Innovations in intermodal freight transport: lessons from Europe

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Abstract

Over the last two decades many innovations in intermodal freight transport have been proposed to boost the market share of intermodal transport. However, only few of them have materialized. In this paper we explore why innovations in intermodal transport are difficult to realize and how barriers for their successful implementation could be overcome. Our focus is on European initiatives. We describe a number of initiatives, succeeded and not (yet) succeeded, and explore their particular strengths and weaknesses. Next, by linking the description of these initiatives to a framework of innovation adoption, we derive critical issues in the implementation of intermodal innovations. We conclude that besides substantive success factors, related to costs and benefits, there are other strategic and process related factors that play at least an equally important role in the realization of these innovations. These include the balance of power in the supply chain, and the alignment of perspectives and preferences of different stakeholders.

Keywords: *intermodal transport, freight, innovative transport concepts, innovation management*

INTRODUCTION

Intermodal transport technology has been a, if not the, main driving force behind the spectacular and on-going growth of international transport in the post-war world. Many books have been written on the concept of standardized freight unitization (see e.g. Levinson, 2006), which has allowed massive scale economies to develop in global transport. Investments in ports followed, as the throughput of major seaside transshipment hubs and their hinterland corridors approached millions of containers per year. The challenge to develop intermodal transport facilities is, however, not only visible by their sheer scale (the planned Rotterdam coastal landfill spans 2,000 hectares and cost 2.7 billion Euro, not counting private investments in terminals) (Port Authority Rotterdam, 2012), but also by their enormous complexity. Intermodal transport not only by definition links different actors (service providers of different modes of transport), it comprises a complicated chain of activities. Because of the limited number of users of transshipment terminals (several orders of magnitude lower than in passenger transport, often not more than a handful) it involves investments in service connections and in synchronized operations. In addition, it involves a far-reaching intrusion in the natural or built environment than unimodal transport projects. Transshipment generates additional activities that cluster around and provide employment, it is space extensive, produces local emissions and noise annoyance and involves public-private investments. The planning of intermodal transport facilities often has a lead time comparable to other transport infrastructures, and requires close involvement of public and private stakeholders. Besides the traditional investments in seaport and inland transport infrastructure, also new logistics service networks are developing, connecting these terminals and infrastructures into new networks. These networks involve a substantial industrial innovation effort, re-organizing logistics networks of the users, and closely interacting with the effort of infrastructure development.

We believe that there is a great need and challenge to develop and implement system innovations in new transport, ICT technologies and new logistics organizations that may go hand in hand with infrastructure development to boost the market share of intermodal transport. This need is particular strong in the inland freight transport market in Europe, in which truck transport is dominant and the share of intermodal transport still limited.

Many system innovations for intermodal transport, incorporating new technologies, new logistics organization and/or innovative infrastructure development have been proposed over the last two decades, but, interestingly, only few of them resulted in operational systems. In this paper we explore why these innovations in intermodal transport are difficult to realize successfully and how barriers for successful implementation could be overcome. Our focus is on European initiatives.

The paper is organized as follows. First a brief outline of intermodal transport in Europe and its main challenges is given. Then intermodal innovation initiatives in Europe are reviewed. This review includes ideas that have materialized and those that did not succeed in getting implemented. After that, we explore briefly some theoretical notions about innovation and implementation processes, to understand success and fail factors. From these general notions key factors are derived that we use to evaluate the success or failure in realizing intermodal innovations. The next section revisits the innovations and identifies critical issues in the implementation of these innovations. The paper ends with an outlook on desirable conditions for the successful implementation of future innovations in intermodal transport, based on the lessons learned from previous projects.

INTERMODAL TRANSPORT IN EUROPE: STATE-OF-THE-ART AND CHALLENGES

Intermodal barge and rail transport play a different role in the European transport system and this difference is also observable at country level. Their current role is a result of different development paths of both intermodal systems and is influenced by different geographical conditions. The presence and quality of the waterway network is obviously a major factor for barge transport development, while for example the need to cross mountains has influenced the development of rail infrastructure and rail use.

Intermodal barge transport

Intermodal barge transport has developed successfully in its role as a transport system for container transport in the hinterland of seaports. In particular the ports of Rotterdam and Antwerp, both well connected to Europe's largest river, The Rhine, and to a fine-structured national inland waterway network, have put their mark on container barge transport in Europe.

In 2010 the barge volume handled in Rotterdam was 2.4 million TEU and 2.3 million TEU in Antwerp. These volumes corresponded with a market share in hinterland transport of respectively 33% for Rotterdam and 34% for Antwerp. In other major container seaports the volumes and the share of barge transport are still modest (Le Havre: 170,000 TEU (7%), Marseille: 59,000 TEU (6%); Hamburg: 95,000 TEU (1%)).

The success of barge transport in hinterland transport is also the result of the ability of the sector to adapt itself to the demand of shippers and the specific requirements of container transport. New logistical concepts but also technological improvements (both in vessels and handling equipment) have greatly supported the spectacular growth of container barge transport.

It is generally believed that there is still a great potential as well as a need for container barge transport to expand its role in hinterland transport. For instance, the target for the port of Rotterdam at the Maasvlakte area where the majority of container handling takes place is to increase its share from 39% in 2011 to 45% in 2035. This ambition implies that the barge volume for Maasvlakte area may more than quadruple from 1.8 million TEU in 2011 to 7.5 million in 2035 (Port Authority Rotterdam, 2011). In view of the current problems perceived in container barge transport it is also believed that such large volumes can only be accommodated if major innovations both in logistics and technology are implemented.

Barge container transport in Europe, however, still functions almost exclusively as a hinterland transport system, and although the current total container volume transported by barge (over 5 million TEU) is impressive, it is only a fraction (about 1%) of total inland freight transport (in tonne-km) in Europe. Hence there is also a great challenge to really open up the market of intermodal barge transport for continental flows, i.e. cargo flows that are not related to seaports. A few isolated successful examples exist, such as the Danube floating motorway service (Roll-on Roll of service) of Donau-Lloyd-MAT, that started operation in 1982, between Germany and Bulgaria, over a distance of 1435 kilometers. Among several initiatives, pallet transport by barge is considered as a high potential growth market, but a wide breakthrough has not been achieved yet.

Intermodal rail transport

Intermodal rail transport can take place in many forms. Following common definitions it may consist of unaccompanied transport, i.e. containers, swap bodies and trailers and accompanied transport, i.e. rail carriage of entire road vehicles (including the driver). In addition, intermodal transport is applied both in hinterland transport and continental transport in whole Europe. Moreover, many operators are involved in the intermodal rail transport market.

In the market of unaccompanied transport the total volume in the European Union (excluding Sweden and Finland) and Switzerland, Turkey, Serbia and Macedonia was estimated at 15.5 million TEU in 2009 (International Union of Railways, 2010). Although the history of intermodal rail transport started with continental transport shipments it seems that its development has been boosted by the emergence of hinterland (maritime land) transport by rail. About 57% of the total unaccompanied volume in 2009 was hinterland transport, while 43% consisted of continental transport. Within these market segments there is also a clear difference regarding the shares of domestic and international transport: domestic services counted for 73% of hinterland shipments and only for 38% in continental transport. A major explanation is that in general the transport distance in continental services must be larger than in hinterland services in order to be competitive to road transport, because in the continental services pre- and end-haulage and transshipments are needed – and the costs of these additional activities offset the initial benefits of the cheaper-per-kilometer transport modes. Particularly in countries with a rather small territory such as The Netherlands, Belgium or Denmark domestic transport distances are usually too short for intermodal transport to compete with road transport.

