Innovative technology: Ro-Ro vessel, terminal, and barge design that will improve the cost position and lead-time for the logistic chain.

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ABSTRACT (The IMDC'03 Conference Paper)

Logistics, including the development and operation of supply and distribution chains, are the means that integrate suppliers, producers and customers. The awareness and importance of logistics as a competitive factor is increasing.

The background study focuses on different transport concept for heavy machinery, new cars, and forestry products. The method developed is general, though the examples are based upon distribution of new cars from hinterland areas in continental Europe to Australia, and transport of paper rolls from mills in the Nordic countries to customers in Europe. Design, technology and organisation are within the logistics chain important aspects to consider. Ro-Ro technologies used throughout multimodal logistic solutions are concepts that represent great potential in cost savings and lead-time reductions, compared to existing systems.

In this paper we will present different Ro-Ro technology for vessels (Enisys), terminals (Ipsi), and barges (Interbarge). We will also show how this technology combined together can represent potential cost position and lead-time improvements for the logistic chain.

The Enisys concept represents state-of-the art high speed and slim body ship design with low fuel consumption and efficient cargo handling equipment. The concept has excellent sea-keeping and manoeuvring capabilities due to "azimuth" technology and bow thrusters. The ship handles containers, trailers, swap bodies, cassettes, with automatic lashing. This solution gives logistics solutions high reliability and flexibility and is environmental friendly due to low emissions. The Ipsi terminal concept represents state-of-the-art terminal layout and fast cargo and high capacity handling equipment. The terminal concept has reduced area requirements compared to conventional terminals. The Ipsi terminal is a multi modal Ro-Ro solution, with automatic guided vehicles (AGV) operations that enables the terminal to handle 2400 TEU per day or 400 TEU per hour at reduced costs. The Interbarge concept represents state-of-the-art barge design with efficient Ro-Ro technology. The barge construction has reduced steel weight through the use of curved plates enabling better cargo carrying capacity and economy for transporters compared to conventional barges of same size. The Interbarge has varying air draught so it can be used

on all main waterways. The Interbarge new construction concept enables building ship hulls and especially barge hulls easier and faster with less use of steel, fewer and easier operations during production, and thinner shell plating due to the concepts increased ability to resist water pressure.

When analysing an existing logistics chain or a chain to be, the cargo owners are seeking for a best possible balance between service level and cost position of that logistic chain. We will use a quantitative mathematical approach to analyse and illustrate the use of new state-of-the-art technology in logistic chains. The authors have through a number of projects worked for both ship owners operating in this market (Ro-Ro, open hatch, bulk, container) and with shipping solutions for cargo owners in commodity industries like paper, fertilizers, fish, and ferro-alloy worldwide.

1 INTRODUCTION

Logistics, including the development and operation of supply and distribution chains, are the means that integrate suppliers, producers and customers. The awareness and importance of logistics as a competitive factor is increasing.

In this paper we will focus on how to improve logistic solutions true a combination of new innovative vessel constructions for sea-going vessels and inland barges with methods to analyse and compare the different logistic chains.

The models and methodology developed are being used to analyse complete supply chains from plant to customer which in most cases involves both sea and hinterland transport. In this paper we will describe different solutions for paper transport where we have used this methodology.

When analyzing a logistics chain, the cargo owners are seeking for a best possible balance between service level and cost position. Not only for the given market situation, but also with respect to being able to uphold competitiveness vis-à-vis alternatives in future market situations. Technology and organisation within the logistics chain are important aspects, when seeking to optimize the chain for the long term.

1.1 Challenges in multimodal logistics

The most important issue in developing logistics solution is the solutions attractiveness to the cargo owners. The success of a logistic solution is dependent on its capability to transport cargo in both directions. To achieve this, the solution must be cost effective, flexible, and short lead-times.

A producer and cargo-owner have to adapt and adjust to the requirements of his customers and the market for services available. Therefore, there is a need for continuous or periodic evaluation of the logistic set-up, as changes occur in the market distribution mix and in the competitive situation between different distribution alternatives and technology. An example is the evaluation between the use of sea-borne versus rail and road transport in logistics chains and the utilisation of barge transport on inland waterways to relieve pressure on European land transport.

2. ENISYS

The Enisys ship-concept [1] represents state-of-the art high speed and slim body ship design with low fuel consumption and efficient cargo handling equipment. The concept has excellent sea-keeping and manoeuvring capabilities due to ”azimuth” technology and bow thrusters. The ship handles containers, trailers, swap bodies, cassettes, with automatic lashing. The vessel enables high reliability and flexibility and is environmental friendly due to low emissions.

