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Challenges for using ICT to improve coordination in hinterland chains

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1. Introduction

The importance of hinterland transport in intercontinental door-to-door chains is widely recognised (Van der Horst and de Langen, 2008). The 'hinterland leg' is often more costly than the maritime leg and port costs combined. Furthermore, whereas the efficiency of the maritime leg has improved substantially over the last decades, due to the emergence of global carriers, with comprehensive maritime networks, increases in ship size and better coordination between shipping services and terminal services, the efficiency of the 'hinterland leg' can still be substantially improved (Van der Horst and de Langen, 2008).

This issue is relevant for ports, and companies in ports (e.g. terminal operators), as the quality of hinterland services is an important determinant of a port's competitive position (Tongzon and Heng, 2005). Furthermore, this issue is also relevant for shippers, that benefit from lower transport costs, and relevant from a societal perspective, as improved hinterland access lowers generalized transport costs and thus enables more and cheaper trade (Limao and Venables 2001). Finally, the quality of intermodal services also leads to reduced pressure on congested road infrastructure.

Many different firms provide (parts of) hinterland transport services. Consequently, there is a need for cooperation and coordination in hinterland chains. However, different firms have different market positions and business models. This leads to differences in incentives, resources, capabilities, and attitudes concerning coordination. Consequently, coordination and cooperation are challenging and necessary for efficient transport chains, but does not always emerge. Thus, it is not surprising that approaches to enhance coordination are center stage in many projects to improve the efficiency of hinterland transport.

In this paper we first discuss some relevant characteristics of hinterland transport markets and reasons for coordination problems in these markets. Second, we discuss coordination problems in hinterland transport in more detail. Third, we discuss the potential role of ICT in improving coordination. We discuss some relevant projects currently underway in the Netherlands. We finalise the paper with some conclusions and a discussion of relevant policy avenues to encourage the use of ICT to improve hinterland services.

2. Organisational dynamics in hinterland transport

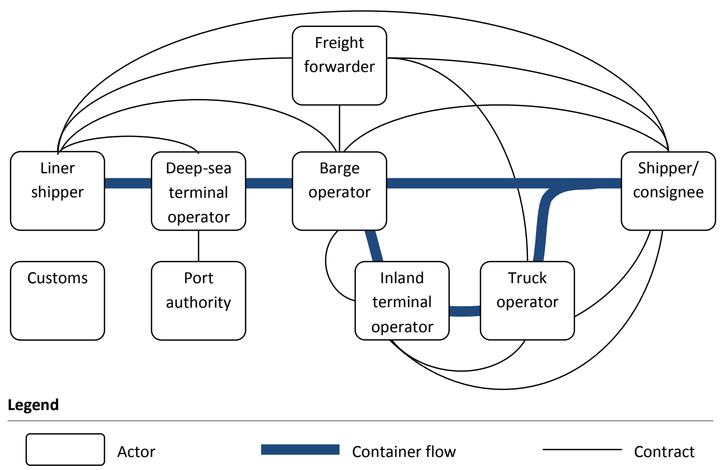
Developing effective mechanisms to improve coordination is more than an operational challenge (e.g. through new ICT applications, standards for information exchange, or simple agreements between firms). We therefore need a thorough understanding of the market positions and business models of firms in the intermodal transport chain. Mechanisms to improve coordination will only be successful if they are in line with the business model of the firms involved. No firm will contribute to improved coordination when this has a negative effect on its market position or when it is not in line with its business model.

As an example, barge operators will not provide information which is sensitive for competitive reasons, notwithstanding potential benefits of systems to improve capacity utilisation based on such information. Such a system would hamper their business model.

Perhaps this is stating the obvious, but nevertheless, academic attention for market positions and business models of firms in intermodal transport chains is very limited. Furthermore, the analysis of coordination problems often focuses on operational issues and neglects the effects of different business models on implementation success. As an example: it is (easily) demonstrated that empty container flows can be reduced by collaborative planning systems in which empties are not returned to the seaport (Jula et al, 2006). However, such a system requires a shift in the business model of liner shipping companies, away from the current model where individual shipping lines manage a fleet of (mostly long term leased) containers..

In this section we provide a schematic description of firms in the intermodal transport chain. This description provides a background for the analysis of coordination problems and the role of ICT to enhance coordination, in Section 3 and 4. Figure 1 gives an overview of the intermodal hinterland chain for the case of barge transport. Similar figures for the other modes are given in Van der Horst and de Langen (2008).

Figure 1: **An overview of the barge transport chain**



Source: Douma (2008), adapted from Van der Horst and de Langen (2008).

Figure 1 shows the main actors in the intermodal barge chain. Containers arrive by ship, are unloaded at a container terminal and then put on a barge directly. A barge then brings the container to an inland terminal, from which it is transported by road to the final destination. In some cases, large shippers have own dedicated barge terminals on-site.