The large size of countries like Germany, France and Italy is one of the reasons why intermodal rail transport in these countries has quite well developed yet. This holds for the continental transport flows as well as for the maritime-based hinterland transport flows. Major seaports in these countries have a much larger share of rail in container hinterland transport than the ports of Rotterdam and Antwerp, that have much better possibilities to accommodate barges (e.g. the rail share in Bremen and Hamburg is respectively 57% and 29% while in Rotterdam and Antwerp it is 10% and 11%).

The volumes of accompanied intermodal trail transport are much smaller: about 1 million TEU in in the European Union in 2009, which represents about 5% of the intermodal rail transport market (International Union of Railways, 2010). Moreover, these flows are even more geographically concentrated: mainly in the corridors crossing the Alpine states of Austria and Switzerland and the Channel Tunnel. These accompanied intermodal flows are largely a result of specific geographical and infrastructure conditions (range of mountains or seaways crossings only possible by train) or national transport policies of these countries pursuing a modal shift aiming at reducing the negative impacts of road transport especially cross-border and transit road traffic.

Contrary to barge transport launching a new intermodal rail service is much more complex and involves higher costs and risks. Finding the necessary critical mass in transport volume is a challenge. This is especially the case in continental transport relations where cargo flows tend to be more fragmented and dispersed.

A major strategy to attract small flows and expand the market for intermodal rail transport is pursuing network innovations, which are most effectively supported by terminal innovations (Kreutzberger, 2008), but so far it has been difficult to accomplish these innovations in practice.

From this brief overview we can conclude that, although intermodal transport is a more complex way of freight transport compared to road-only transport, it can be a competitive and attractive alternative to road transport. However, its development has in general been modest, in terms of current market share.

The costs and quality performance of intermodal transport compared to road-only transport are in the end decisive for the potential success of intermodal transport. It is clear that major innovations can significantly improve the cost and/or quality of intermodal transport and hence are crucial for a breakthrough in intermodal transport development. From this perspective it is useful to learn about the conditions to realize innovations successfully as well as to learn about the success and fail factors regarding their implementation.

Therefore later on in this paper we will review different intermodal transport innovations that have been implemented and some that did not materialize.

OVERVIEW OF INNOVATIONS IN INTERMODAL TRANSPORT

In intermodal freight transport in Europe a great number of innovation efforts have focused on improving the exchange process of cargo between modes, because of the relatively large share of this link in the intermodal chain costs. This holds in particular for intermodal barge transport. However, the driver for innovation in this link is also related to the increasing importance of the terminal performance in the overall quality performance (e.g. reliability and transit time) of the intermodal chain (see also Rodrigue, 1999). A lot of innovations in intermodal transport have a technical dimension, while other innovations include new logistics organization or innovative infrastructure development. However, innovations often cover a combination of these dimensions.

For extensive overviews of innovations in intermodal freight transport we refer to Woxenius (1998), Bontekoning and Kreutzberger (1999), Vleugel et al. (2001), Peterlini (2001), Ballis and Stathopoulos (2002), Van Gorp and Van der Zandt (2003), University of Antwerp et al. (2012).

In our selection of projects to review we have aimed to cover the diversity of intermodal transport innovations, i.e. the different elements of the intermodal transport system (infrastructure, vehicle, handling equipment and load units), including their impacts on logistics organization. As only a selection of intermodal innovations can be presented in this paper we have tried to focus on eye-catching innovations that had high expectations in contributing to a breakthrough in intermodal transport development. In addition, the selection can be motivated by the availability of information about the projects. The review of projects is structured by mode and ends with projects related to load units. The larger number of rail projects compared to barge projects reflects the larger interest and importance of rail transport in the EU.

Rolling highways: Modalohr

A major cluster of intermodal innovations comprises concepts of innovative Roll on-Roll of transshipment technology in rail transport, aimed at a fast and inexpensive transshipment. As these solutions are in principle focused on rail carriage of accompanied units (complete truck and his driver), although also unaccompanied units can be carried, they are often denoted as rolling highways.

The main challenges of these innovative handling technologies are to remain flexible in the possibility to handle all kinds of semi-trailer/load units and to limit required investments in the wagon fleet and/or terminals. Among proposed solutions for instance the Swedish Megaswing-concept only requires special freight wagons (Widell and Linde, 2010), while the German CargoBeamer and French Modalohr system require both special wagons and terminals (CargoBeamer, 2012; Modalohr, 2012). As a matter of fact the transshipment in Cargobeamer is even an automated process.

Megaswing and Cargobeamer are still in a prototype or test phase, but since Modalohr has been introduced into the market it makes this concept more relevant to discuss.

The development of the system Modalohr was driven by the idea that 'the rail must adapt to the road' to make rail transport attractive to road haulers. Key elements of the system consist of special wagons and terminals. The low-floor wagons can swing out in the terminal and hence enable a truck to drive his complete unit on the wagon or to drop its semi-trailer on the wagon. The wagons are passive, i.e. the necessary technology (to swing out) is built in the tracks of the terminal.

Figure 2 Modalohr-terminal at Bourgneuf-Aiton (near Chambery, France)

Source: www.modalohr.com

The system allows fast and simultaneous loading/unloading operations of trains and saves on terminal staff costs. However, large investments in wagons and special Modalohr terminals are required. Due to its system characteristics it is designed for regular block train services within a special Modalohr network. The system was implemented in 2003 in the cross-border Alpine route (AFA) between Aiton (France) and Orbassano (Italy) over a distance of 175 km. The possibility to implement Modalohr can be attributed to the energy of its designer and manufacturer (Lohr) and the strong interests of public authorities (because of environmental considerations and safety concerns regarding truck transport through the Alps). In addition, road haulers being the primary customers of the service could be committed to the project. Furthermore, a large French industrial shipper of dangerous goods played a very supportive role in the development of the system by imposing its transport companies to use the system (University of Antwerp et al., 2011).

The system functions well, since major technical problems have not been reported, but the system is not profitable. Since the start of its operations up to now the system has faced operational deficits, that have been settled with subsidies of the two involved states. The traffic volume is much smaller than a priori forecasted. In 2011 26,000 trucks were carried, while 100,000 trucks were expected when the service was launched. Despite of this the line was kept and will remain into service, and even a second line became in operation in 2007 and the launch of a third line was decided by the end of 2012. Driving forces for these decisions are the political interest to encourage sustainable transport solutions as well as to support the French rail industry, the company Modalohr in particular.

