Information for transparency in transport chains

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ABSTRACT

Intermodal transports chains are complex both through its numbers of players and its number of different processes. The relationships between the players are usually settled through contractual agreements. Although the players have a common goal of providing an efficient transport chain they are also to some extent competitors, both within the chain and in other business relationships.

The transport market is, like most other markets, affected by the overall informatization of society which is characterized by the fact that production tends to be information intensive. Electronic business and the focus on and development of supply chains increase pressure on effectiveness and access to information on the transportation part. At the same time the technology development and the emergence of simplified and low cost communication solutions enable improvement of processes and reduction of transaction costs with information at the core. It provides an opportunity for intermodal transports as it enables real time information to be shared between the actors and thereby improve the quality. However, implementation of ICT systems opens up new possibilities and new threats, which will have implications and consequences on the business, beyond the technical aspects and effect the power balance at all levels.

This thesis sets out to contribute to the understanding of the importance of information in transport chains for achieving transparency as well as its wider implications on the players in the transport chains. In this context transparency is defined as knowledge made accessible to all relevant players involved in the transport chain and it implies:

- controllability of the common task
- focusing actions on a common goal
- defining the players tasks (e.g. required input and output) in the framework of a common goal

all enabling a high quality transport chain.

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The main part of the empirical material used in the thesis originates from projects supported by the European Commission, the Swedish Research Agency Vinnova and the Swedish National Rail Administration. The results quoted have been developed in co-operation with project partners across Europe.

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Terminology and abbreviations related to the transport domain

Consignor[1]	The ultimate sender of a shipment
Consignee	The ultimate receiver of the shipper consignment
EDI	Electronic data interchange
ICT	Information and Communication Technology
Forwarder	A company that is specialised in carrying out the forwarding function on behalf of a shipper. The company can either only carry out that forwarding function or can additionally offer further logistical services and/or owns rolling road stock.
FTMS	Freight Transport Monitoring System
Logistics	"Logistics is the part of the supply chain process that plans, implements, and controls the efficient, effective flow and storage of goods, services, and related information from the point-of-origin to the point-of-consumption in order to meet customers' requirements (Stock and Lambert, 2001)"[2]
Supply Chain	The network of retailers, distributors, transporters, storage facilities and suppliers that participate in the sale, delivery and production of a particular product.
SCEM	Supply chain event management
TCMS	Transport Chain Management System
Tracking and tracing	Tracking stands for "the ability to determine the position of a goods item during the transport" and Tracing for "the ability to determine the history of a goods item during the transport process"

[1] The definition of the actors is from the LogIQ project (Fiedler 1998), adapted and supplemented from „Glossary of Elements of the Transport Chain", SGKV 1998, Frankfurt.

[2] Definition used by Arlbjörn and Hallodson (2001)

1 INTRODUCTION

1.1 Background

In 2001, the European Commission submitted a white paper on the future transport policy "European Transport Policy for 2010: Time to Decide" (European Commission 2001). One important goal of the European transport policy is to contain and preferably increase the availability of the transport networks and at the same time reduce the risks and disadvantages of transportation. The policy includes a shift of transport mode which aims to shift parts of the estimated growth of road freight to alternative modes of transport. The objective is to limit the growth of road freight transport to 38% (down from a possible 50% according to estimations made in 2001, based on 1998 figures).

One way to reach the policy goals is to optimise the use of transport resources available, utilising all forms of transport: road, rail, inland waterways and short sea shipping through increased usage of intermodal[3] transports. This requires a market acceptance of intermodal transport solutions, which requires that intermodal transport solutions must be able to compete with truck transportation, which is characterised by high flexibility and frequencies. Today transports buyers to a large extend prefer truck transport and if intermodal transport is to become a serious alternative to truck transport, it has to be as efficient and as easy to use.

Transport and logistics systems are illustrative examples of complex systems (Bohlin and Hultén, 2002). Intermodal transports chains are complex both through its numbers of players, i.e. the consignor, consignee, agents and forwarders, transport and terminal operators, infrastructure operators and its number of different processes. The relationships between the players are usually settled through contractual agreements. Although the players have a common goal of providing an efficient transport chain they are also to some extent competitors, both within the chain and in other business relationships. It is no surprise that the application of game theory to describe these complex systems (mainly on operational research level) has gained significant attention. Chacon and Netessine (2003) provide an overview of game theories and stress that the increased usage of information technology will open up the

[3] ECMT – the European Conference of Ministers of Transport define intermodal transports as: movement of goods in one and the same loading unit or vehicle that use successively several modes of transport without handling of the goods themselves in changing modes.

door for extended usage of game theory enabling the understanding of the interaction between the independent agents within and across firms.

Information is a key issue in an intermodal transport chain before, during and after the actual transportation. Within the transport chains, rules not only set by contracts but also by tradition exist, on who communicates with whom and who “owns” the contact to the customer. Information and communication technology (ICT) are important means to retrieving, transmitting and storing information. In the transport sector advanced planning and information systems are used to handle consignment and equipment in an efficient way. Examples are information systems for:

- Asset management (rolling stock, handling equipment, vessels, trucks, et cetera)
- Terminal handling (for terminal service bookings and management of the terminal resources)
- Transport management (for planning, booking and follow up)
- Consignment management (tracking and tracing, exception handling)

The information systems are tailored to fulfil the special needs of each player but from a transport chain view the information is needed along the transport chain.

The transport market is, like most other markets, affected by the overall informatization of society which is characterized by the fact that production tends to be information intensive, see for example Hardt and Negri (2000). Electronic business and the focus on and development of supply chains increase pressure on effectiveness and access to information on the transportation part of the transport chain. At the same time the technology development and the emergence of simplified and low cost communication solutions enable improvement of processes and reduction of transaction costs with information at the core. It provides an opportunity for intermodal transports as it enables real time information to be shared between the actors and thereby improve the quality. However, implementation of ICT systems opens up new possibilities and new threats, which will have implications and consequences on the business, beyond the technical aspects and effect the power balance at all levels.

1.2 Purpose of this thesis

The purpose of this thesis is to contribute to the understanding of the importance of information in transport chains for achieving transparency as well as discuss its wider implications on the players in the transport chains. The Oxford English dictionary define "transparency" as: *The quality or condition of being transparent; perviousness to light* and "transparent" is defined as: *Having the property of transmitting light, so as to render bodies lying beyond completely visible; that can be seen through; diaphanous.* In this context transparency is defined as knowledge made accessible to all relevant players involved in the transport chain and it implies:

- controllability of the common task
- focusing actions on a common goal
- defining the players' tasks (e.g. required input and output) in the framework of a common goal

all enabling a high quality transport chain.

1.3 Research questions

The research questions to which an increased understanding is sought are:

- What role does information play for creating transparency in intermodal transport chains?
    - Why is transparency important?
    - How does information contribute to transparency and how can it be made available?
- What are the wider implications of increased transparency on the players in the transport chain?
    - Who wins and who loses from a connection to ICT systems and integration into information networks?
    - How can socially robust solutions be achieved?

1.4 Research environment and methods used

The work presented in this thesis is based on integrated research and consultancy activities[4] carried out between 1998 and 2003. The work has included areas such as re-organisation of transport processes and development of information strategies as well as applying information technology and information systems, e.g. smart cards, electronic identification systems and transport management systems. Experiences from the dotcom period were added during 2000 through work with an Internet start-up, Delego.com[5]. The business idea of Delego.com was to utilise empty capacity in road transport through intelligent matching of supply and demand. The core idea was to increase the transparency between supply and demand and to reduce inefficiencies of the order fulfilment process. The tool used was a platform with route planning, matching engine, pricing module and document handling. By using the platform and the Internet an information network was created.

The above mentioned research, industry and consultancy activities have one thing in common; they are all related to *information in the transportation domain*.

The projects Infolog, D2D and Baninfo are the main contributors to the research. Baninfo was a national Swedish research project and Infolog and D2D was/is part of the 4th and 5th Framework research programmes of the European Commission. The research policy of the Commission has a strong focus on bringing together user and user needs with a diverse group of problem solvers and it is explicitly problem driven. In the case of Infolog and D2D the top level objective set by the Commission was/is to enhance intermodal transports.

The consortiums around Infolog and D2D were made up by a mixture of industrial partners as well as researchers from different institutes and universities. The partners of the consortiums came from different parts of Europe, had different styles of working and internal agendas and all were working part time in the projects. The management of such projects is challenging however both projects provided a heterogenic environment with close interaction between researcher and the industry partners. The industry partners not only brought problems to be solved but also provided deep knowledge on the business environment in which the research was applied.

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[4] At TFK Institute for Transport Research – a Swedish research institution owned by the Swedish transport industry, see www.tfk.se. In October 2002 the Hamburg division of TFK was sold to BMT British Maritime Technology, see www.bmt-ts.com.

[5] www.delego.com

In May 2003 I enrolled as a PhD student at the division of Technoscience Studies at Blekinge Institute of Technology. With an epistemological point of departure based on Technoscience Studies (see chapter 2.1 for further description of technoscience) I gained an additional set of understanding tools to apply to the experiences from the projects mentioned. Figure 1 illustrates a selection of work carried out between 1998 and 2004. Besides the projects which form the main empirical material for my thesis some other projects have contributed to the overall understanding. They are indicated as secondary projects in the figure.

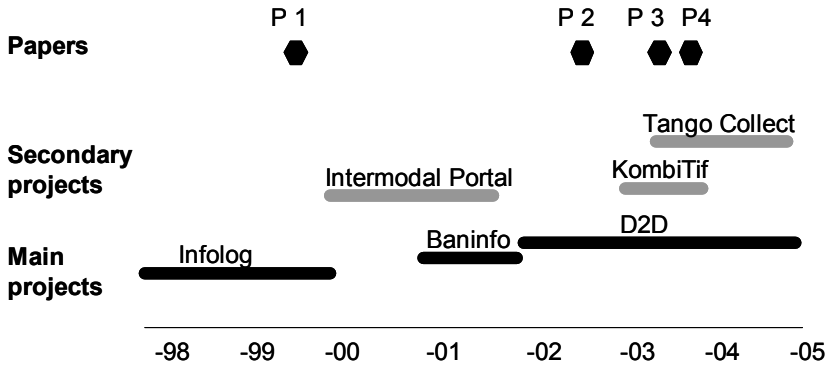

Figure 1: Selection of projects carried out between 1998 and 2004 and overview of the papers included in the thesis.

One leading thinker within technoscience, Donna J. Haraway (1997), discusses the concept of the modest witness. The concept of the modest witness is derived from Robert Boyle and his demonstrations of the air pump with which he produced vacuum. Boyle was one of the first scientists that conducted demonstrations for producing knowledge. His demonstrations were on one level independent of politics and religion – it was a separation of the technical and the political. Special conditions had to be fulfilled to achieve credibility, e.g. the demonstrations had to be witnessed and a written report produced. The report must only include the facts and not the opinion of the witness. The witness must mirror the reality and be self–invisible, be a modest witness. Haraway argues that such an objective observer is not possible; instead the researcher should act as *mutated* modest witnesses and acknowledge his/her involvement in the knowledge producing process.

My work in the research projects can be compared with the one of the mutated modest witness. In the projects, I as a researcher filled a central role as: assistant project manager and responsible for the evaluation (Infolog), responsible for the user requirements (D2D) and project manager (Baninfo).

The projects stretched out over a long period of time Infolog 24 months, Baninfo 12 months and D2D started in 2002 and will be finalised in 2005, all enabling longitudinal studies. The consulting environment strengthens the methodology chosen and the research has been oriented towards solving the problems brought in by the industry partners participating in the projects. This type of research is as well in line with methodological approach of action research where improvement and involvement are central to the research, Robson (1993).

1.5 Related research

Much research has been undertaken in the area of supply chain management and logistics during the last several decades. According to Gubi et.al (2003) the research in *logistics and Supply Chain Management* in the Nordic countries, experienced a significant boom during the 1990s. They have identified 30 research environments and 75 thesis published between 1990 and 2001.

Arlbjörn and Hallodson (2001) stresses that researchers in *logistics* have different academic backgrounds such as business management, engineering, organisation and transport and therefore might look at logistics from different angels leading to different epistemological perceptions of the context relating to research problem. They argue that the boundaries of the logistics discipline are hard to asses and may be fragmented in nature. They suggest that the content of logistics knowledge should be divided into a hard core which consists of a common study of object and a protection belt that reflects the heterogeneity of concepts used to explain and understand the hard core. The unit of analysis in the hard core is essentially the flow (of material, information and services) whereas, e.g. modern information technology to solve logistics problems is a part of the protection belt.

Bontekoning et al (2002) reviewed[6] research carried out within the field of *Intermodal freight transports*. They conclude that there is much isolated research and small research communities focusing on specific aspects of intermodal transport. Today no authoritative publications exist and there is not even a commonly accepted definition of intermodal freight transport[7]. They have distinguished eight research categories where one is: *multi-actor chain*

[6] They reviewed 92 publications (scientific journals, dissertations, books and proceedings)

[7] 18 publications included a definition but only three used the definition by ECMT (which I use in chapter 1.1)

management and control. For this area a number of questions are highlighted, e.g.: What is best for the chain is not necessary best for the individual actors. How can cost and benefits of changes be redistributed when this does not take place automatically via market mechanisms? What are the consequences for individual organisations when they have to give up some autonomy for the sake of chain objectives? (Bonteking et al, 2002)

Russel and Hoag (2003), argue that *social and organisational complexity* is an area of increasing importance in supply chain management, but one that, to date, has received minimal coverage in the top journals[8] (Russel and Hoag, 2003). They specially point out the low research attention in regard of social aspects of IT implementations from logistics and supply chain scholars.

1.6 Outline of the thesis

Chapter 1 and chapter 2 aim to describe the playing field for my thesis and consist of a mixture of traditional transport research and technoscience studies. Technoscience studies is represented through the basic structure of the thinking and it is used as an analytical tool to bring light to the complex relationships between the players.

Chapter 1 includes an introduction to the problem domain, the purpose of the thesis and the research questions as well as a positioning and description of me and my experiences.

In chapter 2 the frame of reference is described including; knowledge production as seen in the technoscience studies, the concept of transport chains, the need for transparency in transport and an insight in the changed fundamentals for information exchange.

Chapter 3 presents the empirical basis for the thesis and are narratives describing the projects Infolog, D2D and Baninfo. It is my intention and hope that a heterogeneous group of readers with different kind of experience will be able to relate to the text.

In chapter 4 the results from the three projects are discussed and combined with results from literature.

Chapter 5 provides the conclusion and in chapter 6 further research and the way forward is outlined.

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[8] The following Journals were reviewed in a time period between 1997/98 to 2001: Journal of Business Logistics, Transportation Journal, International Journal of Physical Distribution & Logistics Management and International Journal of Logistics Management.

2 FRAME OF REFERENCE

2.1 Distributed knowledge production as a methodological approach

The epistemological point of departure is based on Technoscience studies[9] with a focus on distributed knowledge production. The research is an example of a distributed production of knowledge as such and is positioned in the context of application.

Knowledge and its mode of production and dissemination are the core topics for Gibbons et al, in The New Production of Knowledge, (1994). Traditional knowledge generated in strict disciplinary context is defined as Mode 1 knowledge in contrast to Mode 2 knowledge, which is created in a broader and transdisciplinary social and economic context and implies a larger number of participants in the research. In Re-thinking Science, Nowotny et al (2001) further developed the ideas from The New Production of Knowledge and concluded that the closer interaction of science and society signals the emergence of a new kind of science: contextualized or context-sensitive science. The framework of Re-thinking science is set by four main processes:

- *Co-evaluation of science and society towards mode 2*, e.g. the nature of the Mode 2 society. Both science and society are subject to the same driving forces: generation of uncertainties, pervasiveness of a new economic rationality, transformation of time and space and a self-organising capacity. Science and society have become transgressive, e.g society can talk back to science.
- *Contextualisation of knowledge– society speaks back and meetings take place in the agora*. The contextualisation is divided into weak and strong contextualisation. In weak contextualisation, the message from context to science is very general and there is a limited dialogue between user and producer and it is characterised by bureaucratic procedures. In strong contextualisation the researchers both can and want to respond to society.
- *Social robust knowledge*. Socially robust knowledge can only be produced in a mixed environment and will be superior to purely academic knowledge produced in a mode 1 environment due to more intensive testing in more contexts. The site of problem formulation

[9] an introduction to Technoscience studies can found at: http://www.bth.se/tks/teknovet.nsf/

moves into the agora (science meets society, contextualisation occur). Socially robust knowledge is defined as the product of intensive interaction between results and their interpretation, people and environments, applications and implications.

- *Narratives of the experts*, e.g. emergence of socially distributed expertise. The authority of expertise rests on its ability to handle many heterogeneous and context-specific knowledge dimensions involved. Narratives become one of the central ways in which the voices of experts are orchestrated to help produce more wide-ranging epistemic, social, political or legal authority, which then is re-introduced to and fed back into the specific context in which expertise is required.

The process described above corresponds well to the working methods in our projects. The research questions are generated by the problem owners and answers to the policy of society and the work is carried out in heterogeneous environments. The process of achieving social robust knowledge is of high importance for transport chains, which are characterised by uncertainties due to changes in business and technology development, competition between players largely focused on prices, different types of organisations, the player's local knowledge, and rough financial driving forces. One special case is the implementation of ICT systems to support the quality of transport chains. They stir up things; change the power relations and reveal facts not seen earlier.

When defining the research questions, transparency was defined as knowledge made accessible to the relevant parties involved in the transport chain. When this is combined with the epistemological infrastructure of technoscience questions such as; *what is considered knowledge within the transport chain, what is the knowledge needed for, how can the knowledge be gained, who can have it and at what price* arises.

2.2 Transport Chains

Globalisation, lead-time reduction, customer orientation and outsourcing are examples of changes in business that influences the management of logistics. Supply chain management, supply chain integration and collaboration are topics that have been discussed much during the last several years as ways to gain competitive advantages. The competition between and among supply chains has superseded competition among firms (Angels, 2003). Skjott-Larsen et al (2003) discus the changing character of supply chain relations characterised by "partnerships" or "strategic alliances" as opposed to the

traditional "arm's length" type of relations. They conclude that the new relations share the following characteristics: (1) an increased quality emphasis, (2) the co-operation on cost reduction programs and continuous improvements, (3) the exchange of information and open communication, and (4) a long term approach including the sharing of risks and rewards. Supply chain management refers to the management of different processes, such as customer relationship management, customer service, demand management, order management, production and material flows and purchasing (Lambert et al., 1998). This thesis is limited to covering the management (with focus on transparency) of transport chains, which in this context is defined as a sub-process of supply chain management or as Skjott-Larsen et al (ibid) states: *A strategic partnership between two companies, whether it is a buyer-supplier or a third-party logistics arrangement, can be considered as a segment of an extended supply chain.*

Transport chain management organizes the movement and handling of goods between two specific points through the deployment of a possibly intermodal transport chain and involving added-value services. It can be described by five high level processes, see, Figure 2.

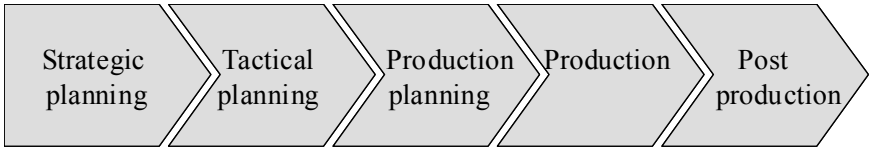

Figure 2: Generic processes of transport management

During the planning processes, transport services are combined to an acceptable solution given requirements for timing, speed, reliability and price. During production, the transport is managed and monitored and in the post production the performance is evaluated against the original planning.

Transport chain management is complex through the interaction between different actors, i.e. transport and terminal operators and infrastructure management. The transport chain is a set of inter-organisational relationships and one of the main challenges of the transport chain manager is to be able to co-ordinate those relationships.

The model of Källström (2002), see Figure 3, illustrates the relationships between a transport chain, the transport actors and the interaction with the management of infrastructure. The lower part of the model illustrates the traffic system which consist of the physical infrastructure and its management.

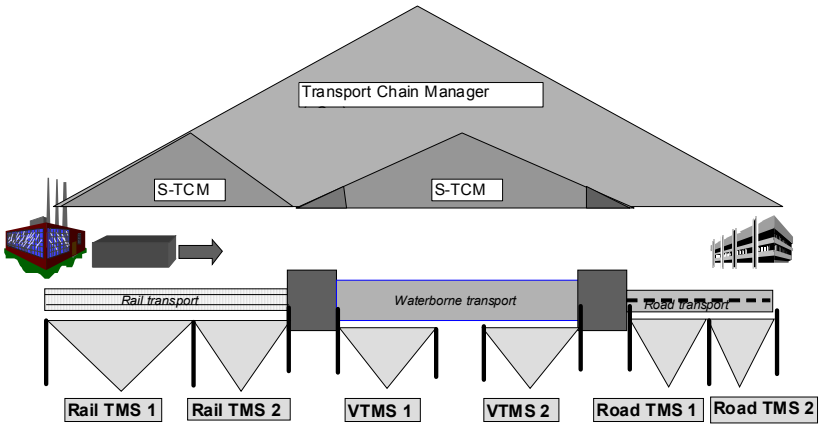

Figure 3: Interaction between transport and traffic management with focus on the transport chain (Källström, 2002)

The upper part of the model illustrates the transport operators and the sharing of responsibilities. The generic transport chain is made up by a rail, sea and truck leg. Terminal handling, i.e. movement of goods and load units as well as added value services, combines the modes. A transport chain manager – normally the shipper or a player with the mission of transporting the shipper's goods from door to door - has the overall responsibility of the chain, but has delegated the logistic between supplier and terminal and between terminal and terminal to other organisations. Those organisations, e.g. forwarders or operators either carry out the operation with their own assets or co-operate with different operators.

The model reduces the real world complexity by taking a horizontal view following the transport chain and not the complex pattern of resource management of, e.g. load units, transport means, handling equipment or infrastructure slots. The resource management is hidden behind the different actors and could be described as a vertical optimization. The resource management is an important topic and it will decide if a business will generate win or loss. However, we argue that it is of secondary importance from a transport chain context. The decisions regarding the planning of the resources are taken by the players at the lower levels of the transport system.

The advantage of the model is that it can be used to understand how the responsibilities are distributed and it enables a discussion on co-operation between the players including the exchange of information. Each player remains responsible for their own operation and their own management of resources but it is important to define which transport or handling service as well as which information has to be exchanged, when and in which format.

The model also highlights the infrastructure manager as a player in the transport chain, responsible for providing information for planning, status and disturbances and contributing to the reduction of the consequences of disturbances. The vital role of the infrastructure manager in a rail context for providing good slots and high priority to handle disturbances in the network has been stressed by Ohnell and Woxenius (2003).

A player in the transport chain has two tasks to fulfil, providing the required physical service and to providing information related to the service. That makes the players not only to users of information but also to important producers of information which is of key importance for the required transparency of the transport chain.

2.3 The need of transparency

In this context transparency is defined as an extension of visibility and it includes a clear understanding of each actor's role and responsibilities in the transport chain. The relationships between the actors are defined through contracts, which prescribe which service will be conducted at which quality level and price.

Bohlin and Hultén (2002) modified a model after the NEVEM-workgroup (1989) in which the hierarchies between actors in a business are described, i.e. how the responsibility can be delegated, see Figure 4. In the model a system is divided in three processes: planning, execution and control. The planning process defines what should be carried out in the lower execution process and sets the task description. What is actually carried out in the production is reported as feedback to the evaluation process. Inside every system the planning process make norms for the execution of the task. The norms are used by the control process for comparison with feedback from the execution. A contract between the actors should not only describe the production but also define the task and feedback information. Bohlin and Hultén argue that information about norms and utility functions must be exchanges as well as the tasks and feedbacks but that today it is difficult to standardise this type of information and put it in a database format.

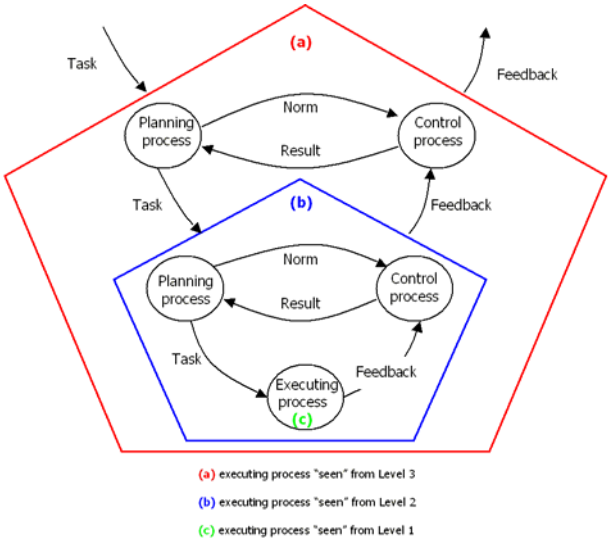

Figure 4: Hierarchies between actors in a business, NEVEM- group modified by Bohlin and Hultén (Bohlin and Hultén 2002)

Checkland and Holwell (1998) discuss the lack of a common understanding of the notion of data and information and define a process in which data is turned into knowledge via capta and information.

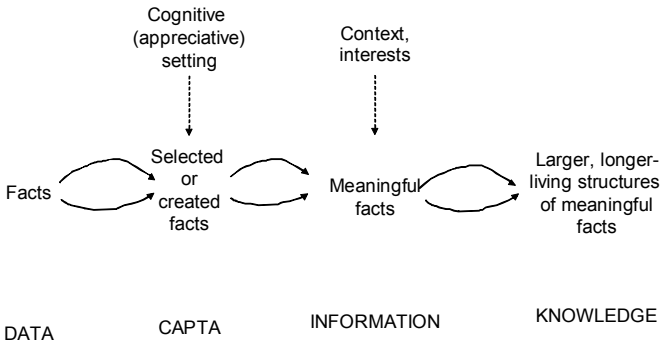

Figure 5: Checkland and Holwells view of the links between data, capta, information and knowledge (Checkland and Holwell 1998).

Data is defined as a product of the myriade of facts about the world. Data that is decided to be relevant is defined as capta (from the Latin *capere* which means to take). When putting capta into context it becomes information. This

process can lead to larger structures of information which is defined as knowledge.

