School of Business Economics and Law
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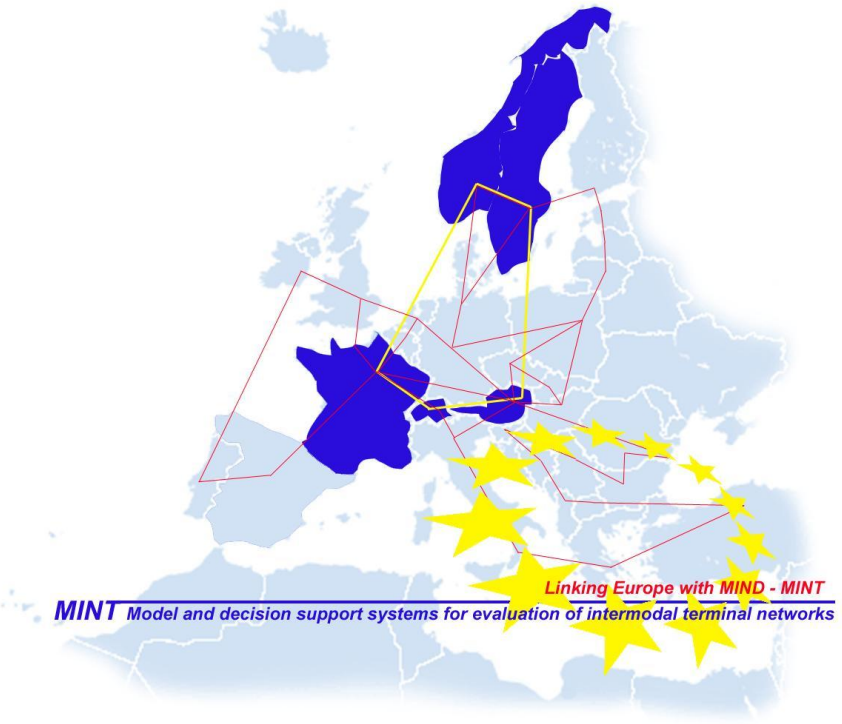
A systems view of the intermodal transport system



Jonas Flodén
School of Business, Economics and Law
University of Gothenburg

Deliverable WP 2.1
MINT - Model and decision support system for evaluation of intermodal terminal networks
WP 2.1 Development of a conceptual model for the intermodal terminal network
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MINT project background

This report is a part of the project MINT - Model and decision support system for evaluation of intermodal terminal networks. The project is a joint strategic and tactic trans-national project researching a new and improved model and decision support system for evaluation of intermodal terminal networks. The result will be a model and decision support system of compatible and integrated models and methods to investigate, evaluate and analyse costs and benefits for terminal networks as well as single terminals. The system is based on a number of models on different system levels and by combining these models some of their individual weaknesses are overcome. Together they form an excellent basis for improved system or terminal network design, investigation and evaluation. To integrate the models an information exchange structure will be developed. Finally an additional deepening network analysis complements the models system - to integrate other non-modelling aspects in the analysis.

The MINT project is a part of the ERA-NET scheme. Participants in the MINT project are:

- TFK, Borlänge, Sweden
- School of Business, Economics and Law at the University of Gothenburg, Sweden
- Railway group, Royal Institute of Technology, KTH, Stockholm, Sweden
- Universität fur Bodenkultur, Boku, Vienna, Austria
- h2 projekt beratung, Vienna, Austria
- Rapp, Zürich, Switzerland

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Author contact information
Dr Jonas Flodén
Logistics and Transport Research Group
Department of Business Administration
School of Business, Economics and Law at the University of Gothenburg
P.O. Box 610
SE – 405 30 Göteborg
Sweden

jonas.floden@handels.gu.se
http://www.handels.gu.se
http://www.handels.gu.se/fek/logistikgruppen

Phone: +46 31 786 5131
Fax: +46 31 786 5244

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A systems view of the intermodal system

One of the first steps when modelling or developing a computer system is to agree on a common view of the system being studied. This analysis step, in which the real-world system being studied is analysed, is commonly based on systems thinking.