MegaHub

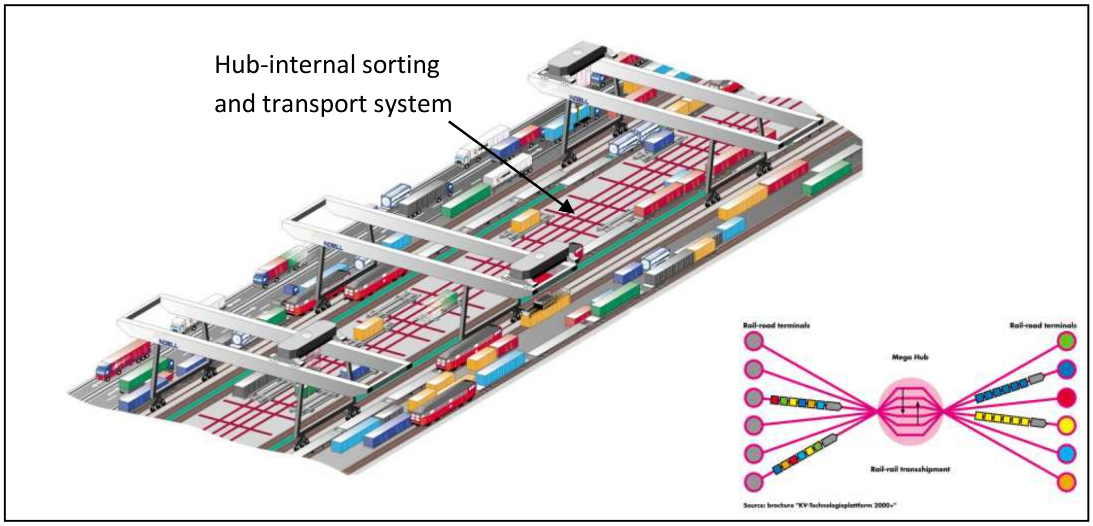
The MegaHub is a production system for container trains that was developed for the transportation of container volumes that are considered as being too small to enable cost-effective direct train transport and otherwise would be left to be served by truck transport (Franke, 2008; Avery, 2000).

In the MegaHub containers that arrive on a train that have different destinations are sorted and regrouped to other trains according to their destination. A key feature of this concept is that the container exchange process takes place through transshipment instead of shunting. As a result the MegaHub leads to much shorter handling times of trains, lower costs per transfer and more efficient land use (Franke, 2008).

Container transfers are carried out using electrically powered and semi-automated cantilevered yard gantry cranes that span the transfer area in which six trains can be handle simultaneously. Transfers over very short distances are performed by crane movements, while the transfer between trains over long distance at the terminal are supported by linear motor-driven shuttle cars, which can move along and across the sorting area.

A test site was built at the premises of crane manufacturer Noell in Germany, that designed and developed the MegaHub-concept. Ever since its first design, which was a response to a design contest organized by Deutsche Bahn (DB) in 1995, the plan has been to implement the first MegaHub near Hannover (Lehrte) in Germany. Despite of the very promising high performances of the MegaHub a final decision was not taken. Reasons for postponement were initially the lack of confidence that the freight flows would be large enough to exploit the hub profitable. Since later on significant investments were committed by DB in Maschen marshalling yard at Hamburg the interest for MegaHub faded. Moreover, reorganizations in DB cut investment budgets. After a planning phase that lasted almost 15 years the construction may now get underway as German government authorities and Deutsche Bahn have agreed upon financing this 100 million Euros project.

Figure 3 Megahub terminal



Source: Franke, 2000

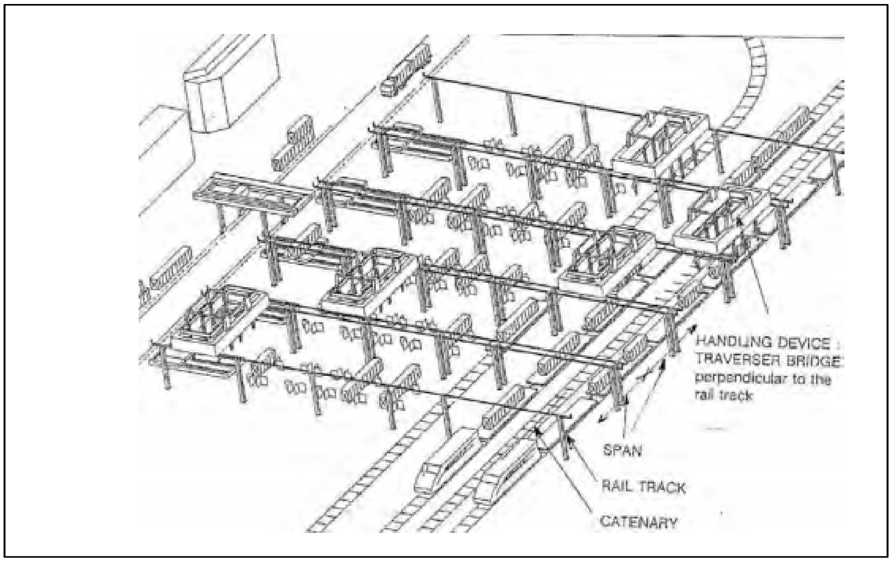
Commutor

The Commutor concept is based upon technologies to automatically transfer containers between multiple trains at hubs, thus avoiding time- and space consuming shunting operations (i.e. replacing the marshalling yard by a terminal). An important driver for this concept was the desire to improve the productivity of rail transport and that of the wagonload traffic in particular. Later in the development, interfaces with road transport were foreseen.

From 1987, the French Railways (SNCF) and some twenty companies specialized in mechanical engineering and industrial robotics, worked to find solutions to automate the handling processes. From 1990 to 1994, SNCF and its partners used an experimental site in Trappes in the Paris suburbs. At the test site positioning technologies for railway carriages, automated handling equipment and container storage, sorting and internal transport systems were tested. Originally, the use of one, standard size railway wagon was part of the concept, due to technological developments, later on some 9 different sizes of – still adapted – wagons could be handled. Eventually, hubs servicing up to 9 parallel tracks were foreseen, able to handle up to seven trains of 33 wagons a day (14 hrs operation a day). Since these automated hubs enable high transfer capacities and very short transfer times, it would making them well suited to serve a hub and spoke design suitable to France, or eventually a multi-node system serving an even larger area. The costs of the commuter system were estimated at 150 million Euro (O'Mahony, 1994).

Critical issues in this system that resulted in the abortion of its development were the complicated technology (including a high degree of automation) causing high investment costs and the requirement to use dedicated rail wagons. Hence, the technology would have restricted its application to an isolated hub-and-spoke network (Woxenius, 1998).

Figure 4 Commuter terminal system



Source: Technicatome, 1996 (adapted from Woxenius, 1998)

CargoSprinter

In 1997 German Railways introduced prototype diesel-powered Freight Multiple Units (FMUs) constructed by Windhoff and Talbot, known as "CargoSprinters". These comprise flat-bed wagons for moving intermodal units, powered by underfloor diesel engines with a driving cab at each end. The CargoSprinter was a railcar featuring characteristics with regard to design and technology that are much related to a truck. For this reason, it was often called the truck on rail, combining the benefits of a fast, relatively cost effective and flexible means of transport. Moreover, since its driving characteristics had similarities with passenger trains this freight train could be much easier integrated with passenger trains, and hence could provide more flexibility in scheduling freight trains.