Figure 2-1The Enisys vessel

Excellent sea-keeping and manoeuvring capabilities enable the vessel to operate in areas out of reach for conventional ships of same size. An example is in the Halden fairway in Norway, where the current legislation limits the vessel size to 140meter length and 20-meter width, but bigger vessels have been accepted by the sea-pilots at specific terms such as daylight, good weather and no stream in the fairway.

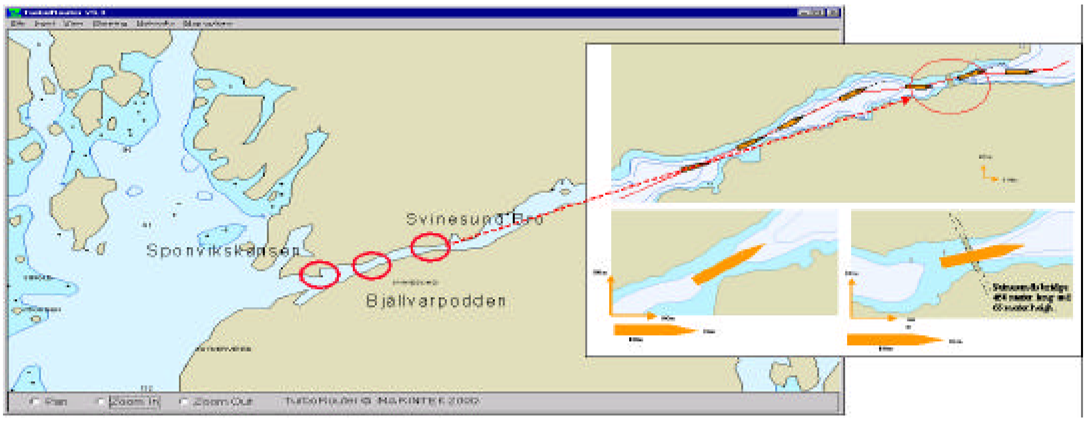

Figure 2-2The Halden fairway

A feasibility project [2] which has been done by Marintek together with Norske Skog (a major global paper producing company) with involvement from local Sea-pilots, Halden Port Authority and the Coastal Department has verified that with a vessel with the Enisys performance and manouvering abilities it will be possible to increase these limits to 180 – 190 meters and less than 26 meter width. In addition to strict requirements to the vessel the project has highlighted that new seamarks and, more lightning should be installed in the fairway, which will of course be an advantage for all vessels going through this fairway.

The principle for this system will be that the vessels either through autopilot control or through computer guidelines and detailed sailing procedures follows the exact same track through the fairway on every trip. An example of the sailing track is shown in Figure 2-2.

The Enisys vessels represent a new generation Ro-Ro vessels to be used in Short Sea Shipping and between countries such as the Scandinavian countries and the European continent. The construction goal behind the vessel design has been to combine the advantages of modern hydrodynamics and aerodynamic design as shown in Figure 2-3 with efficient cargo handling and carrying abilities.

Figure 2-3 Enisys hydrodynamic and aerodynamic vessel design

3. IPSI

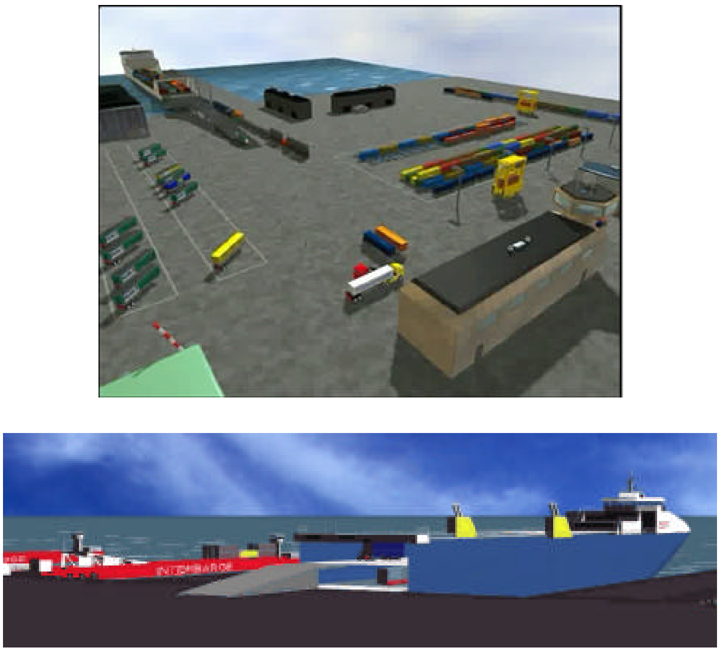

Figure 3-1The Ipsi terminal

The Ipsi terminal concept [3] represents state-of-the-art terminal layout and fast cargo and high capacity handling equipment. The terminal concept has reduced area requirements compared to conventional terminals. The Ipsi terminal is a multi modal Ro-Ro solution, with automatic guided vehicles (AGV) operations that enables the terminal to handle 2400 TEU per day or 400 TEU per hour at reduced costs.