When applying Checland and Howells view of data, capta, information and knowledge to the concept of transport chains, a model as in Figure 6 can be defined.

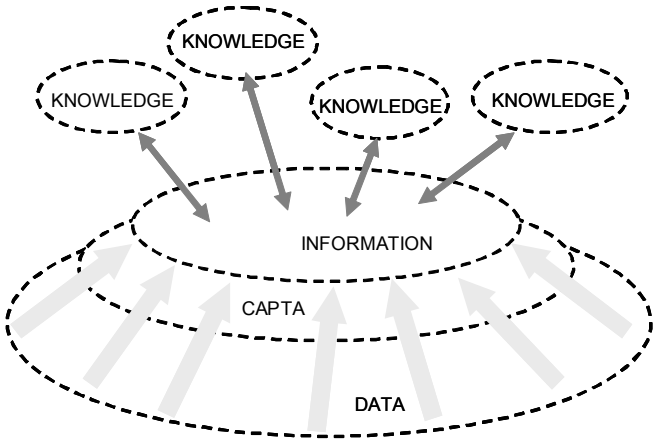

Figure 6: Data, capta, information and knowledge applied on a transport chain

The basis of the model consists of the huge amount of data connected to a transport chain (e.g. data related to infrastructure, customers, assets, weather, environment, et cetera). For the management of the transport chain a selection of the data is required – the capta, if using the notation of Checkland and Howells. From an information system point of view this is data that needs to be accessible in one way or another. The information system constructed in D2D, see paper 2, includes the following types of capta and information:

- Contractual information
- "Classical Tracking and Tracing data"; position and identity of transport means or goods
- Transport chain information, e.g. loading and unloading reports, proof of delivery

This capta and information form the basis for a wide range of usage or knowledge applications which correlate with our definition of transparency – knowledge made accessible to the relevant parties in the transport chain.

2.4 Improved means of communication

The discussion in the previous chapter shows that to reach transparency in the transport chain, information must be collected, evaluated and reported over multi actors' business processes. There are technical, legal and organisational aspects on how the information can be made available. This chapter provides a discussion on how the technical solutions have matured during the last years.

Electronic exchange of information for business has been a key issue for a long time. A standardised method is EDI, which is defined as: "electronic transfer from computer to computer of commercial or administrative transactions using an agreed standard to structure the transaction or message data" (UN/EDIFACT, 1990). The first widespread type of EDI was ANSI X12, later EDIFACT emerged as well as numerous business specific message sets, i.e. ODETTE for the car industry.

In the childhood of EDI it was more or less treated as a magic tool that could only be understood and used by a group of initiated. In 1996 when I started to work with freight transports, the first thing I learned about EDIFACT messages was that they worked fabulously – once they were implemented. The implementation on the other hand was a time consuming and nerve racking experience. I heard people who were users of EDIFACT say: "It takes at least three months to implement a message". EDIFACT is very complicated and although the messages are defined there is still much to agree upon. The philosophy behind EDIFACT is striving for universality, e.g. a message for ordering should be able to cover all possible information. My colleague Jürgen Wehnert - one of the EDIFACT voodoo masters - explained the richness of the messages with the following example: imagine having a tool rich enough to order a nuclear plant and you want to use it to order 12 toothbrushes, it will require a high level of simplifications which you have to agree on with your business partners.

The emergence of Internet provides technically less complicated methods and low cost solutions for exchanging information electronically. The development of XML-based standards covering logistical and commercial activities has played an important role in facilitating the information exchange between the players in the transport chain. However, it still requires the same work regarding agreements on the messages and to aligning the internal business processes. Nevertheless the mindsets seem to have changed – a bit of the magic has disappeared and one does not have to enter the business with the same great respect as before.

This change of mindset including a lack of respect as well as a healthy pragmatism could offer an explanation of the different results achieved between the following two implementations of an EDIFACT message. The first example is from the project Balticom[10], a research project within the 4th Framework research programme of the European Commission. One goal in the project was to implement an EDIFACT message - the manifest of a vessel (COPRAR) - between a shipping line and the Port of Stockholm. At this point both the port and the shipping line were using highly developed internal IT systems. During some months in 1999-2000 implementation work was carried out but no success was reached. The second example is 3 years later, in 2002 the Port of Trelleborg implemented the same message with the same shipping line and the implementation took three days. The Port of Trelleborg neither has the same maturity of IT- systems nor the same amount of IT staff as the Port of Stockholm.

The evolution of ICT technology has fostered the development of powerful tools that are expected to improve supply chain performances dramatically, through higher levels of process efficiency and integration (Cagliano et al 2003). During the last year an 'e' was often added to the name of information and communications concepts, e.g. e-logistics which implies a web front end as an interface for the players in the supply chain.

However, there are no signs that non-Internet-based EDI will cease to exist. Angeles (2003) argues that it will still be around, although in the future new Internet-based technologies can facilitate the transformation of EDI into a much more accessible and cost effective medium. The AMR research inc is cited in an interview[11] as saying that even with all the Internet-based collaborative commerce initiatives, non-Internet-based EDI remains the primary technology used for electronic transactions and with many still relying on phone, fax and spreadsheets.

[10] www.balticom.org
[11] What lies ahead?, Brian Albright, article in www.frontlinetoday.com, January 2003

3 MY EMPERICAL MATERIAL

This chapter provides an overview of the results from the three projects: Infolog, D2D and Baninfo. From a chronological point of view Baninfo follows Infolog but on a content point of view D2D is the subsequent follower of Infolog. The following relationship exists to the papers of the thesis:

Paper 1, "INFOLOG - Managing Intermodal Transport Chains" is based on the results of Infolog. The paper was produced in the last quarter of the project time and reflects the end results of the project.

Paper 2, "Perceived benefits of improved information exchange – a case study on rail and multimodal transport" is based on the project Baninfo. The paper was finalised after the project and reflects the final results.

Paper 3, "Improving the quality of intermodal transports – user requirements on transport chain management systems" and paper 4, "Decision support for handling uncertainty in intermodal transport chains" are both based on the D2D project. The project is still on-going and will be finalised by March 2005. Paper 3 was written after the completion of the user requirements of the demonstrators in D2D and reflects them. Paper 4 was written in the middle of the project phase and focuses on the identified need of simulation as a tool for strategic planning.

Paper 3 and 4 were written in co-operation with Johanna Törnquist, who focuses her research on Computer-based decision support for handling uncertainty in railway traffic and transportation, (Törnquist, 2004).

3.1 The Infolog project

Infolog was a demonstration project within the 4th Framework research programme of the European Commission with the objective to show how information and communication technology can be used to make transports more effective. In Infolog the basis for the case studies were Stora[12] and Avesta Sheffield[13], two major shippers both in the process of changing their distribution concepts. SJ Gods[14], the Swedish national goods railway operator and Port of Gothenburg were the two most important operators in the project.

[12] Today trading as StoraEnso after a merger between Stora and the Finnish company Enso.
[13] Today trading as Outokumpu
[14] Today trading as GreenCargo

At the kick off meeting in the beginning of 1998 it was decided that Infolog should deliver (in order of priority):

1. a common data model for intermodal transport chains
2. a generic systems architecture on which the cases (intermodal transport chains with the industrial partners as leading actors) can be mapped
3. a common library of EDIFACT - messages for each function in the transport chain
4. „add-ons“ which facilitate the exchange of information related to data base concepts.

Although the three first priorities were fulfilled in the project, the main focus turned to the fourth priority. This development can be seen in Paper 1, written in 1999, which describes the concept of a transport chain management system. Three main driving forces can be identified for the change of project focus: the interest of the participating industry partners, the emergence of the Internet and the findings made in the first period of the project, which indicated that many problems in an intermodal transport chain relate to the absence of an overall coordinator.

The interest of the participating industry partners. Three of the main industry partners in the project were in the process of re-defining their information systems. SJ Gods, the rail transport operator, wanted to improve the interfaces for information exchange between the information systems covering the whole process between signing the contract and invoicing. Stora wanted to combine its internal information flow with information about the goods flows and get an added value. Their idea was based on a “data warehouse”, which in principle should be able to provide all information needed for Stora to manage the transport tasks and monitor the transport. For communication with external partners, standardised EDIFACT messages should be available as well as some other means for more “soft information”. Also Avesta Sheffield as a shipper was interested in a database solution (“yellow box” was the working name of the database), which would allow the responsible department in Avesta Sheffield to co-ordinate and manage the transport on a group level and monitor the physical flow. Communication was to be done by EDIFACT messages, but Internet/Extranet type of solutions should also be used as additional support.

The emergence of the Internet. The industry partners in the project used, to a different extent, electronic information exchange for exchange of messages, either by closed flat-files or EDIFACT messages. Although EDI allowed fast

and reliable communication between systems, it had some major drawbacks. The usage of EDIFACT was expensive and time consuming to implement. Although the messages were defined there was still much to agree upon. The differences within the standards were compared to dialects within a language. EDI was therefore only used between partners with whom much information was exchanged and the relation was stable. The emergence of the Internet provided less complicated methods for exchanging information electronically, and opened up new possibilities for access to information. During the kick-off meeting the project partner Fraunhofer[15] introduced a concept they called the IMS-system (Information Management System) which included web-based communication.

The absence of an overall coordinator. The analysis of the user requirements indicated that many problems in the intermodal transport chain were related to the absence of an overall coordinator with ability to consider and act on the complete chain instead of each single leg. Traditionally an intermodal transport chain is organised and monitored by a number of actors leading to multiple information flows, see Figure 7. The concept of sending information along the transport chain is very vulnerable - if one actor fails to send the correct information in time, the performance of the complete chain can be endangered. In addition the decentralised concept does not enable up- and downstream visibility.

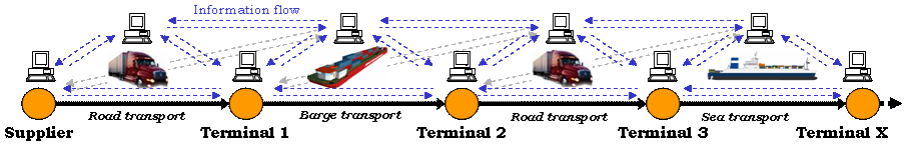

Figure 7: Traditional organisation of an intermodal transport chain

Based on the situation described above the project defined the concept of a "Transport Chain Manager". The transport chain manager implicates an entity responsible for the complete transport chain. One of the main legacies of Infolog is a model which illustrates the required information exchange in a generic transport chain, with the transport chain manager in the middle, see Figure 8. To support the transport chain manager the functionality for a database IT system was defined – the Transport Chain Management System (TCMS). The concept, functionality and expected benefits of the TCMS are described in Paper 1. The TCMS was designed to cover the whole part of the transport chain or parts thereof so that it could be hosted by various actors in

[15] A German research institute

the transport chain. The conceptual version of the TCMS included a large number of functions and was generic so that it could be used by both the different cases in Infolog and by future user beyond the project.

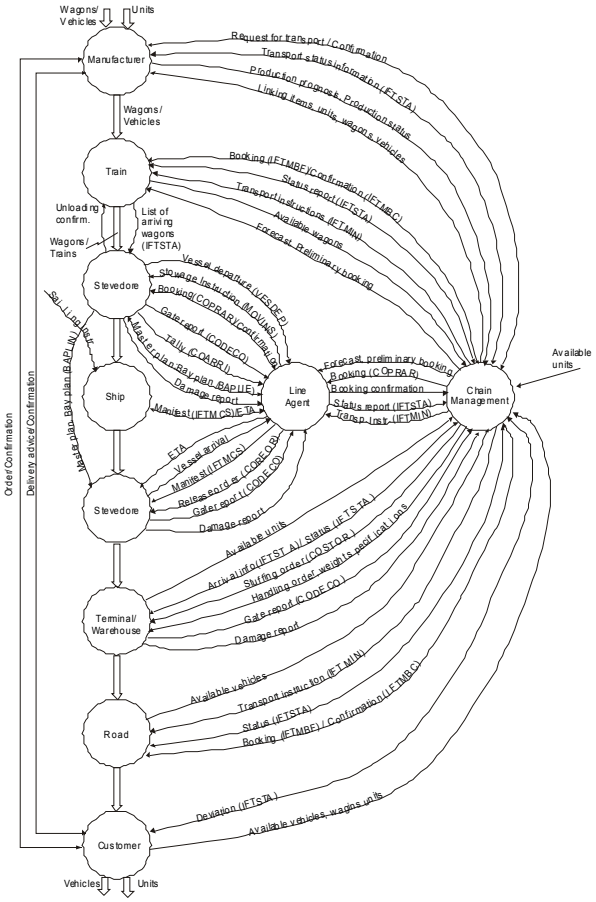

Figure 8: Information exchange in a generic intermodal transport chain, with a data base approach

A number of actors in the cases were small and EDIFACT was not an option for communication. The TCMS was therefore enabled to support web based communication. The usage of the Internet was however critically questioned by members of the consortium. Not only the security but also the performance was believed not to be high enough and therefore the Internet was not an option for business related information exchange but it could eventually be used for "soft-information". The concept of "soft information" was developed in the beginning of the project and defined as:

- Information not sensible for the business process, and
- today not exchanged with EDIFACT

Both Stora and Avesta Sheffield focused on systems transport and sought to improve customer service and efficiency with improved transport to their distribution points. One of the main benefits from the implementation of the TCMS would be a closer co-operation between business units within the company group, e.g. between different production units (the mills) in regard of the planning of the transports. Within the project it was stressed that all involved actors could see their own advantages; otherwise the mills would have little interest in using the system, especially since the implementation would require reconstruction of the internal work at the mills.

During the demonstration phase of the project it became clear that the functionality of the system did not completely satisfy the user requirements. This can be explained by a lack of involvement of the end-user in the design process.

Stora implemented their successful Baseport logistic concept in which the information system is one of the building blocks. During the Baninfo project an interview was made with one of the logistic managers at StoraEnso who stressed the importance of information for the transport management and stated "What can't be measured does not exist – the main building blocks of transport management are: measure, control and handle deviation"

One of the project members founded an IT company in Norway[16] with the business idea to commercialise the TCMS, a process that has continued in the D2D project as well as in private development and systems sold to commercial customers.

The main results from the Infolog can be summarised as:

- Improved understanding of the concept of a transport chain including a data based approach for collection of information see Figure 8, and definition of functionality required for a transport chain management system.
- High quality monitoring requires information along the complete chain, including the small players.
- Web based communication is an option and it makes it possible to include the smaller actors. At the beginning of the project (1998) the

[16] Logit Systems AS, see www.logit-systems.com

solution was viewed with scepticism by the industry partners, but as the emergence of Internet continued the scepticism faded.

- All players (also within the same organisation) must see the advantage of using an ICT system to accept them.
- The end users are to be included in the development phase of ICT systems in order to reach robust solutions.

3.2 The D2D project

The D2D project is running within the 5th research framework of the European Commission. In D2D the findings from Infolog is further being developed with a focus on demonstration. The project includes a set of users forming five intermodal transport chains (further descriptions of the chains are available in Paper 3 and Paper 4):

- John Deere farming equipment from Mannheim (Germany) to dealers in Australia.
- VW cars from Wolfsburg (Germany) to Istanbul.
- Elkem containers from Salten (Norway) to customer in Rheinfelden (Germany)
- PAMESA general cargo from Pamesa (Spain) to warehouse in Cegrisa (Las Palmas).
- UNIFAC general cargo from Lisbon and Tagus Valey (Portugal) to customers in Azores Islands.

The TCMS developed in Infolog supports the management of contracts and administrative tasks, e.g. providing automatic booking. Compared with the generic processes of transport chain manager illustrated in Figure 2, the TCMS supports the production planning and the production.

In D2D the notion for the logistics management and communication system was changed to the D2D system in which the TCMS is a major module. The other two modules are the FTMS which provide status information and the communication platform that handles the exchange of messages. Figure 9 illustrates an overview of the D2D system design with Checkland and Holwells (ibid) notions of capta et cetera applied.

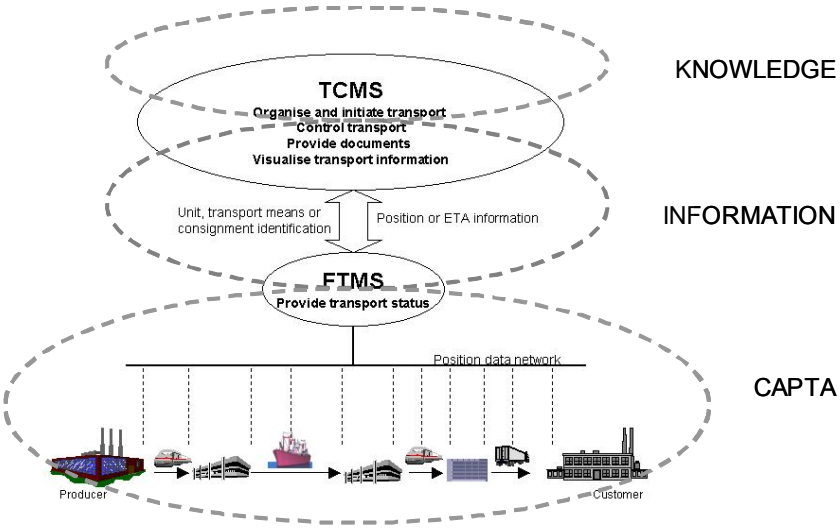

Figure 9: The D2D system with Checkland and Holwells concept of capta, information and knowledge applied.

In the D2D project a more structured and complete analysis of the user requirements was carried out, see the workflow methodology presented in Paper 3. For all chains an "as is" description was carried out. This included a mapping of all activities, information exchanges and use of IT systems. All main processes were identified and broken down into sub-processes that were broken down into work flow diagrams. As a second step the as-is situation was analysed and weaknesses derived.

The exercise showed that there were major differences in IT maturity both between the transport chains as whole and in some cases between the players within each single chain. The understanding of the role of a transport chain manager concept also varied. Below some examples illustrate the differences.

ATG is the transport chain manager of the *Volkswagen chain* and their customer segment is car manufacturers with which they have long term contracts. ATG's business contains of: fleet management, provider of rail service and transport chain management. The fleet management and the providing of rail service are the core business and also the main driver for the profitability of the company. However, ATG has clearly recognised that their customers require a service provider that is prepared to take responsibility for the door to door transport. ATG shows a high level of understanding of the transport chain manager concept and strives for a management of the processes on a chain level, not within individual organisations. ATG has

integrated IT solutions with their customers for forecasts and transport orders and well developed tracking and tracing concepts for their own fleet, which to a large extent is equipped with positioning devices. The Volkswagen chain is identified as having *high maturity of IT* and shows *high level of understanding of the transport chain management concept*.

In the *Elkem transport chain* a number of players show a high level of IT maturity, the shipper has a well developed ERP system, the terminal a system for the terminal activities and ENL, the transport chain manager, an IT system for container handling. But the transport chain manager, ENL lacks an overview of the whole transport chain and no interaction exists between the IT systems in the chain. The only system to system communication in the chain today is the EDI communication between ENL and the customs. All other communication is done by fax or mail. For example when containers arrive in Rotterdam, ENL produces a discharge list from their internal system, that is manually handed over or faxed to the terminal operator who enters it manually into his IT system. The system is updated with information about what was actually unloaded and a discharge report is produced which is sent as an e-mail attachment back to ENL who manually updates its system. The Elkem chain is identified as having *high level of IT maturity per organisation but lack interaction and a clear understanding of the concept of transport chain management*.

The *Nutasa chain* is characterised by the absence of a transport chain manager. Today, the transport chain is built up by a number of services and no actor has a complete overview. This leads to situations where for example a container can arrive at the terminal in the Azores and wait for three days before pick-up. The receiver is responsible for the last leg of transportation but is not informed in a structured way of the arrival at the terminal. The workflow analysis showed that all information in the transport chain is exchanged by fax, phone or by documents handed over from one actor to the next. The Nutasa chain is identified as having *low maturity of IT as well as a lack of understanding of the transport chain manager approach*.

For all transport chains the processes were re-engineered to include the concept of a transport chain manager and the D2D logistics management and communication system. The different starting points and maturity of the transport chains indicates high requirements on the D2D system: a generic solution is required that is able to fulfil those different requirements.

The user requirements formulated in D2D stress some topics not addressed in Infolog:

- In the production phase the handling of deviations is a challenge and a time consuming activity. Deviation handling requires good monitoring abilities – a functionality identified in Infolog but not conceptually developed.
- Support for the other processes of the transport chain management, i.e. during the strategic and tactical planning as well as the post-production.
- The role of the Transport Chain Manager was extended to ensure that existing information can be shared to benefit all actors in the transport chain – provide transparency

Paper 3 provides an overview of the extended concept of the transport chain manager, the required functionality, the importance of information and touches on the topic of additional value of a logistics and management system.

Deviation handling

The logical starting point for deviation handling is that a mature monitoring system detects and alerts deviations or exceeded pre-defined levels of tolerance. The monitoring concept suggested for the D2D system is a top down drill approach. The idea is that the transport chain manager will be able to follow all consignments, also from different customers, on a top level. If a transport chain is under alarm the next level of information is to look into the status per service provider in the transport chain. At this level it will be possible to see which services are active and inactive, how the consignment is spread over the services and which service or services are under alarm status. The next level of information is a drill down of a selected service to a transport means level, e.g. each rail wagon is illustrated for a rail service. The next level of information is a drill down of a transport means level to a cargo item level which has the same structure as the transport means level.

The functionality of the TCMS is dependent, e.g. the deviation handling and monitoring, on access to status data from all critical points along the chain. During the re-engineering phase required status points were identified for each chain. Figure 10 illustrates the identified status points from which a status report was required by the D2D system to achieve a minimum visibility standard, see also Paper 3 for further discussions.

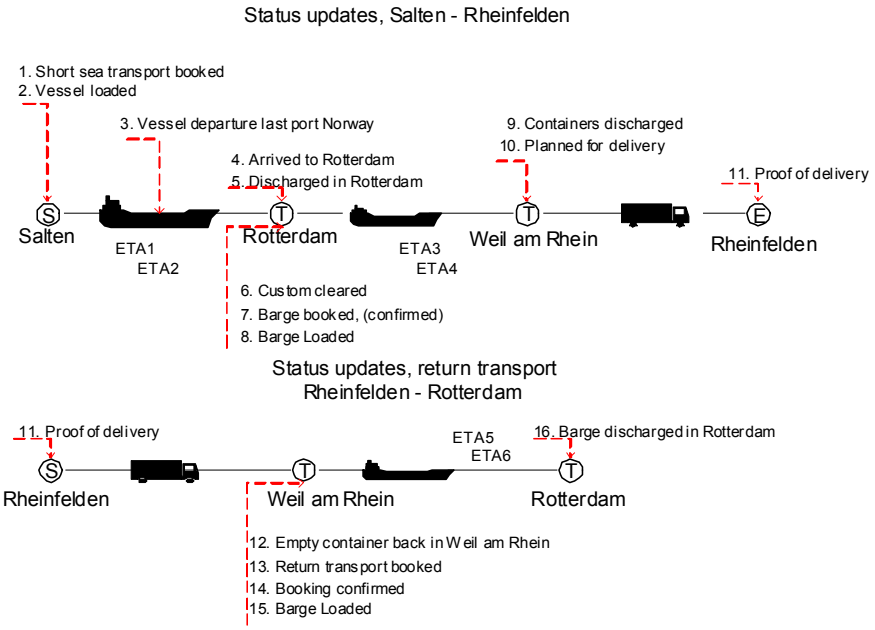

Figure 10: Identified status points in the ELKEM chain

The status data points identified gives example of different type of information that can support the transparency of the transport chain. The following types are identified:

- Transport service status report
- Transport means position, e.g. ETA and ATA
- Load unit position, e.g. loading and unloading reports

Given the low IT maturity of some actors a low cost concept with a low implementation barrier was developed. The basic idea is that for each consignment an information trail is defined in a database. This trail is manually updated in real-time at pre-defined status points during the transport for which the actors will use a mobile device. One possibility is to send a message from the TCMS, e.g. a discharge list based on container numbers to the device. The actor confirms the message or when deviation occurs creates an error message. The other possibility is that the actor uses the device to log on directly to the trail and confirms the status in a predefined way. Such a solution is expected to have a good chance of being accepted by the users in the transport chain since it will be low cost and not require any major changes of the actors' internal processes.

The D2D system as support during other processes.

The deviation handling described above is an example of extended functionality during the transport execution/production. During the work with the user requirements the discussions showed that there is a need for support during the strategic and tactical planning as well as for tracking compliance to contract in the post production phase. These tasks are not necessarily carried out by the same members of the staff responsible for the day to day management of the transport chains, on the contrary it is likely that it is done in other departments.

Once a D2D system is up and running it will include the contractual agreements and the planned performance of a transport chain. During the execution status data is collected and stored. This information provides a good start for supporting further processes then production.

One prerequisite for an economically sustainable business is the design of contracts (both with the customer and sub-contractors) that successfully balance performance and risk levels of the services provided. E.g., what service level regarding reliability can a transport manager offer without risking penalties while still offering an attractive service? Simulation can be used as a tool to support the contract management using historical data and a model of the transport chain with all relevant decision points included. The simulation approach is discussed in paper 4.

The D2D system as distributor of information to the players in the chain

The success of the D2D system depends on the access to the status information along the transport chain. The re-engineering process included discussions with all partners in the chain. The main objective is to include their local knowledge into the re-engineered model and to support the players in understanding their role in the transport chain.

When the re-engineered model was presented to the players in the Nutasa transport chain it triggered some extensive discussions. All players were accepted that in a future situation they would have to deliver not only their physical service but also the information related to it. However, what they found interesting was the visibility that the TCMS would provide and they declared interests in the possibility of getting access to the information. It would not only support them in their internal work planning but also enable for performance checks. Similar reactions also came from the other chains. By providing the players, who originally were information providers and task receivers, access to information of interest for, e.g. internal planning of

resources and work, control of sub-contractors, et cetera the co-operation would be enhanced and improved.

The main results from D2D thus far can be summarised as:

- Benefits of a logistics management and communication system must be clear from each actor in the transport chain and the system must be suitable for actors with different IT maturity.
- The functionality of a logistics management and communication system depends on access to status information. A realistic approach is to provide low cost and low barrier solutions for reporting the status messages.
- When implementing logistics management and communication system it is not only new way of reporting feedback or receiving instructions – it opens up new possibilities and new threats, i.e. provides a new transparency which will have implications and consequences on the business, beyond the technical aspects. Access to information is power!