System thinking is based on a view of the world as a system (Checkland, 1999, p. 13):

> *the existence at certain levels of complexity of properties which are emergent at that level, and which cannot be reduced in explanation to lower levels, is an illustration of an alternative paradigm – that of 'systems'. The systems paradigm is concerned with wholes and their properties.*

A system is viewed as a dynamic whole of components (abstract or concrete) that work together to reach a common goal. The system has clear boundaries, but can be divided into subsystems. The focus is on understanding the interrelationships between the parts in the system rather than the traditional linear cause-and-effect chain. The focus is on the relationships between the parts in the system and not the parts themselves.

Systems thinking also implies that there are no universally true models or perceptions of the system, but that they are all dependent on the modeller or person observing the system (Arbnor and Bjerke, 1994). This makes it very important to agree on a common view of the system at the start of a large modelling project with several persons involved. Otherwise, the project runs the great risk of each person trying to model a different system.

Systems thinking is also closely related to operations research (Pidd, 1979, Woolley and Pidd, 1981), distribution channel theory and management research, which together constitute the fundamentals of logistics (Jahre and Persson, 2005).

Several versions of systems thinking have been suggested. A methodology often used in logistics and transport research is the soft systems methodology by Checkland (e.g. by Flodén (2007), Woxenius (1994), Waidringer (2001) and Holweg (2001)). This is also supported by Bechtel and Jayaram (1997) who, in a literature review, consider soft system methodology to be a promising new area for analysing the processes in a supply chain. As mentioned above, the methodology, or variations of it, is also commonly used in computer software development. The soft system methodology takes a more open view on the system than the traditional "hard" systems theory, where a system is assumed to be well defined with a single goal that can be optimised[1]. This is obviously not the case in an intermodal transport system with many actors with partly conflicting goals. Soft systems methodology also includes the individual in the system and not only the technical system, which is particularly important in systems where the goals are unclear and varying between the actors. For a more detailed description, see Checkland (1999) or Checkland (1988).

The methodology is based on seven steps, see Figure 1, of which the first five steps are relevant for the understanding of the system and the remaining two are relevant for problem solving in the studied system.

[1] The classical example is a thermostat that controls the temperature in a room.

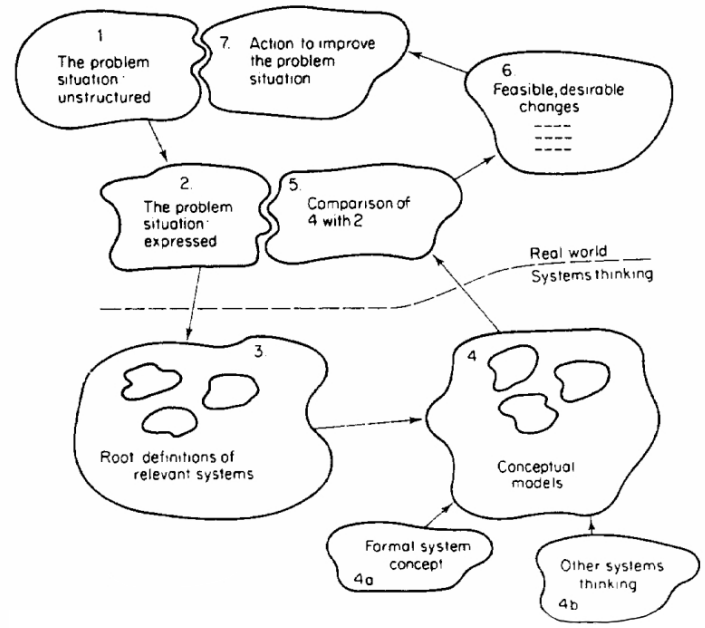

Figure 1 The seven steps of the soft system methodology (Checkland, 1999, p.163)

The first two steps are concerned with creating the richest possible picture of the situation being studied. This is then followed by defining the root definition of the system studied from which a conceptual model of the system is developed. The conceptual model is "an account of the activities which the system must do in order to be the system named in the definition" (Checkland, 1999, p. 169) illustrated on paper[2]. In the following steps, the conceptual model is validated and action is taken to determine appropriate changes to the system to solve the problem.

