

Ports and Innovation

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Abstract

A volatile environment, dynamic markets, and challenges created by new environmental and social consideration demand innovative solutions. Innovation is the implementation of ideas to create value. It promises ports resilience into the future. In this paper we trace some recent successful innovations in the Port of Rotterdam, and also investigate a few promising ideas that have remained on the shelf. After investigating the reasons behind the success or failure of these concepts, we can identify and address some of the barriers to technological innovation. This research corroborates that innovation process is shaped by the interplay of need, economic, and institutional factors. Once the need escalates and reaches a threshold, and initiative is taken to commonly address the barriers, the promising ideas will find implementation. It also establishes that the complex issues surrounding technological innovation require a unified contribution from many sources and disciplines. While the leadership role can be assumed by a Port Authority, a larger role can be set out for the terminal operators, who bear markets considerable risk and face the demands of an increasingly stricter environment regime. The paper concludes that despite everything, innovative endeavours must continue, so that we have a plethora of solutions to fall back upon as new challenges appear.

1. Introduction

1.1. Background

The port sector is in the midst of a significant transition, largely as a result of three major factors: globalization, a changing market place, and rapidly changing technology. The demand pull resulting from the first two factors, and technological push have always been catalysts for innovation. And now, the stricter regulations in response to the growing environmental and social considerations also need to be addressed. The change in role of ports from ‘ports in supply chains’ to ‘nodes between sea and land transport’ is also bringing new challenges to the forefront. There has been an increasing appreciation of how important innovation is to the economy (Kin and Mauborgne (1997), Dundon (2002), Buganza and Verganti (2006)). And many claim that innovation is the only manner to survive since it offers a port resilience in a future (Winkelmann (2009), Chen (2010), Haughstetter (2010)).

1.2. Research objective

Innovation is implementing new ideas to create value. It is not a linear process where new research results lead to developing new products and services, which are then taken up in the market. Innovation is a systemic process with many factors that influence its emergence and success. Before we propose that innovation activities gain a larger priority in the portfolio of organizations, we need to get some insights into the nature of innovation in ports. This means being able to answer questions such as:

- Which forces drive innovative developments?
- What are the barriers for innovative activities? Do these originate within the organization or outside? How significant is the cost factor?
- How important is the role of government or a port authority in promoting innovation?
- Are certain research themes more relevant for present times?

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- Does the focus of innovation today lie solely in elaboration of strategies or visions that already exist, or there is room for what is, nowadays, termed as value innovation?

It is being increasingly realized that innovation is an interactive, complex process in which actors, e.g. firms, interact with a manifold of other organisations and institutions (e.g. research institutes, customers, authorities, financial organisations) (Wolthoff, 2005). The success of innovation depends on this process (Edquist, 1997). Through our case studies we hope to get a clearer picture of the role played by the various actors (government, research institutes, industry, the terminal operating companies, and the Port Authority), in this process. Maybe these roles need to be adapted.

We do not attempt to identify research themes or lay down an innovation agenda, or even suggest how the typology and framework pertaining to innovation should be changed. Having gained insights into the processes tied to successful innovation through case studies, we hope to suggest ways to stimulate innovative efforts in the port sector. We think addressing the barriers to the implementation of new ideas can go a long way towards promoting planned innovation in the port industry.

1.3. Research approach

The Port of Rotterdam (PoR), currently one of the most technologically advanced ports, and has been a pioneer in many fields. In retrospect, we can distinguish many examples of successful innovations in the port sector, but we can also unearth a large number of promising concepts which have never been implemented. Our research approach is to trace the development of these concepts in order to analyse the factors responsible for their success or failure. In addition to a literature study and desk research, this involved conducting interviews at PoR. Some of the interviewed individuals were instrumental in making daring decisions and innovative endeavours, and could be a source for valuable insights.

Some of the innovative concepts that come to mind are:

1. MultiCore pipeline (Port of Rotterdam and Vopak), a multi-user pipeline which has proved very profitable for PoR, and studies for expansion are under way;
2. Container Transferia (Port of Rotterdam), a logistic concept which is in the process of being implemented after facing initial resistance on many fronts.

The following concepts have not been implemented:

3. Multi-functional quay wall (BAM Civiel B.V., Van Hattum en Blankevoort B.V. en Haskoning Nederland B.V.)
4. Multi-user or 'grey' terminal (Port of Rotterdam)
5. Floating crane (many participants including Delft University of Technology, PoR, APM terminals, Kalmar and Royal Haskoning)
6. Combi-road (Holec, Hollandia Kloos, Terberg)

1.4. Structure of the paper

After discussing different types of innovation in the context of ports in Section 2, we devote Section 3 and 4 to tracing the trajectory of innovations listed above. In section 5, we analyse the plausible factors influencing these trajectories. Section 6 discusses if the role of the various actors needs to be adapted. Finally we draw conclusions based on the paper.