3.3 The Baninfo project

The outline of the Baninfo project is quite different from the Infolog and D2D projects, which were driven by a combination of explicit user problems and high level policy goals of the European Commission. In Baninfo, the Swedish National Rail Administration (SNRA) and its existing information policy were in focus. The Baninfo project was defined and initiated by myself and some colleagues and financed through the research programme of the SNRA. The wish to carry out the project originated from a number of experiences. The results from earlier projects showed that information is as important to a successful transport chain as the actual transport and handling services. The Western dot.com industry suffered from a backlash but the experiences from Delego.com showed that technology had matured as well as the mindset in regard to sharing information and using the Internet as a communication means. In many of the projects I had been involved in, infrastructure and traffic management were treated as a black box. It was now time to try and open it and look to see what was inside.

Based on the above described experiences the following statement was formulated and used as a starting point for Baninfo: *Information available at Swedish National Rail Administration can, through an intelligent exchange with its different customers help to promote rail transport by improving the*

total quality of the transport chain, and creating a platform for further applications and information exchange with different customer segments.

To test the statement it was crucial to understand the complex interplay between SNRA and their customers and to identify the customers' needs of improved information exchange. For this purpose, the project chose to take a broad definition of freight customers including; shippers, forwarders, transport operators, line agents, wagon owners, information brokers and terminal operators. The project included a survey with the direct and indirect users of Swedish National Rail Administration: Green Cargo, Transwaggon, RailCombi, Danzas ASG Rail AB, IKEA Rail AB, DFDS Torline, Tågoperatörerna, Akzo Nobel, StoraEnso and E-log.

The project provided the following conclusions:

- *Attractive information crucial for the customer's business is available at The Swedish National Rail Administration.* The Administration has access to information (from long term infrastructure planning and operative traffic information to follow up statistics) for direct and indirect customers.
- *The needs of the customers must be in focus*. The accessibility to this information is an important success factor for the railroad sector and can only be achieved by focusing on the needs of the customers
- *Flexible solutions are required.* The need for information is largely common for all transport chains but vary from customer to customer depending on the role of the customer in the chain. The market is changing, which among others means that certain actors take over new roles. This leads to The Swedish National Rail Administration having to offer flexible solutions.
- *The Swedish National Rail Administration must become clearer in their different roles.* The Swedish National Rail Administration has different roles: responsible for the general development of rail transport, infrastructure manager and traffic manager. The market (mainly the indirect customer of The Swedish National Rail Administration as forwarders, wagons owner and shippers) apparently has difficulties in understanding how this affects the behaviour of the Rail Administration. In addition, the difference between a train operator and the infrastructure manager is also unclear to some.
- *A central contact point is required.* In certain cases customers don't know from whom the information can be received; infrastructure management versus traffic management versus market. A central and

common contact point is missing. Today informal networks replace insufficient routines.

- *System support must be further developed.* With present internal organisation and system support The Swedish National Rail Administration can not fulfil a number of the customers' demands satisfactorily:
    - Network-covering deviation reporting and forecasting time of arrival
    - Faster timetable process
    - Performance per route (for planning and follow-up of improvement measures)
    - Updated infrastructure information
- *Improved marketing efforts of existing services.* The information and the services that are available are for different reasons not used.
- *Improved quality requires better in-data from the customers*. The Swedish National Rail Administration has to make clear demands regarding the reporting from the customers in order to fulfil their undertakings in a better way.

The project clearly showed that the customers' need for information is not fulfilled. SNRA traditionally deals with infrastructure (to build and maintain) and the usage of the infrastructure with focus on safety. They have little tradition of having customers which lead to a lack of customer orientation. There is also a lack of knowledge of the customers' needs and why they need the information and what the implications are for the customers due to lacking or low quality information.

The situation has lead to informal networks of information exchange. DFDS TorLine stresses that their business was very dependent on information about deviations. If they are informed in good time they are capable of re-planning the assets and services in the terminal but if not high expenses result. Today the quality of the formal information exchange is low and as one of the employees stated: "It is good to know some important people along the transport chain".

The weak connection with the customers has led to that SNRA to some extent is seen with scepticism. When asked for their view in regard to SNRA as a service provider for information exchange, StoraEnso stressed that it is doubtful if they would have full confidence in getting into a situation where

they are depending on SNRA to get information that is crucial for their business.

As mentioned above SNRA is by tradition a builder and maintainer of infrastructure. This has caused limited levels of investment in IT systems for customer care. In April 2000, a train with dangerous goods had an accident at the railway station in Borlänge, which happens to be close to the premises of the SNRA head office. It turned out that the existing IT systems did not include information about dangerous goods. There were plans on building one and the accident accelerated the decision to start building.

The system developed is named OPERA and it uses information existing in other internal IT systems and it stores information about dangerous goods per wagon as well as other train related information. The system also stores information for statistical analyses, calculation of fees for the usage of the infrastructure and performance analysis. What distinguishes OPERA from other systems is the approach of letting the train operators use OPERA as a channel for exchanging information to SNRA either through XML messages or manually via a web interface which also opens up the possibility of receiving information from SNRA through OPERA.

The system was implemented in 2002 and the users' reaction was partly negative. There were discussions on how to exchange the information and who should pay for the interfacing. One possible explanation for the negative reaction is that the development of the system was oriented towards the internal needs of SNRA's traffic management without involving the future users (the train operators). The operators were also against reporting all their goods mainly due to the risk that this information could spread to competitors.

Today, two years after the implementation, the system functionality has been extended and more oriented toward the operators' needs. The operators are starting to show an increased interest, i.e. in getting access to information about the traffic situation and trains in the surrounding area.

Today there is an automatic transfer covering all train data from SJ AB and one is under construction for Green Cargo. The plan is to have almost all of the running traffic described in OPERA before the end of 2004. This indicates the needs from the market but also shows how important it is to involve the users in the development phase in order to reach acceptance and achieve a robust system.

Parts of the results from the Baninfo project were recommendations on how to improve the situation. The recommendations did include improved IT systems but the focus was on improving the customer relationships, i.e. enable a communication between the customer and SNRA. It was also stressed that the

existing information and systems should be oriented towards the customers' needs which requires a solid knowledge of the customers and their requirements.

The main results from Baninfo can be summarised as:

- Attractive information crucial for the customer's business is available at The Swedish National Rail Administration which has several information systems for development, maintenance and operation of infrastructure and traffic management. The information systems are well integrated with the internal procedures, but complexity makes changes slow when new tasks are introduced (e.g. new types of user destined information).
- Soft infrastructure, i.e. information describing the physical transport networks and the traffic situation on the physical networks (present, past and future) should be treated with the same priority as hard infrastructure.

4 MAIN RESULTS

The development of ICT over the last years has opened up for new technical solutions for information exchange. But there are still hurdles for transparency. The results from the projects indicate that trust, mutual benefits, incorporation of situated knowledge and respect of all players' business contexts are key factors for achieving socially robust solutions.

The projects show that transport chains require an overall co-ordinator but the success of the chain depends on the co-ordinators' ability to involve the different players in the game. It is necessary to focus on a common goal and play the game by the rules. Each player needs to understand its role and how its performance impacts the other players and the total quality of the transport chain. Throughout the projects it is possible to see that increased transparency is both a possibility and a threat since it reveals issues earlier hidden.

The projects indicate major differences of IT maturity between the players which require flexible solutions in regards to producing and communicating the required information.

Where a lack of transparency exists and formal networks fail their task, informal networks are established. Informal network can probably never be completely replaced by formal networks but it is important to be aware of them and their vulnerability.

How data can be transformed into information and knowledge

In the project KombiTif[17] a model was developed describing how data can be converted into information and knowledge, see Figure 11. The project was strongly user driven and included a mapping of the information requirements of the direct and indirect users of the infrastructure. The starting point of the model is that data is available in different systems at the transport agencies. The data is secured, co-ordinated and packed within each agency, between the agencies and with other actors – thereby added value information is achieved. The users have the possibility to access the information at different levels. Much of the discussions with the agencies were about who should be

[17] A project commissioned by the Swedish Ministry of Industry, Employment and Communications with the objective to develop a strategy and action plan for the Swedish transport agencies for improved information support and exchange via ICT, introduced as secondary project in figure 1

responsible for the process of adding value, how far the responsibility of the agencies goes and how to avoid intruding other players' business.

The model is interesting in this context for two reasons: it can serve as a basis for discussion on how the process to create knowledge can look like in a transport chain context and it indicates how operators and forwarders are depending on input from the infrastructure management for providing high quality status information.

Applied to a transport chain the model is in one sense easier due to the clearer distribution of responsibility manifested through the transport chain manager with the overall responsibility. For managing and monitoring of the transport chain, data and information is collected from the players, e.g. timetables and contract related information for the planning and status information in a wider sense for the monitoring. Each player is responsible, with support from the contractual agreement, for a first step of selection, i.e. data turns into capta and information. Input from the traffic management of the infrastructure supports the players in providing correct status information, especially with respect to estimated time for arrivals. The transport chain manager co-ordinates and add value to the capta and information, i.e. turns it into information and knowledge which can be returned to the players and used for other internal purposes.

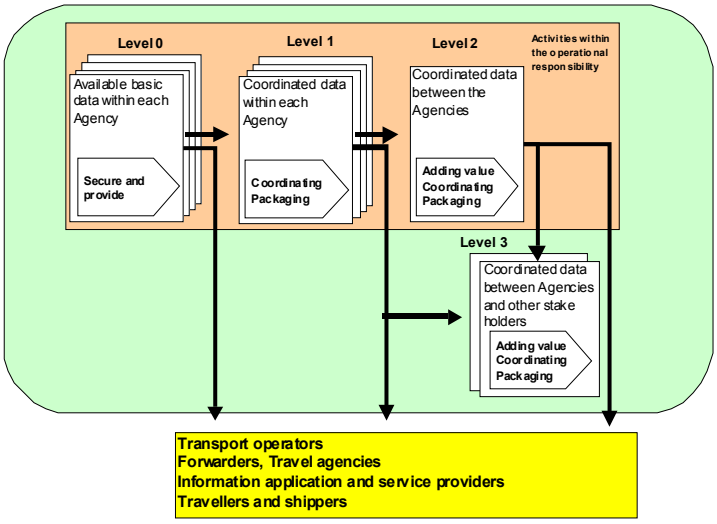

Figure 11: From data to information and knowledge (Lindkvist et al 2004)

Knowledge applications

Once the basic information required to perform high quality transport chain management is secured, a number of more sophisticated knowledge applications are possible and required by the players. If we return to the model illustrated in Figure 6 the nameless knowledge bubbles can be filled with the following examples of knowledge applications: manage and monitor the transport chain, manage customer relationship, fulfilling administrative requirements, transport chain security and constant improvement of business. A discussion on the different knowledge applications based on the understanding from Infolog, D2D and Baninfo follows below. The additional applications can act as driving forces for transparency, e.g. if security is required from a legislative point of view, the dynamic can be used to improve the information exchange and the transparency or as a marketing officer of a SCEM system company[18] phrases it: "*What is good for security is good for the supply chain"*.

Managing and monitoring the transport chain

Managing and monitoring the transport status is the internal operational processes of the transport chain manager. It includes planning and executing of the transport chain, combining transport services to a transport chain, keeping track of the status along the transport chain, detect deviations and perform deviation handling as well as provide input for assets planning. The TCMS started out as a pure management and communication tool with a limited number of functions of an administrative nature. The user requirements were focused on the management and monitoring of a transport chain.

During D2D the understanding of the requirements has increased. It has become clear that organising and monitoring are only the starting points – the main value driver is to detect deviations and support deviation handling. This requires up to date status information, which makes it possible to understand consequences and to get decision support on how to minimise the consequences.

For the visibility of a transport chain a mature monitoring system is evidently the best option but when it is not available, other sources of information can be highly valuable as identified in D2D. The projects show that it is not enough to know where and in what condition a consignment is, it is also

[18] Mr Cosmio Spera, CMO at Vizional Technologies Inc, interview in Global Logistics & Supply Chain Strategies, Spring 2003

crucial to know that the next player in the chain is aware of the upcoming task. The Baninfo project illustrated that information from the traffic management of the infrastructure can also provide important input, e.g. in regards to estimated time of arrivals.

Management of customer relationships

A transport chain can be viewed as the connector between products and customers. Porter (1998), states that physical distribution can be used as marketing tool and that it is a part of the competitive strategy of a company. A survey, CFO Research Services (2003) including 247 senior financial executives, found that two key objectives are driving the CFOs interest in supply chain management; 93% cited the need to reduce operating costs and 82% identified the need to improve customer service.

One direct driving force for the players in D2D to move up the value chain and become transport chain managers is pressure from their customers. The customers require them to take an overall door to door responsibility and are requesting higher quality including control of the consignments under a high cost pressure.

Constant improvement of business

Performance management is identified as top priority among logistics executives, Banker et al (2003). The transport sector is a business with low profit margins and it is important to monitor both the internal performance as well as the performance of contracted processes. Transparency enables discovery of non-compliance with the contracts.

One key issue in the strategic planning for transport chain managers is with whom to co-operate – both in respect of customers and sub-contractors in the chain - and how the contracts should be designed. Simulation can be used as a tool for decision making in the strategic planning a praxis little used today. A German survey[19] showed that only one out of five companies use simulation in the strategic planning. By using historical data it is possible to simulate: what-if scenarios of business changes (variations in demand, new customers, new services, changes in fleet size, etc) and to predict the likely impact of such changes on; fleet capacity requirements / bottlenecks, service quality and

[19] Survey based on 122 major companies in Germany, carried out by Galileo Consulting Group. The main results were describes in an article in DVZ, 13.02.2003.

reliability, financial risk exposure (e.g. in committing to new service contracts), future revenues. The usage of simulation is discussed in Paper 4.

Fulfilling administrative regulations and Supply chain security

A relatively new topic related to the transparency in transport chains is cargo security. As a result of the terrorist attacks on September 11 the US Customs implemented the Container Security Initiative (CSI) which requires that importers provide detailed manifest information 24 hours prior to loading at the origin port. Previously the time limit was 96 hours prior to arriving at a US port. For ocean carriers to meet the regulations they demand their customer to provide detailed shipping instructions well in advance of the loading.

Customs is working at pushing back the cargo inspection and the risk assessment to the point of origin. By keeping track of the transport and handling from the starting point along all handling during the transport an audit trail can be created for the shipment, which can speed up the handling at customs. Other administrative regulations also require good access to information, e.g. reporting of dangerous goods or food and food stuff traceability.

In a consulting paper on a Freight Integrator Action Plan the European Commission (2003) presents the possibility of proposing legalisation for electronic provision of data for all international shipments prior to departure.

Hurdles for transparency

All transport chains and players involved in the projects are far away from a complete visibility or transparency. The advantages of transparency in transport chains are stressed throughout the three projects but there are also a number of disadvantages for different players as well as circumstances that make the striving for transparency difficult. Information has potentially a high commercial value for the player in a transport chain. Traditionally transport service providers consider themselves as exclusive owners of transport related information and do not easily see the benefit of sharing information, or co-operating with others to improve the quality of information. To some players the lack of information is even the business idea and basis for their existence, e.g. different agents in the transport chain.

Transparency also highlights lack in quality and can be disadvantageous and makes it clear who is not fulfilling their task as well as where money is made

or lost to others. For transport and service operators transparency also includes the risk that their performance indicators are revealed to competitors.

Given the potential impact of information it is important that the following quality aspects are respected:

- Accuracy – ensuring that the information is precise and that it is provided on time. "Precise information" provided at the inappropriate time can be considered false information, and could easily be detrimental to critical processes related to transport and logistics.
- Confidentiality – ensuring that the information provided is not distributed to people or organisations that are not allowed to share the information.
- Security – ensuring that no unauthorised access to information is "possible".
- Authenticity – ensuring that the information has not been manipulated.

In the thematic network THEMIS,[20] 33 projects in the area of Supply Chain Management, E-Logistics and E-Fulfilment were analysed and the following conclusion could be drawn, (Fischer, 2004) "*In a competitive environment, the optimisation of processes seen from the perspective of one particular commercial actor is often in conflict with the perspective and interest of other actors. Total supply chain visibility is therefore an unrealistic holy grail*."

These are all hurdles that need to be overcome to achieve transparency. Some of the hurdles are of technical nature and will disappear as the technological development continues. But trust between the partners and mutual benefits must still be solved through close co-operation and careful consideration of the players – i.e. socially robust solutions must be sought.

[20] THEMIS – thematic network within the 5th Framework research programme of the European Commission.

5 CONCLUSIONS

Transparency does not mean that every player should know everything at all times - instead transparency should be viewed as *knowledge* accessible to the relevant players in the transport chain. The production of this knowledge depends on that all players are aware of their role in the value chain. The research indicates that the expertise in the transport chain is distributed among its players and that all players have their own internal agenda. The players possess local knowledge - situated knowledge - which seems to go beyond any knowledge applications on a central level.

One way to enhance transparency is to bring the relevant players to the same table and enable them to bring in their local knowledge, the narratives of the experts. Through a common effort a map and a vision of the transport chain, i.e. the approach of work flow modelling an integration of local knowledge is enabled which lays the foundation for co-operation and distribution of responsibilities. “The players pray from the same book”.

Obviously there are diffuse relations and contradictions between transparency, security and competition which need to be acknowledged. Transparency is a prerequisite for security, i.e. information on the origin and the handling of the consignments is required. However, transparency accessed by someone not authorised can be dangerous. For the players striving for transparency it is a competitive advantage enabling both better customer service and improved performance. At the same time transparency can bring an end to business areas and highlight non performance.

When ICT systems are implemented to support the transparency the players in the transport chain can not be viewed solely as partners contracted to use a pre-defined system to receive tasks and send feedback. Instead the players and their situated knowledge should be involved in the development and implementation phase to achieve a socially robust system.

With expertise becoming widely distributed, trust becomes an even more precious resource.

6 FUTURE RESEARCH

Transparency and socially robust systems will continue to direct my research.

The research on simulation as a decision tool for strategic planning as described in paper 4 is ongoing. Paper 4 also indicates some first ideas of future activities. My research will focus on the access to historical data to produce performance profiles. It is still to be proven if it possible to get access to the required information. Another topic is how to model the local players and their situated knowledge.

The importance of the transport agencies for transparency in the transport chain is another challenging research topic given their legacy systems, including the different roles such as: operator of a network, authority issuing regulations and to a different extent promoter of the general development of their transport sector. For the road sector this is of special interest with respect to future intelligent road tolling systems for heavy goods vehicles. A system which will be widespread (eventually including most heavy goods vehicles in Europe) and where the role of society as a whole will be important. Research challenges are to study how the system's tissue is made up of sticky economic, technical, political, organic and historical threads.

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Papers included in the thesis

Paper 1- Gustafsson I., Källström L., Pedersen J.T., "*INFOLOG - Managing Intermodal Transport Chains"*, (1999), Proceedings, ITS world conference, Toronto 1999. This paper presents the main findings of the Infolog project. The concept of the transport chain manager is defined and the main functionalies for managing intermodal transport chains are identified.

Paper 2- Törnquist J., Gustafsson I., "*Perceived benefits of improved information exchange – a case study on rail and multimodal transport"* (2003). To be published in Elseviers special edition in (ed.) Bekiaris, E., Where theory and practice meet: Innovations and case studies in assessing the economic impacts of ITS and telematics, in the book series Research in Transportation Economics. In this paper the generic business processes connected to a transport chain were modelled and for each process the information requirements identified. Focus is on interaction between the transport chains and the traffic system.

Paper 3 - Gustafsson I., Källström L, (2003), "*Improving the quality of intermodal transports – user requirements on transport chain management systems"*, Proceedings, ITS world conference, Madrid 2003. In this paper the concept of the transport chain manager is further developed. Business modelling is used to create in-depth understanding of transport chains, including understanding the roles, actors, responsibilities of the actors in the transport chain as well as of the co-operation between the actors and the consequences of their actions and non actions. The importance of information in transport chains is discussed as well as how additional value of the information collected for visibility during the actual transport can be achieved.

Paper 4 - Törnquist J., Gustafsson I., *"Decision support for handling uncertainty in intermodal transport chains"*, (2003). In this paper the D2D actors need for simulation is identified and initial concepts are designed for building and assessing transport chains. Submitted for publications.

PAPER 1

INFOLOG – MANAGING INTERMODAL TRANSPORT CHAINS

Proceedings, 6th ITS world conference, Toronto 1999

INFOLOG – Managing Intermodal Transport Chains
- INFOLOG, a project sponsored by DG VII and KFB -

6 th World Congress on Intelligent Transport System
Technical Sessions: TS 1-10 Intermodality

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Summery

INFOLOG – Intermodal Information Link for Improved Logistics is a demonstration project run within the Transport Program of the European Union's Fourth Framework Programme. INFOLOG sets out to ensure the effectiveness and attractiveness of intermodal transport. To achieve this, a Transport Chain Manager – TCMS has been developed.

This paper describes the concept, expected benefits, the technical basis and the first findings.

BACKGROUND

INFOLOG – Intermodal Information Link for Improved Logistics is a demonstration project run within the Transport Program of the European Union's Fourth Framework Programme. Today, using intermodal transports is more complicated than using traditional road transport. The flow of information and the number of documents that has to be handled vastly exceeds the one for road transport. When a shipper decides to use intermodal transports, he has to either carry out more administrative work or outsource the forwarding. An outsourceing leads to less control of strategic information and a higher dependency on an outside actor.

Transport is a part of the service and marketing concept. Intermodal transport chains relay on relatively stable flows, which implies stable contractual relations between shippers and carriers over several years.

If intermodal transports are to be a true alternative to road transports they must be as accessible and easy to organise as road transport and also be cost efficient. INFOLOG sets out to ensure the effectiveness and attractiveness of intermodal transport and to achieve this the Transport Chain Manager – TCMS has been developed.

THE CONCEPT

In brief, the TCMS :

- provides administrative support customised to the needs of the users and their organisation,
- provides the necessary functions to plan, book, carry out, monitor and follow up the transport,
- is flexible; can be used on several levels in the transport chain management hierarchy and it can be adapted to existing systems and communication solutions (EDI, www)
- uses a comprehensive data model (TRIM) developed during the Fourth Framework Programme (Interport, Infolog) and through co-operation in CEN.

The TCMS developed in INFOLOG consists of a generic set of system components capable of performing transport planning and monitoring functions and can be described as a tool box. It consists of around 30 different forwarding functions (see Table 1).

Order Goods	Manage Terminal Stock Stock Control Supplies Forecasting Supplies Ordering
Prepare Transport chain	Build Transport Chain Select Actors Contract Actor Services Report on Forecasts
Prepare Transport	Customs Clearance Book Transport Prepare Joint Booking Prepare Joint Loading Plan Transport Plan Distribution
Perform Transport	Deliver Certificates Report on Loaded Goods Report on Unloaded Goods Report on Delivery Report on Deviation Report on Arrival / Departure Report on Unloading Report on Damage Transfer Invoice
Monitor Transport	Track Load Unit Track Goods Item Display Document Control Entry / Exit Control Loading Control Unloading Control Yard Locations Control Stuffing / Stripping

Table 1:Forwarding functions included in the concept

The system architecture and system specification of the TCMS include all the above mentioned forwarding functions.

The TCMS is built up by a number of components e.g. receiver, dispatcher and sender (see Figure 1). The receiver and the sender are independent of transport protocol and any standard protocol can be supported, e.g. e-mail, edifact etc. The dispatcher component calls the functions related to the incoming message and has a plug-in design (further functions can easily be plugged in). Thanks to the object layer any relational database system can used. This means that an actor can use the existing database for hosting the TRIM database.

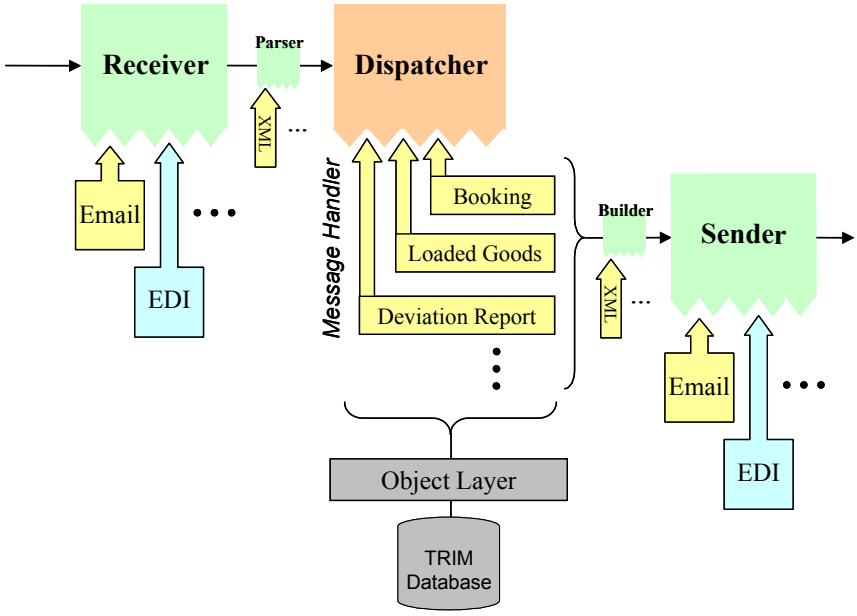

Figure 1: The components in the TCMS

The components approach opens the possibility to implement different versions of TCMS depending on the organisation of the transport chain and the existence of systems already in operation. The TCMS can be implemented by different actors, on different levels and for different parts of the transport chain. It is also possible to have more systems working together. The TCMS can easily be extended with additional application functions by plugging them into the dispatcher. It also

allows adaptation to other communication standards. The advantages of such a system are not only the flexibility for each system but also the re-usability of the components guaranteeing cost efficiency.

