries and continental Europe. In addition, Denmark in itself is too small for substantial domestic CT, which further strengthens its role as a transit country. The other dominant feature is its abundance of islands, which means that all transit transport will comprise at least one ferry leg until the fixed connections are finished. For transports destined to and from Denmark, the dominant market feature is that semi-trailers are not frequently used.

As is the case with Norway, Denmark has not established itself on the map of CT technology inventions. However, a small container service called +box was tried but is now discontinued and a commercial service with bimodal technology was recently started between Denmark and Italy. The intended cargo, meat southbound and vegetables northbound, calls for refrigerated units and the project implies that the Danish CT industry is open for new technologies. The role as gateway for the other Scandinavian countries also means that some technology adaptations are needed.

3.5. GERMANY

Germany is the economic centre of Europe, which means that a major demand for transport services is generated in the country. In addition, its geographical position in the heart of Europe means that a lot of transit traffic flows through the country. Germany is also the world's number one export country adding to the huge demand for goods transport. Topographically, Germany is flat in the north and increasingly mountainous in the south. The large flows of German CT means that the traffic to a large extent can be arranged as direct connections, but the industry concentration along the river Rhine and other inland waterways makes a corridor layout feasible. Integrating road, rail and inland waterways is obviously a task for German transport system designers.

Furthermore, Germany is heavily populated with industry particularly concentrated to areas such as the Ruhr. This means that space for CT terminals is limited and, due to road congestion, the size of pick-up areas is rather determined by haulage time than distance.

The size of the German CT market means that transfer technology R&D is largely market-driven and therefore governmental R&D policies less consequential, even though some technologies has emerged through governmental sponsoring. German CT has benefited from substantial economic help for terminal investments, i.e., the demand side of the CT terminal equipment market is sponsored rather than the supply side.

The high population density and concentration of industry in Germany mean that transfer technologies need to be suitable for fast transshipments along corridors. Terminal operations should also be possible on small terminal surfaces. Another requirement is that integration with inland waterways should be possible since these carry a significant traffic volume.

German transfer technologies that facilitate fast transshipment in a corridor network with limited space demands include the Noell's Fast Transshipment System and Mega Hub concepts, Krupp's Fast Handling System (FHS), Thyssen's Container-Transport-System (development discontinued) and Mannesmann's Transmann. A recently presented building scheme with governmental financing includes Krupp FHS in Dresden, Transmann in Erfurt and Noell Mega Hub Concept in Lehrte (O'Mahoney, 1996).

Small scale transfer technologies include ABB's WAS-wagon, Mercedes Benz' Kombi-Lifter, DB Cargo's Cargo Sprinter and various bimodal concepts. A special device, Umschlagfahrzeuge Schwanhäuser/Lässig (ULS), was developed using governmental support, but the technology was not popular within the German State Railways (DB) since the technology did not meet the requirement of fast transshipment. DB Cargo has marketed a small-box system, Logistikbox but the commercial development has reportedly been halted.

Moreover, stackable swap bodies have been developed for the purpose of stacking at terminals, easier handling with top-lift spreaders and also for integration with inland waterways navigation. Most German transfer technologies are therefore in general in accordance with the established specification.

3.6. THE BENELUX COUNTRIES

The Benelux countries are, with the exception of the Ardennes region in the south-east, flat and populous. In addition, they are not large enough to warrant domestic CT. Instead, the main source of CT demand is the hinterland transport by rail or inland waterways of goods that flow through the major seaports in the area, chiefly Rotterdam and Antwerp.

An automatic barge loading system, the Rollerbarge, well suited to the inland waterway interface has been proposed by co-operating consultants and a barge chain concept, the River Snake, adds to the innovation from the Netherlands (Rutten, 1995).

Efficient sea-port handling is achieved by the ECT/Delta Sea-Land System. However, the large amount of containers generates substantial amounts of traffic to the port area and the urban area suffers from pollution and congestion. In order to decrease these problems, ECT - the company that operates the container port - plans an innovative new system called the Multi Trailer System (also referred to as CombiRoad) for moving the interface towards road, rail and barge traffic from the actual port area (Leyn, 1995).

To handle hinterland transportation in the Benelux, transfer technologies need to be adapted to ISO-containers. In addition, the transfer technologies need to function well with inland waterways and make efficient port handling possible.

The Coda-E bimodal system and the development of a domestic small container (10 foot) system for flowers and vegetables are other examples, the latter a contradiction to the fact that the Netherlands is geographically small. In addition to these, the Abroll Container Transport System (ACTS) and an inclined plane technology, N.C.H. ISO 2000/4000, have been developed for the special needs for transshipment and distribution generated by ISO-containers.