2. Innovation

2.1. Types of Innovation

(Graham, 2008) gives the following definitions of innovation from various sources: Innovation is the profitable implementation of ideas. Innovation is implementing new ideas that create value (Innovation Network, U.S.A.). Innovation is the intersection of invention and insight, leading to the creation of social and economic value (U.S. National Innovation Initiative). Innovation is the process of turning ideas into values and perspectives. A synthesis of views of various authors (Volberda, 1998; Dundon, 2002) results in the following classification of degrees of innovation.

- *Incremental adaptation* (also called adaptive or efficiency innovation) focuses on improving what already exists, e.g., optimizing standard solutions for existing problems. This includes incremental changes such as cost reduction, quality or productivity improvements. It requires small investments and delivers small gains.
- *Evolutionary innovation* mostly addresses existing or new issues using state-of the-art approaches and techniques and is often targeted at new markets. The new issues can be a result of technology or policy changes, new strategies, joint ventures or mergers, or customer feedback. Evolutionary innovation refers to distinctly better products and processes, but like incremental innovation, it is carried out within the existing structure of organizations.
- *Revolutionary or break-through innovation* focuses on radically new and better ideas that may, in fact, transform or even dismantle the existing structure, technology and processes of the organization, as well as the marketplace. These innovative activities lead to the discovery of an intertemporal activity that cannot be, even in principle, be said to actually exist before the opportunity has been created (Kirzner, 1985).

Whereas incremental innovation addresses existing problems (and therefore can often prove limiting through shifting focus of an organization), evolutionary innovation also is also directed at anticipating new problems and issues as a result of long term thinking about future developments. Revolutionary innovation is mostly a result of serendipity, though often triggered by inadequate solutions of existing problems. Which is why, it can be termed unplanned innovation, while the first two can be classified as planned innovation.

Table 1. Degrees of Innovation in ports

	Incremental	Evolutionary	Revolutionary
Prime mover	Market forces	Market forces	Interplay between scientific advances, economic factors, institutional variables and unsolved problems (Goss, 2002)
Costs/ resources	small	large	very large
Issues/ opportunities	Existing or predictable	Both existing and new	new
Associated uncertainty	small	Small to large	cannot be assessed
Routines/ Procedures	Routines or a variation/ combination	changing trajectories, flexible use of routines	Routines mostly violated
Markets	targeted at existing markets	targeted at existing and new markets	Disrupts existing markets

Table 1 lists the characteristics of the different types of innovation – the port sector offers numerous examples of each type.

2.2. Some examples from the port sector

The Internet, Google, and Containerization represent examples of break-through innovation. The Internet has revolutionized world communication, and changed the way we work and play. The invention of the container, and the rise of container shipping has changed the balance of world trade, rewritten the rules of modern manufacturing, and transformed port and manufacturing cities around the world (Zuckerman, 2007). Manufacturing cranes that could handle extra wide post-panamax ships that did not sail yet on the Atlantic route in late 1980s and building of Sea-Land Delta terminal by ECT (now short for Europe Combined Terminals), in the early 1990s, then declared to be the logistic blunder of the century, but later achieved the status of 3rd generation container terminal, exemplify revolutionary innovations. The ensuing development, such as specialized cranes for container handling can be called evolutionary, but subsequent improvements in crane design (twin-lift and followed by quad-lift spreaders (Bromma Conquip, 2010)), or new types of containers falls under the category of incremental innovation.

2.3. Value innovation

David Hughes (Tidd, 2005) states very aptly: “The characteristics of doing business today – rapid change, extreme volatility and high uncertainty – mean that traditional ways of managing technology need to be radically reappraised for any company that sees technical leadership as a critical business differentiator”. Innovation is

seen as a means for survival in this competitive age, therefore we find it useful to bring up a concept termed as value innovation (Kin and Mauborgne, 1997). It is a strategic logic which suggests assuming that competition is not a benchmark, developing new capabilities asking: what would we do if starting anew, even shaping industry conditions, and thinking in terms of total customer solution and satisfaction.

Table 2. Value Innovation

	Conventional Logic	Value Innovation Logic	Examples of value innovation in PoR
Assumptions over the port industry	Industry conditions are given	Industry conditions can be shaped	Bringing the 'container' from New York to the Rotterdam port in 1966
Strategic Focus	Build competitive advantage	Make quantum leaps, competition is not a benchmark	Building automated container terminal for ECT in the early 1990s, declared then as the logistic blunder of the century
Assets and capabilities	Leverage through existing assets and capabilities	Develop new capabilities asking: what would we do if starting anew?	<ul style="list-style-type: none"> – Investing in foreign ports – Looking into new products, i.e., algae factories/ biomass
Product and services	Let core activities and traditional boundaries determine the services offered	Thinking in terms of total customer solution and satisfaction	<ul style="list-style-type: none"> – MultiCore bundle, RC2, Inland Container depots and Container Transferia – Creating networks between clients, terminal operating companies, service providers – Creating synergies between companies through clustering, co-siting

Table 2, adapted from Kin and Mauborgne (1997) compares the logic behind value innovation with conventional logic. Value innovation thinking is to be recommended for ports; in fact some past developments at prosperous ports can be categorized as value innovation, and may explain how these ports have stayed ahead of the game.