EXAMPLE OF THE FUNCTIONALITY

When for instance a transport has to be *booked*, the user sends a booking request to the TCMS. Such a request is usually generated by the user's internal IT system, but it can also be entered manually via the TCMS user interface. By exploring the already configured transport alternatives, TCMS selects a proper route; thereby it takes into account the required schedules for loading and delivery, the transport volume, weight, dimension and all other special properties of the goods. The system sends booking requests for transport capacity, transport means and possibly other services such as storage, cargo handling etc. to all actors involved in the transport chain and evaluates the confirmations. The sender of the initiating booking request receives *one* summary booking confirmation (see Figure 2:)

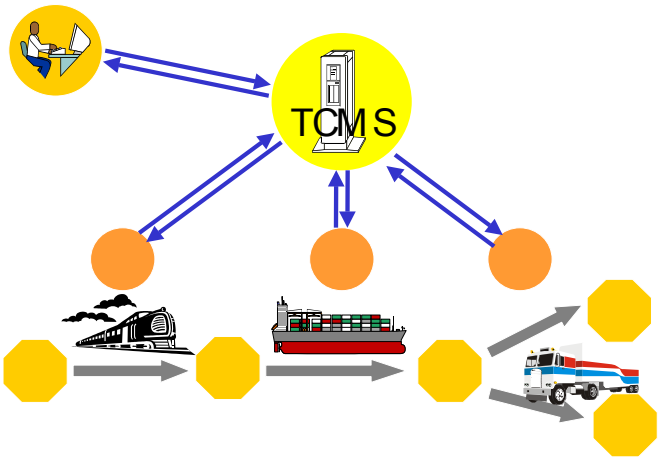

Figure 2: Example of the TCMS functionality.

Further information on a booked transport can be brought into the system once it has been generated in the company. TCMS manages this information and composes accompanying documents, orders etc. The

documents are sent to each actor in the form required; this transmission may happen according to a predefined workflow or as a single action triggered by the user. Incoming responses are analysed and stored for immediate or later evaluation. The status of any transport process can thus be made visible at any time. If there are any deviations or irregularities, which may endanger the proper execution of the transport, TCMS additionally notifies the customer of the transport chain service.

EXPECTED BENEFITS

The TCMS will grant intermodal transports a higher competitiveness by:

- Making intermodal chains accessible, that is, showing "all" available alternatives for transport from a given origin to a given destination combining transport means in the most effective way.
- Simplifying the booking of intermodal transport. This means that all transport services necessary for bringing the goods from origin to destination in an intermodal operation are booked in one operation.
- Making best possible use of available transport resources.
- Automatically communicating documents and information between those taking part in the door-to-door intermodal transport.
- Making the status of the transport visible and thereby providing higher quality.
- Provide better trained staff.
- Providing a better transport logistic control along an intermodal transport chain.
- Making the performance carried out by the transport operators transparent.

- Offering a flexible solution for the transport management; due to the open communication structure it is possible without major software changes to co-operate with new operators.

TECHNICAL BASIS

Information that comes up with the handling of transport processes is stored in a database system. The INFOLOG system is based on TRIM (Transport Reference Information Model), which unites the results of several national and European development projects.

One of the problems of intermodal transports is the amount of information that has to be exchanged. Imagine an article e.g. a paper roll stored on a pallet and put into a container. The container is placed on a lorry or on a train which is later rolled on to a ferry. For high valued goods each article is an individual of its own and it has to be traceable during the complete transport chain. TRIM provides a tool for representing the complex information needed (see Figure 3).

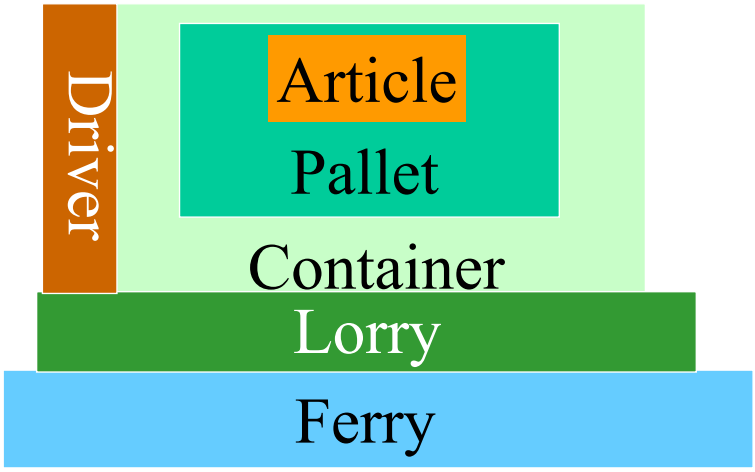

Figure 3: Complexity of information needed to describe an article under transport

Most of the current information systems in the transport chain are unable to communicate with each other because of lack a common

”language”. TRIM is improving the situation and can be used for implementing standard messages between the information systems. TRIM meets the information demand of the participants of international, intermodal transport chains. The information model can be used to generate the respective concrete data model, which can be applied directly to any widespread database system and be adapted to specific requirements.
Development of integrated information systems based on TRIM includes implementation of EDIFACT messages, extension of current systems and development of new systems and system components. These system elements can be integrated in a system architecture where the information flows between the systems in the transport chain, and manual input are only performed at the data source.

Due to an open communication architecture it is possible to integrate the TCMS with existing systems and to communicate with EDI/EDIFACT, e-mail and WEB. This also enables EDI exchange with small actors, who only need to have access to internet. In Figure 4 the five interfaces are illustrated.

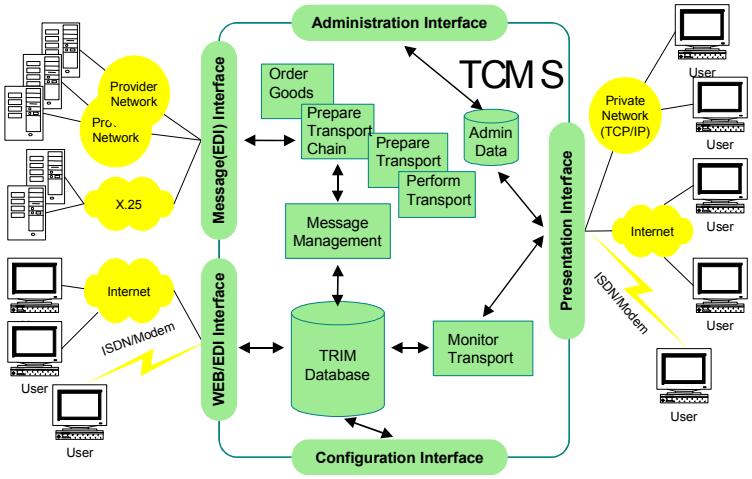

Figure 4: Interfaces to the TCMS

- The “Message/EDI” interface provides a means for the exchange of messages with other systems, e.g. with partners corporate systems;

- The “WEB/EDI” interface offers EDI forms by which EDI messages can manually be entered or viewed;
- The “Administration” interface allows system administrators to configure user data and assign user access rights to application functions;
- The “Presentation” interface allows end users to visualise transport information and documents;
- The “Configuration” interface allows to enter static configuration data (e.g. routes, transport chain, master data of partners) into the system. This can be done manually by an entitled user or via direct link to the corporate system of the company who overtakes the chain management. The “Configuration” interface enables integration with internal systems e.g. production system. AEI information is connected via this interface.

A DEMONSTRATION PROJECT

In INFOLOG different demonstrators appear illustrating the flexibility of the system.

The “Southern demonstrator” is consignee/consumer oriented and the transport activities are triggered by the consumer. The transport co-ordination is subcontracted. The southern demonstrator includes two cases; the Hellasco case in which goods items, paper roles, are handled and the Callitsis case in which load units, containers, are handled. In both cases terminal and warehousing control are the major parts of interest. In the Southern demonstrator the issue is to enhance the efficiency of existing procedures. AEI in different forms is implemented and integrated with the TCMS. 15 EDIFACT messages, all mapped against TRIM, are implemented.

The “Northern demonstrator” is manufacturer oriented and the transport activities are triggered by the manufacturer. The transport is part of the company-wide logistics concept with direct contact with railways, shipping lines, hauliers and own distribution centres. The concept developed in the “Northern demonstrator” is based on the requirements of STORA ENSO and Avesta Sheffield, two companies discussing a implementation of a transport chain management system.

The demonstration carried out is designed to fulfil the functionality required by Avesta Sheffield.

FIRST FINDINGS

The evaluation of the project will be carried out in Autumn 99. Some first findings were made by presenting the conceptual idea among key players in the transport sector. The response of the concept has been positive and a number of actors are investigating the possibilities of implementing the concept.

In one of the cases, Avesta Sheffield, a first feasibility study was performed. The feasibility study showed that the involved partners in the intermodal transport chain will gain a number of benefits by implementing the TCMS. Some of the benefits could be measured in monetary terms while other benefits were not directly convertible into money, but still important for the competitiveness and therefore play an important role for the feasibility, e.g. goodwill, quality and the impact on the users.

Today Avesta Sheffield transports 210.000 ton of finished products yearly from Sweden to the continent. 40.000 ton are transported by intermodal transport on “flat racks” by rail and ferry, the rest is transported by conventional transports mainly by road. The TCMS makes it possible to make joint bookings, both for the goods from the different mills and for the distribution from Gent. This will lead to a higher load factor and less transport work. One concrete example for cost savings is the train running between Avesta and Gothenburg only utilised to 55%. Another 33.000 ton per year could be transported provided a better co-ordination of transport planning could be achieved.

The reduced administrative work e.g. fewer telephone and fax communications will lead to savings between 40 and 60 SEK per consignment for Avesta Sheffield. Also the other actors in the transport chain will benefit from less paper work. One truck operator claimed that the price would be reduced by 60 SEK per consignment if the information was provided by EDI instead of fax.

With the improved information handling a higher transparency follows enabling improved customer service, control of the performance of the transport and terminal operator and a better overall logistics.

PAPER 2

PERCEIVED BENEFITS OF IMPROVED INFORMATION EXCHANGE: A CASE STUDY ON RAIL AND INTERMODAL TRANSPORTS

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PERCEIVED BENEFITS OF IMPROVED INFORMATION EXCHANGE: A CASE STUDY ON RAIL AND INTERMODAL TRANSPORTS

Johanna Törnquist and Inger Gustafsson

ABSTRACT

The interest in achieving more effective railway freight transports in Europe and increasing the railway's market share, has grown the past few years. The use of railway is, however, often rather complex in many aspects and needs to become more flexible and reliable if it will be able to compete with other modes of transport. A study was carried out to investigate if and how improved information exchange between the Swedish National Rail Administration, Banverket, and its customers, can facilitate the use of Swedish railway freight transports. The primary aim was to identify the customers' needs for improved information exchange as well as to understand how they would benefit from it. The results showed that the accessibility to information has a significant impact on the whole planning process and that there already exists substantial information that will benefit the customers if synthesised and made available.

1 INTRODUCTION

1.1 Background

Companies in many nations are continuously changing their production strategies in order to stay competitive and satisfy the customers. Factories located in one part of the world need supplies produced in another part, while the consumers are located all over the globe. The importance of optimised transportation networks is an obvious and accepted fact – particularly in the light of the current economic pressure and when logistics is becoming a prime source of strategic advantage (Stock and Lambert, 2001; Mobert et. al., 2002). To handle these activities in an efficient manner with time constraints and forces to keep costs down, an advanced logistics function is required within the companies' supply chains.

A transport system, outsourced or not, constitutes one important part of that logistics function since transportation often is the single largest cost in the logistics process (Stock and Lambert, 2001). Since transportation also is the channel for flows of products, there are high demands on reliability (e.g. damage risk and punctuality). Rarely, a company is independent of its surroundings, which forces it to alter or adapt to them. The ability to adapt within a specific time frame is often called agility. In the term agility lies the degree of flexibility, i.e. if the company is able to act according to the changes. Degree of flexibility in a transport system refers to the extent of how a transport concept can be changed within a short time frame; for example, volumes of goods can be re-routed. In many cases, it is necessary to take some actions, but an increase in agility may lead to a more complex system.

In International supply chain agility – Tradeoffs between flexibility and uncertainty, (Prater et. al, 2001), several factors of supply chain exposure are identified and explained.

- Extent of geographic areas covered by the supply chain.
- Political areas and borders crossed.
- Number of transportation modes and their speed.
- Technical infrastructure and its degree of use.

- Random occurrences.

As the authors point out, these factors are interrelated to some extent. Another significant factor, of course, is the type and volume of goods transported. Transporting hazardous goods, for example, increases the complexity. Furthermore, which types of transport modes that are used is also an influencing factor. The saying that "a chain is no stronger than its weakest link" is important to consider in this context. Often, railway transports are considered to be a weak link, which in part may very well be true.

When considering the characteristics of railway as a transport mode and comparing it to the other transport modes, it becomes obvious that railway traffic and transportation are quite complex. Railway transportation does, however, offer several advantages (e.g. high capacity, possibilities for high speed and considered by some to be environmentally friendly), and in order to increase its attractiveness, the selection criteria for modal choice must be considered as well as possibilities to fulfil them. We believe that an improved information exchange can facilitate the use of railway transportation and its performance, and thereby strengthen the railway's position as an alternative link in an intermodal transport chain. Intermodal transport is defined to be the movement of goods using several modes of transport without handling the goods per se.

Since the situation differs between countries, this paper focuses on Swedish railway traffic and transports. In the European Union (EU), there has been a process of deregulating and liberalising the railway transport market for quite some time. The aim of the liberalisation is to create competition and thereby achieve a better supply of services that will attract customers. In Sweden, the deregulation of the railway was initiated in the late eighties. In its first phase, the deregulation led to a split of the national railway into a public service enterprise, SJ, responsible for the rail transports and a rail administration responsible for the infrastructure, the Swedish Rail Administration (i.e. Banverket). In 1996, the deregulation was extended, resulting in an opportunity for anyone who conform to the requirements, specified by the responsible authority (i.e. Banverket), to operate on the state owned railway

network. Since then, Banverket is the authority responsible for the railway infrastructure and for planning and managing the railway traffic on the state owned network. Thus, traffic management, including slot allocation, is strictly separated from railway transportation.

1.2 Motivation

Experience from earlier projects regarding management of transport chains e.g. INFOLOG (Källström, 2000), shows that there are high requirements on reliable information to support the process of planning, monitoring and controlling intermodal transport chains. Recent results from the project THEMIS (Källström, 2002) have shown that by integrating traffic information in the transport management process, a higher quality can be achieved. Traffic information refers to information that concerns the traffic network and its flow of transport units while transport information is associated with a specific transport unit or shipment, which can be a part of several traffic networks (e.g. air, road, rail). Based on the findings and the current situation described above, the project Baninfo was initiated by TFK Transportforschung GmbH[1] and Banverket with Blekinge Institute of Technology (BTH) as part of the project group. The project aimed at identifying if and how railway transportation in Sweden can be a more attractive and reliable part of a transport chain through improved information exchange. By being responsible for the traffic management, Banverket has the possibility and authority to collect all kinds of traffic information, and is thus a key actor in this context.

1.3 Methodology

In order to identify the required information exchange, a study was made by conducting qualitative analysis of the customers' opinions and desires within the project Baninfo. Interviews were carried out with a group of customers (see Table 1) including shippers, forwarders, transport operators, line agents, wagon owners, information brokers and terminal operators in order to cover as many relevant aspects as possible.

[1] After the project TFK Transportforschung GmbH has been sold to BMT and trades under the name BMT Transport Solutions GmbH.

In the interviews, the term "information" was given a broad definition to include real-time status data on a specific transport as well as amount of slots available when planning a transport concept, and several other types. The interviews consisted of discussions concerning the customers' different business processes ranging from a strategic to a post-operational level, and the use, benefits and lack of information within each process. The results from the interviews were written down and sent to the respondents for confirmation and opportunity for revision in order to avoid misinterpretation and possible bias by the interviewers.

In addition to the interviews, relevant information systems and their content at Banverket were studied, as well as potential improvements and possibilities to satisfy the identified customer demands.

Company/Organisation	Role/-s
Green Cargo	Transport operator/Forwarder
Transwaggon	Wagon owner/Forwarder
Danzas ASG Rail	Forwarder
IKEA Rail AB	Shipper
DFDS Torline	Transport-/Terminal operator
Tågoperatörerna	Trade organisation
Akzo Nobel	Shipper
Railcombi	Operator for combined transports
Banverket	Infrastructure manager
Stora Enso	Shipper
ELOG	Information broker

Table 1. Customers included in the interview group.

1.4 Outline

This paper will first put the findings from the study in Baninfo in a context by describing the railway's status as an option to other means of transport within a transport chain. Furthermore, the relevant characteristics of railway traffic and transportation will be outlined as well as the importance of thorough planning and the necessary access to accurate information. The presentation of the results from the study

in Baninfo will then follow and be argued for by connecting the information demand to the business processes of the different customers and Banverket. Costs and benefits of the realisation of the information exchange, accessibility and the acquisition of a utility approximation will be discussed in the next chapter. Discussion and conclusions will also be presented along with a description of future research in the last sections.

2 *RAILWAY TRANSPORTS AS AN OPTION IN TRANSPORT CHAINS*

In 1970, railway freight transportation constituted 31% of the total transport work (in tonne-km) in Europe, and by 1995 the market share had decreased to 15 %. During the same period, the overall freight transport work increased by approximately 75 %, which shows that the railway have not managed to keep its market share (Nelldal et. al., 2000). In Sweden, the corresponding market share is 43 % for 1970 and 32 % for 1995. In 2001, the market share was 24 % (11 % of transported tonnes) (SIKA, 2003).

2.1 Selection criteria for choice of transport mode

Several studies have been made during the years to capture the selection criteria of freight transport buyers (Transek, 1992; Nelldal et. al., 2000; Bruzelius, 2001; Golog and Regan, 2002; SIKA, 2002; Vanneiuwenhuyse et. al., 2002) and analyse the distribution of freight over the different modes. The most important selection criterion for transportation mode choice, beside the transportation costs, is quality, which most often refers to transportation time and reliability (Nellldal et. al, 2000). A study was made in 1999 asking 1530 shippers and logistics provider to weight the importance of factors influencing the selection of transport mode (Vannieuwenhuyse, 2002). The results from 500 respondents ranked transport cost, reliability, flexibility (i.e. possibility to influence) and transport time to be the most important factors. Results from a study made by Banverket in 1999 (Nelldal, 2000) showed also that transport cost was ranked most important and that the influence on the environment made a significant difference indicating increased environmental awareness (Nelldal, 2000). In the same study, transport time was ranked second, but if a shipment takes

three or four days makes a minor difference - the most important is that it arrives on time (Nelldal et. al., 2000). There are also studies investigating how to quantify the utility of certain transport variables more specific, see further e.g. (Transek, 1992; Bruzelius, 2001; SIKA, 2002).

It is difficult to separate the factors from each other. Logically transport cost is one of the determining factors, since transport constitutes a significant part of the logistics costs (Stock and Lambert, 2001), and so is transport time. However, a low transport cost and short transport time do not provide any benefits if the reliability is low. Reliability is the cornerstone in effective planning and use of strategies such as Just-In-Time (JIT). In order to make it worthwhile to substitute pure road transports by intermodal transports, including railway, the modal integration must become efficient and each transport relation reliable.

2.2 Status of European railway traffic and transport

Cross-border railway traffic has for a long period of time struggled with ineffective regulations for customs clearance, low priority on trains far from original destination and different standards on the infrastructure (Banverket, 2003). The work towards a European deregulated market and other efforts have resulted in improvements such as establishment of Freight Freeways by using the concept of OSS (One-Stop-Shop). Freight Freeways is a concept that aims to facilitate the use of freight transports on railway through Europe by providing access to certain slots, ensuring an average speed of minimum 60 km/h and a high priority through the whole railway transport. One key to such a concept is the co-operation between the authorities of different nations, which there is a great need of considering that the average speed of cross border freight trains within the EU is as low as 18 km/h. One outstanding exception, however, is the so-called IKEA[2] trains, which operate as a pipeline between Älmhult, Sweden and Duisburg, Germany with an average speed of 70 km/h and a punctuality of 85 %. The reason for being able to achieve such high performance is, according to IKEA, the close contact with the different

[2] IKEA Rail was included in the customer group in Baninfo. However, in the fall of 2003, IKEA Rail decided to stop its operations and instead outsource the services.

infrastructure/traffic managers, which ensures access to high quality traffic information (Transport Idag, 2003).

The lack of established co-operation between railway companies is considered to be one of the major limitations for international railway transports (Nelldal et. al., 2000). One example given by Nelldal shows that in order to create a railway transport between Sweden and Spain, six different companies of varying nationalities have to be involved and manage the part of the transport that occupy their railway network. Beside organisational difficulties, caused by involvement of many companies, the cross-border railway transports also suffer from a complex set of different traffic management rules as well as technical interoperability problems.

Independent of whether it is national or international traffic, there are additional constraints beside regulations and technical differences. Railway transports are less robust and therefore more easily affected by changes in the surrounding traffic than the other modes due to the characteristics of the network and related regulations (Wiklund, 2002). This issue reduces the flexibility to adapt ad-hoc solutions when something unexpected occurs and the possibilities to re-establish original plans. During the whole trip, a train has one slot for each part of the network (i.e. for every block) so if a delay occurs new slots have to be allocated to the train by the traffic manager in real-time. This will either make surrounding traffic suffer to some extent, or the delayed train will only be allocated available slots in between the other already occupied slots, possibly fragmenting its timetable and generating significant delay comparing to its original ETA (Estimated Time of Arrival). This vulnerability affects the reliability immensely. However, by using thorough planning with access to accurate and sufficient information, disturbances can be prevented to a greater extent and punctuality increased just as the reliability.

Railway transports often need to be complemented with road transports since the infrastructure is very limited. When combining railway transports with other modes into intermodal transport chains, the complexity increases further (D'Este, 1996). Intermodal transports are often associated with higher costs than unimodal transports due to the

need for terminal operations in the process of changing transport mode. The terminal operations constitute a large part of the total intermodal cost (Cardebring P, et. al., 2000; Nelldal et. al., 2000) and they are also time-consuming. Furthermore, an increase in the number of involved parties increases the complexity of the transport chains (Heller, 1999). Therefore, the possibility to plan and control by integrating relevant and reliable information from different transport and traffic systems becomes even more important. Figure 1 illustrates an intermodal transport chain consisting of rail, waterborne and road transport. To be able to perform transport operations with high quality (i.e. expectations are fulfilled to a satisfying level regarding e.g. punctuality) in such a chain requires the traffic managers to consider their tasks also from the perspective of their customers and the customers' customer. The traffic management needs to understand the logistic importance of the transport chain from consignor to consignee. This means that also traffic network managers will have to consider what is happening upstream their network and anticipate what is going to happen downstream their area. In addition to their tasks of maintaining safety and providing reliable services and optimal use of capacity, the traffic managers must be able to support customer planning and operational decisions (e.g. by providing accurate information on ETA). This creates new incentives for:

- Interactive planning and communication
- Short planning cycles
- Reliable, accurate and sufficient input data during planning
- Preventive exception handling

In addition, transport operators have a liability to act supportive by using adequate tools to provide the traffic manager and others concerned with the requested information.

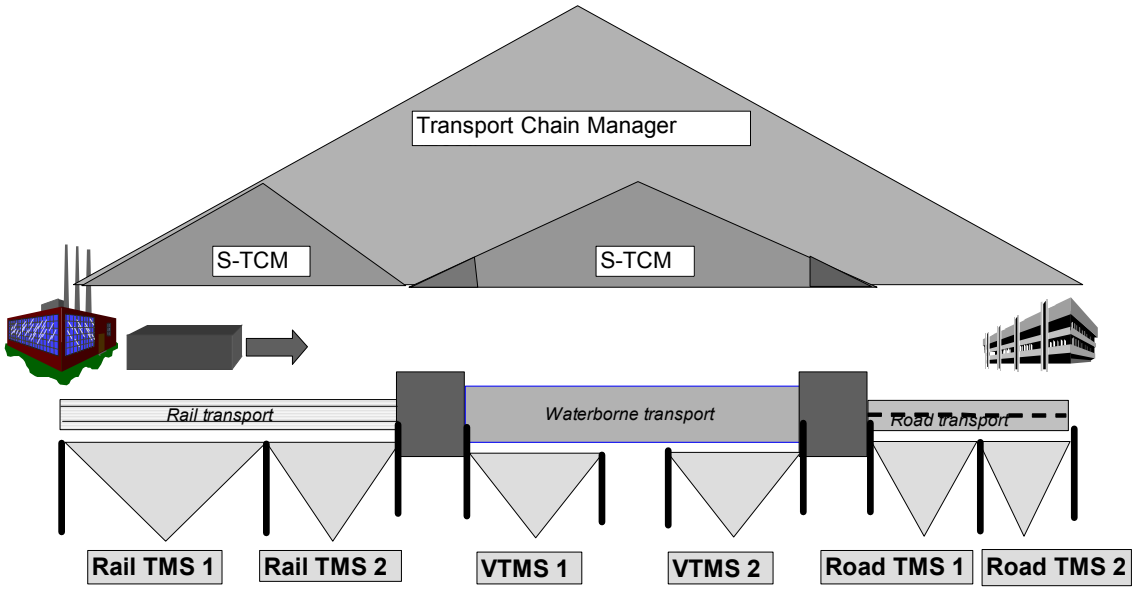

Figure 1: Interaction between traffic and transport management (S-TCM = Sub-Transport Chain Manager, TMS = Traffic/Transport Management System).

3 INFORMATION: A KEY TO SUCCESSFUL DECISION-MAKING

To perform efficient intermodal transport chains including any kind of transport mode, high co-ordination is obviously necessary and can, in part, be achieved by intelligent use of information. However, the benefits are not always so obvious. Results from the thematic network THEMIS (Källström, 2002) have shown that the awareness of the advantages in using both transport and traffic information increases, yet the possibilities for implementations are poorly developed. In contrast, information is widely considered to be a key component of successful supply chains (Moberg et. al., 2002; Gustin et.al., 1995). One reason for the unawareness of the potential of improved information exchange and use of information, is the lack of research and research publications regarding implementations and their effects (Moberg et. al., 2002).

In The Logistics Footprint – Creating a Road Map to Excellence (Herbert, 2002) five key capabilities are defined as important to achieve competitive advantage:

- Performance management – collect and use logistics information to measure the performance of internal logistics functions, as well as external providers, e.g. carriers and 3PLs.
- Shipment planning - activities like load consolidation, mode selection, carrier selection, and routing.
- Documentation and compliance - understanding and creating the appropriate documentation for a shipment as well as complying with the regulations of all countries involved.
- Shipment visibility - proactive and reactive visibility of shipments at the load unit level using multiple query points.
- Event management - alerting and reporting actual transport events in relation to the planned ones.