Figure 1 also shows contractual relations in this chain. It shows that in some cases, even though there is a physical flow between two firms, there is no contractual relationship between the two companies (e.g. deepsea terminal and barge operator). This has an important influence consequence for the coordination of activities of these two companies. Figure 1 also shows that one organization, the forwarder, does organize intermodal transport but does not actually handle containers. Note that forwarders are not always involved, others like shipping lines may play this role as well.

While Figure 1 shows the flow of containers and actors involved, it only show the traditional core activity of shipping lines terminal operators and forwarders. Figure 2 provides a schematic overview to understand the involvement of these firms in complementary activities.

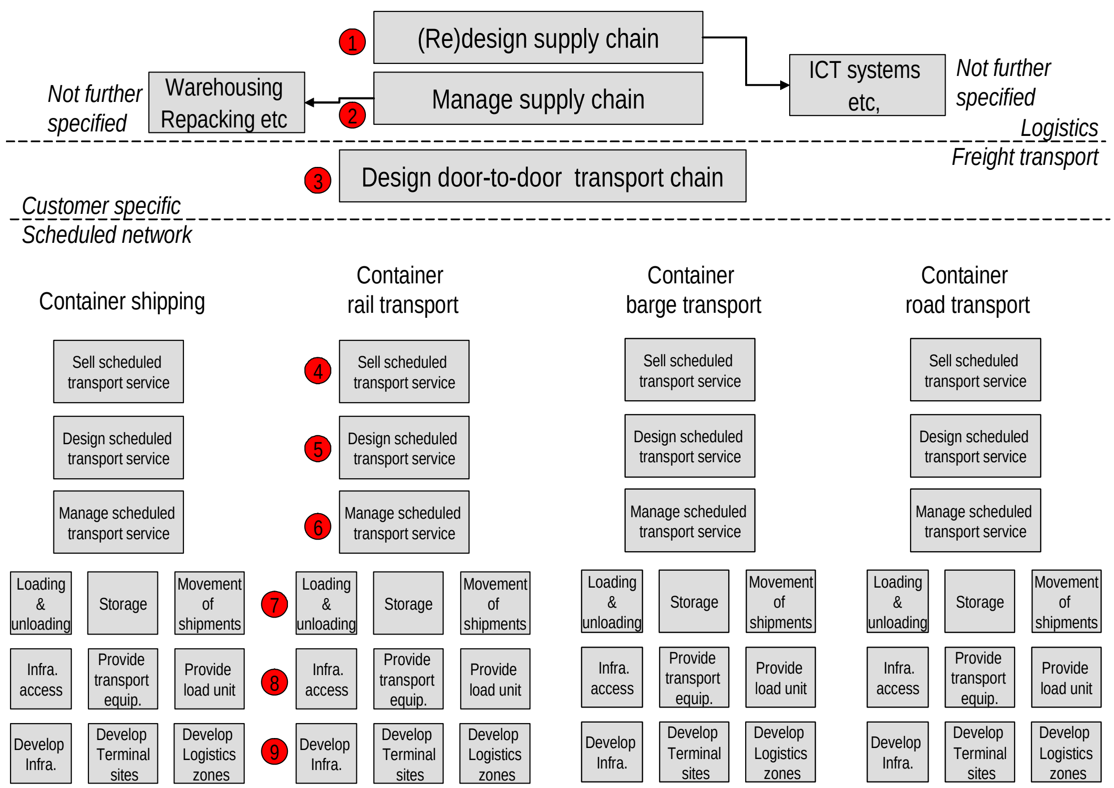


Figure 2 makes a –stylized- distinction between various layers of activities. The layers have some sort of hierarchy: the higher layers influence the lower layers. The 'highest layer' (Layer 1) consists of the design of supply chains. This includes decisions on e.g. make to order vs make to stock, number of storage locations, time to market and so on. Layer 2 consists the management of these supply chains, including inventory management and so on.

International supply chains require door-to-door transport. Thus, Layer 3 is the design of door-to-door chains. These door-to-door chains are customer specific, and consist of various scheduled transport services, such as train, sea and, barge services[1]. For each of these scheduled services, a distinction can be made between:

- Selling scheduled transport services. Scheduled transport services are sold, generally to firms that design door-to-door services (Layer 4).

- Designing scheduled transport services. The scheduled services also need to be designed. The routes, capacity of equipment and frequency have to be set in advance (Layer 5).

- Managing scheduled transport services. Scheduled transport services need to be managed (Layer 6).

Managing scheduled transport consists of activities such as planning of transport means, providing information on arrival & departure times and coordination with other firms in the transport chain. This is different from operations, e.g. the actual sailing of a ship or unloading a train. .

Layer 7 consists of the operation of transport services, divided in three parts: loading and unloading, movement of shipments (the physical transport) and storage. Storage is often done on the terminal, but in some cases, especially for storage of empty containers, is provided at specific sites.