The Ipsi terminal has especially shown to have capabilities as an efficient terminal in intermodal chains, particularly when combined with an efficient Ro-Ro solution such as the Enisys vessel, and the Interbarge that will be presented in the next section.

The idea behind the solution is that cargo handling for barges to be used for inland waterway transportation should be based on the same principle as for the ocean-going vessels, i.e. Ro-Ro. The hub port would then have a layout in principle as shown in the Figure 3-2.

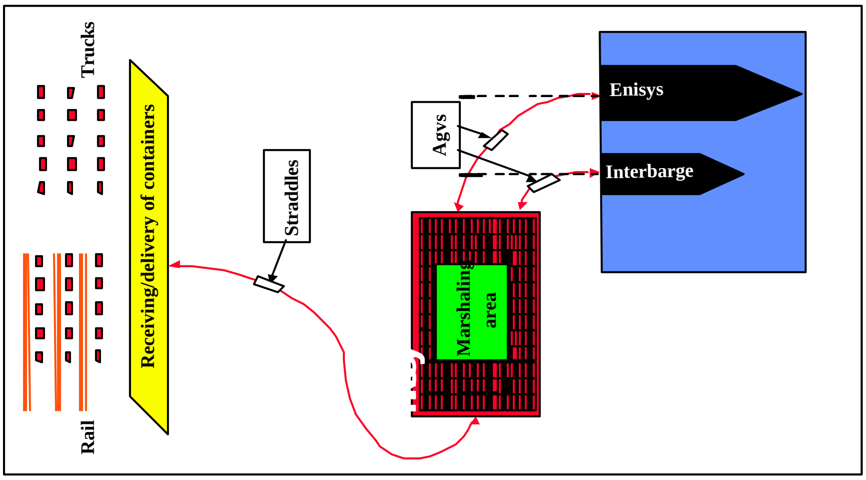

Figure 3-2The Ipsi terminal lay-out

Here the barge and the ship are moored closely together, and transferring cargo from one to the other should be very efficient. By using the principle of straight lanes also in the barge, the cargo-handling speed of more than 60 cassettes per hour should be maintained also for the barges in the hub port.

As stated before, the most recent growth in inland waterway transport has essentially been for handling ISO containers. The containers are loaded and unloaded using cranes. Typical handling capacity is in the vicinity of 30 TEU's per hour (Normally only one crane may operate on an inland vessel). Using a 110-meter container vessel it would take more than 8-12 hours to unload and load this vessel. Compared with the Ipsi solutions this operation would only take about 2 hours.

4. INTERBARGE

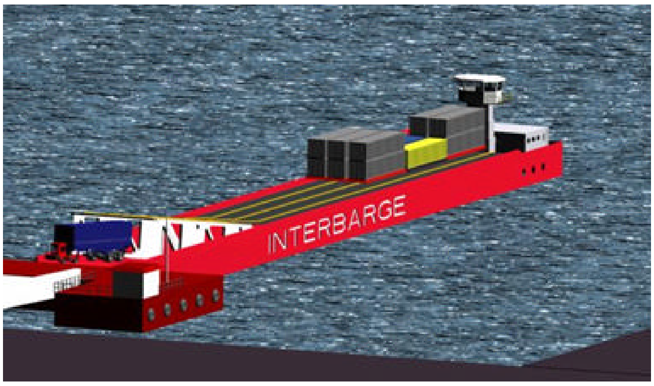

Figure 4-1The Interbarge

The Interbarge concept [4] [5] represents state-of-the-art barge design with efficient Ro-Ro technology. The barge construction has reduced steel weight through the use of curved steel plates enabling better cargo carrying capacity and economy for transporters compared to conventional barges of same size. The Interbarge new construction concept enables building ship hulls and especially barge hulls easier and faster with less use of steel, fewer and easier operations during production, and thinner shell plating due to the concepts increased ability to resist water pressure.

FEM-Engineering in Trondheim, Norway, had an idea for a new structural concept for barge design. By combining the structural concept with the principles of IPSI, the Interbarge alternative was established. The basic idea of the structural concept is to take advantage the imminent strength capacity of a plate after the bending resistance limit is exceeded. A plate clamped at the ends is many times stronger when the acting forces are absorbed in the plate as membrane tensions instead of stresses as in bending; see Figure 4-1.