3. Some successful innovations

In this section, we describe two of the successful innovative concepts from the recent years and trace their implementation.

3.1. MultiCore pipeline

Concept

Rotterdam is home to many companies that focus on oil and chemicals. These companies actively use pipelines for large-scale point-to-point transport. Each year, some 60 million tonnes of various oil and chemical products pass through the pipeline network. PoRA developed the MultiCore pipeline concept in 1997. The pipeline bundle is an underground multi-user distribution system, which offers a cost-effective alternative for trucks and barges, avoiding investments in separate pipelines by the oil, chemical, and gas companies. The customers can obtain transport capacity by simply leasing a pipeline over the required distance and a connecting line with their own facilities. The permit for usage of its pipelines is arranged by the company MultiCore B.V., and the client must transport its products under the conditions of the permit. When the lease contract expires, the customer simply disconnects from the system and returns the pipeline cleaned and ready for lease again (MultiCore, 2012).

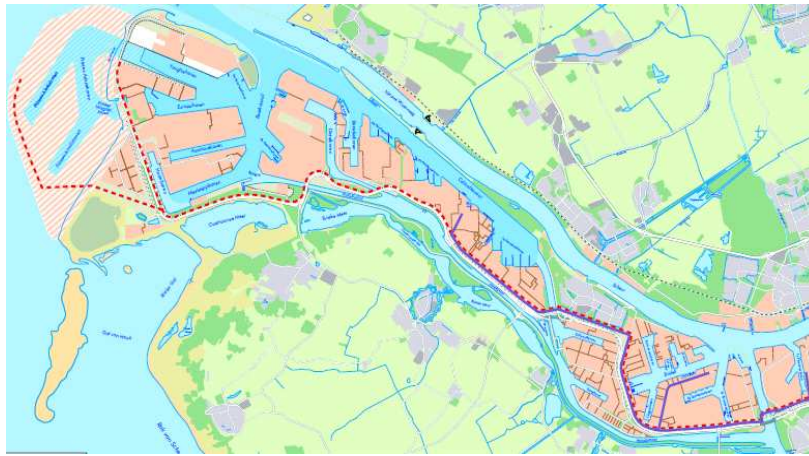


Figure 1 MultiCore route in Rotterdam (Source: PoR)

Some other advantages of this concept are:

- earlier availability than the construction of a new own pipeline;
- environmental friendly, safe and uninterrupted mode of transport;
- CO2 reduction and decrease in traffic congestion;
- efficient use of space, and
- strengthening of the oil and chemicals cluster.

Implementation

After its conception, the concept was taken to the market in a joint venture between PoR and Vopak (named MultiCore BV). In 2002-2003, the bundle of four pipelines was laid and put into operation. In total, today there are 80 kilometres of pipeline in a 20-kilometre stretch between Pernis and Europoort (Figure 1). Initially there was only one launching customer, today seven clients make use of the bundle (MultiCore, 2012). These include ExxonMobil, Air Products, Linde Gas, Shin-Etsu, Koch, Abengoa and Shell Chemicals Europe. In 2011, MultiCore achieved a capacity utilisation of 84% and a record turnover of € 4 million.

Success factors

The following factors have contributed to the success of the concept:

- Phased development in response to demand: Initially there was one launching customer. Presently, expansion plans are now underway. PoRA has started to make an inventory of product flows and interested parties a stretch in the direction of Maasvlakte. The length will depend on the interest shown by parties from Rotterdam's port and industrial complex.
- Flexibility in the concept: It is possible to lease variable transport capacity (pipeline length) for a variable time (5- 25 years) and a range of products.
- Reduced administrative procedures: MultiCore takes care of the required permits for usage of its pipelines saving the clients cost and effort
- There is no upfront investment in expensive infrastructure, since it is a PoRA initiative. This is by itself unique since pipeline investments are done by private parties.
- Support from the government in the form of a 2 million euro subsidy from the Ministry of Infrastructure and the Environment).
- This unique concept contributes to efficient use of space, safety, land side accessibility, and environment and sustainability², all strategic issues which need addressing by PoR.

3.2. Container Transferium

Concept

A Container Transferium (CT) situated in the direct hinterland of the Port of Rotterdam, is a new logistical concept, which allows containers to be transferred by inland vessels in a single movement from the sea terminals at the Maasvlakte to the Transferium and vice versa. Figure 2 shows the concept of the Container Transferium. Trucks load and unload at the Transferium instead of at the sea terminals, and save time by not going to MV; sea terminals are guaranteed shorter dwell times for containers resulting in less congestion (increased capacity). Some added advantages are: a staggered arrival of containers at the sea terminals leveling the peaks; faster

² There are plans to capture CO2 and sell it to Maersk for use in their oil fields in Denmark.

loading and unloading for inland shipping; optimum accessibility for hinterland, better use of equipment by all parties; increased reliability in supply chains, and cheaper transportation than by trucks.