One transport unit could convey up to ten interchangeable containers respectively containers with a length of 7.8 meter and 16 tons individual weight. The coupling was done within a few minutes by means of the automatic train coupling and non-contact data and energy transmission. In fact, each CargoSprinter unit was self-supporting, but within three minutes it could be combined to a container train formation of up to seven units. At common target positions, the individual units were separated or combined to new formations.

In comparison with a truck the CargoSprinter features the same transporting capacity as five trucks, but required one driver only. At that time the diesel engines guaranteed low exhaust gas emission values according to Euro-norm 2. Fuel consumption was by 15% lower than that of five trucks (as per information of railway company even up to 35% saving for several coupled units). With a maximum speed of the train of 120 km/h the CargoSprinter was considerably faster than a truck. In summary, cargo sprinters were high speed, high frequency distribution trains with a loading capacity of 10 TEU's (van Duin, 2003).

Figure 5 CargoSprinter

Source: Windhoff AG Online, 2001

In practice the CargoSprinter concept was not a success as a commercial freight vehicle, trials of the vehicles did not lead to regular work (Sudalaimuthu and Raj, 2009). The technology of the trains did not appear to fulfill the aspirations of its sponsors adequately and seems to have been compromised by issues of track access costs that were equated to those of larger, heavier and slower orthodox trains (Robinson and Mortimer, 2004). The adjusted CargoSprinter was later applied for specialized services such as tunnel rescue, hybrid powered freight trains an maintenance works.

Distrivaart

The aim of the Distrivaart-project was to develop a national intermodal transport network for pallet transport by barge in The Netherlands to distribute consumer goods between distribution centers of factories and supermarkets. The backbone of the network is served by barge transport, the final distribution is performed by trucks. The project focused on retail goods, that typically generate large, steady and almost continuous good flows (so called slow-movers), for which reliability is more important than transport speed. Actually, Distrivaart was also an early example of the co-modality concept, because parallel to the steady cargo flow serviced by barge, peak demand (of the same products) was services by road transport.

In the project an automatic pallet-sorter and transshipment system was developed to operate on board of an inland barge ship, with the aim to transport pallets quickly and efficiently between production plants and retail outlets. The service with the specially constructed ship ‘Riverhopper’ had an operating schedule for less than one year. Main users were beer brewers and retailers to have their products distributed. The technical feasibility was proven. The economic feasibility study indicated a required demand of at least 650 pallets per week (Groothedde, 2005).

In practice this business requirement was never met because of incomplete implementation of the service. Moreover, the costs of pre- and post-truck haulage in the intermodal chain were too high because of the long trucking distances. As a result, truck transport only actually turned out to be still cheaper for the beer producers. One of the partners stepped out the project and the operators of the service were not capable to promote their services to other parties (Kusters, 2007). In addition, the advanced pallet-sorter and transshipment system was vulnerable to disruptions.

Figure 6 Riverhopper

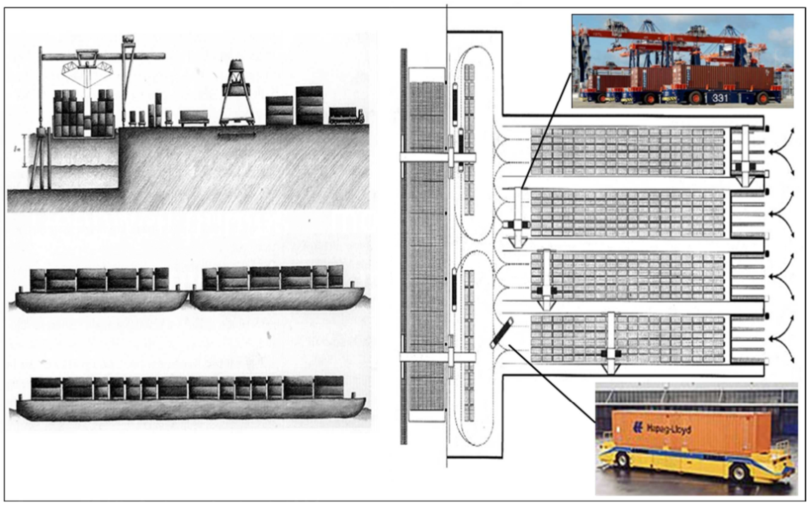
Source: Mercurius Shipping Group

BargeExpress

A barge transport system, named BargeExpress, was proposed in the mid-1990s, as a way to boost the development of container barge transport in the hinterland transport of Rotterdam. The concept aimed at time and cost reductions in handling barges in the seaport as well as cost savings through increasing scale of operations in barging. To accomplish these benefits the concept includes push boat-push barge formations in which giant push barges are operated and automation/robotization of the loading and unloading process. The barges are equipped with cell guides to facilitate the robotized container handling process. Automated guided vehicles (AGVs) and automated stacking cranes (ASCs), that were already applied by ECT terminals in Rotterdam, were envisaged to support the logistical process of barge handling.

The initiators, the government together with a group of scientists, were envisaging a rapid development process, because almost all elements of the concept were based on proven technology, except for the automated quay crane. Moreover, applying proven technology could keep the investment costs as well as the associated costs within limits. Detailed studies showed the technical and economic feasibility of the concept, i.e. cost savings in the barge chain (handling and sailing) were in the range of 10 to 15% (TRAIL Research School, 1996). However, the fact that the barge transport system assumed point-to-point operations between the seaport and a few inland terminals revealed that the container flows were too small at that time. Moreover, there was no perspective to accomplish sufficient large flows by bundling at the planned BargeExpress-terminals, because of economic reasons and lack of willingness of barge operators to cooperate.

Figure 7 BargeExpress concept: terminal and vessels (L) and terminal lay out (R) (top-view)



Source: TRAIL Research School, 1996

Combi-Road

The Combi-Road project was established in The Netherlands to facilitate the movement of maritime containers from the port of Rotterdam to inland freight terminals where they could be transferred to long-distance trucks or trains for connections throughout Europe. It was developed as a public-private partnership between the government and the freight transport industry, both of who had an interest in improving freight movement and in developing alternatives to conventional road and rail transport means.

One of the key features of the concept was the use of special-purpose automated freight transport vehicles that would operate on their own guideway, completely segregated from other traffic in order to avoid congestions and safety problems.

Combi-Road was defined at several levels, ranging from a broad logistics concept for freight handling, to the development of its special purpose freight guideway along a specific alignment for the lateral guidance of vehicles, to the design of an automated, driverless, electrically propelled vehicle (Van der Heijden and Heere, 1997). A prototype of the Combi-Road vehicle was built, tested and demonstrated on a short track facility in Ridderkerk in The Netherlands in 1998.

Combi-Road did not advance beyond the concept definition and prototype vehicle testing stage. The large investments costs needed for Combi-Road were a barrier to further develop the system, including the construction of a pilot track. Moreover, commitment of potential users of the system was lacking. At public level the project was faced with political challenges associated with the development of a competing rail freight line (The Betuweline) parallel to the intended route of Combi-Road. A strong lobby for The Betuweline led the government to decide to construct this dedicated rail freight line.

