EVALUATION OF INTER-MODAL TRANSPORT CHAINS
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ABSTRACT

Intermodal transport chains include several transport modes and several instances of handling at terminals. This means a specific cost structure, time consumption and a risk that goods will be damaged. The aim is to find the weakest link in intermodal transport chains, which can be critical when increasing combined transportation.

The method is to map and analyse a number of intermodal transport chains and investigate each link in the chains with regard to time, cost, risk of damage, and administrative process.

Different transport chains will be chosen with different modes, terminal handling methods and distances. Shock and vibration will be measured in loading units during handling and transportation. A terminal cost model will be developed and interviews held to determine customer experience.

KEYWORDS

Intermodal, freight transport, terminal, railway, container, vibration

BACKGROUND

Intermodal transport chains include several modes and several instances of terminal handling, which means a specific cost, time, and a risk that the goods will be damaged while being transported.

Cost, transport time and quality are the most important factors for customers' choice of transport. The results of a customer investigation at KTH [2] show that transportation cost is a very important factor when choosing a carrier. Actual transportation in today's transport systems is of high quality with few delays and little freight damage. At the same time, the transportation market is subject to stiff competition, which is one of the reasons why transportation customers are sensitive to price.

Intermodal transport is more complicated than direct truck or train transport and consists of more operations at the same time the goods are protected by a loading unit all the way. To find the weakest link in an intermodal transport chain it is important to know exactly how the consignments are handled, the cost, the time consumed, and the forces to which the freight will be subjected as it passes through the chain.

AIM

The aim of the project is to find the weakest links in intermodal transport chains, which is critical to the competitiveness of intermodal transport. The weakest links will be ranked and when the weakest link has been identified it will be analysed to determine how it can be eliminated or reduced. In the next step the second-weakest link will be analysed, etc.

The aim of the project is to follow a number of intermodal transport chains and register each link in the chain in terms of time consumption, cost, administrative routines and physical impact on the goods.

METHODS

For the selected flows, various measurements will be carried out in the loading units during transportation. The following parameters will be analysed:

- Time consumption
- Costs
- Vibration and shocks
- Administrative routines
- Customers experiences

The data obtained from the mapping of time consumption of the real transportation assignments will be compared to timetables and transport plans in order to identify discrepancies and critical parts of the transport chain. For certain assignments, time studies will be carried out in situ by observation, for example in intermodal terminals and ports.

The costs can be calculated by the supply and cost models developed at KTH using Activity Based Costing (ABC) [2]. The results will be compared with price information obtained from different actors in the transport chain. A special terminal cost model will also be developed.

IT-based measurement methods have been used. Shock and vibration instruments and GPS will be attached to the loading units to register vibration and the actual time and position. The data from the instruments will be stored for later analysis with different analytical programs.

Laboratory measurements of different kinds of vibration frequencies will also be performed using a shaker table. Here we will simulate different kinds of vibration and compare the data with the real measurements and the models that have been constructed.

Administrative routines will be analysed by collecting documents and monitoring email and other communication and by interviewing the people involved in these routines. Customer preferences and experience of intermodal transport will also be investigated by means of interviews.

The project requires close cooperation with various actors in the transport chain, especially transport customers, forwarding companies and railway operators. The selection of transport and the identification of all actors involved are therefore crucial in order to obtain all relevant information. Some information will only be published on an aggregated level, in order to ensure that no confidential, sensitive information will be disclosed.