Layer 8 contains three activities that are necessary for the operation of intermodal transport services: the provision of infrastructure[2], transport equipment and load units (mainly the container). Finally, layer 9 contains the *development* of infrastructure, terminal sites and logistics zones.

One company may carry out these different activities in house. However, different activities may also be carried out by different companies. To give one example: large barge operators *design and manage* scheduled barge services. Forwarders *sell* these services (not exclusively, barge operators do this as well), and individual captains and owners *operate* barge services.

Figure 2 allows us to show – in stylized form – how a certain specific company or a certain type of company (e.g. a shipping line) is positioned in the intermodal transport chain. As an illustration, Figure 3 shows the traditional core activities of shipping lines, additional activities they have developed over the years and activities they no longer regard as core activities.

[1] Figure 2 also shows scheduled road transport. Only a (small) part of road transport services are scheduled. Often, services are simply offered on demand. In this case, no network is designed. However, most large international road transport companies, especially in the time sensitive market segments, have developed scheduled transport services that are offered to customers.

[2] Infrastructure is not always provided ´actively´. Barge companies use rivers and canals without ´access contracts. However, access to infrastructure is increasingly priced (e.g. road pricing) and subject to coordination and regulation.

Figure 3: **Activities of shipping lines**

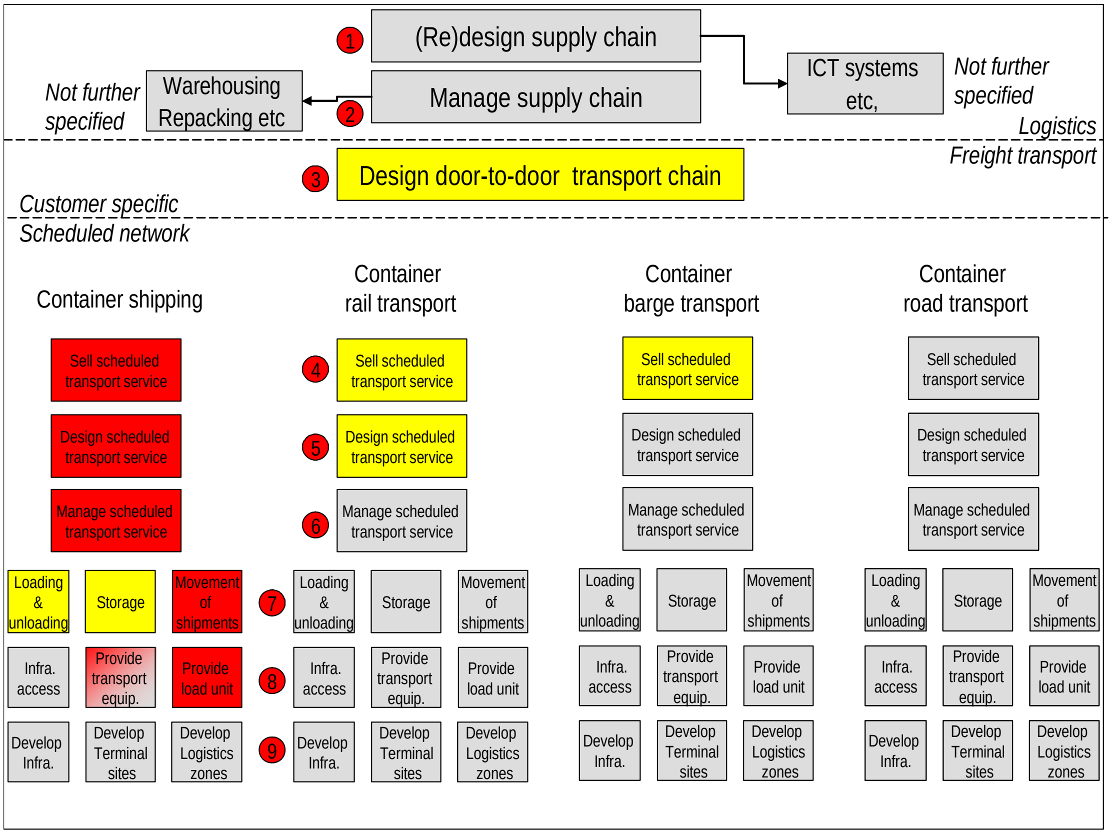


Figure 3 shows liner shipping companies move into designing and selling rail services, selling barge transport services and providing customer specific door-to-door services. Furthermore, they have also moved into the provision of loading and unloading services in seaports. Shipping lines increasingly move away from owning ships, and instead have long term lease contracts. Thus, the provision of transport equipment is outsourced. Figures 4 and 5 show the same, for forwarders and terminal operators.