3.7. THE UK

The UK differs from continental Europe in that it has a limited loading profile on rail, which means that load carriers have to be limited in height to be rail-transportable in the UK. In addition, much of the rail network can be seen as being in less than mint condition.

Semi-trailers dominate road transport in Britain, indeed swap-bodies were only recently introduced in the UK. However, standard semi-trailers cannot be used on rail because of the limited loading profile. Consequently, current R&D policy is aimed at making piggyback transport possible on the existing infrastructure. Although rail transport was invented in the UK, politicians are generally considered to have an anti-rail attitude. Nevertheless, the Channel Tunnel has lead to a boost for containers and swap bodies of semi-trailer length.

The main problem that dictates the specification for transfer technologies in the UK is the need for equipment that allows CT with the semi-trailers that today dominate road transport. An obvious alternative to increasing the tunnel and bridge clearances is to adapt either the semi-trailers or the rail wagons to letting the combined carriage use the existing rail network. In addition, the Channel tunnel places specific demands on the transfer technology that is to be used in connection with this traffic.

Technologies that address the first problem include the Tiphook System, developed in Finland and now abolished, in which semi-trailers with slightly cut upper corners were used and the restricted profile wagons Eurospine by Thrall and the Piglet by Powell Duffryn Rail Projects. The wagons are also suitable for use in the Channel tunnel and investments of some £70 million will give a core network for standard semi-trailer CT (The Piggyback Consortium, 1994). Since the new wagons are alternatives to increasing the loading profile at enormous costs, public money might be used for investments in new wagons.

Cholerton Ltd of Isle of Man has come up with Shwople, a terminal equipment built between the tracks for the purpose of lifting semi-trailers and swing them perpendicular to the tracks for tractor handling. Other than that, rolling highway technology are used for the Channel tunnel traffic, but so far mainly for the core tunnel distance.

3.8. FRANCE

The French rail network is - as is much of the society as a whole - largely centred on Paris, which assumes the function of a national hub. In the different regions very different preconditions exist. The country’s topography ranges from plains in the north to the extremely mountainous south and south-east. Industrial regions coexist with purely rural regions as well as regions dependent on tourism. France also serves as a transit country for transports to Italy and the Iberian peninsula, where a wider rail gauge is employed.

The CT system of France is today merely a domestic phenomenon and almost all international traffic can be referred to as transit between Germany and the Iberian peninsula. Instead, French trade with Germany and the Benelux countries often contains one domestic CT service, but due to lack of technical and infrastructural standards the goods passes the border on rubber wheels.

French State Railways (SNCF) enjoy a strong position in the French society. The R&D policy, of which SNCF are responsible for a large part, is aimed at developing fast transshipment techniques, which is consistent with the hub-and-spoke structure of the rail network. Another problem to solve is the impact of the substantial transit traffic by articulated road vehicles. In addition to this, technologies are also required for use in the Channel tunnel and to handle road transit traffic.

Two development projects for the hub-type transfer technology are Commutor and an automatic marshalling yard. An R&D project of SNCF regards large-scale rolling highway techniques with new and independent infrastructure in order to handle transit traffic by whole road vehicles. Lohr Industries has developed its Modalor for small-scale handling that is regarded to be rather far from the French attitude towards advanced technology that is somewhat between culture and religion.

3.9. SWITZERLAND AND AUSTRIA

Switzerland and Austria are largely dominated by the Alps, which means that the rail network is largely confined to the available mountain routes. Together with France, both countries receive a substantial amount of transit traffic as they form a link between northern and southern Europe. Existing tunnel profiles are limited implying dominating use of swap bodies instead of special Alp tunnel-adapted semi-trailers.

For environmental reasons, road traffic is severely restricted and CT is subsidised. The technical problems concerning emission evacuation, safety measures and tunnel dimensions all favour rail or rail shuttle solutions instead of the highway alternative. The Channel tunnel is a recent example of this technical choice, and the coming base tunnels in Switzerland will probably be built purely for rail and shuttle traffic. This will obviously favour CT, since once the terminal cost is paid, the rail distance can favourable be extended outside the tunnel openings. This is also the main reason for the high market share of Alpine crossing CT today.

Austria also faces problems with the East-West traffic with severely polluting lorries from the former Eastern Bloc. This traffic has been transferred to rail by use of up to 80% subsidisation for rolling highway services together with high road tolls. From the beginning of 1995, however, this traffic is to a large extent lost to road again since Austria has been forced to lower the road tolls and decrease enforcing activities according to EU regulations.