Figure 8 Combi-Road prototype vehicle on test track

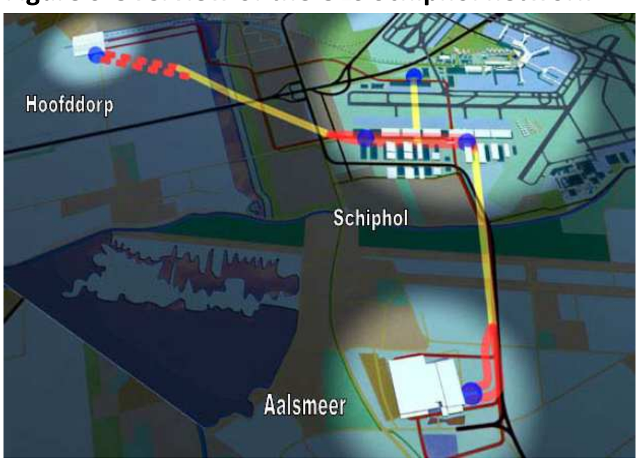
Source: Projectbureau Combi-Road

OLS (Underground Logistic System) Schiphol

In this project the aim was to develop an underground freight transport network (covering approximately 20 kilometers) for air cargo and flowers, which would connect Schiphol Airport to the flower auction in Aalsmeer and a new rail terminal in Hoofddorp. The project was set up in that area in order to address the fact that deteriorating accessibility, increasing traffic congestion, and growing costs were threatening the economic position of the national airport and the flower auction market.

After positive feasibility studies that were completed in 1996, the (conceptual) design of the system was started in 1997 and continued through 1998 and 1999. A test site was realized in Delft (The Netherlands) to test prototypes of the various automated vehicles and handling systems and to develop and test the control system (Pielage, 2005).

Figure 9 Overview of the OLS Schiphol network



Source: Pielage, 2000

The huge investments (about 250 to 500 million Euro) that would be needed to develop the system gave cause to revise the original concept, including for instance the decision not to build completely underground but largely on the surface using dedicated lanes. Despite these concessions the project financing remained a barrier. Related to this, in the project a real problem owner was missing, and hence a strong driving force for project implementation. As a matter of fact, many actors were involved and they had different interest, goals and ideas, and this made the project even more complex, on top of the fact that in the concept also new transport technologies were envisaged (Wiegmans et al, 2010).

City Box

The arrival of various small distribution boxes and the increased use of rolling cargo has encouraged research for a universal load unit for distribution services. Research that was carried out in The Netherlands resulted in a set of functional requirements for a city box. The most important ones are:

- outside dimensions for mass-volume road haulage and convenient city movements: 255 x 215 cm (road: 255 width; city: 215 width);
- internal height comfortably for human access: 210 cm.;
- pay-load about 3000 kg;
- bottom should have all functionality for handling (forks, rollers, skidding), fixations and box stiffness;
- the box should allow an easy, low-noise loading and discharging of rollcontainers;
- the box must be aesthetic, easy to clean, effectively lockable;
- the box cover should allow a variety of applications for various branches.

A first prototype of such a box has shown that the application of aluminum and sandwich panels of synthetic material can result in a tare mass of about 300 kg. Lashing methods from the air cargo industry will allow for simple effective means of fixation onto vehicles.

A standardized box enables the development of a variety of other facilities required for an efficient distribution of goods into the cities. Multi-modal transportation demands for standard provisions on vehicles, barges, trains, metro's and the related warehousing functions in districenters, logistic parks, retail outlets, shopping centers etc. However, the standard city box bottom allows for simple modifications onto existing equipment. The selection of one (or a few) techniques(s) for the identification of city boxes will facilitate tracking and tracing; transponder, RFQ and bar code techniques are already widely and reliably in use within the warehousing and retail industry.

Standardization of city boxes, vehicles and handling equipment will definitely encourage the interchangeability within logistics networks. "Grey boxes" will be helpful to avoid empty legs for unbalanced supply chains and in addition standard city boxes for many supply branches could be transported by common carriers serving these various branches with optimized (cost effective) transportation networks.

Figure 10 CityBox

Source: Stadsbox consortium, 2005

Although major stakeholders (retailers and logistic service providers) were involved in the development of the CityBox this load unit was not commercially introduced. A major explanation was that the project was focused on an immediate national-wide introduction rather than first starting to demonstrate the value of such a load unit in small-scaled pilots. Commitment among retailers for the intended large-scale introduction was too limited. Moreover, a large retailer that initially was a driving force in the project got increasingly convinced that introduction of the CityBox could well undermine its own strong position in the retail market. When this retailer withdrew its support to the project CityBox was doomed to fail.

Foldable containers

One of the long-lasting innovation ideas in intermodal transport is the concept of foldable containers. Designers believe that operating foldable containers can significantly reduce the costs of repositioning empty containers, which is of major interest to the intermodal transport industry, shipping lines in particular. If a set of folded containers can be transported together less transport capacity is needed and hence costs per unit are lower. Moreover, savings can also be realized in transshipment costs if folded containers can be bundled, interlocked and transshipped in one move.

The first concept for a folding loading unit that was patented dates from 1973 (Baer, 1973). Since then several designs have been suggested, but most of them did not even pass the phase of patent granting (Binsbergen *et al.*, 2000). Two of the early designs (Six-In-One (SIO) container and Fallpac container) that were tested and even introduced to the market could not meet the technical requirements and cost and logistical performance needed to be competitive to standard containers (Konings and Thijs, 2001). The more recent designs are striving to overcome the technical barriers that prevented the marketing of previous attempts.

In the range of contemporary designs the foldable container by Holland Container Innovations (HCI) now seems to be in the most advanced phase of development. It is a 40-foot-high cube that has been developed according to the 4:1 folding principle, i.e. 4 folded units have exactly the same dimension as a standard container. In 2013 it was granted ISO certification, an important incentive for raising interest among potential users, since it confirms that the foldable container, when erected, meets the performance requirements of a standard container. HCI has now plans to test the technical performance of its container in practice, in close co-operation with a shipping line and a container manufacturer.

Figure 11 Foldable container

Source: Holland Container Innovations

INTERMODAL INNOVATIONS: AN INNOVATION ADOPTION FRAMEWORK

An innovation can be defined as an idea, practice or object that is perceived as new by a unit of adoption (Freeman, 1989). These adopters can be individuals (e.g. customers) or organizations (e.g. companies). Every innovation goes through an innovation development process (Rogers, 1983). This process consists of a series of actions and choices over time through which an individual or organization evaluates the innovation and decides whether or not to incorporate it into practice. According to Rogers the process covers 5 phases, namely: 1. Knowledge: the awareness and exploration of a new solution to a problem; 2. Persuasion: the unit of adoption forma a favorable or unfavorable attitude towards the innovation. The characteristics of the innovation are especially important in this stage; 3. Decision: phase in which it is decided to adopt or reject the innovation; 4. Implementation: the phase in which the innovation is being developed and tested, and 5. Confirmation: the adopter evaluates the decision that was taken to adopt the innovation.