By giving the plate a curvature, this state will be obtained and the stress level in the plate decreases compared to a flat panel. This again will allow the plate thickness to be reduced without a reduction of the strength of the plate.

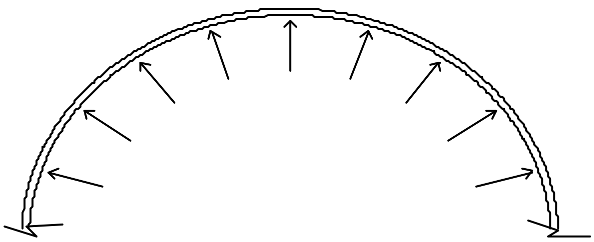

Figure 4-2 Curved plate with water pressure at the inner wall. The plate acts like a membrane.

The second benefit that comes from using this concept is that the number of strengthening members in the construction can be greatly reduced. In contrast a flat panel, as illustrated in Figure 4-3, has to be supported by closely spaced supports due to the low bending resistance of the plate. A curved plate in tension will need no support between the clamping. This will reduce the weight and simplifies the production of the structure, see Figure 4-4.

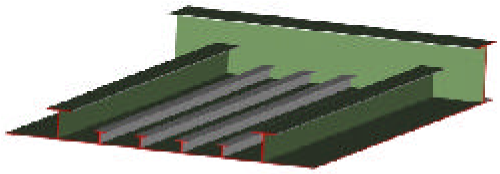

Figure 4-3 Flat panel with necessary support

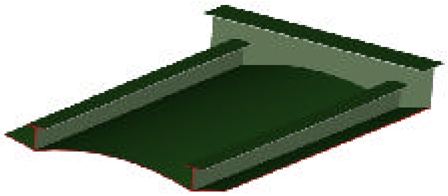

Figure 4-4 Panel based on the new structural principle

Figure 4-5 shows how the structural principle is applied in the design of a barge.

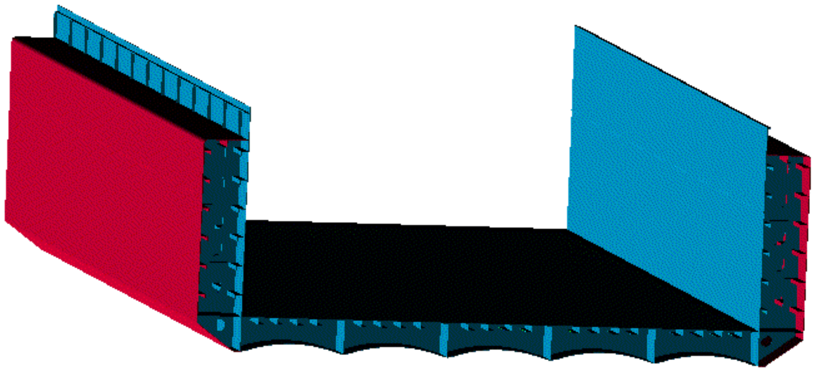

Figure 4-5 Cut through a barge using the structural concept

Figure 4-6 shows how the Interbarge solution might be built to accommodate the ENISYS requirements for cost, and speed of handling the cargo.

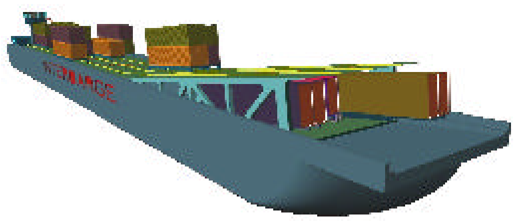

Figure 4-6 Interbarge applied for ENISYS purpose

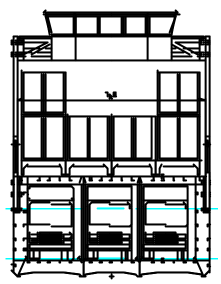

Figure 4-7 Possible configuration of Interbarge for ENISYS, with wheelhouse in lifted position

Ro-Ro-services are not as well developed, and few, if any, inland port has the facilities to accommodate the type of operation envisioned in this ENISYS–IPSI-Interbarge solution. The infrastructure required is not complex or expensive, but it must be established. A practical Ro-Ro ramp for inland waterway transport is shown in Figure 4-8.