Neither Switzerland nor Austria is large enough to make traditional domestic CT feasible for time-sensitive cargo. Consequently, R&D policy is aimed at developing transit traffic solutions and small-scale terminal techniques for low value cargo.

The conditions for Switzerland and Austria generally require technologies for transit traffic through the Alps and, in addition, small-scale solutions for the much less dominant domestic transports.

Standard rolling highway technology is used for the transit traffic of articulated vehicles. Technology development on decreasing maintenance and problems related to the small wheels' speed of rotation is emphasised. Existing small-scale technologies include

ACTS and other turntable systems. Contrary to the domestic needs, Tuchschmid Engineering advocate its Compact Terminal for large volumes, probably aiming for the German market or possibly for a gateway function. The Rolling Shelf by Jenbacher, is perhaps not a true CT technology since it is intended for palletised goods and not unit loads, but it is still interesting since it competes for the same market.

3.10. ITALY

Italy is mostly mountainous. The most outstanding regional difference is that the industry is concentrated to the northern part, whereas the southern region is more rural. Due to Alpine transit by CT, Italy is one of the large European CT countries when it comes to international traffic. In fact, together with Germany, Italy account for 95% of all international CT in Europe (Bukold, 1995). Italy also serves as a transit country for transport to Greece via Port of Brindisi. However, Italian CT is seriously unprofitable and far-reaching measures are needed to enhance the economic performance.

On the network operation side, the terminals in the north sometimes operate as gateways between domestic and international CT. This is a coming trend with the purpose of integrating different networks without restricting the possibilities of optimise each network for the common preconditions. Also empty positioning of wagons can be decreased by transferring unit loads instead of marshalling wagons.

At the moment, there is no governmentally sponsored R&D programme dedicated to transshipment technology. R&D policy is focused on the CT related issue of freight villages (interporti), primarily on the management side.

Italy needs technologies that are suitable for use as connections to the transit traffic through the Alps and, in addition, small-scale solutions for the less dominant, but still substantial, domestic transports. Development projects must cut operations costs or enhance the overall system performance in order to attract high value cargo. The Italian CT industry must strongly prioritise long term profitability in order to survive in the new era of the European national railways.

Traditional rolling highway is normally used for the Alpine traffic, since it is what is used in other areas along those routes. However, as mentioned in the section for Denmark, a bimodal technology is now also used in this function. Existing small-scale technologies include the Firema Twistwagon (a turntable system for complete lorries) and also the Ferrosud/Breda bimodal system called Carro Bimodale.

3.11 SPECIAL PRECONDITIONS ON THE EUROPEAN LEVEL

The geographical and demographical conditions for Europe as a whole is for obvious reasons just a compilation of the national features. However, seen as a unit one can note that the central parts are densely populated in contrast to the outskirts. Mountainous areas and sounds also screen off some of the main parts of Europe from each other. The crucial point for international integrated transport chains is the technical compatibility of infrastructure and technological components, mainly load units and rail wagons. The EU Commission has a great harmonising task in these fields.

The trans-European networks (TEN:s) for rail, highways, inland waterways as well as CT as such will obviously influence integrated transport chains. Interesting to notice is that the terminals are part of the CT network outlined by the EU. However, the situation is not clear and today the EU neither has the available funds nor the authority to force national governments to establish the networks (de Bock, 1996). If the EU is convinced of establishing the network including terminals, it will strongly affect coming terminal technology development and investments. For reasons generally referred to the cohesion of the Union, EU tends to spend money on infrastructure not in central countries with massive transit flows but in the periphery which logically should be more of a domestic issue. The general attitude of the EU commission (Chraye, 1995) is that they trade subventions for a certain degree of control.

The giant four-year fourth framework programme for R&D, comprising a total budget of 12.3 billion ECU, is the most important single action for promoting European CT terminal technology development. The transport R&D budget is 240 million ECU, and it aims at increasing efficiency and environmental friendliness in transport systems. It also aims at facilitating interconnections between different transport networks and modes, which means that it is largely dedicated to different types of combined transport technology. Transport-related research features predominantly in four of the specific programs of the framework; Telematics, Industrial and Material Technologies, Non Nuclear Energy and Transport. The research tasks in the dedicated area of Integrated Transport Chains have been defined along two axes - quality of the network and quality of the terminals/transfer points. For developing integrated transport chain operations, Pilot Actions for Combined Transport (PACT) play a significant role (European Commission, DG VII, 1995).