Although abundant literature exists on the adoption and diffusion of innovations in general, literature that addresses these issues to freight transport innovations is still rather scarce. NEA (1997) specifically focused on diffusion of innovations in the freight transport sector and based their conceptual model on the more general model of Rogers (1983). Bontekoning (2002) developed an analytical model, building upon the work of Rogers (1983), Frambach (1991), Moon and Bretschneider (1997) and NEA (1998), to identify potential obstacles for the implementation of advanced (e.g. robotized) intermodal terminals. The main groups of explaining variables in the model of Bontekoning relate to:

- perceived characteristics of the innovation;
- characteristics of the potential adopting organization;
- characteristics of the communication process, and of the information that is communicated;
- characteristics of the social system to which the adopting organization belongs;
- characteristics of the competitors of the potential adopting organization;
- the role of the government;
- characteristics of the innovator / supplier.

The role of the government in fostering intermodal transport innovations has been highlighted by Holguin-Veras et al. (2008). Focusing on the American freight transport system the authors identify different sets of factors that explain the difficult challenge government has in fostering innovations: lack of cooperative tradition between the government and the freight transport industry, mismatched planning horizons of the private and public sector, lack of identification between private industry success and national policy objectives and last but not least the typical industry structure (size and complexity of the transport system) and transport modality based priorities.

Wiegmans et al. (2010) have also been inspired by the general conceptual model of Rogers and adapted the model to three key factors to explain whether an innovation will materialize or not:

- user requirements: the operationalization of the relative advantage of the innovation over the existing transport system performance in terms of reliability, costs, efficiency, flexibility, safety/security, speed and catchment area;
- Product characteristics (attributes of the innovation): compatibility, simplicity, try-out possibilities, social context and relative advantage;
- the innovation system: focusing on the role that all kind of actors and their relationships play in the innovation process.

Wiegmans et al. (2010) used this model to review the barriers and enablers for the development of underground logistic systems in The Netherlands.

Although all phases of the innovation process are important to achieve a successful adoption of an innovation there is much empirical evidence that the implementation phase is one of the most difficult and critical stages in the whole process (see e.g. Van Binsbergen, 2007). In this phase usually more and other actors become involved and other skills and competences are needed than in the study phase, and this increases the complexity of the process.

Based on the above notions about the innovation process and the critical stages in this process we can conclude that the bottom line for a successful implementation of an innovation is the quality and complexity (perceived characteristics) of an innovation on the one hand and the process and social context in which an innovation should materialize (the innovation system) on the other hand. We consider these aspects as key decisive factors to evaluate potential success or failure in our review of large-scale innovations. We define these aspects as follows:

Perceived characteristics:

- Relative advantage: the degree to which the intermodal transport innovation is perceived to perform better than the existing intermodal transport option or competing modes (e.g. road-only transport). The better performance may for instance relate to transport costs, transit time, reliability and/or flexibility.
- Compatibility: the degree to which an intermodal transport innovation fits to existing transport and logistics chains. Compatibility can be an issue from technological and/or organizational perspective.

- Complexity: the degree to which the intermodal transport innovation is perceived as relatively easy to develop (e.g. using proven-technology), understand and use.
- Testability: the degree to which an innovation can be experienced and tested.

Innovation system and process:

- Composition and diversity of actors involved (stakeholders): number and type of actors and their interests, balance of power of actors, distribution of costs and revenues between actors, the role of investment actors (capital/subsidies), the role of lobby groups and/or public opinion.
- Characteristics of competitors: degree of market competition, possibility for niche-market development
- The role of the government: government can be involved in different ways and levels (facilitating, initiating, developing / financial, legal, co-ordination)

CRITICAL SUCCESS FACTORS

In the previous section we discussed the characteristics of innovations that are critical for the implementation of innovations. In the table below we summarize which of these characteristics have played a decisive role for the intermodal innovations that we presented in section 3.

Project / initiative	**Initiator -participants/ stakeholders**	**Result**	**Key success/fail factor**
RAIL			
Modalohr	Truck/trailer manufacturer / railway companies, road hauliers	In operation	**Perceived characteristics**: - simple technology - relative advantage: time savings **Innovation system:** - commitment of customers - involvement of public authorities
Noell megahub	German Railways / crane manufacturer	Pre-design and physical test-site; still under discussion.	**Innovation system:** - role stakeholders - funding problem
Commutor	French railways / engineers	System components tested; stopped.	**Perceived characteristics**: - too complex - not compatible
CargoSprinter	German Railways	Commercially tested.	**Perceived characteristics**: relative advantage: unsatisfactory
BARGE			
Distrivaart	Retailers	Tested in practice, but stopped.	**Perceived characteristics**: - testability: test too limited - relative advantage: misperception **Innovation system:** Committed market actors
Barge Express	Government / knowledge institutes/barge operators, port authority	Feasibility studies, so far not been followed up	**Innovation system:** misinterpretation of market/ wrong timing (too small cargo flows)
NEW MODALITIES			
Combi-Road	Engineering company / consultants	Pre-design, physical test-site and demo; stopped.	**Perceived characteristics**: too complex **Innovation system:** - funding problem - role of government
OLS Schiphol	Transumo/Flower auction/freight cargohandlers/Airport Schiphol	Pre-design and physical test-site; stopped.	**Perceived characteristics**: too complex **Innovation system:** - insufficient commitment of potential users - funding problem
LOAD UNITS			
Citybox	Retailers, transport service providers	Design and physical demo; stopped.	**Innovation system:** role of actors involved: power balance / distribution of revenues and costs
Foldable containers	Container designer / container manufacturer	Prototype and demo; in development, planned tests in practice	**Perceived characteristics**: relative advantage: doubtful **Innovation system:** untapped interest at potential users

Following the findings in our review of intermodal innovations and their key success and fail factors as summarized in this table we can define a number of issues that are in general critical for the implementation of intermodal innovations.

Level of investment costs (funding problems)

The intermodal transport industry is a highly capital-intensive industry. In general large budgets are required for investments in intermodal equipment (vehicles and handling facilities) and in particular when intermodal investments include infrastructure development (e.g. construction of rail lines, canals or locks, or dedicated infrastructures – such as in the case of Combi-Road and OLS). Such intermodal investment costs are even much higher when innovations are concerned, because the transfer facilities are innovative, i.e. they are produced for the first time, so it is not possible to benefit from economies of scale in production yet. This is clearly illustrated by the MegaHub, Commutor, BargeExpress and OLS cases as described earlier. Also when specialized transport vehicles are needed, high initial investment costs can hamper a successful implementation – as is illustrated with the Distrivaart and BargeExpress cases (expensive barges), Combi-Road and OLS (automated vehicles) and CargoSprinter (specialized trains).

For individual commercial actors the large investment budgets that are needed may be a problem in itself. As far as the innovation is developed and to be implemented by a consortium other financial issues may arise, e.g. distribution of costs and revenues between the partners in the project.

It seems, however, inevitable that commercial actors that invest will be confronted wither higher costs in the start-up phase than their non-participating competitors. This brings the investing actors in an unfavorable competitive position, and therefore it may raise a threshold to invest, although the innovation may offer promising perspectives. Van Binsbergen (2007) defines this situation as a prisoners' dilemma. As far as the innovation is concerned with infrastructural developments the involvement of the public sector is a prerequisite to enable such developments.