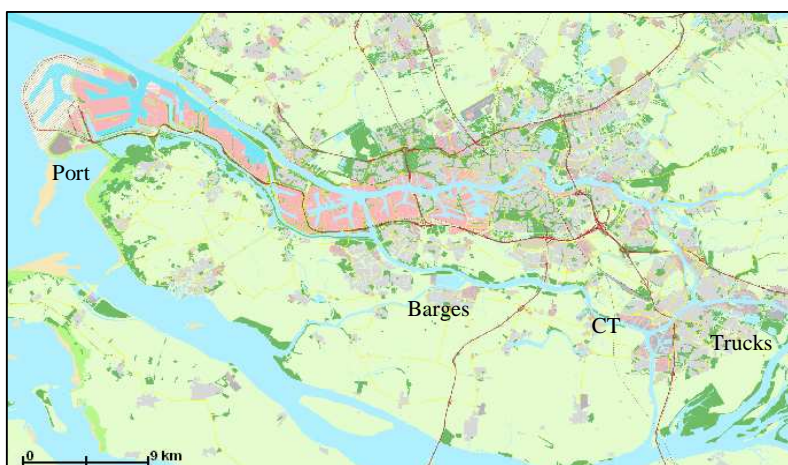


Figure 2 Concept Container Transferium (Source: PoR)

Implementation

After the logistic concept was conceived, PoR took the initiative for the CT in October 2007. In the exploratory phase, a market concept was developed and a business case set up. Subsequently, the business model was presented in May 2008, and a LOI³ signed by 12 parties and PoR. PoR set up its business case and brought the market parties in a consortium to develop a joint business case. In mid 2009, matters such as location and finances were arranged, and a MOU⁴ with the market parties was signed.

The exploitant BCTN⁵ has been selected in an open process. BCTN and PoRA have signed a new contract for the operation of the Container Transferium in Alblasterdam. The parties are already working on the preparations for the construction of the quay and the terminal. The terminal is expected to be operational at the start of 2014 (PoRA, 2012).

Success factors

Despite facing resistance from VITO⁶ who viewed it initially as unfair competition (de Kruijf, 2007), and problems such as the selected exploitant declaring his business case as nonviable, CT is on its way to being implemented (albeit after adaptation such as reduced terminal size and quay length compared to the original business plan).

This innovative concept will take care of present bottlenecks such as decreasing reliability of flows, longer waiting times for inland shipping, rapidly declining accessibility of Maasvlakte for trucks, capacity limits of sea terminals, fine dust and CO₂ emissions, and inaccessibility of port for emergency services. Some other factors which account for the success (bridging the gap between idea and implementation is defined as success) are discussed here.

- The PoR has taken a leading role when it comes to obtaining support and approval from the authorities, both national (Project Randstad Urgent) and local, as well as assumed the role of a manager to supervise the market parties. This has been the key factor in overcoming institutional barriers.
- The business model has been prepared after careful considerations in order to avoid vested interest or a conflict of interests. PoR will serve as landlord, investing in land and infrastructure in exchange for competitive rent. CT will be a neutral terminal which is free to act both commercially and operationally within formulated boundary conditions. A separate, independent organization will run the terminal. Such a model prevents controversy among the collaborators.
- For the CT to compete with direct truck transport to the Maasvlakte, a customs regime was necessary to make the terminal and the seaport a single area. Attention has been paid to such aspects by involving customs in the project.
- An added stimulant has been the enhanced green image for the participating companies, and in due course, CO₂ certificates for them.

³ Letter of Intent

⁴ Memorandum of Understanding

⁵ Binnenlandse Container Terminals Nederland

⁶ Vereniging van Inland Terminal Operatoren

4. Innovative concepts on the shelf

We go on to discuss four innovative concepts, which despite considerable investment and effort in engineering, have not been implemented.

4.1. Multi-user terminal

As the name indicates, a terminal which can be exploited by more than one user or client is a multi-user terminal. At present, 99% of the quays in PoR are dedicated to one client or cargo segment. The berth occupancy is relatively low. By increasing the berth-utilization and thus increasing the volumes of cargo handled, more revenues can be generated for PoR.

A few decades ago, the innovative concept of a 'grey terminal' was investigated and even brought to the market. A grey terminal is essentially a multi-user terminal, where the quay and the crane can be rented per hour. It is expected to cater to niche markets which do not require specialized handling. The grey terminal would require some initial support from the landlord Port Authority (which generally limits itself to investment in infrastructure, without involving itself with operations). However, when this concept was launched in the market, some of the other operators in the port, seeing it as unfair competition, raised objections. Finally, the innovative concept did not take off.

Despite this development, in September 2009, the management team at PoR initiated a pilot study over multi-user terminals (ITR, 2009), with the aim to achieve high berth utilization at a quays or jetty. This initiative belongs in the framework of innovation under the theme 'efficient use of space'. An exploratory brainstorm session highlighted the need for an investigation into legal/organizational problems which play a role in case of shared use of handling facilities. It also suggested an investigation into how multi-user contributes to raising berth occupancy and the handled cargo volumes. The study will focus on, and is expected to give insights into the financial, commercial, and legal aspects related to this concept.