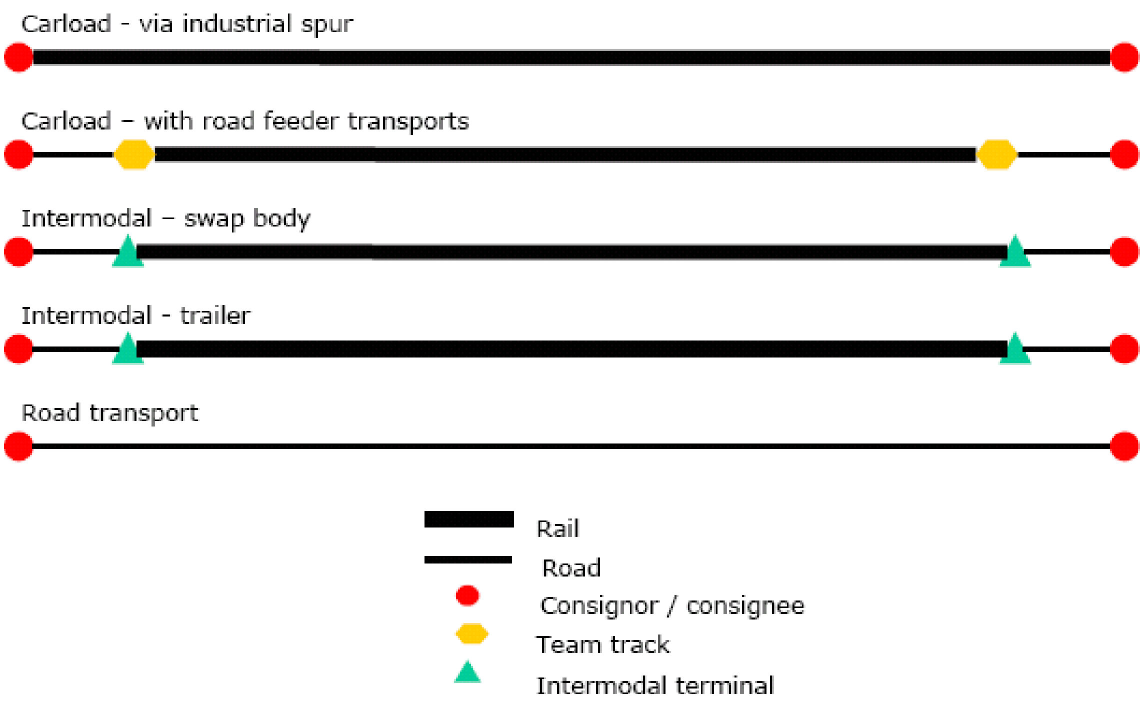

Figure 1: Different kinds of intermodal transport chains compared with direct rail (carload) and road transport.