Figure 4: **Activities of forwarders**

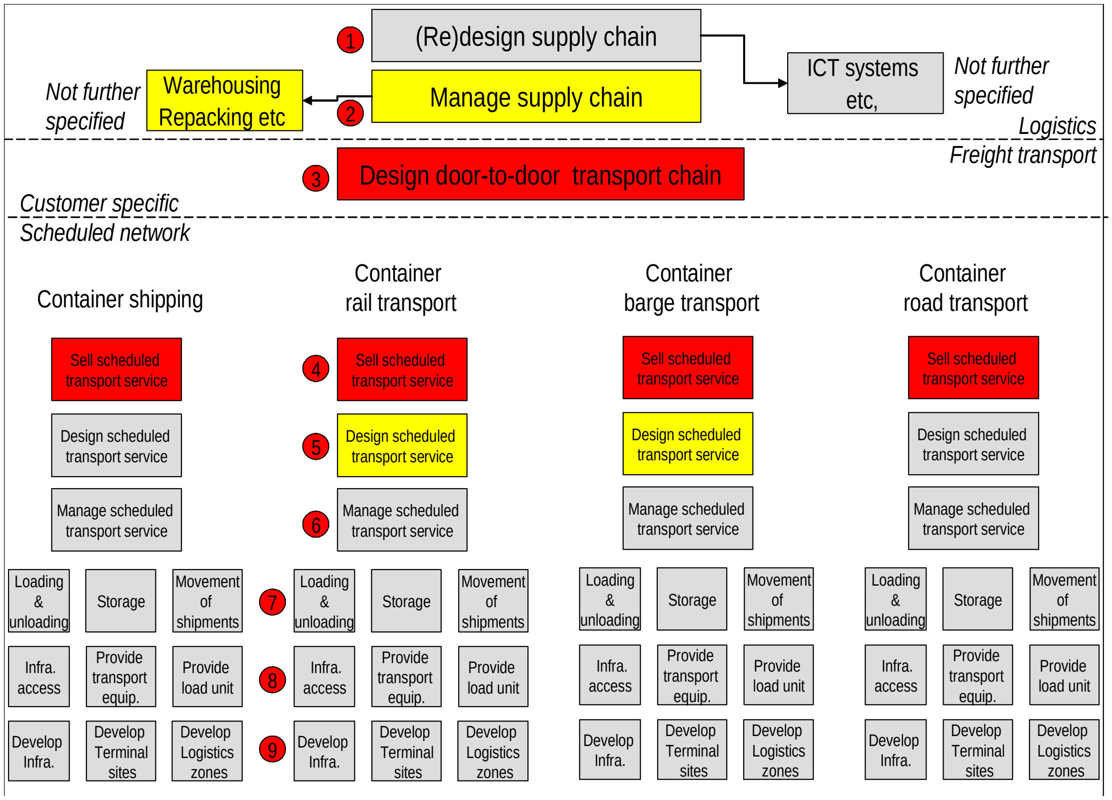
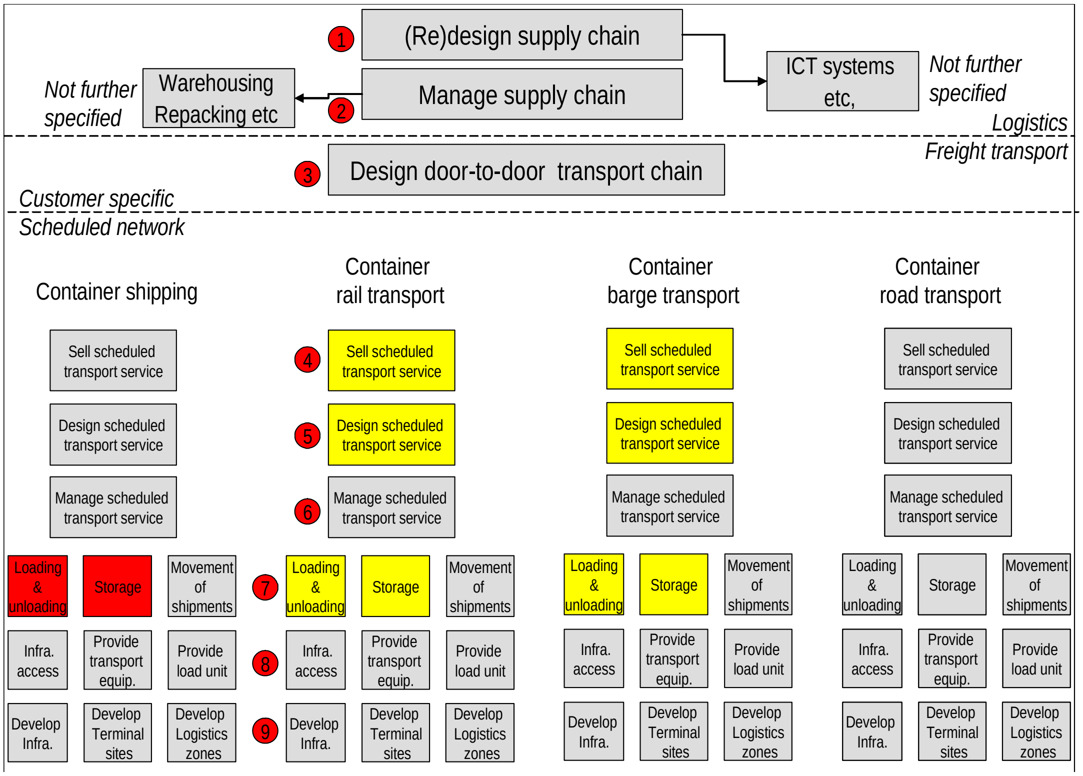