Step 1 and 2 – The problem situation

In these steps a so called "rich picture" is created that displays the system, or situation, in a as neutral way as possible. The function is to "display the situation so that a range of possible and, hopefully, relevant choices can be revealed, and that is the only function of these stages" (Flood and Carson, 1993, p. 110). This helps in developing and understanding and revealing different viewpoints on the system. A rich picture almost looks like a cartoon and uses pictures, arrows and keywords to display the situation. Rich pictures should not be drawn with systems in mind, as this limits the interpretation of the situation. A rich picture could also include the character and characteristics of the actors, e.g. points of view and prejudices. A rich picture of the intermodal transport system has been drawn below.

[2] Note that the conceptual model in soft systems thinking is not a computer model, but a drawing on paper of the different activities and the way they are connected. Figure 1 could, for example, be considered a conceptual model of the soft systems methodology.

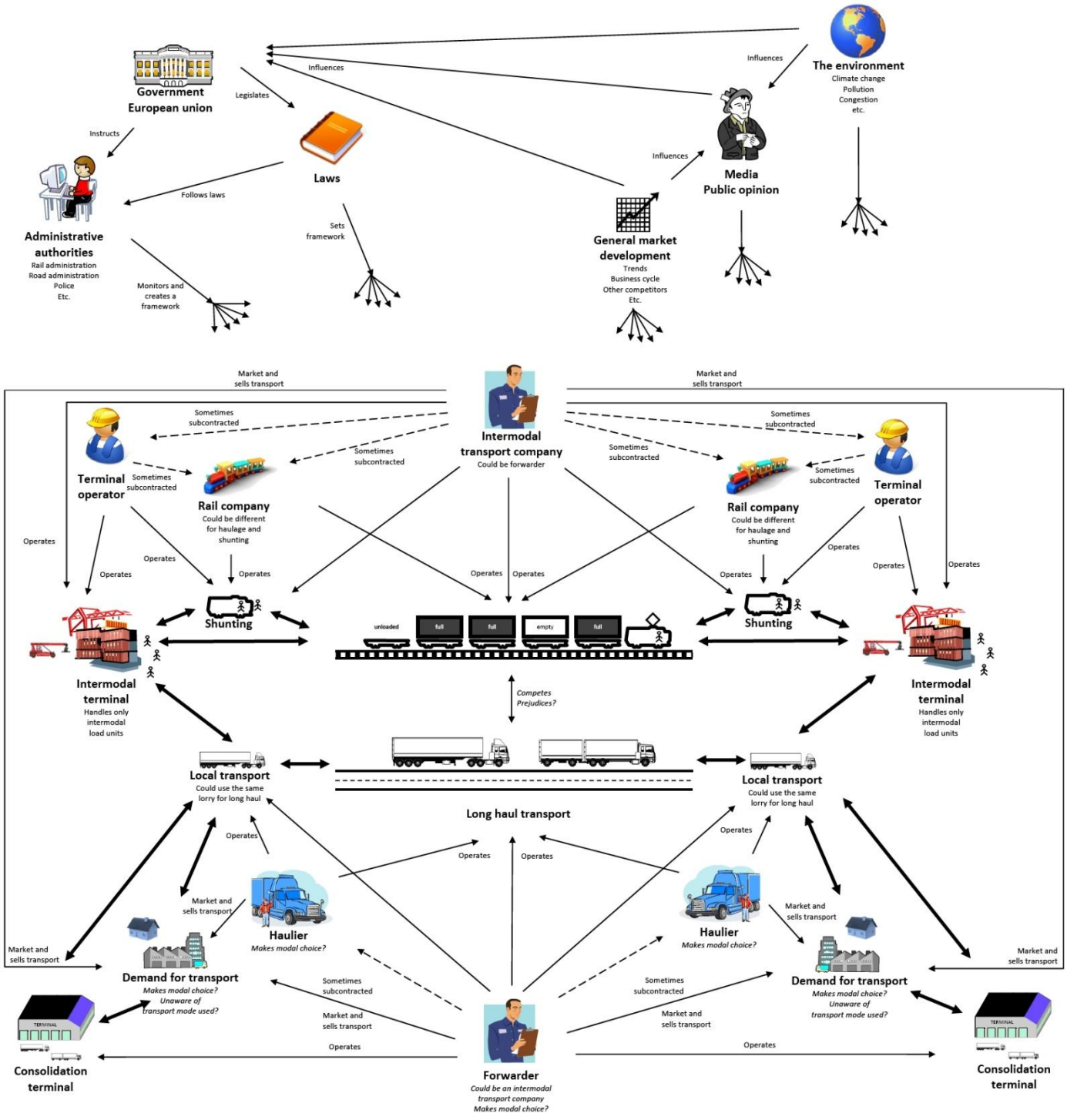

Figure 2 Rich picture of the intermodal transport system

Step 3 and 4 – Root definitions and conceptual model

In stage 3 and 4, a "root definition" is developed that describes the activities in the system. The root definition will depend on how we choose to view the system and how it fits in with the surrounding world. This is explained by the German word "Weltanschauung", which has no suitable English translation. It can best be explained by "What view of the world makes this system meaningful?". Each view will generate a different root definition of the system. It is possible to look at the system from different views and create several root definitions to better understand the system.

A root definition can be analysed using the abbreviation CATOWE, where the root definition should reflect all aspects highlighted by CATOWE. The abbreviation stands for (Checkland, 1981, Flood and Carson, 1993, p. 112):

C	Customer	Who would be victims or beneficiaries of this system?
A	Actor	Who would perform the activities?
T	Transformation	What input is transformed into what output?
W	"Weltanschauung"	What view of the world makes this system meaningful?
O	Owner	Who could abolish this system?
E	Environmental constraints	What in its environment[3] does this system take as given?

An intermodal transport system could, for example, be viewed as:

- A technical transport system
- A system offering a transport service to the market
- A logistics channel system
- A marketing channel system
- A system creating time and place utility
- A system to reduce the environmental impact of transport