Distribution of costs and benefits

When innovation projects require co-operation or joint investments in equipment and/or infrastructure to accomplish the comparative advantages of the innovation it is often difficult to establish a fair mechanism to distribute the costs and revenues between the participants. If participants believe that their partners will have greater benefits or lower investments than themselves they will be less willing to co-operate. This attitude will be reinforced if efficiency gains cannot easily be reaped by the initiators of the innovation, for instance if the transport market in which they operate is so competitive that they actually have to pass on their gains to the shippers. For example in the cases of CargoSprinter and Distrivaart the initial investment costs in vehicles rendered the systems too expensive in competition with road transport. In the case of OLS, the new system would reduce truck traffic on public roads; however public authorities were not willing to 'pay' for this reduction in truck traffic.

This problem of failing to achieve an accepted distribution of costs and revenues has been one of the most manifest and persistent barriers for many innovations that have been proposed to improve the handling of barges in the port of Rotterdam (see Binsbergen et al, 2009).

In principle this distribution issue plays a part in every project that requires co-operation, but it increasingly endangers the viability of a project when the required investments and/or the potential profits are large.

Innovations are increasingly focused on contributing to sustainable mobility, e.g. reduction of emissions and noise and efficient land use. As a result such innovation projects usually score positive in social cost-benefit analyses. However, these social benefits generate very limited monetary benefits to the actors that implement the innovation in practice. So although the innovation may be socially desirable, in the end the business case must be promising to materialize the innovation.

Effects on the power and identity of actors in the transport chain

Intended participants in an innovation project may believe that the implementation of the innovation may lead to (unintentional) changes in power relations between the participants. These expected changes may for instance relate to loosing customer contacts, and related to that loss in commercial identity, and/or loosing grip on operational processes. These effects especially emerge when new logistics concepts and/or new transport concepts are introduced, such as in the examples of MegaHub and Commutor (‘new’ railway concepts), Combi-Road (new modality) and CityBox (new distribution concept).

Possibly, at strategic level, it may even affect the dependency of a company, for instance the issue whether business units can still be sold if they are embedded in the materialization of the innovation. Potential changes in power relations is an issue that plays a part in almost any concept that is based on co-operation, both in situations of chain co-operation (vertical) and in situations of horizontal co-operation, e.g. intermodal transport operators that have to bundle flows to make a new concept profitable.

Continuation of consortia and concepts: sufficiently long period of testing

Transport and logistics innovation have a long-lasting impact: investments are made in equipment, software, staff, buildings etc.. Along with these investments a transformation to new logistic processes needs to take place and this is usually a rather slow process. Pilot and test project are often scheduled for a too short period of time, in which this transformation has not been accomplished, and related to that, the pilot or test results may be disappointing. When pilots or tests have a longer time schedule it is important that sufficient commitment of the involved actors can be retained, even if some actors withdraw. In this context, the role and attitude (commitment) of sufficient employees of the involved companies seems to be of utmost importance: project support should not be based on the support of one key person only in the company. In fact, all innovations have to deal with this aspect, as either huge investments or (costs made for) significant adaptations in logistics processes and/or vehicle fleet have long pay-back periods and all innovations need multiple actors to stay involved over a longer period of time. For example, in Distrivaart one crucial partner stepped back, rendering the whole of the project less profitable.

Minimum required scale of operation

In several concepts the real comparative advantages of the innovation do not materialize to full extent when the concept is tried out in a pilot or test phase, because the scale of operation is too limited. The limited scale of operation may relate to a minimum number of participants (users of the innovation), a minimum transport volume, a minimum number of equipment (vehicles, cranes), a minimum service level, etc.. In general budget restrictions are a major explanation for setting up small-scaled pilot projects. Due to the biased performance of the innovation it becomes much more to difficult roll out the concept to wider application. Especially innovations that require fundamental changes in logistics operations (such as MegaHub, Commutor and BargeExpress) and/or require the use of dedicated vehicles and infrastructures (Distrivaart, OLS, Combi-Road) are not scalable, and need a significant transport flow from start to be able to grow into a competitive position. Also concepts like CityBox and Foldable Containers can only be successful when a significant market share is achieved, and as long as this is not the case, the concepts cannot be competitive.

Institutional context: role of governments

Intermodal freight transport systems are typically created (planned, designed, financed, operated, maintained) in a public/private context. The strong interaction required by these parties is fuelled by, amongst others, the existence of regulations that affect the choice of technologies, the need to join or align financing for infrastructure and equipment, and the responsibility to prepare spatial plans and involve the local citizenship and industry stakeholders. Plans are seldom well aligned, however, because of the mismatch of private and public actors' objectives, perceptions or beliefs. It is at this stage, of early planning, that the root cause lies for failures of many initiatives. While governments can play an important role as innovation agent, sometimes covering first year losses of new systems (the cornerstone of the European Marco Polo funds for intermodal systems), they sometimes resort to negative measures such as restrictive actions for competing modes (Platz, 2009) or on-going subsidization of operations. For example, Modalohr is still in operation by the grace of state subsidies. Still, fundamental aspects – some would say flaws – in traditional waterway, rail and road transport markets, hamper successful introduction of new, alternative concepts. Examples of such flaws are the misbalance between modes of infrastructure costs/tariffs, low vehicle costs due to outdated equipment (rail, barge), low labor costs due to loopholes in legislation (road), low transport tariffs due to pricing strategies (especially road), and legislation/regulation not adapted to new developments (cf. CargoSprinter example). An early alignment between private and public interests may not only increase the chances of success, but also ensure acceptance of discontinued projects (van Duin et al, 2010).

Changing external conditions

Several innovations require a long-term commitment of governments and/or private companies. Due to internal or external causes some of these actors are no longer able (or willing) to maintain their commitment. Examples can be changes in the political scene, leading to changing long-term visions, in the government, mergers/taking-overs, reorganizations and strategic reorientations at governments or companies. In addition, social and economic developments at national or even global level can have impact on the commitment for an innovation. For example, the financial crisis that started in 2008 has dramatically curbed the interest in large investment projects (such as for MegaHub), and changing freight market conditions combined with the inflow of a relatively cheap labor force as a result of the extension of the European Community reduced the advantages for automated and high capacity transport (such as CargoSprinter, Combi-Road, OLS and new rail systems). To some extent such developments cannot be foreseen, but innovations are more likely to successfully materialize if they can somehow be robust to such changing external conditions. Nowadays an innovation that is not just focused on profitability but can also score well on sustainability criteria will have better prospects to succeed.

Overestimation of potential of ‘hardware’ solutions, underestimation of importance and impact of ‘orgware’ solutions

In general there is the perception that technological innovations can have a ground-breaking impact on the performances of systems. This view is also noticeable in the intermodal transport industry, since many innovations have a technical dimension. This perception is strengthened by the fact that these innovations are often well tested under laboratory conditions (including simulations, etc.) and therefore show very promising results. However, performance claims often cannot be fulfilled in practice. The reliability of innovative technologies usually has shortcomings when they are commenced in applications. In a very competitive environment, such as the intermodal transport industry, unreliable performances can therefore endanger the market competitiveness. For this reason potential users may reluctant to be the first user of these new technologies. These kind of barriers may arise in ‘hardware’ innovations (engineering developments), but also arise in ‘software’ innovations (IT/software developments). In fact most innovation examples have a strong technology orientation – MegaHub, Commutor, OLS and Combi-Road related to infrastructure and equipment, OLS, Combi-Road, Modalohr and Distrivaart also to vehicles, and CityBox and Foldable containers to specific elements in the chain. All these new technologies are largely new, hardly tested in practice, and argued to be vulnerable in the harsh environment of freight transport. Above that, most innovations require important changes in logistics operations and/or a change in habits, and such changes are hard to implement.