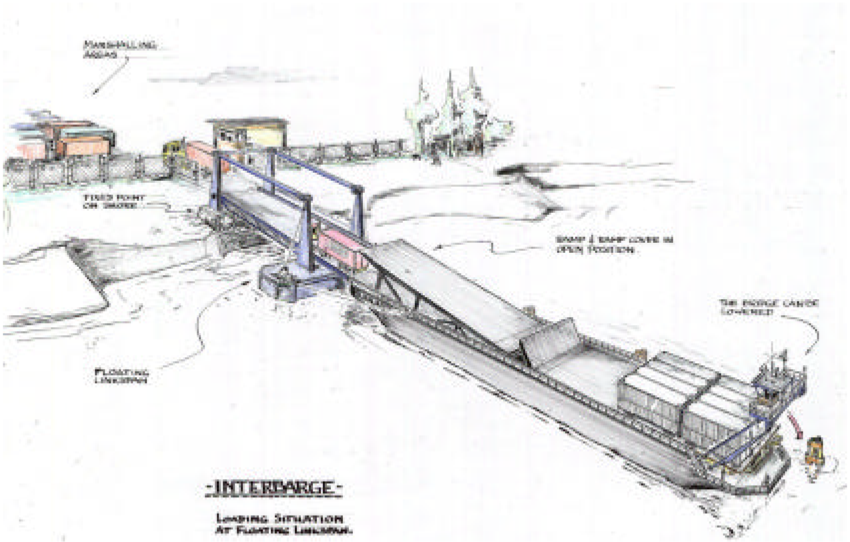

Figure 4-8 Ro-Ro ramp for inland waterways

The main challenge for efficient Ro-Ro operation on the Rhine is to cope with the different water levels in a way that is cost-effective and practical. In certain areas a long ramp may be the solution, and in others, use of the riverbank might be possible. These alternatives need to be investigated further, based on the specific volumes to be handled. The Interbarge has varying air draught so it can be used on all main waterways.

5. LOGISTIC SOLUTIONS

Figure 5-1 illustrates a paper distribution chain from plant to customer [6]. The distribution chain is a multi-modal chain consisting of road, sea, and road or rail transport modes. The chain consists of road transport from paper mill to terminal warehouse where the paper rolls are being unloaded from trucks, and stacked into the warehouse. The paper rolls are then being put onto cassettes, lashed, and then rolled into a Vessel-vessel with a terminal tractor. The vessel then transports the cassettes, holding the paper rolls, to a European terminal. At the European terminal the paper rolls are unloaded from the cassettes and stacked into the warehouse or loaded directly from the cassette onto the final distribution mode. Final distribution to the customer is road or rail transport dependent on the customer locations and/or preferences.