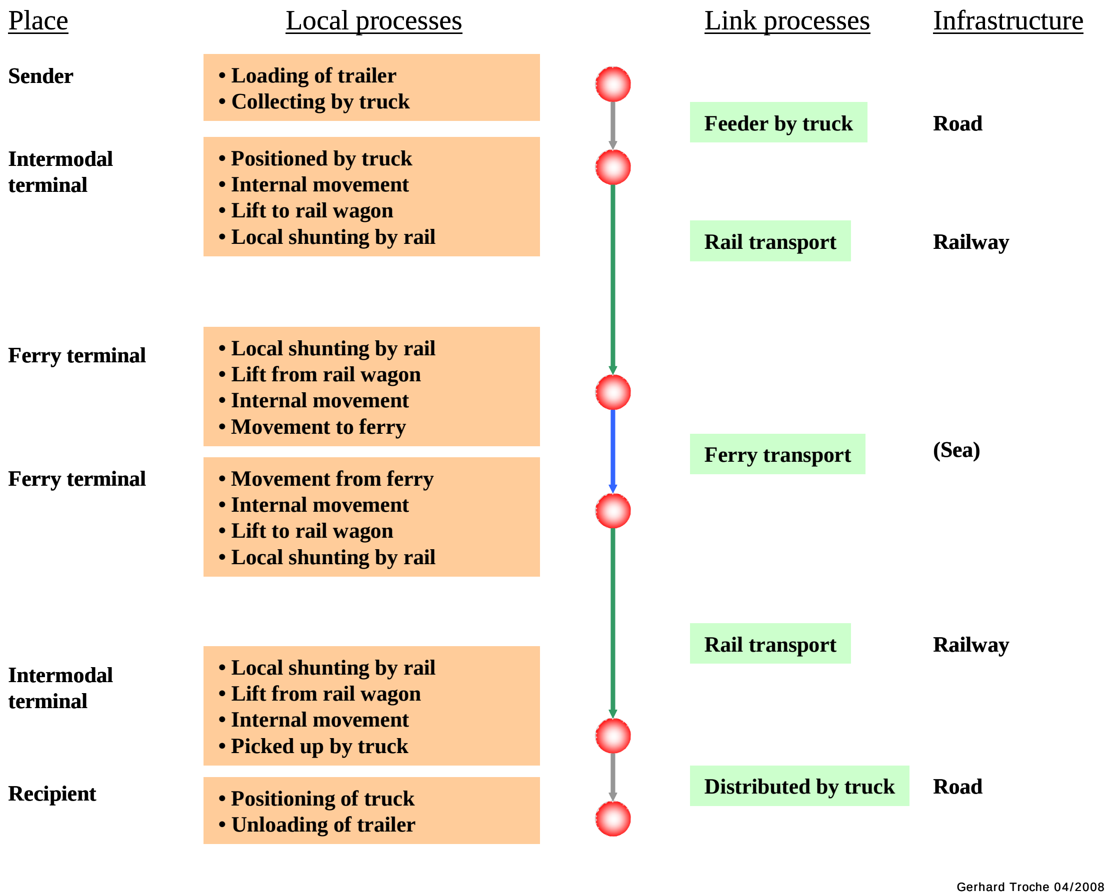

Figure 2: Example of a process chain for an international trailer transportation assignment.

A COOPERATION PROJECT OF SiR-C

The project is funded by the Swedish Rail Administration and the Swedish Road Administration through the virtual research centre SiR-C (Swedish Intermodal Research Centre). The participating parties are: Dept. of Transport & Logistics and the Marcus Wallenberg Laboratory (MWL) for Sound and Vibration Research at the Royal Institute of Technology, Stockholm, TFK Transportforsk AB, Stockholm and Mariterm, Höganäs.

SELECTION OF TRANSPORTATION

A number of flows of different kinds will be selected, focusing on: **Type of loading unit** (container, swap-body, trailer), **type of transloading equipment** (portal crane, reach-stacker, forklift truck), **combination of transport modes** (road-rail-road, road-rail-ship), **commodity/shipment size** (less-than-carload/less-than-truckload, finished products, sensitive cargo, e.g. perishables, furniture, semi-sensitive cargo, e.g. rolls of paper), **organisation of loading/unloading** (e.g. cargo loaded by customer, cargo loaded by customer with assistance from the truck driver, mixed cargo (less-than-truckload), loaded by the driver).

The intermodal transport chains will be compared with direct rail (carload) and direct road transport.

A number of transport chains have been selected for a careful examination, see table 1. They represent different distances and types of transportation assignment. For the selected assignments, times and costs will be investigated. Customers and operators will be interviewed about their experience of intermodal transport.

Measurements of shock and vibration have been made of some typical assignments and handling equipment sequences, see table 2. Laboratory tests will be conducted on some sensitive products using a shaker, see table 3.

Statistics of damaged goods will be obtained from a company that can provide statistics of high quality and sufficient quantity. We have not found many companies that maintain statistics about goods damage because it is not felt to be a significant problem today.

COST STRUCTURE FOR INTERMODAL TRANSPORT

The cost structure of a typical intermodal assignment has been calculated using a cost model [3]. It can be seen that the terminal costs, i.e. lifting off, account for a large proportion of the costs, 48%, as does the feeder transportation, which accounts for 23%. Together they are responsible for 71% of the costs before the load is even on the train. The long-distance haulage then accounts for only 23%. Administration and planning costs are low, only 6%, since the system is relatively simple and sales are not direct to customer but via haulage companies and shipping agents.

For a typical single wagonload the cost structure shows that feeder transportation (at both ends) accounts for most of the cost, i.e. 50% with marshalling costs included. Long-haul transportation accounts for 30%, and administration and planning for a relatively large proportion of 22% when the cost is to be borne by one wagon. The cost structure of direct trucking is very simple: 95% is haulage costs (because feeder transport is included) and approx 5% is administrative costs.