We can ask ourselves, if the increasing shortage of space in the existing port, and the increasing pressure to intensify use of the existing infrastructure could be an effective trigger for the implementation of a multi-user terminal. Or will the trigger be a completely new niche market in the future? The past experience has taught us that implementation of a multi-user terminal would require PoR to create a level playing field for all parties, probably at significant expense. If yes, will these extra investments weigh out the extra revenues generated due to increased use of the facilities?

4.2. Multi-functional quay wall

A multi-functional infrastructure (whether a terminal or a quay wall), which aims at an efficient use of resources, has been a subject of numerous studies. In the period 1996–1999, PoR formed a consortium with one of its clients Odfjell Terminals Rotterdam BV and some other firms, to investigate the innovative concept for storage of oil products in a quay wall. The other members of the consortium were BAM Civiel B.V., Van Hattum en Blankevoort B.V. and Haskoning Nederland B.V. (CO3, 2005).

Besides the expected benefits due to multi-functionality, such a design would win (scarce) space in the existing port. A lot of time, money, research and engineering effort went into developing a technically feasible design concept. However, this innovative design proved to be expensive, and when the business case for various parties proved to be nonviable, the project was given a no-go. The traditional alternative with a single function of berthing ships was selected. Up till now this concept has not been implemented.

If at that time, the companies could have viewed it as a pilot project in the framework of innovation (which requires initial investment but pays off later), the project might have gone ahead. Even if the joint business case was nonviable, the innovative concept could be later sold to other users to be implemented at other locations in the port. Moreover, the business cases were based on a ceiling price which included quantified risk in categories such as 'unexpected events' and 'incomplete design due to innovative nature of the project'. In reality, these risks may not have been so high for the pilot project, and even lower for subsequent projects. Even in absence of exact quantification, if these factors were taken into account, the management might have opted for the innovative solution instead of the traditional solution.

A short-term vision coupled with a commercial perspective, and an ill-defined collaborative effort (lack of leadership) was responsible for a failed initiative.

4.3. Floating crane

A floating crane makes double sided container handling of a ship possible, increasing the productivity and reducing vessel time at berth, and may reduce total handling costs (Visser, 2000). Due to the increasing ship- and call sizes, and the stringent demands of the shipping companies, this innovative concept has a lot to offer. Floating cranes could be of interest to terminals reaching their maximum capacity, or as a means to reduce road congestion in port areas. A survey of the potential markets for floating crane established that of the 7 European ports (33 terminals reviewed), 14 terminals (belonging to Antwerp, Rotterdam and Hamburg), could successfully deploy floating container cranes. According to Van Beemen (NT, 2007), floating crane can also be used for humanitarian or military operations in regions with minimum infrastructure, or as a temporary terminal in developing countries.

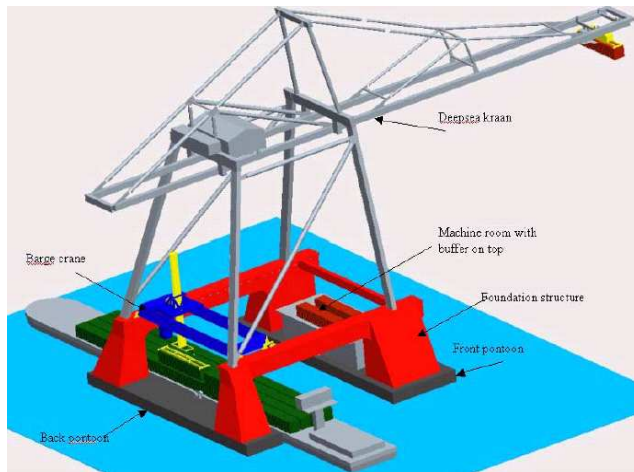


Figure 3 Floating Crane (Source: PRC)

The conceptual design was developed based on proven designs and standard components (Figure 3). In addition to the technical feasibility, various logistic concepts were investigated by Pielage (2007). Some concepts required a change in the vessel stowage planning, others, the presence of an inland barge hub terminal and in others the floating crane could be directly integrated in the current logistic operations. The most beneficial alternative requires a barge terminal, but provides the added benefit of reduced pressure on the deep sea terminals and on the connecting road infrastructure.

In spite of the many advantages (NT, 2005a), and the existing potential markets, many practical and institutional barriers exist (NT, 2005b). The cargo of a mega-container ship has diverse sources and destinations, which

makes it difficult to plan a fast and efficient handling from container to inland vessels (and vice versa). The possibility of being able to influence the stowage planning of the container or inland vessel is almost negligible. Customs and empty containers add to the problem. Pielage (2007) stated in their study that though results were positive with regard to the technical and operational matters, issues such as distribution of the costs and benefits among the parties involved must be resolved before such a concept can be implemented.

A possibility would be to dispatch the containers to an inland depot (e.g. Duisburg) under custom regime and sorted there. Or this concept could be interesting for a transshipment hub such as Singapore, with enough volumes in a single bay of a ship. Also in cases where no fixed quay infrastructure is present, a floating crane offers a solution especially in combination with a floating terminal.