Information exchanged, or not exchanged, before, during and after the operations has a significant impact on the performance of the operations. Using inaccurate information as input for planning will most likely not generate the best possible prerequisites for the

operations – a phenomenon more commonly known as GIGO (Garbage In, Garbage Out). Being able to monitor and control the flow of transports in real-time, puts high demands on access to status information and reliable prognoses if unexpected events occur. Gaining knowledge about the performance of past operations, such as punctuality statistics, is also important. With this in mind, the project chose to investigate the customer's information requirements during the following five processes; strategic planning, tactical planning, production planning, production and post-production. The processes are illustrated in Figure 2, where strategic planning refers to planning on relatively long term, while tactical is mid-term and production planning short term. Production refers to the level where operations are carried out in real-time and post-operation is the level where information collected during operations is evaluated and synthesised. There is no strict line of separation between the different processes.

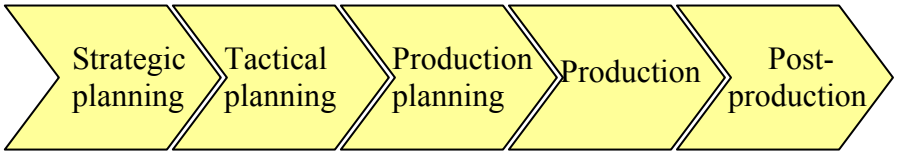

Figure 2: Generic business processes at the customers.

The customers' generic processes together with Banverket's internal processes (one process for traffic management and one for infrastructure management such as maintenance) were the basis for a model used in Baninfo. The model is depicted in Figure 3 below.

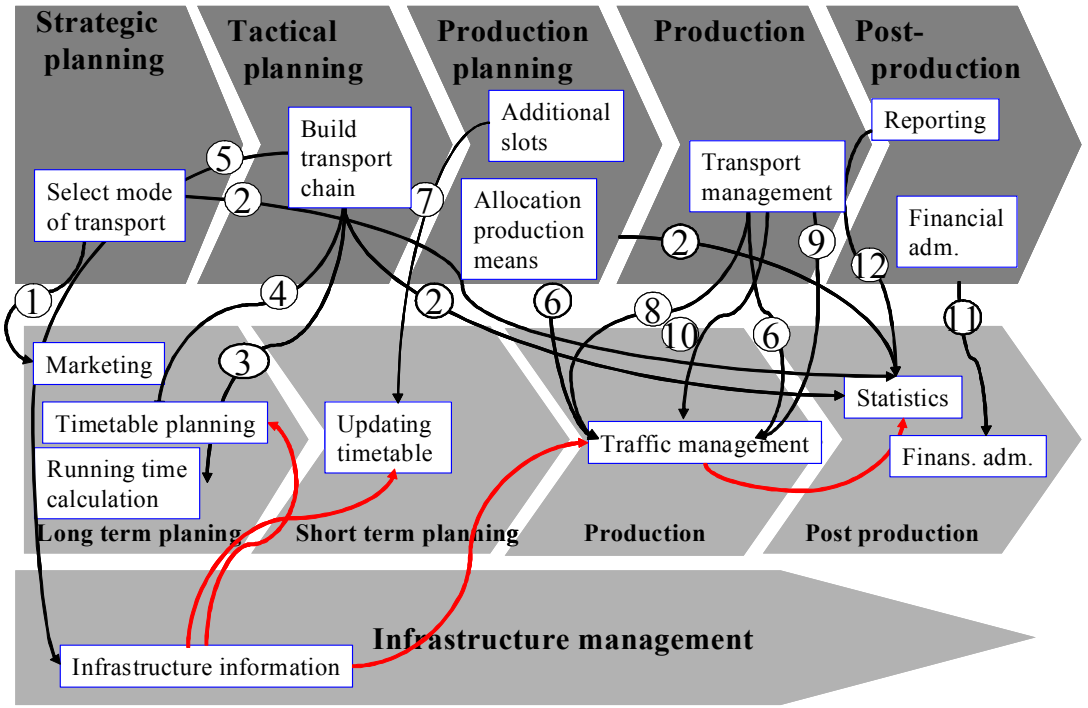

Figure 3: The relations between the processes of Banverket and its customers. From the top: processes of the customer, the traffic management at Banverket and the maintenance for the infrastructure at Banverket.

During the project the customers' main functions were identified and mapped into the processes (illustrated in the upper part of Figure 3). For each function, the information required was identified as well as where this information could be found within Banverket. In the model, this is illustrated by the arrows connecting the activities. Each information type/functionality is described by a number according to the list below:

1. Product information (product, price, accessibility and quality)
2. Performance indicators (a route's reliability and quality)
3. Running time calculation
4. Simplified slot allocation process
5. Infrastructure information (including planned network maintenance)
6. ETA, including reliable forecasting of deviations
7. Short term slot requests (additional slots)
8. Positioning data
9. Structured deviation reporting
10. Prioritisation during disturbances
11. Statistics for financial administration
12. Statistics reporting

Below follows a description of the activities within each process and examples on what information is demanded by the customers. The benefits that the improved information would provide have also been described as well as the problems that poor access to and low quality of information may cause.

3.1 Strategic planning

In the strategic planning, the mode of transport is selected (Select mode of transport), i.e. a strategic consideration regarding how to transport the goods is made. In order to make this activity function properly Product information (nr.1) (access to information about possible services, prices, quality etc) and Performance information (nr.2) (a track's reliability and quality, e.g. punctuality at a certain track) are required. Improved access to this kind of information would lead to decreased transaction costs. The barrier to choose railway as a part of a transport chain will remain high as long as this kind of information is not made available in an easy way (cf. the many named and well-

defined services provided by the road transport operators and forwarders).

3.2 Tactical planning

The tactical planning consists of the activity build transport chain, including route planning and slot inquiry. In the tactical planning, the detailed transport alternatives are defined. This activity also requires access to reliable and relevant information regarding the Performance (nr.2), since operations on tracks with low performance need higher security margins for route planning. If the security margins could be decreased, the transport time may be reduced, which in turn could reduce the costs.

For the route planning, Running time (nr. 3) is required, i.e. how long time a train (given vehicle type, load and other influencing characteristics) needs to make a certain trip (given detailed information about the tracks' physical condition). Major operators own internal system for running time calculations. For minor operators it would be an improvement if they could calculate running time via the system that Banverket internally uses today for running time calculations. This would also improve the prerequisites for traffic management since the customers would have an incentive and possibility to provide Banverket with reliable data.

The tactical planning is depending on a flexible slot allocation process (nr. 4). Today, the process between train operators and Banverket is complicated, time consuming and inflexible. Planned track maintenance may affect the slot request process and, thus, timetable planning. Unawareness of planned maintenance leads to unnecessary slot requests from customers. Today the access to information of planned track jobs is unclear. A valuable service for the customers would be to be able to subscribe to changes on defined links, see Infrastructure information (nr. 5). Furthermore, the infrastructure information must be made available and accessible in different versions, i.e. when planning a transport that will take place in six months the infrastructure information used must contain data for that particular time.

From a customer's point of view, the time and the problems related to the slot request process are not acceptable, especially compared to the situation on the road transport market. The process is time-consuming and has a too long decision lead-time. Improved slot allocation process is probably one of the most important issues that need to be solved to improve the railway's possibilities to become stronger in the competition of freight operations with the road.

3.3 Production planning

During the production planning, supply and demand are matched and the allocation of the production means is carried out (e.g. staff, wagons and locomotives). An optimal allocation of production means requires correct information, or at least good estimates, on arrival times and possible deviations. A good ETA (Estimated Time of Arrival, nr.6) is required to be able to plan further utilisation of wagons and locomotives. In addition, access to performance information (nr.2) is required for this function. As mentioned earlier, operations on tracks with low performance need higher security margins for the allocation planning.

An optimal allocation of the transport means can make the difference between profit and loss for a transport operation. This is especially true for the allocation of locomotives since the locomotives constitute the major part of the production costs.

For the customers, the need for slots often changes after the timetable has been defined and additional slots must be requested (nr.7). From the customers' point of view, the time to get an additional slot is not acceptable, especially not if compared to how easy it is to hire additional trucking capacity.

3.4 Production

Production is the process where the need for information exchange is most obvious. Information to operators, forwarders and shippers about the goods' status (in certain cases limited to deviation reporting) is the basis for the logistics management. Within this area the most dominating customer demands have been identified.

Transport management requires information on Position data (nr.8), Deviation reporting (nr.9) and ETA (nr.6). The demands for this type of information vary. Some customers require only information regarding deviations, while others demand continuous position reporting, which implies that a future solution must be flexible in terms of information delivery. One of the cornerstones of transport management is information about where the goods are. This information has to be reliable and easily accessible, e.g. via system-to-system solutions.

Deviations from the timetable have to be reported to the customers in a structured way. Today the reporting is done by e-mail, but incompleteness often requires additional information acquired through informal networks over the phone.

ETA can be described as high value information. It is very important for a customer to know when a deviation occurs. For the customer to make a rational decision concerning possible counter measures, information is also needed regarding what consequences a deviation will be at the end of the transport chain.

Today the customers can not influence the actions that Banverket takes when deviation occurs, and therefore it would be beneficial if discussions regarding Priority (nr.10) between trains could be enabled.

The access to and the quality of information have a major impact on the customers' operations. Many customers have access to alternative transport systems; however, selecting the optimal alternative requires that the problems can be detected in an early stage.

3.5 Post-production

The post-production consist of financial administration and reporting of statistics. Today, payment of track fees is based on a system where the users of the railway network specify themselves how much they have used the network. An automatic billing system (nr.11) would reduce the administrative costs. The customers of Banverket have a certain reporting duty, and smaller customers would appreciate if Banverket could support this reporting (nr.12) by, e.g. a portal solution, which also could lead to reduced administrative costs.

4 COSTS AND BENEFITS OF INFORMATION EXCHANGE

When deciding on whether to invest in e.g. an IS (Information System) or not, it is important to measure and determine the monetary net value of the investment. The net gain can be assessed by subtracting costs (i.e. the resources required to create the necessary prerequisites, maintenance and training) from benefits (i.e. utility generated by the investment). An analysis of costs and benefits is often merely an approximation, but should be a good one if decisions are based upon its value. Some methods that are widely accepted are the various kinds of Cost-Benefit Analysis, CBA (Cronk and Fitzgerald, 1999). Methods such as CBA require that costs and benefits can be quantifiable and turned into monetary terms. Thus, the purpose of the investment must be defined along with its desired and expected outcome, i.e. the utility function must be identified. The investment referred to in this paper is the effort to collect, synthesise and make information accessible to the different customers of Banverket as well as Banverket itself. The underlying reason for using information in transports (to support the decision-making and management process) seems, however, to be neglected from time to time in favour of the rapid development of new technology. Hence, the question posed by Hultén and Bolin (Hultén and Bolin, 2002) is significant to consider:

"Is the information exchange improving the controllability of the logistics system?"

One important aspect of the study was to understand how the requested information at Banverket would bring value to the customer, i.e. we set out to understand the customers' utility functions. The study was, however, limited to understand the utility function at the customers without conducting an in-depth quantitative cost-benefit analysis.

4.1 Understanding the utility function

A utility function, or a pay-off function, is often associated with a mathematical formula describing the correlation between a state with

certain properties and the value this state would generate. In this context, a utility function merely refers to a description and argumentation of the importance of different properties, i.e. access to certain types of information and ability to use them, for the users of the information, i.e. the customers[3]. Despite the lack of precision, the utility functions reflect the magnitude of certain needs for information exchange.

To provide good customer service, it is important that the service provider fully understands the customers' different requirements, and also has an organisation to react upon them. For instance, a train with goods that are to be transferred onto a ship for further transportation, on a tight schedule, is more sensitive to delays than a train with goods that are scheduled with a waiting time in a terminal. However, this type of information is neither available to the traffic manager (Banverket), nor able to be included in the manager's decision-making process. In order to pinpoint the need for e.g. this kind of prioritisation information during traffic management, it is, however, desirable to achieve a more quantitative description of the usefulness of the information for the different actors, including Banverket. As will be mentioned below, this is associated with making difficult assumptions and delimitations on what to include and exclude.

4.2 Identifying and evaluating costs and benefits

The European project ROSETTA (Giannopoulos, 2001) addresses obstacles hampering ITS (Intelligent Transport Systems). One of the major obstacles is that ITS applications are developed without addressing the user needs. The other main obstacle is a lack of end-users' knowledge about ITS development. In the Baninfo study, focus has been on the end-users, and their understanding regarding the need for information to support their business.

In several research papers and project reports in the transport and logistics domain, including this one, benefits of information technology

[3] In this paper, the expected utilities for the customers are described together in the following chapter. A more customer-specific presentation can be found in the Swedish project report.

and information exchange are mentioned and advocated for. Rarely, an overview of the costs and the benefits is presented (Irani, 2002; Moberg et. al., 2002). The difficulties lie within the task of quantifying benefits and costs, and this is one of the reasons why many companies run into problems when trying to justify investments in IS (Information Systems) and IT (Information Technology) (Irani et. al., 1998).

The costs can be difficult to estimate, but the main challenge, though, is the calculation of benefits. The benefits need to be estimated since they are not always obvious and the positive effects may not appear right away. It is also hard to isolate the effect of one action from another as well as quantifying the cost for not doing the investment. While analysing the financial implications of an IS, decision-makers have realised the need for considering multiple criteria such as competitive advantage and future growth (Stewart and Rodney, 2002). When the benefits are distributed to such an extent, as in the case for customers of Banverket, a deeper analysis for each party might be necessary in order to gain understanding of how valuable the information is considered to be. This also pinpoints the significant difference between user's perception of usefulness and the "true", or more objective, opinion. Hence, it is not only difficult to calculate the benefits. There is also a lack of understanding regarding the notion of benefits. In the article Understanding "IS business value": derivation of dimensions (Cronk and Fitzgerald, 1999) this issue is addressed. Several different ways on how to look upon the business value added by an IS are described with comparisons. The methods vary between basing the value on user satisfaction, system objective fulfilment or ROI (Return On Investment) while others base it on the measured effect of information on the receiver or a combination of several evaluation methodologies. There are thus several ways to attack this.

The focus of this study is primarily on the customers' demands on improved information exchange and their benefits. Banverket, on the other hand, will also benefit from an increased and improved information exchange. Traditionally, the primary task of the rail traffic management is security maintenance, and the second is the optimisation of capacity. The user needs identified in the study stress that a third task is highly important for the traffic management, i.e. to

support the customers' planning and operational decision-making. However, this is still a controversial view and before it has been fully accepted, it will be very difficult to quantify the customers' benefits. As mentioned earlier, there have been some major structural changes within railway transportation due to deregulation and the players are trying to adapt.

Since techniques such as CBA are not always applicable, there are other techniques that also tries to capture the net gain but in a different way. One such technique is Cost-Effectiveness Analysis (CEA) that tries to quantify the gain in other tailored units (Belli et. al., 2001) than money. A pure CEA is not appropriate either at this point, but if the impact of some of the information types can be modelled and simulated (e.g. earlier access to accurate disturbance information and ETA), then it would be possible to get a hint on the usefulness in terms of e.g. reduced total delay in the transport chains and increased robustness.

4.3 Overview of potential effects identified in the study

The results from the study show that improved exchange of information can lead to a number of benefits for the customers. Having routines and automated information systems for data collection and data filtering tailored to customers' need, would take less effort from Banverket to satisfy immediate information demand. Furthermore, information inconsistencies can be reduced and to some point replace the need for personal contacts and informal networks, which are one of the primary sources of information for some actors today (Gustafsson and Törnquist, 2002).

Access to accurate information regarding performance indicators on parts of the network and characteristics, and status of the different parts of the network for a specific time frame, would increase possibilities for effective planning. Comparisons on different transport concepts can then more easily be done and their robustness may be evaluated. Furthermore, redundant request for impossible slots can be avoided to some extent and the planning can be carried out according to the conditions that apply to that specific time frame. The prerequisites for a shorter and more effective slot allocation on both long and short term

are then improved, which is necessary to make railway transportation more flexible to use.

The ability to perform reliable transport plans within a short time frame is necessary, but being able to monitor and control the transports are also crucial. Receiving accurate data is useful for follow-ups and feedback to following planning cycles, but more important is to know if anything unexpected occurs and if so, what the consequences will be. Tracking one train set can be done in several ways, but getting information about the consequences (i.e. new ETA) about a disturbance in the timetable can only the traffic manager be responsible for.

Access to the right information and well-defined ways of communication provide, among several other advantages, a possibility to achieve:

- Better use of capacity in the railway network.
- Reduced need for iterative slot requests and decision lead-time.
- Improved utilisation of production means and more robust transport concepts.
- Reduced transportation time.
- Improved quality of the logistics service through increased transparency.
- Improved customer service and customer satisfaction.

All of the above benefits would support the overall competitiveness of rail transportation, which serves the goal of supporting intermodal transportation.

4.4 Possibilities to meet identified demands

As mentioned earlier, not only the desires of the customers in the interview group were considered, but also to what extent the wishes and demands can be satisfied with existing conditions and what adjustments need to be carried out to meet additional requirements. In Appendix A, an overview can be seen of the customers' demands as well as a rough description of the required changes at Banverket to fulfil those. The table describes both the changes that are related to organisational changes as well as those of a more system-related

technical nature. The requirements are also connected to their functionality in the management process of the actors as described in Figure 3. Nr. 11 and 12 are already under investigation at Banverket within the process of implementing a system named OPERA.

Nr. 4 and 6 have been identified by the project as more challenging to achieve than the others. The main reason why timetable production and ETA have been classified as difficult to satisfy is their complex nature. Timetable production is complex from an organisational point of view due to a decentralised traffic management and planning process, and with regard to the large size of the problem. Creating ETA is, primarily, a technical challenge, but also depending on organisational issues of e.g. coordination between decentralised traffic management centres, and the access to and presentation of the required traffic information.

In Figure 4a-c, an illustration is presented to show how sensitive the train traffic system is to disturbances, and why there is a need for support in calculating ETA. The illustration shows three time-node charts with three train routes and how they all become affected when one (train B that is starting at city B) is deviating from its timetable. This is a very simplified example, but it shows how complicated it is to decide which train to go first and how the system as a whole suffers. Between two vertical lines is one block, which only one train at a time is allowed to occupy. Thus, two train paths can only cross each other at a vertical line – not in between two lines. So, when train B is delayed, it is deviating from its original timetable (the straight line) and the traffic manager is forced to re-plan the timetable. Since several trains share the same railway network, they also get affected since their timetable is depending on the other trains' timetables.

Train B is allocated a new timetable that generates the dotted train path. Since that path is interfering with the other non-deviating train paths, also these start deviating and each gets an alternate dotted train path. So, one delay of two time units at one block for one train, is causing two non-deviating trains a delay of 2,5 time units each if the disturbance is solved in that way. Imagine a larger network with additional trains, less meeting possibilities between blocks and a

decentralised traffic management where one part is handling the network between city A and B, another between B and C, and so forth.

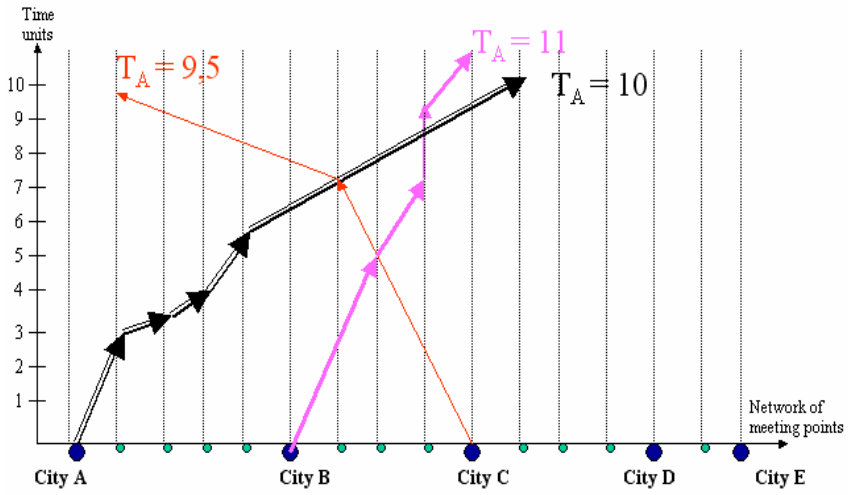

Figure 4a. Initial timetabe for the trains.

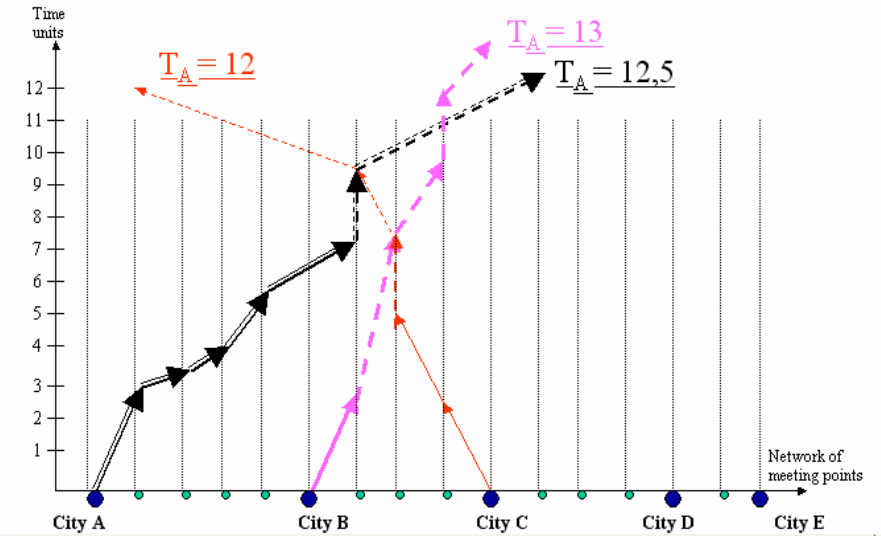

Figure 4b. Resulting outcome due to a disturbance.

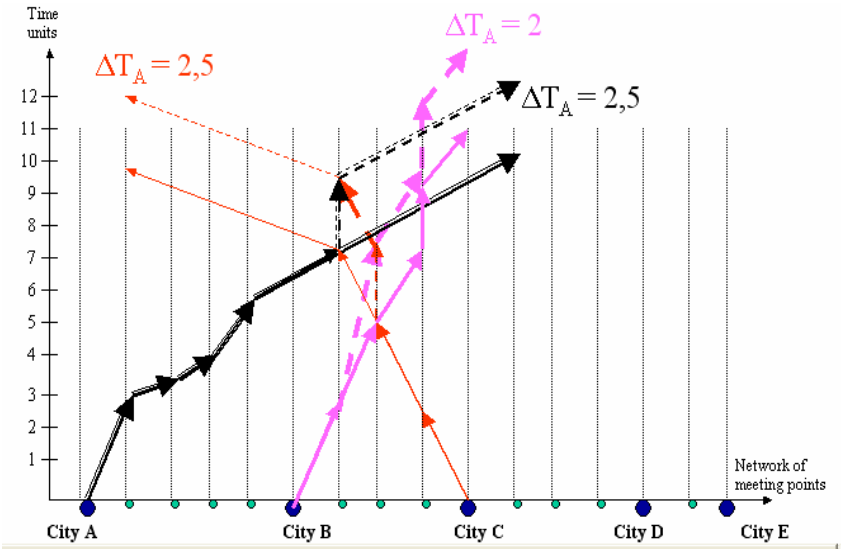

Figure 4c. Comparison between initial plan and real outcome.

The need for a possibility to calculate ETA and simulate consequences of different potential measures, is obvious for several reasons:

- An accurate ETA given in an early stage of the disturbance can provide information for the transport operators to take measures and limit their negative impacts that may propagate into their intermodal transport network and their customers' production plans.
- The traffic management can evaluate different measures and to some point predict the propagation of the disturbance to other parts of the railway network by the simulation.
- Strategies can be evaluated at a strategic level to determine how to prioritise different types of trains and simulate the effect of one single disturbance.

The overall quality of intermodal transports is depending on several activities in the transport chain. A delayed train can, among other things, as part of an intermodal transport chain generate:

- Overtime for the staff
- Unavailable resources due to failed schedule of resource allocation
- Propagating disturbances in other parts of the traffic network or transport system
- Customer dissatisfaction

As mentioned, a realisation of such a decision support system (DSS) would be quite complex and require several challenging issues to be addressed and solved. A more detailed outline of this challenging area can be found in (Törnquist and Davidsson, 2002)

5 CONCLUSIONS

The results from Baninfo show that the current situation is far from ideal. Banverket is not yet able to provide its customer with the information available in their internal systems (e.g. position of train, priority decisions, and performance indicators), well-defined information exchange is not possible between the actors, and there is no clear organisation at Banverket to support the customers. The customers have designed their operations to work with poor access to information, i.e. within the transport chain large inefficiencies are built in, and informal networks substitute a proper information exchange. However, these conditions are the heritage from the time when each country regulated its own railway traffic. When SJ and Banverket was one and the same company with common information systems and had monopoly, the prerequisites were different. Today, competence, as well as information systems, is split up due to the liberalisation. A study made by NIM (Nordic Infrastructure Managers) from 2001 concludes it:

"The current processes and arrangements were developed at the time of monolithic national railways and are not intended to be commercial. The weaknesses of these arrangements in the changing environment are becoming increasingly clear" (NIM, 2001).

It is difficult to determine which information that is most important of the ones listed, since all processes affect the outcome. In best cases, could improved planning reduce the numbers of disturbances to such an

extent that large deviations can be avoided and thus, information during operations becomes redundant. One hint of the customers' view, however, can be derived from a workshop arranged by Banverket for the main operators in Sweden, on October 8, 2002. Banverket presented ongoing and planned efforts for improving the access to information. The operators were asked to prioritise which improvements should be carried out next. The production of timetable, quality of production data and improved descriptions of the railway infrastructure were given highest priority by the operators.