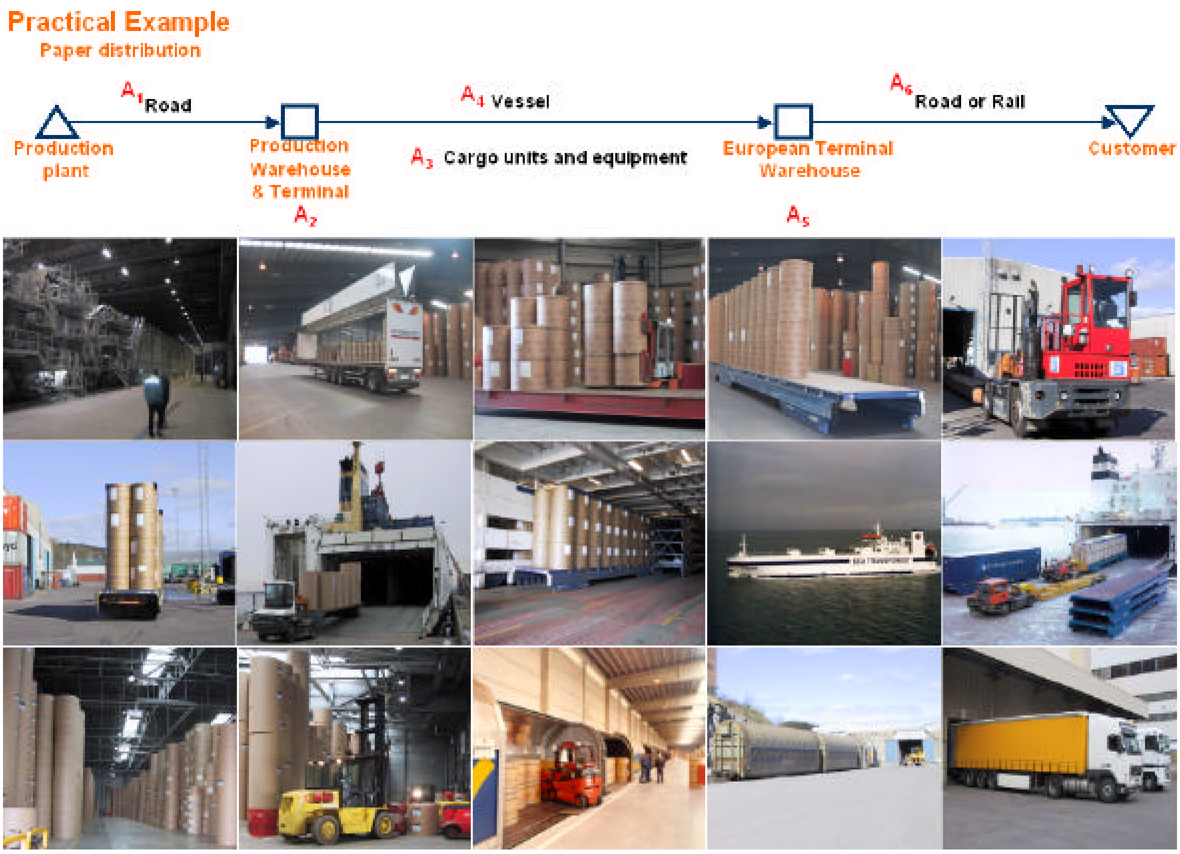

Figure 5-1 A practical example illustrated with pictures from the distribution chain

The problem at hand is then whether this form for technology and organization of the multi-modal logistics chains is the best or most competitive alternative, both for the given market situation, but also seen in relation to expected development in the future European market for transport and logistics services.

To show some alternative multi-modal distribution chains available to a paper producer, we have in Figure 5-2 and Figure 5-3 illustrated different logistics set-ups for distribution of paper from the Nordic countries to the European market. The two first alternatives, A and B, illustrate a multi-modal distribution chain with three transport legs, with two warehouses. The transport modes are road or rail, sea, and road or rail. The differences between the two are the use of road or rail modes in the first and third transport leg. The third alternative, C, illustrates a multi-modal chain distribution with four transport legs, three transhipment terminals with dependent warehouses where products will be stored according to market and production fluctuations.