Figure 5: **Activities of terminal operating companies**



Figures 3, 4, and 5 only show the scope of thee players in door to door chains. Similar figures can be made for barge operators, rail operators, port authorities and others. However, these three illustrations allow for some conclusions that are relevant for analyzing coordination in intermodal chains:

1. Various firms, with different business models and market positions, have overlapping scopes of activities. They expand into new activities, thereby changing the nature of competition. This does have important consequences for their attitudes towards cooperation & coordination in hinterland transport.

2. Many players aim to become involved in designing hinterland services, as service design has important implications for the efficiency of their core processes and the value they create for their customers. Influence and capabilities to design scheduled networks is increasingly a strategic asset. This also has important consequences for their attitudes towards cooperation & coordination in hinterland transport.

3. Coordination in hinterland chains

In this section coordination in hinterland chains is discussed in some more detail. First, we discuss five general arguments that explain why coordination problems arise. Next, we briefly mention specific coordination problems in the hinterland chain. These general reasons for lack of ‘spontaneous’ coordination & alignment in transport chains are:

- *Distribution of costs and benefits*. The unequal distribution of the costs and benefits of coordination. If one actor in the chain has to invest (e.g. in ICT systems) while other actors obtain the benefits, coordination may not arise spontaneously. Gain-sharing mechanisms that redistribute benefits may fail owing to high transaction costs and the risk of free-rider behaviour.

- *Willingness to invest in (parts) of the chain*. The lack of resources or willingness to invest on the part of at least one firm in the transport chain. Even though all actors may agree that investments (including management involvement) are required to improve coordination, some firms may not be able or willing to take part. This issue is especially relevant for coordination problems involving relatively small firms.

- *Strategic considerations*. These can also impede coordination. Firms may be reluctant to improve coordination if competitors would also benefit. This situation is likely to arise in a market characterized by fierce competition.

- *The lack of a dominant firm*. A firm with *supply chain power* will have a major impact on the structure of a transport chain (see e.g. Groothedde, 2005). A lack of *supply chain power* reduces coordination.

- *Risk aversion*. Risk-averse behaviour and a short-term focus of firms in hinterland chains. Firms that expect the process of establishing better coordination through cooperation to be time-consuming and feel that results are uncertain may be reluctant to put any effort into this process.

Given the reasons provided above, the involvement of various actors in international door-to-door chains, the overlapping activities between these actors and the competition in the design hinterland networks, coordination problems arise frequently in hinterland chains. We argue that indeed, these coordination problems are the most important barrier to further improvement on the efficiency of these transport chains. Table 1 show important coordination problems for barge, rail and road hinterland transport, as well as coordination problems that apply to all these modes (see Van der Horst and De Langen, 2008, for more details).

Table 1. **Coordination problems**

Transport mode	Coordination problem	Main actors involved
Barge	Poor alignment of terminal and barge activities. Results in long waiting times, uncertain port stay times, idle time of terminal quay resources etc.	Barge operator, container terminal operating company, terminal operator in port, forwarder
	Limited exchange of cargo between barge operators	Barge operator, forwarder
Rail	Poor alignment of terminal and barge activities. Results in peak load on terminals, long waiting times of trains.	Container terminal operating company, Rail terminal operator in port, rail terminal operator in hinterland, railway company, infrastructure manager
	Unused rail tracks because of insufficient information exchange and dynamic planning	Railway company, infrastructure manager
	Limited exchange of traction (locomotives), results in waiting times of trains at terminals and waiting yards	Railway companies
Truck	Poor alignment of truck and terminal activities. Results in peak hours at terminals, congestion on the roads, long waiting times for trucks etc.	Container terminal operating company, truck company, infrastructure supplier
	Limited exchange of cargo and truck capacity	Truck company, forwarder
Acros all modes	Insufficient information exchange of container data causes inadequate planning and inefficient pick-up proceses	Container shipping line, container terminal operating company, forwarder, truck company, barge operator, rail operator
	Investments in hinterland terminals do not come about spontaneously	Forwarder, rail terminal operator hinterland, barge terminal operator in hinterland
	Introducing new hinterland services requires volume; 'cargo controlling' parties do not commit to new services of other transport providers	Forwarder, shipper, container shipping line
	Insufficient planning on transporting and storing empty containers	Container terminal operating company, rail terminal operator in hinterland, barge terminal operator in hinterland , container shipping line

Source: Adapted from van der Horst and De Langen (2008).