Moreover, as strong technologically oriented innovations are concerned the financial issues and organizational impacts are often neglected in the R&D process and turn out to be serious barriers when it comes to implementation. The intermodal transport industry is a typical multi-actor environment where innovations in interorganizational co-ordination and co-operation can be even more fruitful to improve the performance of the intermodal transport system.

Innovation project management

A critical issue for a successful materialization of an innovation is proper management of the whole development process of the innovation. In the first place, several innovations have suffered from the fact that the initiators have been insufficiently aware of the (international) state-of-the-art and/or experiences with similar initiatives. This phenomenon has for instance been typical for many efforts in the past regarding the development of foldable containers. Innovation projects often start from scratch and often face the same kind of barriers as previous projects. The concept of

Modalohr, for example, is almost identical to the Walda-system developed about a decade earlier in The Netherlands, and the MegaHub concept is very similar to Commutor. Also the attempt to implement the CityBox in The Netherlands has many predecessors, partly successful (e.g. Stadsdistribution plus of Harry Vos in The Netherlands, Playbox of Hellmann in Germany) and partly unsuccessful (e.g. Logistikbox of DB in Germany, C-sam in Sweden, +Box in Denmark) (see also Binsbergen et al., 1998). These previous initiatives can provide useful insights to avoid pitfalls in developing new initiatives. It is questionable whether the initiators of the 'newer' systems knew the ins and outs of the earlier initiatives.

Major causes for the lack of quality in the process management are related to financial structures and conditions (e.g. budgets are provided in small amounts, one by one and other strict conditions regarding spending budgets) and a lack of a strong project manager.

In addition, problems and challenges in the innovation project which are identified or defined in the early phase of a project are not always adequately dealt with in later phases of the innovation development. This may relate to very fundamental issues, such as 'does the innovation really contribute to solving a problem' or 'can the innovation really be implemented in practice'. For instance, in the Combi-Road project the development process was strongly technology-driven, while as the project progressed it became clear that the technology that was chosen did not fit very well to the envisaged application of this automated transport system.

The causes of such fallacies can be attributed to a group process. In which participants are not really able to review and revise their project visions or are not willing to do so, because one dominant participant or some of them have a vast interest to develop a project according to the initially defined plan.

Finally, innovation projects that have a large scope, both in terms of its number of new system elements (regarding technologies, logistics organization and infrastructure development) and in number of actors (companies and individuals) that are involved, will face typical management problems, because just of their large scope, participants will be less committed and feel less responsible.

CONCLUSIONS

Innovations in intermodal freight transport face many different barriers and challenges during the process of implementation. This especially holds for large-scale, system innovations – projects that ask for heavy investments and/or demand fundamental organizational changes throughout the transport process. As with most large-scale innovative projects, acquiring funding is nowadays an important challenge as infrastructural development requires large budgets, pay-back periods are long and future profits uncertain. Also, as funding relies heavily (though not uniquely) on public funding, long term project impacts are important.

Not only there should be a long-term net societal benefit, also the private business case must be(come) viable. For initiatives with a net societal profit, but a negative business case, some way of compensation – for example by subsidies for the introduction and operational phase could be considered. Authorities, however, can be reluctant to do so because of apprehension of causing distortion of competition in the transport market. Moreover, alignment of public and private strategies is needed well beyond the stage of political decision making. During the (private) operation of facilities, public regulations determine the effectiveness and efficiency of the new infrastructure. So, size does complicate the realization of projects.

The sheer scale of intermodal freight transport projects are not the main reason for projects to be challenging, however. The key critical factors that we have identified here are typical to the transport industry. While the transport industry is very competitive and profit margins on operations are generally low, intermodal transport systems require operators of competing modes to collaborate. This raises complex questions concerning alignment of strategic objectives, synchronization of services, sharing of investments (in physical or ICT infrastructure) and sharing of gains. In short, in a world of heavy competition, intermodal transport is a multi-actor service that suddenly requires good co-operation between the actors – often being competitors - in the logistic chain. To complicate things further, changes in transport services can impact on the broader supply chain, influencing inventory management (through e.g. changes transport schedules) and possible the quality of delivery of goods. This influence affects the business of the shipper, who has to consider changes in the supply chain surrounding the transport service. If these changes are too complex and do not result in an overall, supply chain level improvement, shippers will not accept this change.

A reluctance of companies to pioneer such innovations can be explained by the difficulty to create a balanced outcome. These barriers will be highest in the start-up phase, in particular when the performance of the innovation does not meet the expectation yet.

Solutions to overcome these barriers will have to focus on some main substantive critical factors. Firstly, the relative advantage of the new technology need to be clear. Secondly, the compatibility with the existing system has to be understood by all parties, irrespective of the question if the innovation is transformational or incremental. Thirdly, the lower the complexity of the change, the higher the probability of implementation. Fourth, the innovation has to be such that it can be experienced and tested, if necessary at a large scale. Finally, the new concept must eventually be based on a positive, private business case that can compete with alternatives; this could imply the introduction of subsidies in the introduction and in some cases even in the operational phase.

As the innovation process itself is concerned, there is a need for a strong process management during the whole development process, starting from the elaboration of the idea until implementation of the innovation. The freight projects discussed in this paper show that this is only possible if stakeholders are willing to invest in the process, firstly in the role of championing institutes, later in the role of mediation and aligning of preferences, and finally in joint decision making en implementation.

The potential success of an intermodal transport innovation, however, will depend on the reaction of competing intermodal actors, but definitely also on the reaction of competing modes, the road transport sector in particular. It is striking that road haulers, while confronted with continuous increasing operating costs, have still managed to improve their productivity to keep up their strong competitive position towards intermodal transport. These improvements could not have been accomplished without road transport innovations also taking place, such as more intelligent (dynamic) route planning systems and co-operative agreements between haulers to improve vehicle utilization rates and to avoid trips with empty containers. From this perspective, positive experiments with so called longer and heavier vehicles (LHV), up to 25,25 m. length and 60 ton gross weight, that are taking place in some European countries are considered as a threat for rail and barge transport to lose market share (both in traditional and intermodal operations of rail and barge). However, it remains to be seen to what extent and under which conditions access of these trucks will be permitted.

In view of the major social ambition to make our transport system more sustainable it would be more useful to focus on the complementarities of the different modes rather than propagating intermodal transport as the only recipe for sustainable transport. Governments, including the European Commission, increasingly acknowledge that striving for optimal combinations of various modes, including road transport, (so called co-modality) is a more preferred option in achieving sustainable transport. However, it is evident that to make co-modality really works there remain needs for innovations. It is most likely that these innovations would be most needed in information and telecommunication technology and organizational issues.

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