The results from the project showed that a number of the customers' needs regarding an improved information exchange and access to services can be satisfied with relatively small changes (organisational as well as system related) within Banverket. An example of organisational changes is to create clear structures about where/by whom the information can be received. A new information system (OPERA) developed by Banverket opens up new possibilities for a number of applications (e.g. positioning data, external production system for smaller customers, statistics and performance) that correspond to some of the needs of the customers. Such information should be accessible to the customers via different channels (web interface and system to system).

A prerequisite for the fulfilment of other customer demands is improved access and quality of the internal information. Information about the traffic situation has to cover the entire network of tracks, and systems for decision support are required in order to be able to calculate arrival times and forecast the consequences of disturbances. Yet, this assumes that the operators deliver accurate information, e.g. regarding vehicle characteristics. Responsibility of information accuracy and confidentiality are two issues that will rise. Such considerations, however, are beyond the scope of the project Baninfo and this paper, but need to be addressed in the future.

All the identified customer demands have to be fulfilled in the long run in order to make the railroad a competitive alternative to road transport. The selection criteria outlined earlier pinpointed the importance of price, transport time, reliability, flexibility and degree of environmental

impact. Railway transports are not expensive per se. There are, however, additional costs due to terminal handling and other attendant costs. Regarding transport time, railway transportation could become better if the average speed would increase, which in turn depend on the strain in the network, the interoperability between systems of different nations and time spent on e.g. shunting, etc. The reliability can also be significantly improved, as pointed out before, if more accurate planning is made as well as if there are decision support working at both a strategic level to simulate and evaluate the network and create appropriate principles for managing the traffic, and in real-time receive information on network forecasts. Flexibility can also be improved if the contact towards customers becomes clearer as well as if the customers are able to access information by themselves and evaluate different concepts. This can also reduce the inertia for considering and comparing new transport concepts as well as increase the possibility for new customers to get information about what the railway can offer.

The railway has for a long time and by many, not all, being considered to have less impact on the environment than road transports. The railway is not involved in accidents with personal injuries like road transports, and does not contaminate in the same way by noise and pollution. This, in parallel with its ability to carry large and heavy amount of cargo, have been the railway's main advantages.

The benefits of using information to co-ordinate transport chains have been studied in several projects. An increase in the number of involved parties makes use and sharing of information more complex. In railway traffic, however, the infrastructure manager plays an important role as neutral and within the authority of control. In road transports, for example, an equivalent and central role is missing which makes it more difficult, but not less important. To promote intermodal transports, effective information flow in all transport modes is important for the whole chain.

Even though this paper, and the research behind it, has limited the study of benefits to a qualitative analysis of the customers' demands and without quantifying their utility, we find it most important to turn the results into comparable and practical units. An increased and

improved information exchange is only one measure to improve the competitiveness of railway and intermodal transports. A more market-oriented approach with e.g. product differentiation by offering high value slots to a higher price with higher priority during operations could be another step in the right direction. Other problems that need to be addressed are insufficient capacity in parts of the train traffic networks, technical differences and conflicts between public and freight railway transports. Policies and regulations need also to be adjusted. As mentioned earlier, there is an outspoken and declared desire of increasing the use of railway transportation by the EU, and at the same time there are problems managing the existing traffic.

6 *FURTHER RESEARCH*

The EU has decided to financially supported research within this area and one of these research projects is INFOLOG (Källström, 2000), whose results have been further used in the ongoing EU-project D2D[4]. D2D (Door-to-Door) has the intention of implementing a transport chain management system in five European intermodal transport chains to show that intermodal transportation can achieve the same level of efficiency and quality as pure road transports. One important issue is how existing information can be shared to benefit multiple actors, and the importance of integrating traffic information with transport information from various parties. However, as expected, the characteristics of the infrastructure management and the railway transport business differ among the European countries on different levels. Hence, the varying prerequisites have to be studied as well as how these can be integrated to make international railway and intermodal transports smoother to use.

Furthermore, robustness of railway traffic networks and transport systems will be investigated. The robustness can be evaluated on different levels by exposing the traffic and transport system to disturbances and simulating the effects. Considering robustness from a transport perspective would be to analyse a transport's impact on the traffic flow and vice versa. From a traffic point of view, the relationship between and magnitude (in time) of primary and secondary disturbances will be investigated as well as the effects of the principles used during traffic management of disturbances, see (Törnquist and Davidsson, 2002).

[4] Further information can be found at http://prosjekt.marintek.sintef.no/d2d/.

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9 APPENDIX A

Table from Baninfo presenting customer demands and required changes.

Nr	*Information type*	*Organisational changes*	*Technical changes*
1	Product information	Key account; a person who co-ordinates price with product characteristics and conditions, and communicate it to the customers.	Updated infrastructure information in different versions (nr. 5)
2	Performance indicator	Key account.	Accessibility to statistics with ability to filter and sort depending on several parameters.
3	Running time calculation	System manager for a transport scenario simulator.	Transport scenario simulator with access to time-dependent infrastructure information (nr. 5), performance indicator (nr. 2), etc.
4	Simplified slot allocation process.	Key account. Clearer decision-making. Better contact between traffic management and network maintenance unit.	Infrastructure information (nr. 5) Communication systems Reliable data from customers'
5	Infrastructure information.	Better contact between traffic management and network maintenance unit.	Infrastructure information in different versions depending on time frames in focus.
6	ETA (Estimated Time of Arrival).	System manager for decision-support system.	Decision-support system for calculation/simulation of ETA of different parts of the network.
7	Short term slot requests.	Routines for quick decision-making. See also nr. 4.	See nr. 4.
8	Positioning data.	Marketing of existing information.	Adjustments and improvements of existing information collection and accessibility.
9	Structured deviation reporting.	Key account (co-ordinator of information and intermediary). Formalised agreement on what to report and when.	Development of existing system to include more specific information regarding causes and consequences (see nr. 6).
10	Prioritisation during disturbances.	Routines for efficient co-operation and communication between traffic management centres and customers.	System for analysis of consequences (nr. 6). Platform for discussion of priorities.
11	Statistics for financial administration.	Key account.	Possible adjustments to OPERA and standardised tailoring possibilities for all customers. Possibilities to collect the information required.
12	Statistics reporting.	Key account.	See nr. 11.

PAPER 3

IMPROVING THE QUALITY OF INTERMODAL TRANSPORTS – USER REQUIREMENTS ON TRANSPORT CHAIN MANAGEMENT SYSTEMS

Proceedings, 9th ITS world conference, Madrid 2003

IMPROVING THE QUALITY OF INTERMODAL TRANSPORTS

– USER REQUIREMENTS ON TRANSPORT CHAIN MANAGEMENT SYSTEMS

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SUMMARY

Transport Chain Management Systems can support the planning and monitoring of intermodal transport chains making them a real alternative to pure road transports. The success of such systems depends on the ability to collect the required information – a challenge often more of an organisational nature than a technical. Once a reliable information access is secured the information can bring added value to multiple users for different kind of functions, e.g. Supply Chain Security, controlling and simulations.

INTRODUCTION

In the last 20 years, the road share of European freight transport has increased from 30% to almost 45% whilst rail has decreased from 21% to 8%. The transport buyers evidently prefer truck transport, but this causes problems for society in the form of congestion and a high death toll on European roads. The desired solution is to optimise the use of transport resources totally, utilising all forms of transport: road, rail, inland waterways and short sea shipping. If multimodal transport is to become a serious alternative to truck transport, the use of multimodal transport must be as efficient and as easy to use.

A significant amount of international research over the last years has focused on the development of an Intelligent Transport System. Most of these developments, have been orientated towards road transport and transportation of people. (In cars, ITS systems help drivers navigate, avoid traffic hold-ups and avoid collisions. On trains and buses, they let managers optimise fleet operation and offer passengers automatic ticketing and real-time running information. On the road network, ITS systems co-ordinate traffic signals, detect and manage incidents and display information, guidance and instructions to drivers.). On the freight transport sector the development has been partly different. During the last years a number of supply chain concepts and supply chain IT tools have been developed. However, the major part of this development has focused on single modes transport.

PROBLEM DOMAIN

In order to reduce the external cost and to ensure that European industry improves its competitive advantage, it is important to make better use of the total transport infrastructure. Hence, combined transport, or multimodal freight transport would be the solution. However, according to a working group of the European Freight and Logistics Leaders Club [1] the user confidence in intermodal transport is limited. The working group claims that single shipments / loads are extremely difficult to manage and that there is a lack of suitable ICT systems providing punctual and reliable information. The systems that

are available on the market today are primarily single-mode and not multi-mode oriented, which means that mostly trucking services or intermodal services based on rail (and offered as one package by an intermodal operator) are being used.

D2D – Demonstration of an integrated management and communication system for door-to-door intermodal freight transport operations is a research and demonstration project running under the 5th framework programme of the European Commission [2]. The project is demonstrating how to efficiently organise and manage intermodal door-to-door transport chains by using logistics management and communication systems, the D2D system. The D2D system contains two sub-systems; the Transport Chain Management System (TCMS) and the Freight Transport Monitoring System (FTMS).

This paper focus on describing the required functionality on a logistics management and communication systems based on the findings from the D2D project as well as an analysis of the information required to fulfil those.

METHODOLOGY

In order to achieve its objective, the D2D project is conducting a business modelling including analysis of real-life transport chains to derive the necessary requirements for logistics management systems including tracking and tracing capabilities. The requirements serve as input for developing the D2D system. The 5 transport chains chosen for demonstration of the system and technology are:

- John Deere farming equipment from Mannheim (Germany) to dealers in Australia.
- VW cars from Wolfsburg (Germany) to Istanbul.
- Elkem containers from Salten (Norway) to customer in Rheinfelden (Germany)
- PAMESA general cargo from Pamesa (Spain) to warehouse in Cegrisa (Las Palmas).
- UNIFAC general cargo from Lisbon and Tagus Valey (Portugal) to customers in Azores Islands.

For all chains an "as is" description was carried out. This included a mapping of all activities, information exchanges and use of IT systems. All main processes were identified and broken down into sub-processes that were broken down into work flow diagrams. As a second step the as-is situation was analysed and weaknesses derived. Based on the findings a re-engineering took place and the "to-be" situation was mapped using the same methodology as for the "as-is" mapping. In the "to-be" models the transport chain manager role was introduced as well as the D2D system and its functions. Figure 1 illustrates examples from the business modelling, ELKEM case.

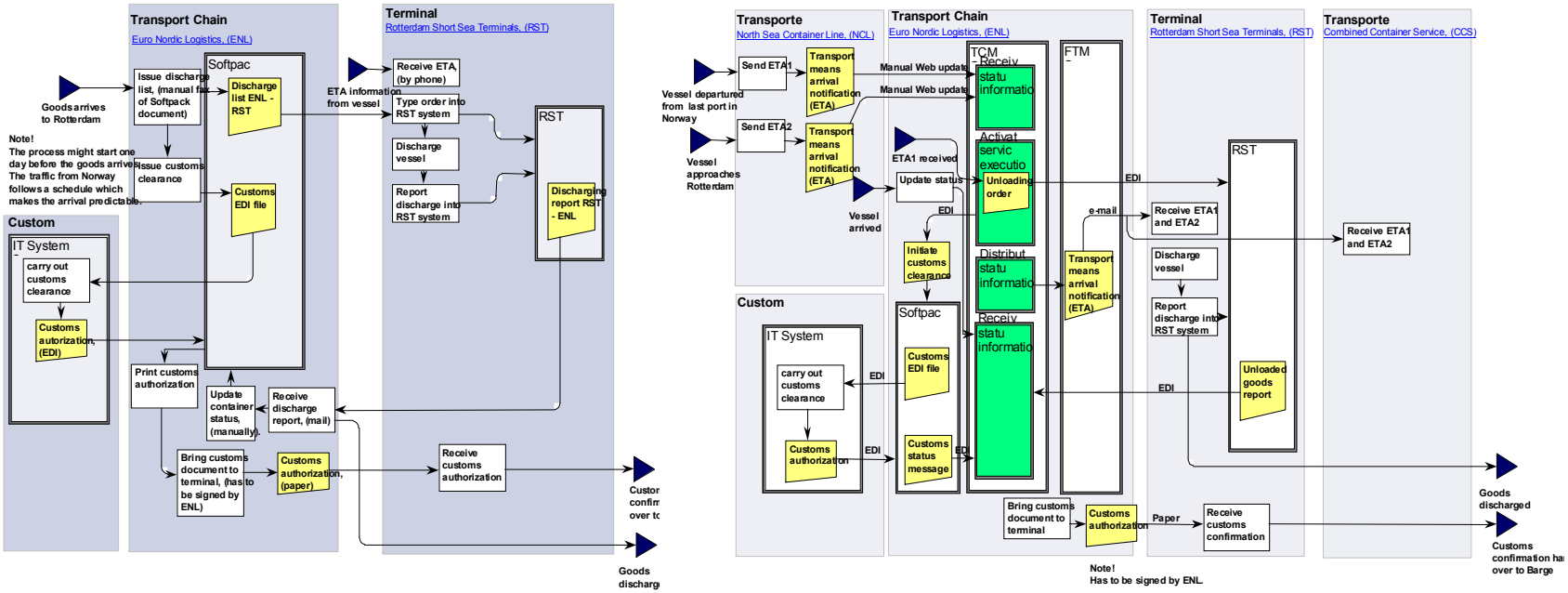

Figure 1: Example from the business modelling. The process ”Manage discharge and customs clearance” ”as-is” and ”to-be”

THE CONCEPT OF THE TRANSPORT CHAIN MANAGER

The European research project INFOLOG [2] addressed the obstacles in integrating several transport modes, and the importance of using improved information flows to overcome them. One of the findings was the concept of the Transport Chain Manager – a role that ensures existing information can be used to monitor an intermodal transport chain and be shared to benefit multiple actors. Traditionally an intermodal transport chain is organised and monitored by a number of actors leading to multiple information flows, see Figure 2. The concept of sending information along the transport chain is very vulnerable - if one actor fail to send the correct information in time, the performance of the complete chain can be endangered. The concept of the Transport Chain Manager has been further developed in D2D and is illustrated in Figure 3.

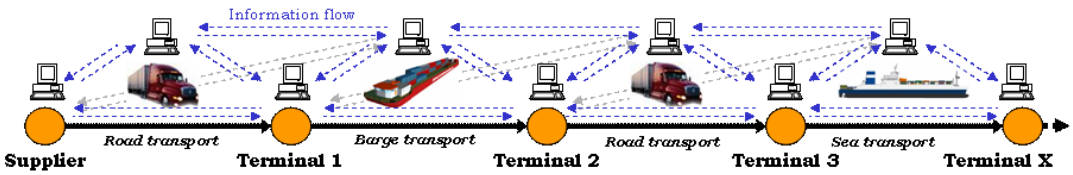

Figure 2: Traditional organisation and monitoring of a intermodal transport chain.

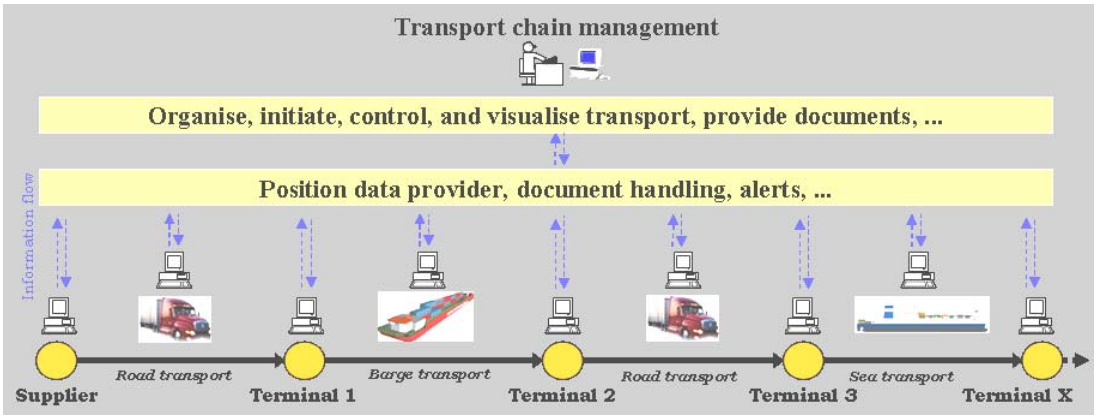

Figure 3: Introducing the Transport Chain Manager.

Intermodal transport chains are complex by nature due to the numbers of actors involved. The execution of an intermodal transport chain requires collaboration between multi actors business processes. Such collaboration normally requires a driving force that sets up the environment for the collaboration. In this case the transport chain manager fulfils this role.

REQUIRED FUNCTIONALITY ON A LOGISTICS MANAGEMENT AND COMMUNICATION SYSTEM

The D2D system was designed to support the Transport Chain Manager. The main functionality of the D2D system can be summarised as:

- **Organising transport**. This is facilitated by enabling the definition of a transport chain through describing a set of services that must be executed in order for the transport to be performed smoothly. In practice this means handling of contracts, quality indicators, time-tables etc. The services thus defined and linked may or may not be involved in the physical handling of cargo (a customs office is an example of an actor in the transport chain that is important to the success of smooth transport, but that does not handle the cargo, only the documentation related to the transport). When the chain is defined, the services may be booked automatically through the exchange of electronic booking and confirmation messages. Booking can be triggered by an ERP-system, by a stock-control system in a warehouse, or by a client application designed for booking.
- **Providing documents**. The different service providers along the Transport Chain need different forms of documents in order to ensure that the transport is performed efficiently and legally. These documents are distributed to the different actors when they are needed. Product documents may also be transmitted to the receiver of the cargo. One example is a certificate documenting the quality of the product.

- **Monitoring and controlling** the transport. It is important that the Transport Chain Manager (TCM) has a complete understanding of the status of the transport and the cargo at all times, even if it might not always necessary to inform the cargo owner. It is particularly important that information regarding irregularities in the transport chain compared to the agreed schedule is made available as soon as possible. If the deviation from the schedule is unacceptable, the transport must be reorganised, by using the same functions that was used to organise the transport in the first place. If the deviation is acceptable, information about it should still be communicated to the actors in the remaining part of the chain, and to the consignee .
- **Visualising the status**. As indicated in the previous paragraph, many people may be interested in learning the status of the transport. In order to make the multi-modal transport chain more transparent, this status is made available to the authorised people. Such visualisation may be achieved through exchanging messages or through WEB technology. The D2D system has both capabilities.

THE IMPORTANCE OF INFORMATION

Common for all activities carried out by the Transport Chain Manager is adequate access to information. In the Swedish research project BANINFO [4] an in-depth analysis was carried out on the required information exchange between a railway infrastructure operator and the railway's customers. Being able to monitor and control the flow of transports in real-time, puts high demands on accessing status information and reliable prognoses if unexpected events occur. Gaining knowledge about the performance of past operations, such as punctuality statistic, is also important. With this in mind, the BANINFO project chose to investigate the customer's information requirements during the following five processes; strategic planning, tactical planning, production planning, production and post-production. The processes are illustrated in Figure 4, where strategic planning refers to planning on relatively long term, while tactical are midterm and production planning short term. Production refers to the level where operations are carried out in real-time and post-operation is the

level where information collected during operations is evaluated and synthesised.

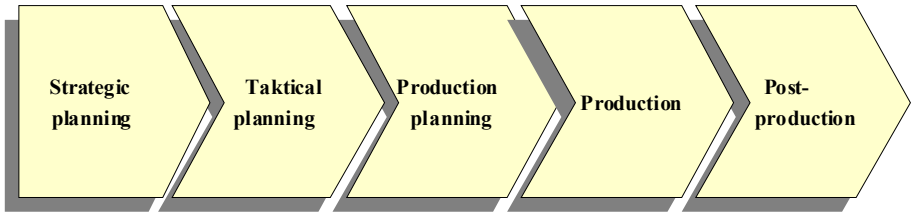

Figure 4: Process model for analysing the information requirements

The model developed in BANINFO corresponds well to the concept of the Transport Chain Manager. The **planning** process (strategic, tactical and production planning, corresponds to the D2D functionality "organising transport"). In the planning processes information regarding the services is needed which primarily is based on static infrastructure information and commercial information. The infrastructure information should be available and accessible in different versions, i.e. when planning a transport that will take place in six months the infrastructure information used must contain data for that particular time.

The commercial information includes both timetables and contracts defining prices, service levels and contract terms.

The **Production** process corresponds to the D2D functionalities "Provide documents", "Monitoring and Controlling" and "Visualise the status". During production the visibility of the transport chain is crucial. In this context visibility stands for knowledge about the status of the goods items in the transport chain in real time, i.e. the position of a certain identity, temperature, damages etc.

This information is closely related to T&T (Tracking and Tracing) where *Tracking* stands for "the ability to determine the position of a goods item during the transport" and *Tracing* for "the ability to determine the history of a goods item during the transport process", [5]. Other parameters that can be included in T&T concepts are speed, temperature, direction, etc. Much research has been carried out in the field of T&T both regarding the concept of T&T and on feasible

solutions. Van Dorp [6] provides an extensive overview of the understanding of Tracing and Tracing showing that no uniform understanding exist.

There is also a proactive element to visibility, if it includes knowledge about the upcoming performance of the transport, i.e. will it fulfil the planned tasks, e.g. arrive at the right time in the right condition or will there be a disruption in the transport chain? In case of disturbances it is important that the system is able to evaluate downstream activities that would be effected and provide decision support to minimise the effects. The integration of traffic information from traffic management systems from the relevant modes as well as other production disturbances are important elements for a high quality of this kind of analysis.

Today, highly developed T&T technology does not exist in many transport chains. This was confirmed through the business modelling of the transport chains in the D2D project. None of the chains has the required technology for fulfilling the requirements of tracking [5]. For the visibility of a transport chain a mature tracking system is evidently the best option but when not available, other sources of information can be highly valuable. One of the tasks of the re-engineering of the ELEKM chain was to identify status points in which a report to the D2D system was required to achieve a minimum visibility standard. Figure 5 illustrates the 16 identified status points.

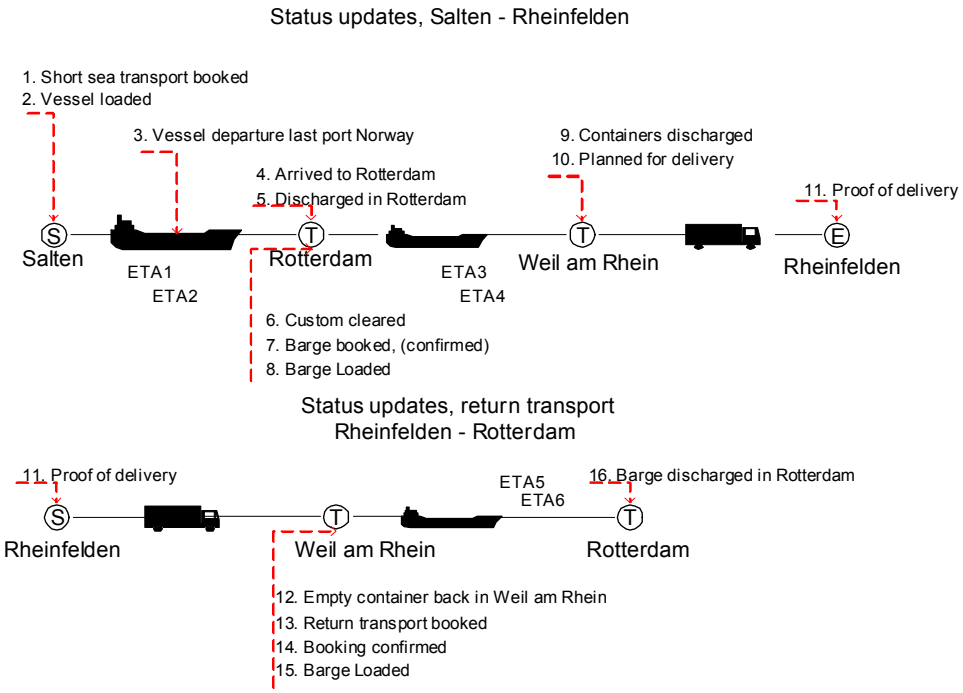

Figure 5: Identified status points in the ELKEM chain

As the figure illustrates, the 16 identified status points consist of a number of different information sources, e.g. loading reports, customs clearance reports, booking confirmations, etc.. Most of the identified status points exist but are today not used for visibility purposes, e.g. loading reports are produced but not reported to the customer on a real time basis. The analysis of the chain showed that in some cases the required information existed in electronic form but it is also common that paper documents are sent faxed.

For the visibility it is crucial that the status information is reported to the system in real time. As the figure indicated, a number of different actors are required to report the status to the D2D system for achieving the required visibility.

The reporting of the status information is complicated by the fact that the information exist in different systems and in different data structures. A number of attempts exist, e.g. under the initiative of the European Commission, i.e. SITS and Parcel Call, that sets out to develop platforms for seamless tracking and tracing through

standardised interfaces. Such approaches still have to proven especially regarding issues like willingness to pay and who the operator should be of such a platform. In the D2D project this issue is solved by the FTMS system.

Post-production. With a well running reporting of information in the previous processes the post production is mainly about evaluation of the existing information and providing feedback to the planning process. For the post-production a mixture of information from the planning (the contractual agreements) and the production (the actual status information) is needed to conduct the performance calculations.

ADDITIONAL VALUE OF A LOGISTICS MANAGEMENT AND COMMUNICATION SYSTEM

The value of the D2D system goes beyond supporting the Transport Chain Manager in the planning and monitoring of transport chains. Indeed the system should provide support to the company's strategy, production planning and customer relation programmes.

Below some examples on how the information collected for visibility during the actual transport can be used.

Performance management A well defined performance management including the right key numbers can enable monitoring and analysis of the performances on an actor level or even on a process/activity level of both the internal logistics functions and external providers, e.g. carriers and 3PLs. Thereby providing input for the development of new strategies and organisation of the processes with the goal to improve the total quality and efficiency of the transport chain. Performance management is identified as one of the core capabilities for achieving competitive advantage in "The Logistics Footprint – Creating a Road Map to Excellence" [7]. By including a financial component to the performance management, important input for **Controlling** can be gained.

Supply Chain Security. By keeping track of the transport and the handling during the transport an audit trail can be created for the shipment and an eventual electronic seal, which can speed up the handling at customs. Also compliance with the 24-hours requirement of the US customs can be supported through usage of documentation such as packing lists or a complete event trail available in the D2D system.