In general, various approaches can be used to improve coordination. First, companies may change the scope of their organisation (by engaging in new activities or by outsourcing) to improve coordination. Second, firms may develop contracts and agreements to enhance coordination. For instance, firms may change their pricing structures to provide incentives for information exchange, early booking and so on. Third, firms may develop inter-firm alliances, and improve coordination within such an alliance. Finally, collective sector wide initiatives for coordination may be taken. ICT systems play an important role in all these approaches to enhance coordination.

4. The role of ICT to improve coordination in hinterland transport chains

Information and communication technology is developing rapidly and many companies in the hinterland transportation chain realize the potential of these systems for their businesses. Over the last decades we have seen that the role of ICT in hinterland transportation has become more and more important. Especially over the last five to ten years new initiatives have been set-up aiming at connecting links in the hinterland transportation chain. These systems are built and designed for different purposes reflecting the fields in which ICT adds value to hinterland transportation. Looking at the different (inter-organisational) information systems in practice we distinguish four purposes of these systems:

- Facilitate information exchange.
- Collect real-time performance data.
- Facilitate coordination (or alignment) of activities of different players.
- Facilitate the exchange of freight between players.

Let us give some examples of applications in each of the four groups. The examples we mention have been set-up over the last ten years.

PortBase is the port community system in the Port of Rotterdam and the Port of Amsterdam. PortBase offers services for efficient and simple information exchange between companies (B to B) and between companies and the government (B to G). Nowadays, most companies in the port are connected to PortBase. The amount of messages exchanged between companies was about 2.4 million per month in the first half year of 2009. Another information exchange application is Digipoort (former Government Transaction Gate). Digipoort is a service offered by the government and provides a single gateway to different governmental organisations. Information send to the gate is automatically distributed to the governmental organisations concerned, for example the customs. In fact, Digipoort is the electronic post office of the government.

In the last five years, barge operators and inland terminal operators have been investing in systems that track their barges and make the performance of their ships transparent. They use GPS and GPRS technology to have real-time information. They aim to establish a system that provides reliable performance information. This information is currently lacking and is considered to be important to objectively show the reliability of (players in) the hinterland chain.

A system to facilitate the coordination between players is for example BargePlanning. The aim of this Portbase (see above) application was initially to evaluate whether barges and terminals lived up to agreements. This attempt resulted in more insight in the barge handling process but did not offer a solution to the problem (Melis et al., 2003). Currently, the application supports the planning of barges at the ECT and APM terminals. The name of the application is not accurate since no planning is done; it only *supports* the planning of barges.

In the road transport five (competing) companies cooperate by means of ICT to exchange freight and thus reduce their empty miles. Their initiative (Truck Load Match Rotterdam B.V.) took about seven years from idea to implementation. The idea is that all five companies offer more or less the same container transportation services from the port to the hinterland and vice versa. However, it happens frequently that the truck of company A travels empty to the port whereas the truck of company B leaves the port empty to pick up a hinterland container. By exchanging freight these companies are able to reduce their empty miles. They report 30% savings on transportation costs when a match of two freights is found. The reported benefits are a reduction of CO2 emissions and transportation costs.

These examples show advances in the application of ICT to enhance chain efficiency. However, chain wide information systems are complex to design and to establish. The acceptance of these systems depends strongly on the way they deal with information and whether they restrict the autonomy of players. Sharing information can be a serious thread for companies. If information is not well protected,the market position of,companies can negatively affected.. In the next section we describe some cases about the use ICT for coordination in barge and rail transport. These cases show the potential but also the difficulty of setting up chain information systems.

Barge hinterland container transportation

We first consider a case in the barge hinterland container transportation. In the Port of Rotterdam about 36% of hinterland container shipment is done by barge, which was about 2.4 million TEU in 2008. In the port a coordination problem arises, as barges and terminal have to align their operations to tranship containers from a barge to a terminal and vice versa. We explain the problem in more detail (see also Douma, 2008).

Container barges that arrive in the port visit on average eight container terminals to load and unload containers. These barges are usually contracted by barge operators, which are companies that offer and organize barge container transportation services to and from the hinterland. There are about 60 barges daily in the port and in total there are about 30 container terminals. The barge operators compete with each other, just as the terminal operators. This complicates cooperation and coordination.

Barge and terminal operators try to align their operations by making appointments. Clearly, barge and terminal operators have their own interests. This means that barge operators try to make their appointments such that their barge can keep sailing according to its sailing schedule. Terminal operators on the other hand want to use the quay resources as efficiently as possible and want timely and reliable arrivals of barges.