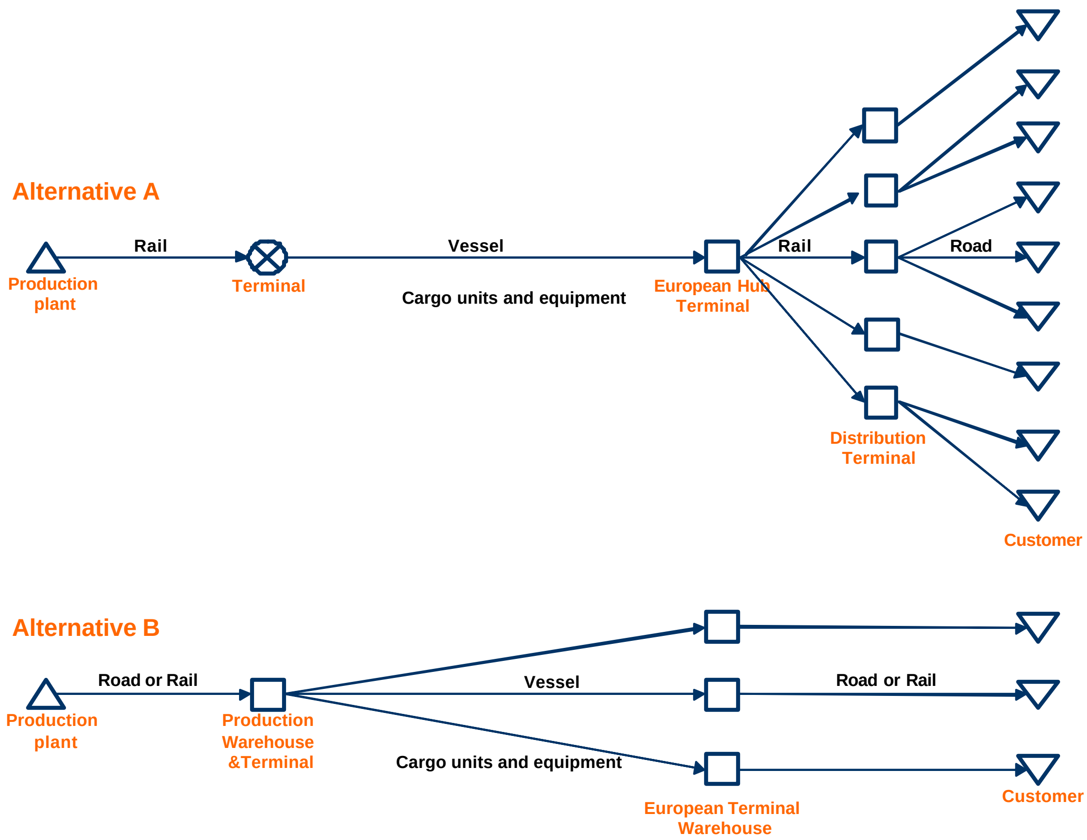

Figure 5-2 Logistic set-up by paper producing companies

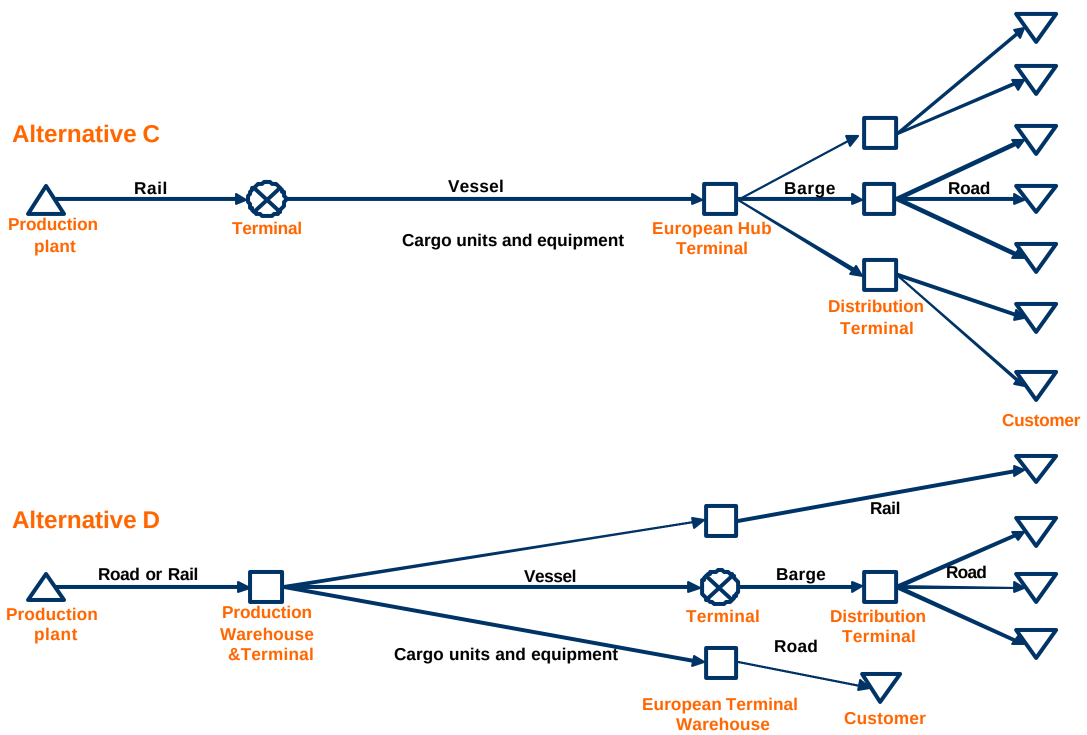

Figure 5-3 Logistic set-up by paper producing companies

6. ANALYSIS

In our work, Operational Research methods, which focus on studying practical problems by quantitative mathematical models, are essential. Despite that both land and air transports have found enormous value of Operational Research, the intermodal and maritime industry has lagged behind. Some reasons for this may be low visibility of intermodal and maritime transport due to the fact that in the USA, which is the major source of research in quantitative methods, ships and intermodal transportation are minor modes compared with truck or rail [7] [8]. The paper "Optimal policies for maintaining a supply service in the Norwegian Sea" [9] describes stepwise how this methodology is used to optimize a maritime supply chain by combining operation research with practical cost models.

When analyzing different alternative logistic solutions for paper transport and compare them with the present state solution, we find that an ENISYS-IPSI-Interbarge solution will improve the cost position as shown in Figure 6-1.