Table 1: Selection of transport chains for evaluation of intermodal transport

	Origin-destination	Mode	Company	Product
1	Gävle-Milan	Intermodal	Sandvik	Steel
2	Fors-Göteborg (- Great Britain)	Intermodal	Stora-Enso	Paper
3	Helsingborg-Stockholm	Intermodal	ICA	Provisions
4	Skåne-Bro	Wagon load	Coop	Grocery
5	Torsvik-Stockholm	Intermodal	IKEA	Porcelain
6	Göteborg-Södertälje	Intermodal	Maersk	
7	Malmö-Stockholm	Trucking	Schenker	Less than carload
8	Göteborg-Insjön	Intermodal	Claes Ohlsson	Manufactured goods
9	Uddevalla-Göteborg	Intermodal	Green Cargo	
10	Norrköping-Trelleborg-Duisburg	Intermodal	Hector Rail	

Table 2: Selection of transport mode and handling equipment for measurements of shock and vibration

	Place	Mode/Transport Equipment	Loading unit
1	Malmö-Stockholm	Intermodal-Railway wagon	Trailer Swap-body
2	Helsingborg	Intermodal-Trailer-distribution	Trailer 25 ton Trailer 12 ton
3	Trelleborg, port	Tugmaster-rolltrailer Tugmaster-chassis Tugmaster-chassis+Reach-stacker	Swap-body
4	Helsingborg, port	Port crane Reach-stacker Vehicle Mower	
5	Malmö intermodal terminal	Valvport crane Reach-stacker	Trailer Container Swap-body

Table 3: Selection of products for test of shaker in laboratory

	Commodity	Product	Company	The test includes
1	Paper	Bale of fine paper	Stora-Enso	Shock and vibration test
2	Porcelain	Plates	IKEA	Shock and vibration test
3	Glass	Glass	IKEA	Shock and vibration test
4	Grocery goods	Glass jars of cucumbers	ICA	Shock and vibration test

A calculation of the cost per ton for three containers transported by intermodal shows that conventional intermodal transportation has difficulty competing both with road haulage and wagonload on price in Sweden on a distance of 500 km with 50 km feeder transportation at both ends. In Sweden trucks are 25.25m long and have a payload of 40 tons. One reason is that the freight must be loaded into a container for intermodal transportation, and the payload is then smaller since it is the feeder transportation by road that dimensions the weight. It should be emphasised that with other prerequisites, for example shorter feeder distances, lighter freight etc, intermodal can compete with direct trucking and wagonload.

MEASUREMENT OF SHOCK AND VIBRATION

Measurements of operations

Shock and vibration in cargo transport units have been measured at ports and intermodal terminals and during transportation by trailer and train. The measurements were made by the Swedish consultant company Mariterm, who are cargo securing specialists.

The measurement equipment consisted of various instruments connected to laptops placed in a box specially built for this purpose. The box was placed on the floor of loading units. Accelerometers with their own electricity supply were placed outside the box on the floor of the loading unit. A GPS receiver placed on the roof of the loading unit and connected to the computer registered the position at intervals of one or a few seconds. The handling procedures at the terminals were also video-taped.

Measurements on trains were carried out on trailers and swap bodies with different loads transported between Stockholm-Malmö, a distance of 600 km, for four single trips. The trains' position and speed were measured all the way by GPS. Measurements of trailer road transport were made on a 70 km long distribution route in and around Helsingborg. In the terminals the handling of the loading units was measured for careful, normal and rough handling. One observation was that the equipment was moved at close to maximum speed already during normal handling, but in the case of rough handling several operations, such as lifting and parallel movement of the loading unit, were carried out at the same time. Examples of the results are shown in figures 3 and 4.

The measurements worked well technically and the data has been analysed [4]. In normal operation, no extreme shocks or vibrations have been registered, but when handling has been provoked the results are, of course, different.