The purpose in this report is to create a common view of the system that can be used in the project. Naturally, parts of the MINT-project will focus on different parts of the intermodal transport system where it, temporarily, might be necessary to have a different view of the system. For example, a technical view of the system is necessary when modelling the physical behaviour of the system. However, the overall view of the system should be common in the MINT project, i.e. the "Weltanschauung" or overall purpose of the intermodal transport system. For this reason, the conceptual model of the intermodal transport system is kept on an overall level, without going into details. The intention is to keep the conceptual model on a general level that can be accepted for all intermodal road-rail transport systems. The focus is to capture the core of the system without going into individual organisational aspects that might differ between different real-world systems, i.e. to capture the core from the rich picture. Each building block in the conceptual model might thus represent several ways to actually perform the activity.

[3] Note that the word environment refers to the setting and situation in general terms and does not (necessarily) refer to environment in the form of pollution etc.

It is also possible to divide any system into subsystems. The level of detail and number of subsystems will depend on the purpose of the systems modeling. Each subsystems is given its own root definition, conceptual model etc.

It is important to highlight that the intermodal transport system operates on an open market where the customer have a choice to use intermodal transport or not. It is of no use designing a transport system that does not meet the customer's requirements, as such a system will not get any customers. Naturally, the system must also be technically efficient, but to only have a god technical system is not enough. The technical aspect is also included indirectly in a market based view on the system, as a good technical system is required to be able to compete effectively on the market. The intermodal transport system is therefore viewed from a market perspective as a "system offering a transport service to the market". From this view, a root definition of the intermodal transport system has been determined as:

A system, operated in cooperation by one or several actors, for performing intermodal transport of load carriers in competition with other transport systems, aiming a providing a competitive transport solution while being subjected to influences from society.

This root definition takes into consideration the market aspect of intermodal transport, e.g. that it has to be competitive. The "competitiveness" also includes that aspects such as market preferences, modal choice preferences and business cycles are considered. The definition also highlights the influence from society that has become very apparent by the great political interest in intermodal transport. Factors such as reduced environmental impact, reduced congestion etc. are indirectly included as a part of being a competitive system and by the influences from society. The factors themselves are not a part or a goal of the system, but only indirectly imposed on the system by the desires of others. (These factors are determined in WP2.2, so we also do not know them yet).