In the present situation, appointments are made by telephone, fax, e-mail, and BargePlanning. Unfortunately, it happens frequently that appointments are not (or cannot) be met by either the barge or the terminal operator. There are several reasons (see, Melis et al., 2003, Moonen et al., 2007). Some appointments are not even feasible from the outset, for instance barge operators sometimes claim to arrive in short notice when they still are more than one hour away from the terminal..In addition, the fact that barges usually visit several terminals, creates dependencies between the activities performed at the terminals. Thus, a disruption at one terminal can quickly propagate through the port and disturb the operations of other barge and terminal operators. The result is that barge operators face uncertain waiting and handling times at terminals, and that terminals deal with uncertain arrival times of barges.

The main problem of the current 'manual' way of aligning terminal and barge activities is that appointments are unreliable. This has several undesirable effects, which are among others unreliable transit times of containers to the hinterland, long dwell times of barges in the port, and idle time of terminal quay resources.

The problem is hard to solve for individual players, since no player has the power to change the situation. Moreover, players have made clear that a solution is only acceptable when commercial autonomy is maintained and only limited information is shared. These two demands exclude the possibility of central coordination. This makes the problem even harder to solve.

Central coordination is hard to achieve for another reason. It requires a central trusted party that weighs the interests of players, which are often conflicting. It also requires a form of gain and loss sharing, since the central party sometimes makes decisions in favour of one player at the cost of another player. One can imagine that this could lead to a lot of discussion between players and make the system instable. Central coordination is also difficult from an optimization point of view, since information changes over time which makes it hard to define an 'optimal' solution.

All players can benefit when appointments become reliable. However, reliability is currently not a performance indicator for several reasons. First, there is no objective performance registration which makes it hard to 'prove' how well or poor a player performs. Second, the performance of players is strongly depending on the performance of other players. However, here ICT can help.

The real-time tracking systems of barge and inland terminal operators, described above, is a first important step in realizing coordination of terminal and barge activities. Without such a system a coordination system could easily fail as players will disagree on reasons for not meeting an appointment. Such discussions give room for players to behave unreliable which undermines the system even further.

A difficult issue with systems that connect different competing companies is the use and protection of information that is collected by a system. The systems mentioned above (tracking the positions of ships) require clear agreements by all participants and trust that information is dealt with in the agreed way. Note that participants of these systems are competitors.

Barge operators and inland terminals consider their systems only as first steps in the development of chain wide information systems. For them it is important that information is shared quickly and reliably and also that the owner of information is always in control of its own information.

To solve the coordination problem several initiatives have been proposed in the past. However, most of these initiatives failed because they were not acceptable for all players, the quality of the coordination was low or the solution was too labour intensive. One initiative already mentioned was BargePlanning (Melis et al., 2003).

Instead of a centralized approach, in 2003 the companies INITI8 B.V. and Port of Rotterdam took the initiative to investigate a distributed approach to the barge handling problem. The idea was that every player gets a software agent that make decisions in the best interest of the player it represents. The major advantage of this approach was that it did justice to the different interests of the players involved and leaves their business models intact (see Section 2). This was a promising step in developing a solution for the barge handling problem. This approach combined a different concept of coordination (distributed planning) with the advances of information technology. The study showed that decentralized coordination offers a promising solution (Connekt, 2003, Melis et al., 2003, Schut et al., 2004).

The initial system aimed for creating feasible (not necessarily optimal) plans and was therefore not suitable for implementation in practice.

Therefore a real-time Multi-Agent system was designed focussing on optimization of the operations of the players involved, under the name 'Planning Apart Together' (see Douma 2008). The system requires only limited information sharing. Simulation results show that the performance of the overall system can be improved significantly. Barge and inland terminal are positive about the potential of the system. Port terminal operators are more reluctant but interested as the use of the Multi-Agent system could help to improve the reliability of the barge handling. Currently projects are defined to make next steps towards implementation.

Rail hinterland container transportation

Another case is taken from rail hinterland (container) transportation. In rail transportation several examples can be found that require coordination between players in the chain. We focus on one example, namely the use of the public rail infrastructure in the port. The rail infrastructure in the port is used by all terminals in the port that ship freight by rail to the hinterland. Coordination between the rail operator and the connected terminals is necessary to realize a high throughput. The situation in rail transportation is even more complex than in the barge transportation, since we deal with different players such as rail operators, rail carriers, shippers, terminal operators, and the infrastructure operator. Clearly, each of these players has its own interests. To give an example: Terminal operators want trains to leave the terminal immediately aften being (un)loaded. If they do not yet have an international train path, than they need to be parked on a public yard so that new trains can be (un)loaded. If every terminal operator releases train to the public rail infrastructure without coordination, the throughput of the rail will drop dramatically and long waiting times of trains are to be expected. This is undesirable for all players.

Coordination between players is necessary. However, as we discussed in Section 2, this should be done such that the business models of players stay intact and such that every player benefits from coordination. In fact, all players share partly the same interests, namely fast, cheap and reliable rail hinterland transportation.