4.4. Combi-road

A Combi-road is a high capacity, unattended, freight container transport system introduced in 1994. The containers are pulled on semi-trailers by electrically powered vehicles which ride on air-filled tires. The vehicle combinations ride in specially designed tracks constructed as separate roads or as extra lanes alongside existing motorways (Figure 4). The system reduces the amount of vertical handlings in the transport chain. On so-called transfer stations containers are exchanged with sea shipping, road, railway and inland shipping. A technologically innovative concept, it offers congestion-free transport of containers for a maximum distance of 200 km and at a maximum speed of 50km/h.

In 1996, a prototype vehicle was successfully tested on an approximately 200 meters long test track. It was established that system reliability and functionality could be realized without having to use fallback scenarios (Van Gennip, 1999). Combi-road could lead to a break-through in automatic goods transportation in ports, and other densely populated urban and interurban areas with intense traffic congestion problems (Mecherts and Heere, 1998).



Figure 4 Combi-road (Source: Centrum Transport Technologies)

Despite extensive studies over the logistic concept, detailed technical designs, implementation trajectory, social-economic aspects, and safety aspects, Combi-road concept has not been implemented due to high capital investment costs. As ir. Heere (de Lange, 1997) stated at that time: “If we finance Combi-roads as roads and rails, than commercial feasibility is not a problem, but if has to be financed privately we had better stop immediately.” As long as existing modes do not reach their limits, there is no serious driver for new concepts. In Rotterdam inland shipping still has a plenty of capacity on the

waterways and the Betuwe railway line has added new railway capacity. It might, in future, be applied for inter terminal transport, this forms a bottleneck in the supply chain for any reason.

5. An analysis

5.1. Analysis

The issues addressed in each of the above concepts (namely, increasing congestion and scarce space), are not new, yet the new technology is responsible for magnifying the scale and extent of these problems. Each of these concepts is targeted at existing market. Most of the solutions are variations of existing solutions – bundling (Multicore), extended gates (CT), multiple uses (multi-functional, multi-user facilities), automated roads (Combi-road), and floating bulk crane (floating container crane), and would fall into the category of evolutionary innovations.

Generating new ideas is only the first step. To bring an idea to its implementation requires establishing its technical feasibility (prototyping, pilot studies, modelling) and economic feasibility (developing business cases) and the possibility of integrating it into the system. This requires knowledge- as well as human resources, and could demand intensive collaborations or organizational changes within an organization. An analysis of the selected concepts follows in Tables 3 and 4.

Table 3. Innovative concepts

Innovative concept	Issues / advantages	Procedures / processes	Market uncertainty	Contribution to sustainability
MultiCore	<ul style="list-style-type: none"> – efficient use of space – improved accessibility – CO2 reduction – safety improvement 	<ul style="list-style-type: none"> – innovative design of pipe bundle – interaction with legal bodies for permits – subsidy grant 	medium	high (underground infra.)
Container Transferium	<ul style="list-style-type: none"> – improved accessibility – CO2 reduction – safety improvement – efficient use of space and equipment on terminals 	<ul style="list-style-type: none"> – new business model – interaction with the market – interaction with legal bodies for permits – subsidy grant 	low-medium	high (promotes modal shift)
Multi-functional quay	<ul style="list-style-type: none"> – efficient use of space – diversification (reduced risk) 	<ul style="list-style-type: none"> – intensive R&D with a multi-disciplinary team, study into permits 	low-medium	medium (underground infra.)
Multi-user terminal	<ul style="list-style-type: none"> – intensive use of resources (quay and equipment) 	<ul style="list-style-type: none"> – routine 	high	medium
Combi-road	<ul style="list-style-type: none"> – improves accessibility – reduces noise 	<ul style="list-style-type: none"> – intensive R & D – pilot test 	low	medium
Floating Crane	<ul style="list-style-type: none"> – increased productivity – promotes modal shift 	<ul style="list-style-type: none"> – intensive R & D 	high	high (promotes modal shift)

Table 3 lists the advantages of the innovative concepts, the processes involved, the degree of uncertainty (risk) related to the markets being served, and the contribution of the concept to sustainability (government support can make sustainable projects viable). All these are significant in the path of innovation. In Table 4 we analyze the possible reasons for the innovative concept not being implemented. A discussion over possible actions to stimulate their implementation, now or in the future, is a part of this analysis.

Table 4. Reasons for failure and some suggestions

Innovative concept	Collaboration	Possible reasons for non-implementation	Suggestions
MultiCore	MultiCore BV		
Container Transferium	Leader PoR		
Multi-functional quay	Consortium CO3 (client, PoR, consulting engineers)	<ul style="list-style-type: none"> – high costs – added value, such as lowered market risks both for client and PoR, not included in business case – lack of trigger such as scarcity of space or high land prices 	<ul style="list-style-type: none"> – jointly market the patent – apply for subsidy – wait for a trigger such as lack of space or high land prices
Multi-user terminal	Leader PoR	<ul style="list-style-type: none"> – market approach not clearly thought out 	<ul style="list-style-type: none"> – let the market suggest a business model – select neutral operator, maintain level playing field – create a collaboration among potential users of the terminal
Combi-road	Project bureau Combi-road	<ul style="list-style-type: none"> – costly 	<ul style="list-style-type: none"> – Wait for triggers such as EU directives over sustainable solutions to obtain financing/ subsidies
Floating Crane	Extensive – includes crane manufacturers, terminal and barge operators, PoR	<ul style="list-style-type: none"> – costly (requires inland barge terminal) – institutional problems such as customs 	<ul style="list-style-type: none"> – PoR should be leader and market the concept in developing countries – concept could be workable for MV2 where operators have a dedicated barge terminal, and large volumes of containers – wait till increasing congestion due to appearance of mega vessels provides a trigger