Shock and vibration tests in the laboratory

The shocks and vibration measured during operation will be used to design laboratory shock and vibration tests using a shaker table. The tests will be carried out at the MWL laboratory at KTH. Shock response spectra and acceleration power spectral densities have been estimated from the measurements in operation and sorted by place and direction. In the measurements using the shaker table the test begins with horizontal shocks and a series of tests for each kind of goods until something happens as follows:

- The goods are displaced
- The goods are damaged
- The maximum values for the vibrator have been reached

If nothing happens, vertical vibration will also be tested. The aim of the laboratory tests is to find upper shock and vibration limits for different types of goods with regard to goods damage during the various phases of a hypothetical intermodal transport assignment.

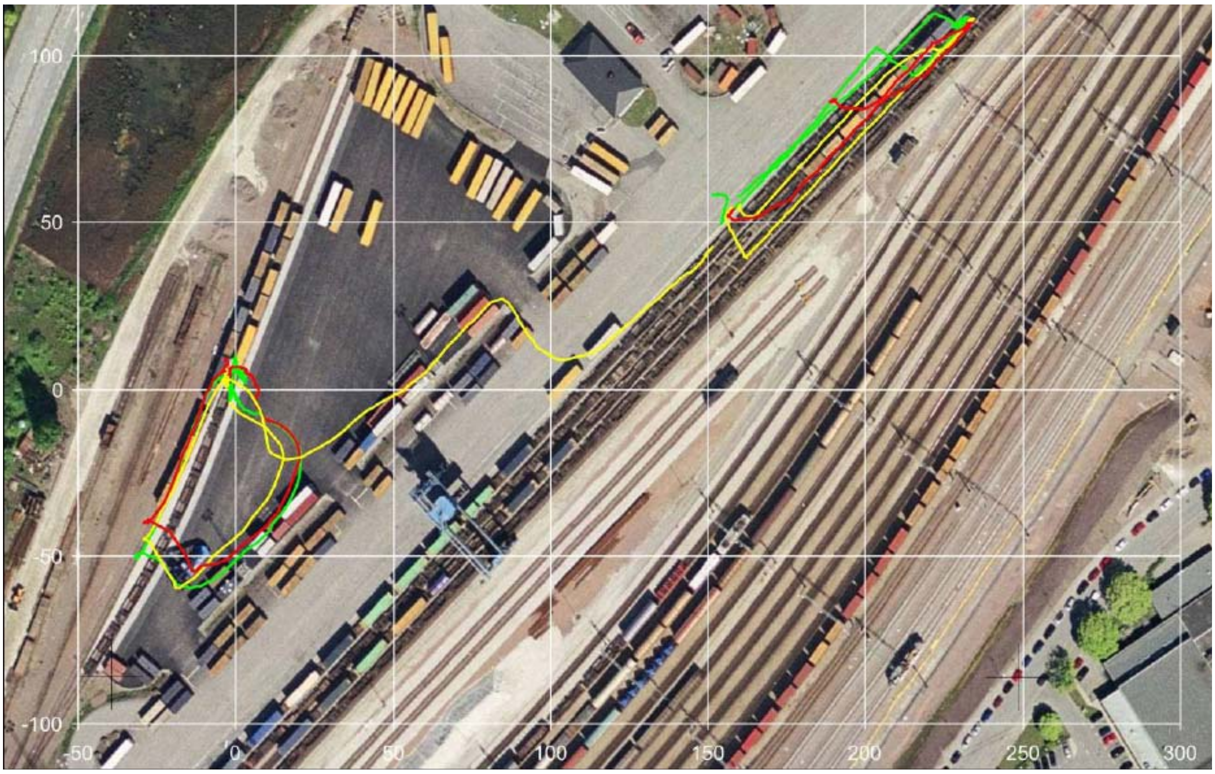

Figure 3: The intermodal terminal in Malmö. Movements registered by GPS when handling trailers: to the left by Reach-stacker and to the right by valvport crane [4].