A CATWOE analysis of the root definition is:

C	Customer	Actors needing goods transported
A	Actor	Companies in the intermodal transport system
T	Transformation	Untransported load carriers to transported load carriers
W	"Weltanschauung"	Transports need to be performed, preferable as efficient and effective as possible
O	Owner	Participating actors and customers
E	Environmental constraints	A need for transport on a free market, subject to laws and regulations.

A conceptual model is then constructed by listing a number of verbs that describes the activities in the system. The list should not be to long, but represent the core activities in the system. Aim at 5-9 activities within the system (Checkland, 1999).

A list of activities from the intermodal transport system is:

- To market and sell a transport service
- To make a modal choice
- To compete with other transport systems

- To coordinate an intermodal transport
- To perform an intermodal transport
- To operate a train service
- To operate a lorry service
- To operate a terminal
- To set and monitor laws and regulations
- To monitor compliance of laws and regulations
- To try to influence the system
- To monitor laws an regulations
- To develop and select a business model

This list is then transformed into a conceptual model describing the intermodal transport system. The arrows indicate dependencies between the activities. The thick black line represents the system border. The different activities are explained below.

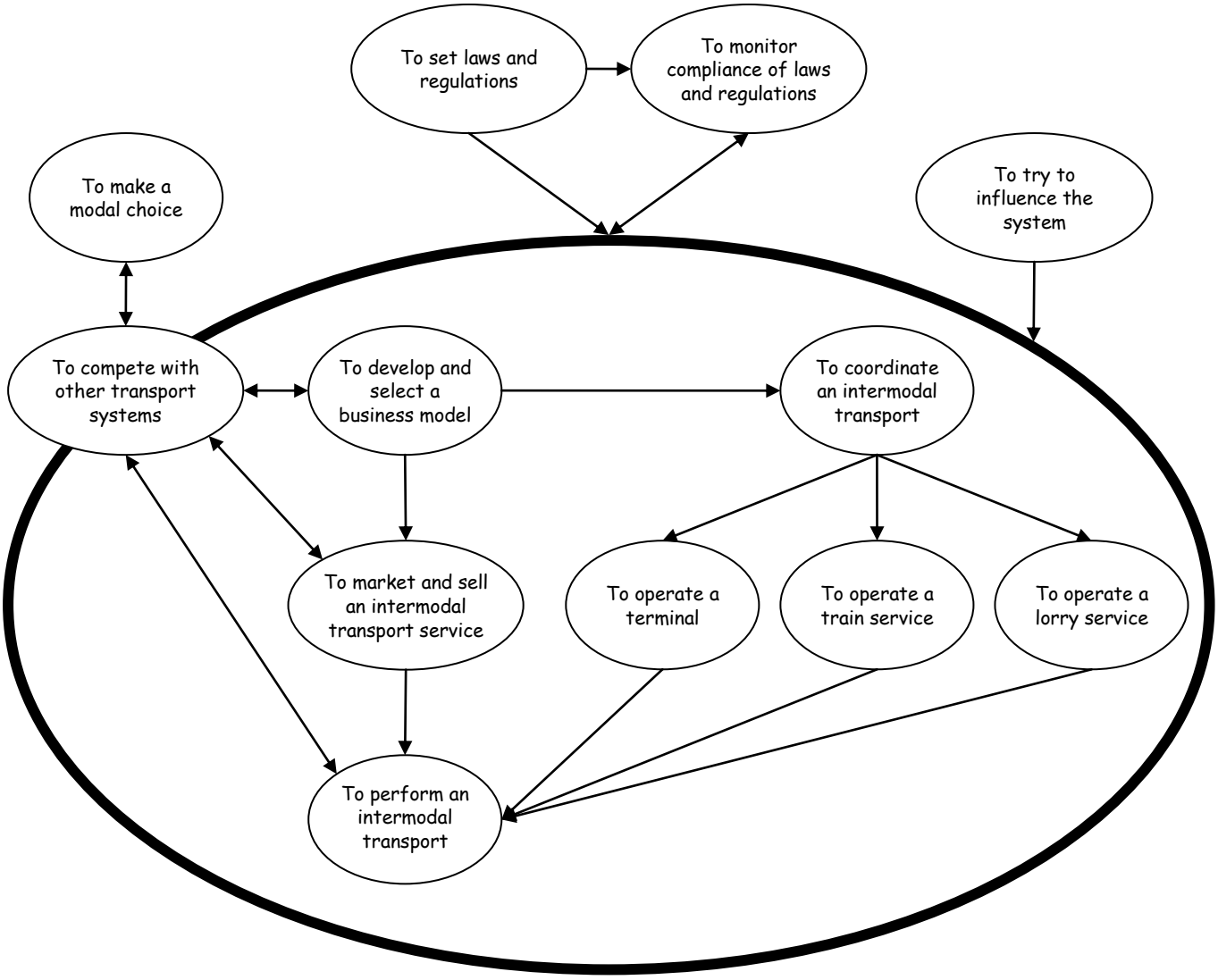

Figure 3 Conceptual model of the intermodal transport system

To set laws and regulations
To set the compulsory laws and regulations that the system has to comply to, e.g. traffic law, competitions laws, distribution of rail track capacity etc.

To monitor compliance of laws and regulations
To make sure that the actors complies to the laws and regulations and to inflict penalties if they are violated.

To try to influence the system
To trying to change the system in one or several aspects without imposing compulsory laws and regulations, e.g. interest groups, media, public opinion, politicians etc.

To make a modal choice
To decide to use a certain transport system for the goods the deciding actor needs to have transported.

To compete with other transport systems
To compete with other transport systems on an open market, where the customer has a free choice of which transport system to use.

To develop and select a business model