5.2. Enablers and barriers to innovation

On the basis of the above cases, we can shortlist some factors that act as enablers or deterrents to innovation; most of these are relevant in general.

Vision and daring: Vision and risk-taking are essential components of innovation. PoR and Vopak had the vision to see the direct and indirect advantages of the MultiCore concept for all parties, and dared to take a risk. Today, it is a profit-generating venture in the port.

Costs: Costs include the investment costs, the exploitation costs (including maintenance) and the revenues. Especially for commercial organizations, costs, coupled with a long payback, are a critical issue for implementation of a new technology. Once the technical feasibility of a new concept has been more or less established, its adoption will depend on its economic feasibility. Combi-road exemplifies this fact. High capital investments to be financed privately meant end of the project. The classic Go-No Go thinking, based on economics, seems logical, but it has the unintended consequence of stopping innovation dead in its tracks (VanPutten 2009).

It is important to keep in mind that if an innovative endeavour contributes to sustainability (on the top of the agenda of most governmental organizations), it is possible to make a strong case for subsidy. This worked in favour of both Multicore and CT.

Innovative financing methods are also a means to redirect choice to support research and development initiatives.

Compatibility with the existing system: The compatibility/ interoperability of the innovative concept, and therefore its integration into the existing system, both from a technological and organizational perspective is vital for its success. For example, a floating crane requires technical changes to the system (presence of a barge terminal) or organizational (a uniform customs regime at source and destination, or a change in vessel stowage plan). Such changes are difficult to implement, which is one of the reasons why the project is on hold.

Triggers: Many of the barriers vanish if a certain threshold of necessity is reached. Necessity is the mother of invention, and new technologies will gain momentum when the need escalates. For example, once accessibility became the biggest threat for the Port of Rotterdam, especially due to the planned port expansion Maasvlakte 2, Container Transferium, a new tunnel and many other initiatives got an impulse (Tansumo, 2009).

Entrepreneurial initiative and collaboration: Innovative technologies carry with them significant uncertainties and risks that may be beyond the capacity of a single organization to consider in isolation. It requires capital, resources, specialized knowledge in many fields, information over the target market, willingness to take risk, the resilience to handle risk, and a degree of leverage with various actors (the public sector, private sector as well as the private citizens). The many requirements clearly indicate that cooperation is essential to assemble expertise. Collaboration spread the risk of innovation, and critically brings diverse intellectual and expertise to the problem(s) (Dale, 2007). Entrepreneurial initiative is required for collaboration and generally the party one with the largest stake takes action.

Network and framework failures: Key deficiencies of companies and failures in systems can be responsible for the failure of the innovation process. Various authors (Carlsson and Jacobsson (1997), Smith (1997), Edquist et al. (1998), Woolthuis (2005)) have proposed frameworks for analyzing or addressing failures in innovation systems. Network failures refer to problems in the interaction among actors in the innovation system such as inadequate amounts and quality of links, 'transition failures' and 'lock-in' failures as well as problems in industry structure such as too intense competition or monopoly, while framework failures include gaps and shortcomings of regulatory frameworks, intellectual property rights, health and safety rules etc., as well as other background conditions, such as the consumer demand, culture and social values.

The no-go decision for the multi-functional quay concept can be attributed to a network failure, since the parties did not come together to find a viable solution, after the business case proved nonviable (Rebel, 2009). Likewise, mandatory custom check acts a barrier to the concept of floating transshipment hub and floating crane (which would allow the containers to by-pass sea terminals (and the customs), with many benefits for all parties. This represents framework failure.

A recent study carried out by Erasmus University in assignment from Port of Rotterdam and Port of Amsterdam, to evaluate the innovation performance port related industry in the two ports revealed that port innovation is directed two thirds at efficiency and only one third at products and processes (evolutionary innovation). Even though 'planned' innovation is mentioned in the strategy of a company, the concrete translation into policy, personal, organization structure and services mostly lags behind (INSCOPE, 2009). The following bottlenecks were listed by the people questioned:

- Changeability of rules and regulations: 38%
- Budgetary issues: 32%
- Lack of competences, friction between partners and resistance from the workers: 20%.

6. Role of different players

A number port related organizations have been set up with various objectives: direct involvement in the design, development and maintenance of ports, waterways and coastal areas (PIANC, USCAE, AAPA)⁷, or to foster cooperation among ports and by providing a forum to exchange opinions and share experiences on the latest trends of port management and operations (IAPH)⁸, or to influence public policy in order to achieve a safe, efficient and environmentally sustainable European port sector (ESPO)⁹. These organizations can play a large role in facilitating and stimulating innovations.