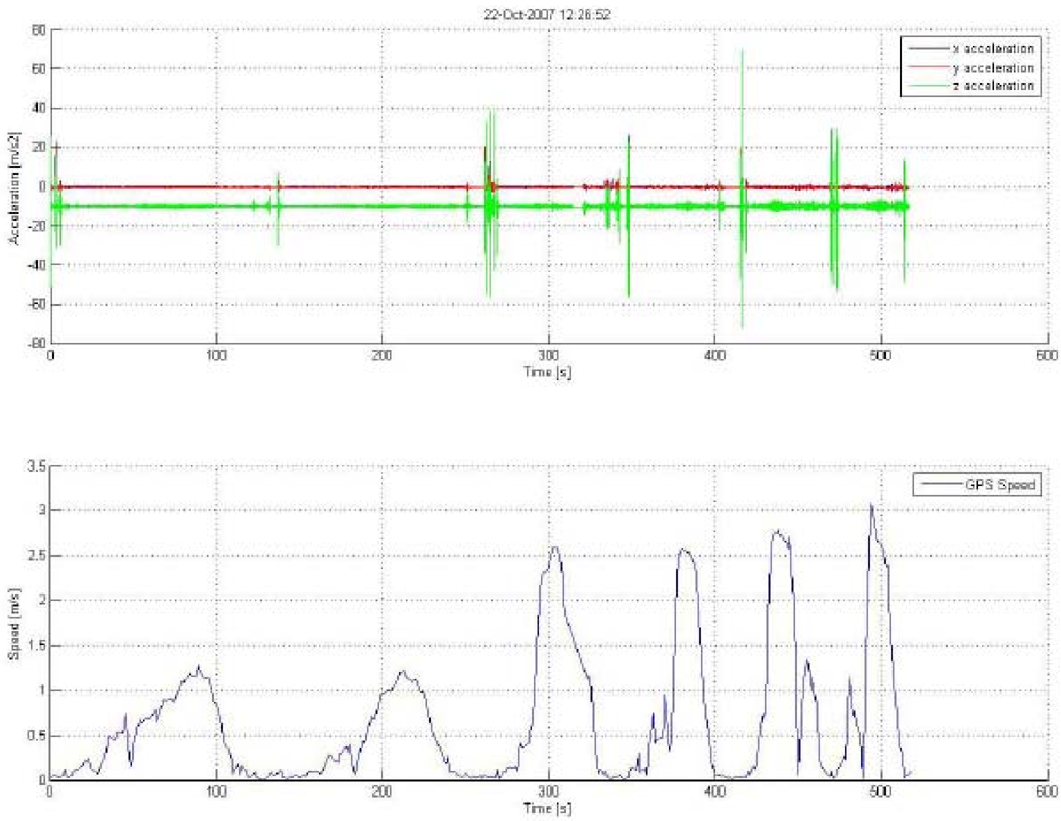

Figure 4: Handling of swap-bodies in Malmö intermodal terminal. Measurements of accelerations (upper graph) and movements and speed (lower graph) [4].

RESULTS SO FAR

The elimination of weak links in intermodal transport chains can make intermodal transport more competitive and efficient, resulting in higher market shares. This will in turn give benefits for the whole of society in the form of fewer road accidents and a better environment.

An intermodal transport assignment differs from a direct transport assignment in that the goods always need to be handled in a terminal along the way. There are also more parties involved with more modes, more transport companies and operators even if a forwarder is responsibility to the customer.

At the same time the loading unit has the function of packaging the goods and protecting it during transportation. The loading unit can also be used for longer in the logistics chain from shop floor to store.

The results from the project so far indicate that terminal handling is the most critical operation in an intermodal transport assignment with regard to both time and costs. The risk of damage is generally slight but is also highest at the terminals. The complexity of an intermodal transport assignment is also a weakness compared with direct transport.

One conclusion is therefore that it is important to develop terminal technologies that allow cheaper terminal handling in a short time and with low forces. Such a system is horizontal transfer equipment which can be fully automated.

To eliminate complexity there must be fewer parts involved. The deregulation and specialization of the transport sector sometimes develops in the other direction. But there are examples of ports which have organised intermodal shuttles themselves and been successful in developing feeder transport to the ports by rail. One example in Sweden is the Port of Gothenburg which now has 23 intermodal lines, also on very short distances from the port.

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