A Planning Apart Together approach may be helpful in this market as well. Similar to the barge handling problem: another approach (distributed planning) combined with the advances of ICT could lead to significant improvement of the use of the public rail infrastructure.

However, one of the key differences between barge and rail is the role of the infrastructure manager. In the case of barge transport, access to the waterways is not managed (apart from requirements for barges), while access to rail infrastructure is managed. The dedicated freight line that connects the ports of Rotterdam and Amsterdam to the European hinterland is managed by Key-rail, a company owned by the Dutch public infrastructure manager and the port authorities of Rotterdam and Amsterdam. Key-rail aims to actively enhance the efficiency of rail utilisation, both by more dynamic planning systems, based on better information exchange and by pricing systems that ´send the right signals´.

Investments in coordination and business models

As discussed in section 2, understanding business models is relevant for the analysis of coordination in transport. We finalise this paper with a short observation on incentives in business models to invest in improved coordination based on two cases.

First, the case of Portbase, owned by the port authorities of Rotterdam and Amsterdam. Both port authorities have an incentive to invest in Portbase as it enhances overall port competitiveness. Both port authorities finance Portbase partially in an indirect manner: from port dues and land rents. Such a financing structure is necessary because a business model purely based on direct financing through user charges is not possible, given the free riding, unequal distribution of costs and benefits and other reasons for lack of coordination discussed before.

A similar argument applies to Key-rail, the second case. The principal revenue stream of this organisation are the infrastructure charges. These provide a clear incentive to invest in coordination: this improves the overall rail product and capacity utilisation. This alignment between business model and investments in coordination is important. This is an important principle for policies to promote coordination. For instance: governments that enable a port community system with ownership that provides incentives to invest in coordination to act as business to government infrastructure give such a platform a basis to be more effective in business to business coordination.

The above cases show several issues that also are relevant in other coordination problems in hinterland transportation. Let us mention some of these issues:

- *Conflicting interests of players.* In coordination problems we usually deal with different (competing) companies that have their own interests. It is important to respect these interests since it impacts the extent to which new systems are accepted and can thus be effective.

- *Lack of objective performance registration*. Individual players are depending on the performance of other players. If an objective performance registration is lacking, players start to discuss about the facts. These discussions stimulate strategic behaviour and worsen the performance of the system even further.

- *The risk that players undermine the system*. Since all players have their own interests, there is an incentive to behave opportunistically, i.e., regardless of the consequences for other players. Chain information systems should be designed such that behaviour of a player that undermines the performance of the overall system is at the players disadvantage and does not seriously damage the functioning of the system as a whole.

- *The use and protection of shared information.* The collection of information about operations of companies can be sensitive for competitive reasons. Companies are very reluctant to participate in systems that collect information. In the design of hinterland information systems these issue should be carefully addressed.

- *Voluntary participation is preferred*. The participation of companies in hinterland information systems can possibly be enforced. We clearly prefer voluntary participation. Enforcing participation can lead to behaviour of companies which is not aiming at a proper functioning of the system but just to meet the basic requirements. In case of the barge handling it could mean that companies make appointments using the system, but still continue making 'real' appointments in the current way.

- *The power of single players*. For single players it is hard to improve the system on their own since they are depending on cooperation of the other players. The power of a single player for that purpose is small. The paradox is that a player can have a larger power when it comes to undermining the system.
- *The importance to design systems that are acceptable for all players to use*. Acceptance should a major design factor in the design of hinterland information systems. This means that the system meets basic requirements such as autonomy and limited information sharing in case of the barge handling. If requirements to participate are such that companies are not willing to participate, then the system might be very efficient but for sure not effective.
- *The potential of distributed planning*. Distributed planning in combination with advanced ICT might offer solutions to hinterland coordination problems where traditional centralized systems fail. The study of Douma (2008) shows that through distributed planning it is possible to align the operations of barges and terminals.

5. Conclusions & policy recommendations

In this paper we discussed coordination in hinterland transport and opportunities of ICT to enhance coordination. This issue is relevant for port competitiveness, but also from a wider societal perspective. And there are several coordination challenges in hinterland transportation, even to such an extent that coordination may be the single largest bottleneck for further transport chain efficiency.

In order to understand coordination in hinterland chains, we need to understand the business models of actors involved. Analysis of their business models suggests that there is so much competition between payers with different business models, especially for roles in design of scheduled transport networks, that initiatives to enhance coordination often have strategic implications. Consequently, apart from operational analysis, understanding this strategic dimension is necessary. The distributed planning approach is promising in this respect.

Policy makers have an important contribution to improving coordination in transport chains. For instance by allowing access rules for rail infrastructure, by developing a regulatory framework that allows organisations with incentives to enhance coordination to develop coordination-prone rules and contracts, and by enabling synergies between B to G communication systems and B to B communication systems. In all these issues, ICT is a key-enabler in making these systems work.

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