To determine the business logic of the intermodal transport system. Simply put how to run the business on a strategic level, e.g. which type of customers should we market us at (forwarders? shippers?), how many partners should be used (one company runs everything? outsource road haulage? rail haulage? terminal operations?), where should our revenue come from?, what is our core product? etc. This is a strategic activity that is performed seldom.

To market and sell an intermodal transport service
To market and sell the transport service according to the business model.

To coordinate an intermodal transport
To coordinate the activities involved in the intermodal transport. Several actors might be involved in the performance of the actual transport and these activities need to be coordinated. The actor performing this activity is the actor perceived by actors outside the intermodal transport system as responsible for the transport service, e.g. an intermodal transport company or a forwarder. This is a continuous activity need for the day-to-day operations of the system.

To operate a train service
To be responsible for the operation of train service, e.g. a railway company. Note that some activities can be outsourced and equipment leased.

To operate a lorry service
To be responsible for the operation of a road transport, e.g. a road haulier. Note that some activities can be outsourced and equipment leased.

To operate a terminal
To be responsible for the operation of a terminal. Note that some activities can be outsourced and equipment/facilities leased.

To perform an intermodal transport
To perform the actual physical transport of a specific intermodal load unit.

Step 5 - Comparison

This step goes back to step 2 and compares the conceptual model, that has been the outcome of step 4, with the rich picture from step 2 representing the "neutral" view of the situation. This is much a validation of the conceptual model from step 5, and a possibility to go back and make changes in the model.

By comparing the rich picture with the conceptual model, it can be seen that the conceptual model covers the important aspects of the rich picture. Each building block of the conceptual model covers several ways of performing the activity and could involve several actors and different actors in different real-world systems. The list of actors identified in the rich picture and their involvement in the activities is summarised in the table below. The list shows the actors that potentially could take on these roles. The actors are identified according to their roles and not their legal/company organisation. One organisation/company can take on the role of several actors, e.g. a forwarder can also be a road haulier.