The collected information can also provide sophisticated material for **simulations**. Using the available performance information (in contrast to the planned performance, e.g. time according to time table) on individual transport services the expected performance of door-to-door transport chains can be simulated. Also questions of "what-if" nature need to be analysed both to create preparedness for acting when

disturbances occur and to support decisions between alternative solutions.

Some of the additional functionalities, e.g. controlling and performance management is of advantage also for actors other than the transport chain manager. During the business modelling, operators in the transport chains claimed their interest in having access to information collected during the transport for their internal use. Given the flexible structure of the D2D system it is possible to define which actor is allowed to access what information.

DISCUSSION AND CONCLUSIONS

The research in the D2D system sets out to illustrate that advanced IT support can bring intermodal transports to a more competitive situation towards pure road transportation.

The market of logistic management and communication systems are emerging. Common to all systems are that their success depends on reliable access to the required information.

To reach visibility in the transport chain information must be, collected, reported and evaluated over multi actors business processes. This requires close co-operation between the actors in the transport chain. Results from D2D shows that information often exist but it is not used for visibility purposes. One way to enhance the co-operation is to give the information providers access to information of interest for, e.g. internal planning of resources and work, control of sub-contractors etc. This can be solved either by push or pull solutions depending on the actors needs.

Some of the functionalities of logistic management and communication systems requires input from traffic management systems as well as information on the infrastructure but today infrastructure operators lack knowledge about the users processes and their needs. Research carried out in Michigan, US [8] indicated that integration of real time road traffic congestion information with vehicle routing leads to 7% cost

savings and 11% decrease in usage time for the trucking industry when used in a congested traffic environment.

The European Thematic Network THEMIS points out the importance of integrating traffic information with transport information from various parties. However the results [9] have shown that the awareness of the advantages in using both transport and traffic information increases, yet the possibilities for implementations are poorly developed.

When sufficient information is available, a number or of additional functions distributed over a number of different users since the information allows the users to mine data for, e.g. strategic and tactical decisions.

FURTHER RESEARCH

The work carried out in D2D will be one of the building stones in a PhD thesis which will focus on information in transport chains. The research will be extended to analyse the role of interaction with traffic management data and which role authorities are to play for improving the conditions for intermodal transport.

Within the D2D project the development of the systems continues in parallel to implementation of the system in the transport chains. Special focus will be given to designing a concept of low cost reporting of status data, a user friendly simulation module and a module for exception handling .

ACKNOWLEDGEMENTS

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PAPER 4

DECISION SUPPORT FOR HANDLING UNCERTAINTY IN INTERMODAL TRANSPORT CHAINS: A CASE STUDY

Submitted for publications.

DECISION SUPPORT FOR HANDLING UNCERTAINTY IN INTERMODAL TRANSPORT CHAINS: A CASE STUDY

Johanna Törnquist and Inger Gustafsson

ABSTRACT

Intermodal transport chains involve multiple actors, a fact which complicates overview and control. Experience shows that many problems in intermodal freight transportation are related to the absence of an overall coordination mechanism providing the ability to consider and act on the complete chain instead of each individual part. Analysing a large amount of interconnected activities over a certain time period is difficult without the assistance of some kind of decision support system (DSS). In the D2D (Door-to-Door) project, which focuses on the management of intermodal freight transport chains, five case studies have confirmed the need for such a DSS. The idea is to investigate how discrete-event simulations (DES) can be used for evaluations of costs, performance and robustness of alternative transport chains, thus providing an opportunity to compare different chains. This paper suggests a first step towards realisation of a DSS, by providing a modelling approach of a transport chain and a design of some decision support functionalities.

1 INTRODUCTION

Intermodal transportation is an important transport option in the face of increasing road capacity problems in many parts of Europe, and the corresponding delays and uncertainty experienced by consignors and consignees. One of the current political transport philosophies is, due to the situation, to increase the use of intermodal transportation, i.e. use rail and waterborne transports for long distance and road transports for feeder transports, where appropriate. Intermodal transportation can be defined as any combination of transport modes where the loading unit (Intermodal Transport Unit, ITU) stays the same throughout the entire chain. In this paper, we exclude air transportation when we discuss the concept of intermodality, but normally can air transports be included.

Some of the strengths of intermodal transportation are (European Commission, 2003):

- Available capacity for railway transports, inland- and short sea shipping.
- Potentially less environmental impact than road transportation.
- Fewer accidents.
- High potential for scale effects when flows of cargo are co-ordinated.

Some of the difficulties related to intermodal transportation are:

- High complexity due to a large number of actors involved.
- Low performance for railway transportation.
- Expensive and time consuming handling when changing mode of transport.
- Heavy administrative processes if borders are to be crossed due to the fact that different national regulations have not yet been harmonised.

Many agree that it is challenging to co-ordinate the many actors involved and the large number of activities that take place within intermodal transport chains (TCs). Traditionally, the different parts of a TC have been handled as mainly separate events that need to be

planned for and carried out in the best way possible. Experience (Bürckert, 2000; D'Este, 1996; D2D, 2003b; PISCES, 2000) show that the integration of the different links in a transport chain is insufficient. The large number of factors and actors to take into account provide little insight in what actually happens and where the time is spent. According to an overview of transport chain lead-time (D2D, 2003b), for one of the cases in D2D, the relation between active and passive time is 67 % and 33 %, respectively. To form an opinion on whether or not this is an acceptable number, in-depth analysis need be carried out.

Regarding transport chain planning in general, if the true prerequisites for a TC could be investigated and potential built-in flaws identified, problems could be addressed in the planning stage instead of having to observe (and suffer from) their impacts during operations. Slack providing no robustness could instead be introduced somewhere else or reduced. An analysis of the overall and piecewise performance of TCs is, hence, highly important. Impact of random occurrences is always a challenge, however, but an increased awareness of their influence and possible appearance will most likely improve the ability to handle them.

Based on several case studies provided by the D2D-project, this paper will present a decision support approach suggesting a way for intermodal transport chain managers to handle the uncertainty in the transport chain planning and validation, i.e. a decision support system (DSS). The paper investigates how simulation can address the particular requirements identified in the case studies, and what these requirements would imply in practice. Much research has been done on how to increase performance in terminals and transportation systems, but the overall management of intermodal transport chains has rarely been considered.

The background as well as the terminology used is presented in the next chapter, followed by an overview of the problem domain in Chapter 3. Chapter 4 addresses briefly the use of simulation in the transport domain and related research work. Chapter 5 outlines the result from the requirements elicitation regarding the DSS, and Chapter 6 presents an initial design of the DSS functionalities. Chapter 7

contains a discussion concerning the utility of the DSS, while Chapter 8 presents and discusses the findings. Finally, Chapter 9 suggests topics for future research.

2 BACKGROUND AND TERMINOLOGY

The transport users' choice of a particular transport solution is based on the evaluation of a number of performance criteria, of which the primary ones are referred to as key performance indicators (KPIs). Common KPIs are cost, reliability, lead-time and likelihood of damages. Today, intermodal transport chains often have difficulties to meet customer's performance criteria when compared to other transport options. The challenge in improving the performance by analysing the true prerequisites is the kernel of the D2D (Door-to-Door) project (D2D, 2003a). The D2D project and the case studies it is based on are described below.

2.1 Transport chain management system

D2D focuses on the role of an overall intermodal transport chain coordinator – a *Transport Chain Manager (TCM)*, and the main intention is to demonstrate a management support system for the TCM – the *Transport Chain Management System (TCMS)*.

The main functionality of the TCMS is to facilitate the organisation, monitoring, control and evaluation of transport chains, and the development of the TCMS is based on the requirements of five cases (i.e. intermodal transport chains and involved actors). Some of the prospective users of the TCMS in D2D have also, in addition to the primary functionalities of the TCMS, expressed a need for support regarding handling uncertainty in transport chain planning. The users referred to are Wallenius Wilhelmsen Lines (WWL), Autotransportlogistics GmbH (ATG) and Elkem, which all act as intermodal transport chain managers, but with different demands, preferences and settings.

The suggestion was to design a decision support system based on simulation and embed it within a module, referred to as the simulation module, to use in combination with the TCMS. Appendix A presents an overview of the architecture of the D2D system, which is a composition

of three separate systems: the TCMS, the FTMS and the simulation module. The FTMS (Freight Transport Monitoring System) is the system that collects real-time dynamic information related to the cargo, e.g. tracking and tracing information, and provides the TCMS with that. The TCMS is the information provider for the simulation module.

2.2 Transport chain descriptions

Since ATG, WWL and Elkem are the three cases explicitly interested in the simulation module, the other two chains will not be presented:

- WWL is responsible for John Deere farming equipment transported from Mannheim (Germany) by RoRo barge to Antwerp (Belgium). By truck from Antwerp to Zeebrügge, where terminal operation in port of Zeebrügge takes place. Further by RoRo-ship to port of Freemantle (Australia). Terminal operation and pre-delivery services in Freemantle and then truck transport to final destination in Australia. Except acting as a transport chain manager, WWL is the operator of the RoRo transport from Europe to Australia.

- ATG is responsible for Volkswagen (VW) cars transported from Wolfsburg (Germany). By truck from Wolfsburg to a rail terminal, where rail terminal operation takes place followed by a rail transport to Koper (Slovenia). Terminal operation in Koper, and further to the domestic Slovenian market by truck and to Turkey by waterborne transportation. In addition to the transport chain manager task, ATG operates the rail transports and owns a large fleet of rail wagons.

- Elkem is responsible for its own transportation of silicon metal from Salten (Norway) by short sea shipping to port of Rotterdam (Netherlands). Terminal handling in Rotterdam and then barge transport to Weil am Rhein, where terminal handling is carried out. Further on by truck to the customer in Rheinfelden (Germany). Elkem is using its company Euro Nordic Logistics (ENL) for the operative transport chain management.

To classify, evaluate and compare the transport chains, KPIs are used and the ones that have been identified as most important in D2D are

cost, reliability (punctuality), lead-time, occurrence of damages and environmental impacts. The actors consider the importance of each KPI differently. In this context, it is primarily the three first that are considered.

3 PROBLEM DEFINITION

Depending on the role of the company concerned in each case, the need for decision support varies. The primary task for ATG, Elkem and WWL is, however, to co-ordinate their transport chains including design, planning and control. Making best use of resources and at the same time take into account occurrence of disturbances requires a structured way to analyse efficiency, robustness and performance. The companies are aware of the existence of weak links and unnecessary slack, but where in the chains they occur and what their magnitude is, is unknown.

In this context, we will investigate how discrete-event simulations and analytical computations using empirical distributions can be used to facilitate these types of analysis on a tactical level for design and planning. In order to do this, we first need to study how to model the transport chains.

4 SIMULATION IN TRANSPORTATION

In this paper we refer to simulation as any kind of computerised imitation of a system, where in this case a system is one or a set of transport chains.

Simulation is considered to be a flexible method for the modelling and investigation of systems, allowing insight into their behavior and effects of different changes. By having the opportunity to make experiments on a virtual version of the system, any hypothesis can be tested without having to suffer from any real-life consequences if the system behaves badly. Experimenting with the real system may not only be expensive and make the system break down, but long-term effects can be impossible to study. In simulation, time is a fictional and controllable variable with the clock ticking according to the user's specification.

All these characteristics have made simulation a very commonly accepted method in the transport domain and simulation has proven to be useful for several purposes, cf. (Kondratowicz, 1994; Law and Kelton, 2000; Brooks and Robinson, 2001). Compared to other commonly used operations research methods like optimisation, a simulation model allows much easier the introduction and depiction of uncertainty and does not need to have all influencing factors mathematically defined explicitly.

There are, however, some common and known pitfalls when using simulation. The most common ones are related to validity and credibility of results, how to handle the impact and modelling of stochastic processes and how to decide on the appropriate scope and level of detail. For simulation models that will be used on a daily basis, questions regarding how to update the model along with its input data and how to ensure validity continuously, are also issues that need to be dealt with along with several others that are described more extensively in the literature, for example in Law and Kelton (2000).

The classic distinctions of simulation models are *discrete-event simulation (DES)* and *process-oriented simulations* (Law and Kelton, 2000). In DES, events are the driving force of the simulations and make the states change. The states are also discrete and within a set of specified ones such as having binary variables representing if a terminal is open or not. A process-oriented simulation is continuous in the sense that there are no specific states of the simulated system, rather having a continuous variable changing its value, such as temperature. Since a transport chain at this level of detail can be divided into discrete events of departures and arrivals at different nodes, DES seems to be an appropriate choice.

4.1 Related work

Since the concept of intermodal transportation is a multidisciplinary field, several areas and issues have been addressed and studied over the years. The analysis and planning of transport chains is often carried out by using hands-on methods such as spreadsheet analysis or ad-hoc methods, which have their limits regarding size of the problem to be

analysed and type of scenarios that can be studied. Chwif et. al. (2002) discuss the differences between the use of spreadsheet analysis and DES for supply chain analysis. In addition, Chwif et. al. provide a case where both methods are applied. The conclusion is that if there are parameters not depending on variations over time or random fluctuations, the static-deterministic spreadsheet analysis method is sufficient, however, if there are parameters with dynamic and/or stochastic properties, simulation is the better choice. The conclusion is not based on the premises specifically for supply chains but can be applied to planning of transport chains as well.

Regarding use of simulation for performance measuring and evaluation, Carey (1999) provides an extensive evaluation of the use of heuristic methods for measuring schedule reliability as an alternative to stochastic simulation analysis. The advantage of using heuristic measures is, according to Carey, that they can be computed more easily than detailed simulations, and they require less data. The approach is said to be useful particularly for scheduling problems where knock-on delays have a large impact on the reliability, i.e. that delays propagate easily. The approach was theoretically applied to a train traffic problem having those characteristics, and the results were, according to the author, promising.

All sorts of structured analysis need some kind of model of the system in focus. D'Este (1996) outlines a conceptual event-based approach on how to model intermodal freight systems. The model is intended to be embedded in a traditional network model and provides an opportunity to model and evaluate performance of intermodal systems. The author does not state, however, whether or not his approach has been applied when modelling a real intermodal freight system or been used in combination with a network model for a real setting. D'Este also addresses the need for algorithms appropriate to search and find paths for flows within a network of services and refers to known approaches for network flow problems such as the *shortest-path problem.*

Bürckert et. al. (1999, 2000) and Rizzoli et. al. (1999, 2002) model the components of a transport system using agents (see further Wooldridge (2002)). Bürckert et. al. (2000) suggest the agent-based Teletruck

approach for the real-time, online planning and optimisation of intermodal operations. The Teletruck system is developed by DFKI (German Research Centre for Artificial Intelligence) and uses market-oriented mechanisms for the optimisation of plans by having agents representing the different roles (e.g. company agents, rail service agents, ITU agents) and negotiating and trading in auctions supported by communication protocols. The papers by Bürckert et. al. (1999, 2000) reveal no experimental evaluation results of their approach, but the system is said to be under development in close cooperation with potential users.

Rizzoli et. al. (1999, 2002) provide a description of an agent-based architecture for the planning of intermodal operations and simulation of intermodal terminals in an inland environment for rail and truck operations. The approach is a result from the PLATFORM project (PLATFORM, 2003-11-18), and is divided into a planning module based on the Teletruck concept and a simulation module based on Modsim III. The purpose is to plan operations and then simulate the operations to verify feasibility and evaluate the performance on a tactical basis. The performance of the rail corridor, for example, is analysed by simulating the transports according to a pre-established schedule and then introduce a stochastically generated delay. Terminal simulation experiments with artificial input scenarios (ones that are real world like, according to the authors) have been carried out. The results from the simulation were discussed, but not to what extent the values correspond to real ones for the same scenarios.

Kondratowicz (1994) presents a specific simulation tool for freight transportation. He addresses the need for a tool analysing scenarios in a transportation system and describes the *simulation modelling expert system* MULTIMOD. The purpose of the expert system is not stated, but the author provides some hypothetical examples on possibilities that the simulator supports. The methodology for developing a model for the simulator is outlined, and advice when using simulation for analysis of multimodal transportation is included.

This paper concerns only intermodality from a freight transport perspective, but there are several similarities with public transportation.

Febbraro et. al. (1996) address the issues of modelling, simulating and controlling intermodal urban public transportation and present an approach with the purpose of supporting the management and control of the network as well as providing information about it to the users. The paper deals specifically with the management and control of the different parts of the network by using simulation. The simulation approach is based on a special-purpose discrete event simulator, called INTRANET (INtegrated TRAnsportation NETwork). A discrete-event model represents the network of various transport services and a traffic simulator is used to analyse their behaviour, interaction and performance by including disturbances to capture the stochastic characteristics. The schedules of the transport services can then consequently be modified until the desired performance of the network is achieved. Some experiments for a case study where carried out applying control strategies to one setting while not to another. Comparisons of the two settings showed the proposed strategies to be effective, but there were no comparisons or discussions carried out related to how well the simulations captured the behavior of the real system.

Considering the transport processes in a transport chain separated from each other, the area of intermodal railway transportation and intermodal terminal management have gained most attention (Kulick and Sawyer, 2002), while not much attention has so far been given to transport chain analysis, i.e., the analysis of performance and other comparative criteria for different scenarios. There are, however, other areas where similar problems appear such as telecommunications where the performance of parts of a network is analysed and strategies for the distribution of data packages can be evaluated. Supply Chain Management (SCM) is also an area where simulation is used to analyse the performance of each link in the supply chain, see (Bruzzone and Orsoni, 2003). However, transportation is usually only one part in SCM, whereas in our case it is the primary issue. Considering the intermodal transport chains in a supply chain context may be useful also for other reasons such as analysing transportation in a larger perspective getting insight in the modelling of the relationships between production, inventory, transport, purchasing, etc, in a supply chain.

5 REQUIREMENT IDENTIFICATION

This chapter serves to describe the methodology used to identify the specific requirements, and further translating them into decision support functionalities in the DSS.

5.1 Methodology

In order to fully understand the transport chains involved, an extensive mapping of the existing transport chains was carried out in the initial phase of D2D, leading to a business model for each transport chain. The business models describe roles, actors, responsibilities, activities, decision points, transport documents, information systems and flows, thus mapping the "as-is" situation. Based on the business models, re-engineering activities were carried out to suggest potential improvements in the processes. The result was a "to-be" business model for each transport chain, based on the introduction of the TCMS. The needs for transport chain management support were identified; of which one was the desire for support to analyse and handle the uncertainty they face in transport chain planning. It was determined to make this decision support an external system connected to the TCMS, as already mentioned.

The needs for decision support was classified in three main requirements and described in a *use case* context according to the structure of Cockburn (2000). Initially, use cases on a top-level with little detail were constructed and then developed to include additional levels of detail. The use case documents and a graphical presentation of their purpose were discussed with WWL, ATG and Elkem representatives in order to reach a common understanding of what their real requirements are. The use cases were modified according to results from the discussions and then further expanded.

The use cases were later translated into decision support functionalities, each composed of a set of queries followed by an analysis of the expected output and the necessary requirements regarding input data for each query. An initial design regarding how to construct the queries was also carried out.

5.2 Requirements

An important part of the transport chain management is the design of the network of services to be used, i.e. to *select appropriate route and service providers* according to the specific customer demands or for future business opportunities. This is a complex task due to the high numbers of alternatives and the different evaluation criteria (KPIs). A system enumerating feasible combinations with the specific KPI values would provide a possibility to overview, compare and make good decisions.

The network of services is based on the contracts made with service providers. One prerequisite for an economically sustainable business for a TCM is the design of the contracts (both with the customers and sub-contractors) in such a way that they successfully balance performance and risk levels. Finding the service level regarding reliability that a transport manager can offer its customers without risking penalties due to varying performance of the services, while still providing an attractive service, is one important task. Due to the varying performance of the sub-contractors' services, a tool for *robustness and performance analysis* would increase the transport chain manager's ability to illuminate existing risks and weaknesses in the chain. For this purpose it would also be valuable to *analyse impacts* of changes in specific transport chains, e.g. the impact of an increased demand or increased/decreased supply.

The three main requirements identified are thus related to decision support regarding:

1. Route and service provider selection
2. Robustness and performance analysis
3. Impact analysis

The three main requirements have been further analysed and turned into decision support functionalities with a set of queries. Some of the functionalities and queries are presented in Appendix B, and these will be further discussed in Chapter 7.

6 *MODELLING THE COMPONENTS*

This chapter will describe the model of the components involved in the functionalities and then Chapter 7 further outlines each functionality separately by an example. The model is object-oriented and considers a *transport service* as a transport of a specific mode carried out by a specific transport operator and from one point to another. Thus there may be several transport services using the same mode between the same points, but carried out by different operators.

A *terminal service* is a service taking place at a specific location (a terminal), and consequently a *transport chain* is a sequence of transport and terminal services from its origin to its destination.

S is the set of transport services. A transport service $S_i \in \boldsymbol{S}$ is a tuple $<O_i , D_i, L_i , M_i, T_i >$ where

O_i = origin of transport service S_i.
D_i = destination of transport service S_i.
L_i = set of transport service links of transport service S_i.
M_i = transport mode type of transport service S_i.
T_i = transport operator that carries out transport service S_i.

L_i is the set of transport service links. A link j for $\forall\, j \in L_i$, for $\forall\, S_i \in \boldsymbol{S}$, is
a tuple $< d_{ij}, a_{ij}, p_{ij}, c_{ij}, y_{ij}, w_{ij} >$ where

d_{ij} = departure time of link j of transport service S_i.
a_{ij} = arrival time of link j of transport service S_i.
p_{ij} = performance profile of link j of transport service S_i.
c_{ij} = cost of link j of transport service S_i.
y_{ij} = capacity of link j of transport service S_i.
w_{ij} = time window for departure time of link j of transport service S_i.

Thus, L_i specifies the timetable for the physical modal transport provided by transport service i. d_{ij}, and a_{ij} specify departure and arrival times, and their difference gives the planned lead-time. p_{ij} gives the performance profile of the link and specifies the empirical distribution

of lead-times. That is, a performance profile could be used to estimate the probability of having a lead-time larger or equal to a specific value, and is a function: $p_{ij} = f(a_{ij} - d_{ij})$. For transport services that have flexible departure times, an interval can be used instead of fixed departures by using the time window, w_{ij}.

The transport mode type, M_i, is important when choosing a succeeding terminal operation such as a loading service from trailer to railcar. Similar to the set of transport services, **S**, there is also a set of terminal services $\boldsymbol{Q}$, where each service, $Q_k \in \boldsymbol{Q}$, is the tuple $< f_k, g_k, h_k, q_k, b_k, >$ where

f_k = location of terminal service *k*
g_k = schedule of terminal service *k*
h_k = duration time profile of terminal service *k*
q_k = cost of terminal service *k*
b_k = service type of terminal service *k*

A schedule consists of intervals of opening hours. The duration of a service can be a constant or distributed according to a performance profile. b_k specifies the type of terminal service, e.g. unloading semi-trailer from truck to railcar and vice versa.

$\boldsymbol{C}$ is a set of transport chains appropriate for a specific purpose. Each transport chain, C_u is a sequence of transport and terminal services. Each transport chain has also an origin and a destination, which are implicitly defined by the first and final transport service in the sequence of services.

Since a transport chain, C_u, does not take the time dimension into account, several instances, i.e. combinations of transport service links and terminals services, are created when considering the structure of a specific transport case. Then a transport service link j is connected to another transport service link, or terminal service if it is not the end activity before delivery. See illustration in Figure 1 below for a description.

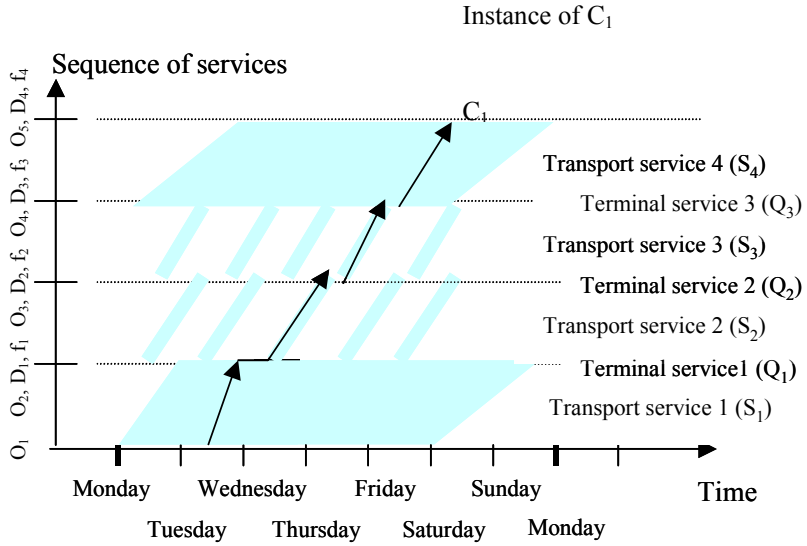

Figure 1. Illustration of instances of transport chain 1. Each cycle is one week which makes departure and arrival times refer to time of day on day 1-7 (Monday through Sunday).

The shaded parts in Figure 1 represent feasible departure times for transport service links, and the thick ones for transport service 1 and 4 mean that they can pick up and leave any time during those hours, and represents a very flexible transport service, for instance a trailer transport. Different links depending on their lead-time related to the departure time of next link and terminals services can then be combined into different transport chain instances. The combinations are enumerated only according to deterministic parameters comparing start and end times of each link and schedules of terminal services, and form a set of feasible transport chains, $\boldsymbol{C}$.

The main difference between two links, (i,j) and (i,j+1), of the same departure set L_i, is that they have a different departure and arrival time, and may have a different lead-time, time window, cost, capacity and performance profile (performance profile and reliability will be discussed further in the next chapter). Thus, all $j \in L_i$ are the same physical transport from A to B operated by the same company, but due to the timetable of transport service *i*, there may be peak hour rush affecting link (i, j) but not (i, j+1). How many links (i.e. tuples) a transport service has depends on which time horizon that is used for one cycle, i.e. if the time horizon is one week and the service has only one departure a week, the number of tuples will be one. If the time horizon is a month, consequently the number of tuples will be four.

7 DESIGN OF FUNCTIONALITIES

See tables in Appendix B for an overview of the queries within each functionality, where *user input data* refer to data that the user will provide the simulation module with. *System input data* refers to data that automatically is provided by the TCMS or a similar information system. In the tables, a link refers to one specific part of a transport chain instance.