The extensive investments in current technology is also important to take into consideration. Generally speaking, it can be said that the current CT networks seem well-suited for co-operative actions at a European level. Some state that such efforts have not been forthcoming from the EU prior to the fourth framework programme (Kiriazidis, 1994). Also practical problems in co-ordinating the national railways have been experienced, not at least when trying to set up the Avesta-Sheffield Shuttle between Sweden and UK through the Channel Tunnel where the problems of integrating the national railways' operations made the whole project impossible (Wijkander, 1995).

An interesting project on the European level is the Flexible Intermodal Horizontal Transshipment Techniques (F.L.I.H.T.T.) with duration until March 1999. With a total funding of more than a million ECU's, the project co-ordinator Costamasnaga S.p.A. will try to fulfil the objective of defining innovative load units and an automated transshipment system for combined transport (www site).

4. CONCLUSIONS

Today's CT systems are generally compatible since the terminals contain all specific equipment for the transshipment operation. Most terminals active today were also established during a short period of time implementing the best technology available then which means that gantry cranes and counter-balanced trucks dominate at the European CT terminals. Wagons are rather universal and so are the unit loads. Exceptions are semi-trailers intended for use in the UK or on Alpine transit routes as well as 2,77 m high swap bodies that are not compatible with all current European rail loading profiles.

The new systems however, are, as is indicated by Appendix, to a large extent designed with dedicated wagons and all unit loads are not technically suited for the new systems. Appendix also shows that the developed technologies correspond to the national preconditions rather than those for the EU as a whole. Even worse for European integration, the systems are to a large extent designed with specialised wagons giving nationally restricted networks and services. In order to avoid a scattered European CT system with pronounced national CT networks due to shifting technology choices, the EU has an important co-ordinating role to play in the future.

If the fourth framework programme is not successful to develop operating standards and technologies for later commercial implementation, the integration programme for European railway infrastructure will be obsolete for CT. Of course, the gateway principle with transshipment at network interfaces is feasible, but the optimum is certainly compatible systems and full trains operated directly between two terminals where the demand is sufficient. The potential buyers of new transshipment technology must carefully decide whether to go for a national system or invest for the future in systems compatible over national borders and thus competing for the most promising part of the European CT market.

REFERENCES

Bukold S. (1995) *The crisis of combined transport*, ECIS Newsletter, No. 5/1995, p. 5.

O'Mahoney, H. (1996) Terminals in a nutshell, *Cargo Systems,* No. 4, April, pp. 39-41.

Chraye H. (1995) Officer for CT policy, DG VII, the EU commission, interview, Brussels March 28.

De Bock, J. (1996) Guest lecture at Chalmers University of Technology, November 4.

EURET 409/95 (1995) *Present optimum transfer technologies,* SIMET Action 2.2, Brussels.

EURET 410/94 (1994) *Future fast transfer technologies*, SIMET Action 2.2, Brussels.

Kiriazidis T. (1994) *European transport: problems and policies*, Avebury, Aldershot.

Leyn R. (1995) *Rotterdam; the ”hub-to-hub port”*, presentation at Interterm 95, Atlanta May 8.

Lundberg, A. (1995) SJ utvecklar lättkombinät för partigods (SJ develops a light-combi network for part loads) *Transport & Hantering*, No. 10, pp. 29-30. In Swedish.

Manheim, M. L. (1979) *Fundamentals of transportation systems analysis,* Volume 1: Basic Concepts, MIT Press, Cambridge, Mass.

Nelldal (1994) Järnvägstransporter år 2010 (Railway transportation in 2010), *Transportjournalen*, No. 2, pp. 28-31. In Swedish.

European Commission, DG VII (1995) *PACT - Pilot Actions of Combined Transport*, Brussels.

Rutten, B. C. M. (1995) *On Medium Distance Intermodal Rail Transport*, Dissertation, Faculty of Mechanical Engineering and Marine Technology, Delft University of Technology, Delft.

Schreyer, R. (1996) *Beiträge zu einer ökologisch und sozial verträglichen Verkehrsplanung,* Master's thesis 1/1996, Institut für Verkehrsplaung und Verkehrstechnik, Vienna University of Technology, Austria. In German.

The Piggyback Consortium(1994) *The feasiblity of a piggyback network for the British Isles*, MDS Transmodal and Servant Transport Consultants, investigation sponsored by the European Commission DGVII under the PACT (Pilot Actions on Combined Transport).

Wijkander, E. (1995) *Can European Rail Nationalism be overcome*?, Intermodal 95, October 24, Amsterdam.