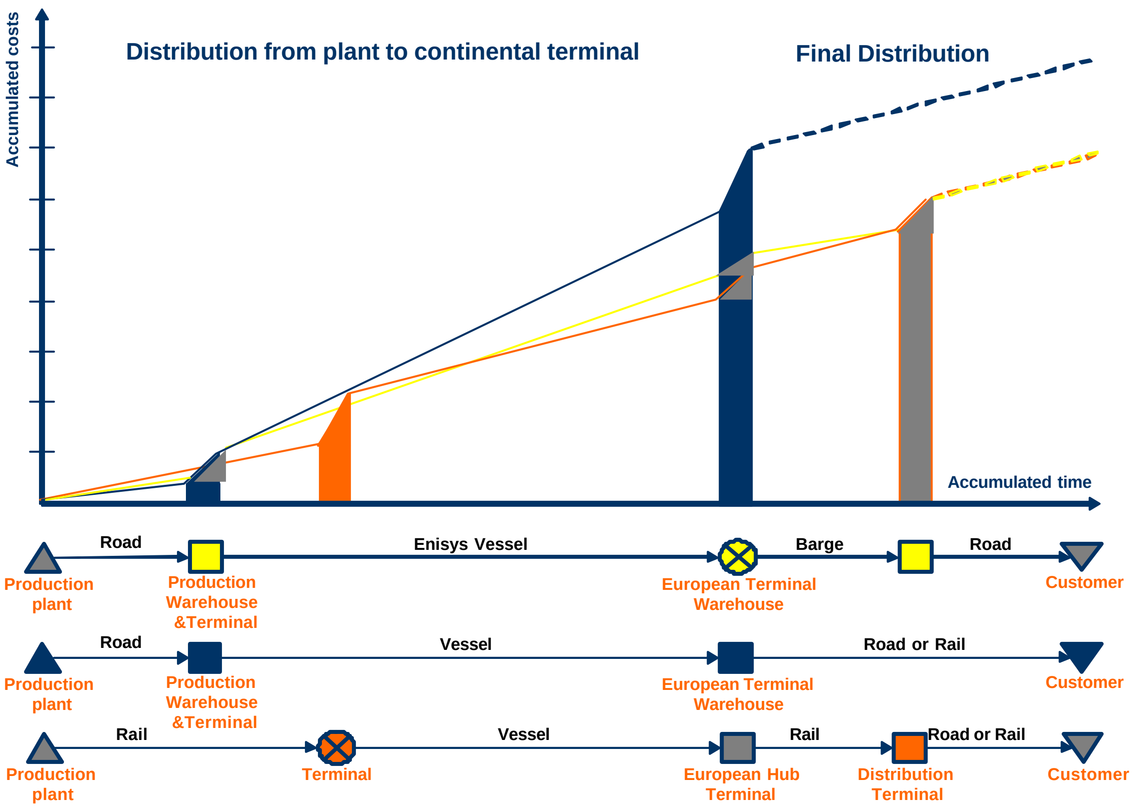

Figure 6-1 Cost analysis of different logistics solutions

The cost and time/service models have been developed on the basis of estimates from several different projects. This experience makes it possible for us to compare different logistics chains. In Figure 6-2 we see other cost position examples based on alternative logistics chain concepts, from the Norwegian southeast or the Swedish west-coast regions to European continental locations.

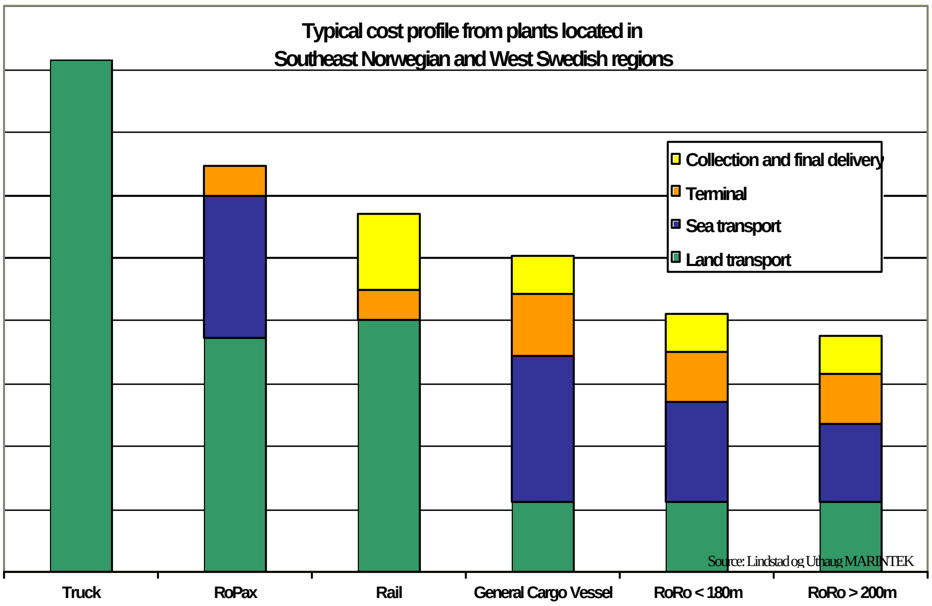

Figure 6-2 Cost positions from paper plants located in southern Scandinavia to market [10]

7. REFERENCES

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