7.1 Overview

Each functionality has a set of possible types of queries, which are different from each other depending on how restricted the user wants the functionality to be. That is, a functionality that serves the purpose to search for transport chains from A to B can have a query taking no other things into account than origin and destination, while another query limits the alternatives further to the ones that also have a maximum cost and/or a minimum reliability. The queries can be seen as several levels of detail.

Searching for a set of alternative specific transport chains, by combining various services, i.e. creating the set **C**, requires that a logical network of nodes and links is implicitly defined, if not explicitly. A node is a point at which at least one service takes place (terminal service) or originates from (transport service). Nodes are identified according to a code system in the TCMS (UN (United

Nations) codes are used if available or else other codes such as latitude and longitude). A link is then a transport service link between two nodes. The nodes and links contain all information necessary to perform network searches.

It is assumed that all information that is required by the model in Chapter 6 is provided by the TCMS. The performance profile is based on historical data that is synthesised into an empirical distribution of lead-times for a particular link. The historical data is continuously updated with every new transport instance or can be manually included as a static property. The information provided is depending on the need of each user.

Some of the queries can be seen as enumeration of alternatives and analytical calculations of a change in one or several parameters. All simulations and calculations are static of which some are deterministic and others stochastic. In query 1.1-1.4, the main algorithmic functionality is restricted route finding through the network of different services linking them to each other from the origin to the destination according to a set of constraints. As mentioned earlier there are specific KPI values that specify how good a transport chain instance is. The main ones used here are lead-time, cost and reliability. Lead-time is the time elapsed between departure and arrival at final destination. Reliability is the calculated likelihood of success, i.e. reaching its final destination within the specified time. Hence, reliability can only be used for transport chain instances, and is calculated from the reliability of each transport service link (i,j) to reach its destination no later than time x, $r(x)_{ij}$. The reliability of the transport chain instance is then the product of the corresponding reliability of all links in the sequence. Reliability does not consider if there are any other possible transports service links – that would make a different instance. The KPI reliability is therefore deterministically calculated.

Robustness and performance analysis focuses on a defined TC instance that needs to be further analysed. Here can also the likely lead-time (the stochastic value generated by simulations as a contrast to the KPI value of reliability that is deterministic) be estimated. That is, the objective is to imitate a consignment that must reach its destination, i.e. when a link

fails to connect to next link, deviation handling starts with one of the three different actions; a new consignment is triggered, the initial consignment waits for the next scheduled service or use alternative services all in line with a defined rule-base. The output of this calculation is a set of alternative scenarios with lead-times and costs, as well as indications on where in the transport chain instance the problems occur, i.e. weak links. This is a tool for improvement and risk analysis, i.e. which services in the transport chain jeopardise the overall performance. To improve the overall performance of the transport chain instance, different measures can be taken and evaluating their effect can be done by using the simulation functionality *Impact analysis*.

Obviously many of the queries provide enumerative deterministic calculations. The stochastic simulations are the ones where the stochastically distributed lead-time is used and several replications of the calculations are carried out instead of having one calculation using the deterministic value of the reliability, which only reflects a steady-state over a longer period. Each decision support functionality will be presented in more detailed below.

7.2 An example

Imagine that we represent a TCM who wants to investigate the available transport options from city A to city E that satisfies some requirements. The TCMS would then contain information that specifies the possible routes and services between A and E, see below in Figure 2.

A first step (route and service provider selection) of the analysis would be to ask for the set of possible transport chains from A to E, and then to create instances of the transport chains to investigate whether any of them satisfies the requirements.

Secondly, the feasible transport chain instances can be analysed further regarding robustness and performance. The ones that are appropriate can be investigated even further, in a third step, by exposing them to a variety of changes and random events. Naturally, all steps do not have to be gone through, but each one can be used separately.

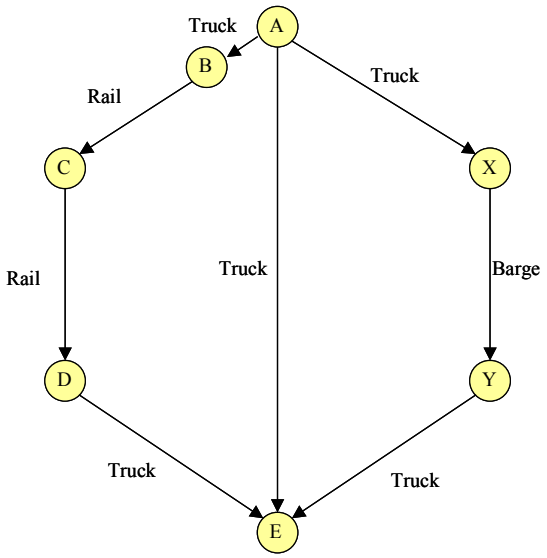

Figure 2. Network of services for transportation between A and E. Three different physical alternative chains (Alt. 1, 2 and 3) exist, out of which several transport chain instances can be generated.

In this example we will only look at alternative 1 (the left-most in Figure 2, which also is depicted in Figure 1) having a weekly cycle. In modelling terms, it can be formulated in the following way:

Transport chain 1:
$C_1 = (S_1, Q_1, S_2, Q_2, S_3, Q_3, S_4)$

Transport service 1:
O_1 = A
D_1 = B
L_1 = {<day *1* 0.00, day *1* 02.00, 1, 2000 Euro/trailer , 5 trailers, 7*24 h>}
M_1 = Trailer transport
T_1 = T_one

Terminal service 1:
f_1 = B
g_1 = day *d* 06.00 – day *d* 19.00 for d = {1..5}
h_1 = 3 h
q_1 = 400 Euro/trailer
b_1 = semi-trailer to/from truck/railcar

Transport service 2:
O_2 = B
D_2 = C
L_2 = {<day *d* 12.00, day *d+1* 09.00, see Appendix C, 1000 Euro/trailer, 10 trailers, 0>} for d = {1..5}
M_2 = Piggy back transport[1]
T_2 = T_two

Terminal service 2:
f_2 = C
g_2 = day *d* 08.00 – day *d* 17.00 for d = {1..7}
h_2 = 6 h
q_2 = 80 Euro/railcar
b_2 = railcar shunting

Transport service 3:
O_3 = C
D_3 = D
L_3 = {<day *d* 17.00, day *d+1* 09.00, see Appendix C, 1000 Euro/trailer, 10 trailers , 0>} for d = {1..5}
M_3 = Piggy back transport
T_3 = T_three

Terminal service 3:
f_3 = D
g_3 = day *d* 08.00 – day *d* 17.00 for d = {1..7}
h_3 = 2 h
q_3 = 400 Euro/trailer
b_3 = semi-trailer to/from truck/railcar

[1] Piggy back refers to the transportation of a semitrailer on a railcar.

Transport service 4:
O_4 = D
D_4 = E
L_4 ={<day *1* 0.00, day *1* 05.00, 1, 2000 Euro/trailer , 5 trailers, 7*24 h>}
M_4 = Trailer transport
T_4 = T_four

The truck transports can make a pick-up any time of any day, while the railway transports depart on specific times only weekdays. Below, the functionalities will be applied to this example.

7.3 Route and service provider selection

The selection and combination of services resulting in an initial set of transport chains, is based on origin and destination and then further restricted by desired values of cost, lead-time and reliability for a transport chain instance.

Example 1a:
Query 1.1 Find alternative transport chain instances for zero demand between A and E that satisfy:

Departure time from A	>= Day 2, 7.00 am.
Arrival time at E	<= Day 5, 17.00
Reliability	>= 85 %

Since both departure and arrival times are restricted, the maximum feasible lead-time is implicitly stated. Cost and capacity restrictions are not of primary interest.

The algorithm will search for a feasible combinations of links (i.e. tuples) between A and E by using a network flow problem formulation of some kind, e.g. adapting the shortest-path problem, see further (Pardalos and Resende, 2002), to become a most-reliable-path problem.

The first link in any of the alternative sequences must obviously have a departure time later or equal to Day 2, 07.00. There should also be an

upper limit depending on the normal minimum transportation time for this distance in order to minimise the search space.

Iteratively and recursively, a succeeding link, (i, j) from the sequence of services is chosen until the destination is found or any of the other two conditions (minimum reliability and latest time of arrival) is violated, i.e.

(1) $\Pi\, r_{(\text{Day 5, 17.00})ij} < 85\ \%$, for $\forall\ i$ and j in the instances of C_1
(2) $a_{ij} >$ Day 5, 17.00, for $\forall\ i$ and j in the instances of C_1

Out of all combinations of links there are three possible transport chain instances – chain 1.1 – 1.3 (only one feasible, however). Their respective transport plan is given below.

Activity	**Chain 1.1**	**Chain 1.2**	**Chain 1.3**
Depart from A	Day 2: 07.00	Day 2: 07.00	Day 3: 07.00
Depart from B	Day 2: 12.00	Day 2: 12.00	Day 3: 12.00
Depart from C	Day 3: 17.00	Day 4: 17.00	Day 4: 17.00
Depart from D	Day 4: Latest Day 5 12.00	Day 5: Latest 12.00	Day 5: Latest 12.00
Arrive at E	Day 4: Latest Day 5 17.00	Day 5: Latest 17.00	Day 5: Latest 17.00
Reliability	91. 0%	6.2 %	5.6 %

Table 1. Transport chain instances of chain 1 in Example 1a. The influence of terminal handling and schedules is taken into account but for simplicity excluded in the table.

The reliability is the product of each transport service link's likelihood of reaching next critical link's departure. The probability of catching transport service 3 in chain 1.1. is , for example, the probability of having a lead-time from B to C that is less or equal to the maximum possible lead-time given the duration of transport service 2 and terminal service 2. See the calculation of reliability of chain 1.1. below:

Probability	**of departing from _ in time**	**at/before**
1.0	A	Day 2: 07.00
1.0 * 1.0	B	Day 2: 12.00
1.0 * 1.0 * 0.91	C	Day 3: 17.00
1.0 * 1.0 * 0.91 * 1.0	D	Day 4/Latest Day 5 12.00

Table 2. Reliability calculation of chain 1.1.

Calculated lead-time (hours)	**Maximum feasible lead-time (hours)**	**Between points**	**Probability of having maximum lead-time**
2	2	A-B	1.0
21	23	B-C	0.91 (diagram 2, Appendix C)
16	17+24	C-D	1.0
5	5	D-E	1.0

Table 3. Reliability calculation of chain 1.1.

In practice, one could say that the reliability for chain 1.1 is higher than in Table 1 since there is a chance to use next rail transport at day 5 if original connection is missed. The reliability would then be 91.0 + (9.0 * 6.2)/100 = 91.6 %. That is, however, considered to be another transport chain instance. So, in this case within this subset and at this level, chain 1.1 would be the only feasible alternative.

7.4 Robustness and performance analysis

The purpose of this functionality is to analyse transport chain instances and illuminate if and where there are weak and/or expensive links, or terminal services that do not offer services according to a good schedule. Imagine a transport chain instance which overall have a low reliability, but it depends only on one link, which may be possible to

improve. Illuminating that relation may be useful. Other things to investigate are for example:

- What are the KPI values for each link in a chain?
- How much inactive time is there and where, according to the transport plan?
- If the departure of a link would take place earlier, how would that affect the reliability?
- If the timetable for a RoRo ship would change, how would that affect alternative transport chain instances?
- What is the "true" reliability of a transport chain instance, i.e. taken into account back-up options as mentioned for chain 1.1?
- How would the chain instance respond to the introduction of a disturbance – is it robust for all seasonal fluctuations?

Since this is only an initial suggestion on what the simulation module may provide within this functionality, several other types of questions may be useful to pose.

Example 1b:
Continuing with the example and use it further by still considering chain 1.1-1.3, we would like to investigate what the changes regarding reliability would be if transport service 3 would depart two hours earlier. The general result is a decreased likelihood of catching transport service 3 (from 91 % to 19.2 %) since it departs earlier, but an increased likelihood of catching transport service 4 (the final road transport service) in time:

Chain 1.1: = 0.192 * 1.0 = 19,2 %
Chain 1.2: = 1,0 * 0.562 = 56.2 %
Chain 1.3: = 0.192 * 0.562 = 10.8 %

The calculations are done as before in Example 1a, but maximum feasible lead-time between C and D becomes 21 hours instead of 23 for chain 1.1, which there is a 19.2 % chance of getting (see diagram 2 in Appendix C). Since chain 1.2 is scheduled to take transport service 3 a day later than chain 1.1, it has a maximum feasible lead-time of 21 + 24 hours, which there is a 100 % chance to get.

7.5 Impact analysis

In many ways, the impact analysis functionality is the same as for robustness and performance analysis, but here is the analysis carried out with more depth and with regard to other parameters. Questions that may be useful to pose are:

- How much can the quantity of goods be increased in this chain?
- What would such an increase imply regarding costs?
- Where is the primary binding constraint regarding capacity/cost/reliability, i.e. which link is the main bottleneck and the one to focus?
- What is the risk for penalties if promising clients a delivery reliability of 95 %?

Example 1c:
Suppose that we want to investigate the monetary risk of promising a reliability of 95 % to a customer during approximately 500 shipments. The performance profiles of the services are used when simulating the chain instances for an appropriate number of replications, i.e. making Monte Carlo simulations with empirical distributions from the performance profiles, and analyse the mean, median and maximum of all delays. Evaluation of a set of linear and a non-linear penalty functions in the simulations may be useful in order to acquire the monetary cost for such a scenario.

Further useful analysis could be to investigate which other customers that use the same resources and if so maybe it would be wise not to combine two or more time-dependent customers in the same chain.

7.6 Prerequisites

Since this is only an initial design of decision support functionalities, there are several parts that need to be further investigated, e.g. how to perform network searches based on the TCMS location coding of nodes and links and the use of an O-D (Origin-Destination) matrix.

Furthermore, the likely size of the search space, i.e. the number of attributes and relations between nodes and links, and the impact it will have must be analysed. In any case, some initial appropriate constraints limiting the search space and avoiding unnecessary enumerations are necessary.

Regarding the use of performance profiles, this approach is based on that they are independent of other links, making them useful also when making and evaluating new combinations of links. Making sure that this is the case is obviously crucial. As is the question concerning how to tackle the influence of seasonal patterns and abnormal circumstances both regarding data collection and usage.

8 ISSUES REGARDING BENEFITS

So far, the planning of the intermodal transport chains has been taken care of by different people, been based on old expertise and rules of thumb and some events handled separately from others. As a result of fragmented planning and management of activities, transport chains include unnecessary slacks in timetables and built-in buffer time for terminal handling since the real need cannot be analysed. Just by modelling the chains graphically and providing a simple possibility to filter and synthesis information, may provide a solid ground to illustrate the relationships between several activities. Such a DSS will not, however, substitute the decision-makers but rather support and provide with necessary information. Since the information already is collected and stored in the TCMS, it provides a good opportunity to use it for further purposes.

One good example of how the TCMS and DSS would be beneficial can be found in the Elkem case. Today there are six actors responsible for separate parts of the chain with little coordination between them, leading to deficient transparency in between and insufficient control and visibility of cargo and resources, i.e. containers. Low utilisation of own containers creates difficulties to satisfy the total demand of containers and forces Elkem to rent external ones. By implementing a system such as the TCMS, information is made available that could be used in a decision support system for e.g. improving planning and allocation of resources. Modelling the activities and simulating the transport chains, the need for containers can be analysed.

The utility of the decision support presented is quite obvious, but it does, however, require a certain level of IT maturity. Simulation is not the magical answer, but only facilitates analysis of the processes if used correctly. Going from spreadsheet analysis and ad-hoc planning to use decision support based on simulation and advanced analytical calculations is a large step, which may provide lucrative improvements, but common methods should not be abandoned.

9 DISCUSSION AND FUTURE WORK

This work assumes that the users will use the TCMS or a similar system, and therefore have no investigation been carried out focusing on if it is likely that all the required information would be available for non-TCMS users. Furthermore, this approach assumes that the organisation of the transport chains is clear and that there are well-defined responsibility structures with authority to make decisions and control.

Important consideration about the use of performance profiles must also be made. Routines for collecting, storing and synthesising information into good performance profiles must be established, as well as having some way of deciding if they are good enough by e.g. have comparisons made to check whether or not the support provided is feasible. Another issue is how much the users need to know about statistics necessary to analyse stochastic elements through confidence intervals, variance, etc.

Considering an implementation, further dimensions will also appear, e.g. presentation of results in a graphical and other format, and confirmation of correct input data used. Furthermore, if such complex chains can be modelled as suggested, must be investigated in detail as well as how reliable the results would be.

Validation of the model and algorithms in the functionalities must be done, and not only in the initial phase, but also continuously since the input and the transport chains will vary. The complexity and size of the transport chains that will be analysed and the large amount of information needed must be investigated. A virtual implementation can provide opportunity to in an early stage acquire knowledge on how the system would fit as a real application, and serve as a means of communication with potential users to facilitate the establishment of credibility and further development.

In a future conceptual extension, if the modelling and use of information function well, additional intelligence may be useful. Instead of having to know which what-if questions, i.e. specific queries, to pose, an optimisation approach may be useful for providing e.g.

answer on which links to change in order to achieve a certain likely lead-time or reliability. Since this is only a very first step, one should take it slow and not underestimate the complexity of the situations to be modelled, the influencing factors and the importance of access to updated and large amounts of data.

Before an implementation can be considered, existing risks such as credibility issues must be clarified through an analysis of the conditions under which the computations will be valid.

10 ACKNOWLEDGEMENTS

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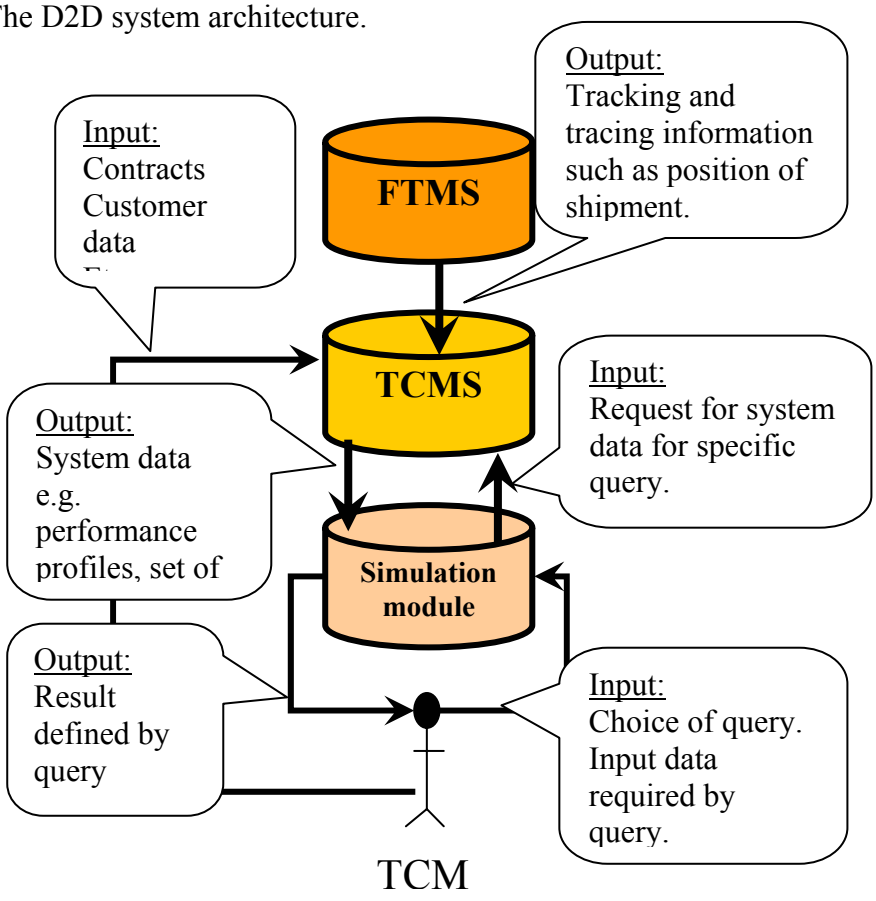
12 APPENDIX A

The D2D system architecture.



FTMS = Freight Transport Monitoring System
TCMS = Transport Chain Management System
TCM = Transport Chain Manager

13 APPENDIX B

Presentation of identified decision support functionalities and their queries.

1. Route and service provider selection

Nr	Query	User input	System input	Output
1.1	What alternative transport chain instances exist for a given demand?	Transport demand, Origin and destination KPIs	Logical network of legs and nodes. Characteristics of service providers.	All possible combinations of routes and service providers including KPI values.
1.2	What alternative transport chain instances exist for a given demand, and maximum/minimum value of KPI_i?	As in query 1 with KPI_i restrictions[2] added.	As in query 1	All possible combinations of (given the restrictions) routes and service providers including KPI values.
1.3	What alternative transport chain instances exist for a given demand, and a restriction on earliest ToD and/or latest ToA?	As in query 1 with time restrictions added.	As in query 1	All possible combinations of (given the restrictions) routes and service providers including KPI values.
1.4	What alternative transport chain instances exist for a given demand, in ranked order?	As in query 1 with ranking rules (highest/lowest) based on KPI_i added	As in query 1	Ranked combination of routes and service providers including KPI values.
1.5	What are the characteristics and capabilities of a certain combination of services?	Transport demand, Origin and destination Service providers KPIs	As in query 1	KPI values

Table 4.Overview of functionalities for comparing and selecting between different transport chain instances.

[2] Several KPI restrictions can be applied simultaneously, e.g. a minimum reliability of X % and a maximum cost of Y euro.

2. Robustness and performance analysis

Nr	Query	User input	System input	Output
2.1	What is the overall reliability of the TC instance?	Specific TC instance	Characteristics of transport chain instance including demand, rule base.	Reliability, i.e. probability of success.
2.2	Where are there weak links?	As in query 1.	As in query 1.	Graphical indication of the performance of every link and their interference in the total TC, e.g. weak links marked red.
2.3	How is reliability changed if modification/-s is/are carried out?	As in query 1, but modification in schedule for one or several parts of the TC instance. Selected KPIs	As in query 1.	Graphical indication of the performance of every link and their interference in the total TC instance, e.g. weak links marked red. Selected KPI values

Table 5. Overviews of functionalities for analysing transport chain instancess in more detail.

3. Impact analysis

Nr	Query	User input	System input	Output
3.1	What is the maximum capacity of this TC instance, and which activity is the constraining one?	Specific TC instance	Characteristics of transport chain instance, rule base.	Capacity restriction on each activity.
3.2	Can the TC instance handle a demand increase of X units?	Specific TC instance Total new demand	As in query 1.	Graphical indication of links with lack of capacity. Increase in costs.
3.3	What are the impacts of a change in one or several: performance profile, lead-time, departure, arrival, cost, capacity, for link *L*?	Specific TC instance Link *L* Changes in performance profile for *L*.	As in query 1.	KPI values.
3.4	What is the risk and its magnitude of promising a customer a reliability of X % for delivering before time t_d in the TC?	Specific TC instance Penalty level in contract Reliability t_d	As in query 1.	Probability of failure and the costs for different scenarios.

Table 6. Overview of functionalities for studying different scenarios and changes to a transport chain instance.

14 APPENDIX C

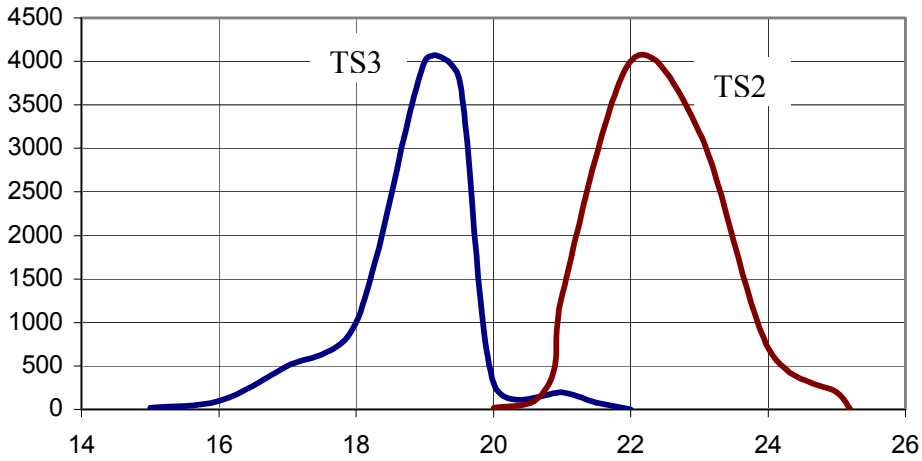


Diagram 1. Performance profile for transport service 2 (TS2) and transport service 3 (TS3) regarding number of instances versus lead-time. In this example, all tuples of a service has the same performance.

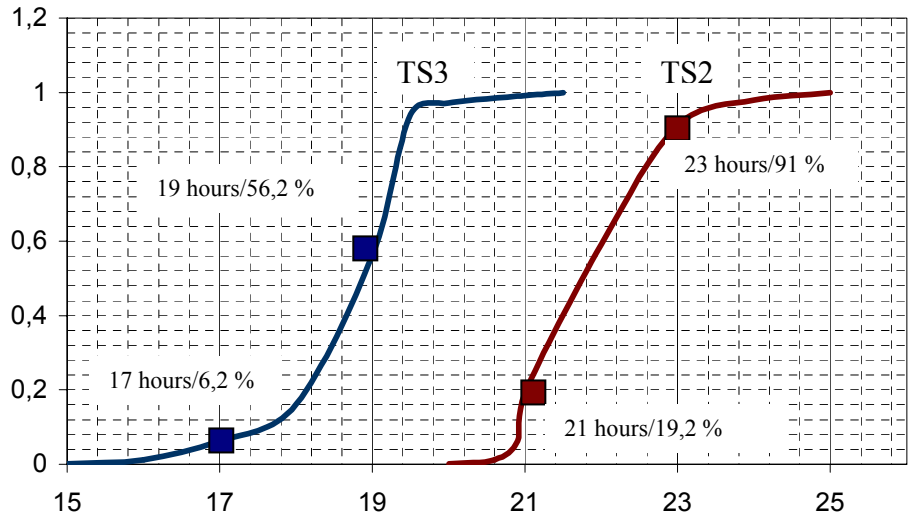


Diagram 2. Performance profile for transport service 2 (TS2) and transport service 3 (TS3) regarding probability of having a maximum lead-time.