Woxenius J., Lumsden K. R. (1994) *System and functional requirements for RoRo cassettes in multimodal transport*, Paper presented at RoRo 94, Gothenburg 26-28 April. Shorter versions published in *the Scandinavian Shipping Gazette* Vol. 90 (1994), No. 40, pp. 82-85.

Woxenius J., Sjöstedt L., Hellgren J. (1994) *Five traffic designs in combined transport systems - a theoretical discussion,* Paper for a seminar within the EEC Tempus-project JEP 3238, Warsaw February 24. Also published in *Logistyka - Engineering Machines Problems,* Vol. 2 (1994), No. 2, pp. 111-127.

Woxenius, J., Hellgren, J., Karlsson, O., Sjöstedt, L. (1995*) Combined Transport Transshipment Technology Trends in Europe*, Paper presented at a seminar within the TEMPUS programme in Wroclaw, Poland, July 13, 1995. Operation of the Technical University of Wroclaw, No. 77, Series: Conferences No. 23, 1995, pp. 73-92.

www site: http://sungaz.casaccia.enea.it/flihht.html.

APPENDIX: EUROPEAN DEVELOPMENT PROJECTS REFERRED TO IN THE TEXT

Project	***Countries***	***Wag.***	***Dedicated requirement issue***	***Develop-ment Phase***
ACTS	B, NL, L, A, CH	D	Small-scale/ISO-containers	Operational
Arctic trailer	S	D	Small scale transfer of full lorries	Design
Berglund's wagon with inter-nal handling	S	D	Small scale transfer through internal equipment	Design
Bimodal System	DK, GB, NL, D, I	D	Small-scale transfer	Operational
C-sam, +box	S	D	Small-scale transfer without transfer equipment	Abolished
CarConTrain	S	D	Small-scale transfer	Prototype
Commutor System	F, NL	D	Fast transfer/hub-technology	Abolished/ parts soon operational
Firema Twist wagon	I	D	Small scale transfer of full lorries	Design/ pro-totype
Inclined Plane ISO-Container	FIN, B, NL	D	Small-scale/ISO-containers	Operational
Kombi-Lifter	D	D	Swap body transfer on a sim-ple terminal	Design
Kombiflex	S	D	Small-scale transfer	Prototype
Krupp Fast Handling System	D	S	Fast transfer on small surface	Prototype
Logistikbox	D	S/D	Small scale transfer of small load units	Resting
Logistikbox	D	D/S	Small boxes door-to-door	Halted
Modalor	F	S	Small scale semi-trailer trans-fer	Design
Noell Fast Transs. System	D	S	Fast transfer on small surface	Design
Noell Mega Hub Concept	D	S	Large scale transfer on small surface	Building plans
NS Cargo's Small Cont. Syst.	NL	S	Transfer of small containers	Impl. plans
Piglet	GB	D	Small-scale/use of infrastr.	Design
Roll-On Frame	B, NL, L	D	Small-scale/ISO-containers	Operational
Rollerbarge	B, NL, L	n. ap.	Fast transfer/ISO-containers (maritime)	Feasibility study
Rolling Highway	GB, F, I, DK, A, CH	D	Small-scale/use of infrastr.	Operational

EUROPEAN DEVELOPMENT PROJECTS REFERRED TO IN THE TEXT, CONT'D.

Project	***Countries***	***Wag.***	***Dedicated requirement issue***	***Development Phase***
Shwople	GB	D	Horisontal transfer of semi-trailers	Design
Side-Loader	S	S	ISO-cont. distribution	Operational
Small Scale Terminal Concept	S	D	Small-scale transfer	Concept
Stackable Swap-Bodies	D	S	Top-lift/small surface	Operational
Stenhagen's System	S	D	Small-scale transfer	Prototype
Supertrans	S	D	Fast transfer on simple terminal	Design
The Compact Terminal	CH	S	Large scale transfer on small surface	Design
The Rolling Shelf	A	D	Large scale transfer without unit loads	Design
The Wheelless System	FIN	D	Trimodality, simple terminal	Design
Thrall EuroSpine	GB	D	Small-scale/use of infrastr.	Prototype
Thyssen CTS	D	S	Fast transfer on small surface	Abolished
Tiphook System	GB	D	Small-scale/use of infrastructure	Ex-operational
Transmann	D	S	Conventional handling under electric catenary	Building plans
ULS	D	S	Small-scale transfer	Prototype
WAS-wagon	D	D	Swap body transfer on a simple terminal	Test runs

Explanations for the Wagon column: S = Standardised; D = Dedicated; n. ap. = not applicable.