The government too, has a key role to play. It has the authority to adapt or change regulations where they interfere with innovative endeavors. It can make available financial support in the beginning of a project in the

⁷ The World Association for Waterborne Transport Infrastructure; The International Association of Ports and Harbours; European Sea Ports Organization

⁸ American Association of Port Authorities

⁹ U.S. Army Corps of Engineers

form of state aid, through fiscal measures or funding for research infrastructure and programs or apply regulation to stimulate alternative financing methods. It can foster public-private sector collaboration and networking and clustering of firms to create the necessary critical mass and synergy. Knowledge flows are the glue of the innovation system (Cowan, 2000). The government also contribute by setting up data banks, performance indicators, and policy and guideline documents. Dale (2007) proposes mechanisms be considered to alleviate risks associated with the implementation of leading edge as well as proven state of the art technologies, such as 'guarantee' programs, subsidized insurance and reduced pay-back periods. Internalization of external effects into cost of production, to generated revenue to support innovation, could be a possibility.

Dekker (2003) suggests that a justification for the public contribution for port projects could be found in the indirect economic impacts, which are outside the scope of the commercial exploitation but within the social welfare scope of the government. The government may contribute a portion in the investment equivalent to the discounted indirect economic impacts over the project's lifetime. There is, however, considerable controversy among analysts how indirect economic impacts should be accounted for.

Aside from the government, only a few organizations are likely to have a sufficiently broad perspective, knowledge base, or the necessary leverage to bring about and manage change that accompanies innovative endeavors. Lately, many have proposed this role of innovation leader for Port Authorities, citing reasons for doing so.

- Chen (2010): A regional port has a symbiotic relationship with key government strategies and programs, regional finance, development organizations and local enterprises in the context of the transport infrastructure. These enable regional growth for mutual benefit and building on these interrelationships, innovation can develop.
- OECD (2010): Port Authority has wider responsibilities to other parties – e.g. for the sustainability of operations on which the port depends. Having a secure capital structure and relatively robust sources of revenues mean that it is better placed than many – probably most – other infrastructure owners and managers, particularly in the currently adverse economic times. With many small enterprises involved, the lead can't really come from the market. On this basis, the Port Authority should be taking more of a lead, given the authority to influence or set down how things should happen.
- Haugstetter (2010): Port authorities, located in inter-modal hubs, have many opportunities for collaborating and linking strategically across boundaries. Capturing and integrating the knowledge and learning from these collaborations and networks into their strategic knowledge system and creating opportunities for collective strategy is critical to Port Authorities' resilience and sustainable competitive advantage.

Thus Port Authorities have a stake with innovation – improving operations, gaining competitive advantage, and nowadays, achieving and maintaining a social 'license to operate'. And due to their unique position in the network at various levels, they are an ideal vehicle for leading innovation in collaboration with research institutes, consultancies, other ports, and industry.

Many of the risks are passed by a landlord port authority to its terminal operators (through use of innovative contract-forms). These operators who must increasingly stringent contractual demands (e.g. modal split requirements in case of Maasvlakte 2 project), also need innovative solutions. Thanks to the ongoing vertical consolidation in the industry, many of these are now multinational enterprises, which have the resources and leverage to contribute to innovative initiatives.

7. Conclusions

Innovation is the implementation of new ideas. It is being increasingly realized that nowadays, innovation is an interactive, complex process involving research institutes, customers, authorities, financial organizations and institutions. In this paper we attempt to gain insights into the processes tied to innovation through case studies from Port of Rotterdam. Once we can identify the factors influencing the process of innovation, we are in a better position to stimulate innovative efforts in the port sector. Investigating the barriers to innovation in the port sector is also essential – addressing some of these issues can help us bridge the gap between invention and implementation thereby promoting planned innovation in the port industry.

This research corroborates that innovation process is shaped by the interplay of need, economic, and institutional factors. It also establishes that the complex issues surrounding technological innovation require a unified contribution from many sources and disciplines. Port Authorities have a stake with innovation – improving operations, gaining competitive advantage, achieving and maintaining a 'license to operate', and finally achieving resilience against a changing environment. Due to their unique position in the network, they are an ideal vehicle for leading innovation. And while the leadership role can be assumed by a Port Authority, a larger role is set out for the terminal operators, who also bear considerable risk and face demands resulting from strict

environment regulations. Thanks to the ongoing vertical consolidation in the industry, many of these are now multinational enterprises, which have the resources and leverage to contribute to innovative initiatives.

Technological development and advancing knowledge make technically feasible tomorrow, what is today a fantasy. And as new issues appear in the arena, a shift of focus and priorities takes place so that things not socially acceptable today may very well be in the future (and vice versa). Once need escalates and reaches a threshold, and initiative is taken to commonly address issues, the promising ideas will find implementation. Thus innovative endeavours must continue, so that we have a plethora of solutions to fall back upon as new challenges appear.

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