Table 1 List of actors and activities

Activity	Actors involved	Comment
To set laws and regulations	Government Government agencies, e.g. rail administration EU	
To monitor compliance of laws and regulations	Government agencies Police EU	
To try to influence the system	Politicians Media Interest/lobby groups Public opinion Etc.	Separate between a politicians role as a government member with legislate powers, and an influencing actor without direct power.
To make a modal choice	Forwarder Road haulier Shipper Receiver	One company can often have several of the roles.
To compete with other transport systems	All actors inside the intermodal transport system Actors making the model choice	
To coordinate an intermodal transport	Separate intermodal transport company Forwarder Railway company Road haulier	Only one coordinating actor for each transport service, e.g. a daily transport service

		between A and B. This actor is the organisation that is associated with the intermodal transport service for actors outside the system.
To select a business model	The actor coordinating the intermodal transport system	
To market and sell an intermodal transport service	The actor coordinating the intermodal transport system Separate sales organisation Forwarder Road haulier	Several actors can sell the transport service offered by the coordinating actor.
To operate a train service	Railway company Forwarder	The ownership and operation of physical resources can be outsourced
To operate a lorry service	Forwarder Road haulier Railway company	The ownership and operation of physical resources can be outsourced
To operate a terminal	Terminal company Forwarder Road haulier Railway company Municipality Government agency	The ownership and operation of physical resources can be outsourced
To perform an intermodal transport	Road haulier Forwarder Terminal company Railway company	Normally performed by several actors in cooperation.

Real world systems in the conceptual model

To further validate this, the conceptual model has been used to show the activities of some real-world intermodal transport system. Two systems have been selected, representing the two major intermodal road-rail systems in Sweden. The first one is the system operated by the intermodal transport company CargoNet and the other is the port shuttle system to the port of Gothenburg.

Table 2 CargoNet

Activity	Actors involved	Comment
To set laws and regulations	Swedish government Rail administration Road administration	
To monitor compliance of laws and regulations	Rail administration Road administration Police	Other authorities might be involved, e.g. financial authorities.

To try to influence the system	Politicians Media Interest/lobby groups Public opinion Etc.	
To make a modal choice	Forwarder Road haulier	
To compete with other transport systems	All actors inside the intermodal transport system Actors making the model choice	
To coordinate an intermodal transport	CargoNet	
To select a business model	CargoNet	The business model is market the transport service to forwarders/hauliers and not to shipper/receiver
To market and sell an intermodal transport service	CargoNet	
To operate a train service	CargoNet Green Cargo	Some train services are outsourced to Green Cargo
To operate a lorry service	Several forwarders Several road hauliers	Road hauliers can be both independent and subcontractors to a forwarder.
To operate a terminal	CargoNet Terminal company	Most terminals operated by CargoNet
To perform an intermodal transport	CargoNet GreenCargo Terminal company One or none of several forwarder One or several road hauliers	

The Port of Gothenburg rail shuttles are described below. The description represents an average shuttle. A different real-world system applies to some shuttles. The sea shipping to/from the port is not considered in the description.

Table 3 Port of Gothenburg rail shuttles

Activity	Actors involved	Comment
To set laws and regulations	Swedish government Rail administration Road administration	
To monitor compliance of laws and regulations	Rail administration Road administration Police	Other authorities might be involved, e.g. financial authorities.

To try to influence the system	Politicians Media Interest/lobby groups Public opinion Etc.	
To make a modal choice	Shipper Receiver Forwarder Road haulier	
To compete with other transport systems	All actors inside the intermodal transport system Actors making the model choice	
To coordinate an intermodal transport	Local road haulier/small forwarder	Each rail shuttle is operated by a separate company, often a local haulier/forwarder at the inland destination.
To select a business model	Local road haulier/small forwarder (the coordinating actor) Influenced by the Port of Gothenburg	The local haulier markets directly to local shippers/receivers but also to other forwarders/hauliers. The local haulier/forwarder needs the ports permission to operate a port rail shuttle.
To market and sell an intermodal transport service	Local road haulier/small forwarder (the coordinating actor) Assisted by the Port of Gothenburg	
To operate a train service	Independent railway company	Often a small company
To operate a lorry service	Local road haulier/small forwarder (the coordinating actor) Several road hauliers Several forwarder	
To operate a terminal	Local road haulier/small forwarder (the coordinating actor) Port of Gothenburg	The port operates the port terminal, but no inland terminals. The local haulier/forwarder operates the inland terminal.
To perform an intermodal transport	Local road haulier/small forwarder (the coordinating actor) Independent railway company Port of Gothenburg One or none of several road haulers One or none of several forwarders	

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