Port Community System Implementation: Lessons Learned from an International Scan

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ABSTRACT

Port community systems (PCSs) can be defined as holistic, geographically bounded information hubs in global supply chains that primarily serve the interest of a heterogeneous collective of port related companies. These heterogeneous companies often include terminal operators, carriers (ocean, road, and rail), freight forwarders, enforcement agencies (i.e. customs), port authorities, and various lobby groups (including workers’ unions, environmentalists, and other policy makers). Port community systems that bring these diverse parties together in transaction recordkeeping and information sharing can serve to improve the flow of goods. Despite these potential benefits of port community systems it is challenging to find documentation on PCS implementation lessons learned. The process of designing and implementing a PCS can be roughly divided across four stages: project initiation, system analysis and design, implementation and adoption, and maintenance and growth. In this article, we document lessons learned within each life cycle stage as derived from an international scan of PCS deployments.
INTRODUCTION
As long as humankind has been using the water as a means of transportation, ports have served a critical purpose, permitting the transfer of goods and people from water to land. This unique role as a physical hub for freight flows has similarly given ports a unique and longstanding role in information flow. In fact, Phoenician documents, dating from 1110 B.C., record trade transactions within the Phoenician network of Mediterranean ports (1). In many ways this ancient network of ports coupled with a system of recordkeeping could be considered an early form of a port community system.

Port community systems (PCSs) can be defined as holistic, geographically bounded information hubs in global supply chains that primarily serve the interest of a heterogeneous collective of port related companies. These heterogeneous companies often include terminal operators, carriers (ocean, road, and rail), freight forwarders, enforcement agencies (i.e. customs), port authorities, and various lobby groups (including workers’ unions, environmentalists, and other policy makers). When such a diverse user community is considered, ports emerge as playing a pivotal role in facilitating effective supply chain operations.

Port community systems that bring these diverse parties together in transaction recordkeeping and information sharing can also serve to improve the flow of goods. Specifically, with the advent of modern information and communication technology the transaction data that once traveled with the cargo can now travel in advance of the cargo. This phenomenon coupled with the challenge of landside access at many of the world’s ports (2, 3) clearly motivates the desire (and need) to exploit the information flows for more than mere recordkeeping purposes. These information flows can simultaneously serve to enhance the physical flow of goods; thereby ameliorating the bottlenecks that so often occur at ports.

Despite these recognized potential benefits of port community systems it is challenging to find documentation on PCS implementation best practices or lessons learned. The most relevant literature originates from two sources. First, the inter-organizational information system (IOS) implementation literature provides insight on the technology deployment life cycle (see e.g. (4)). Second, many specific PCS implementations and intermodal technology deployments are well documented in a variety of government reports (see e.g. (5, 6, 7, 8)). This article seeks to fill the PCS lessons learned void by using the IOS deployment life-cycle framework to perform an international scan of PCS deployed in North America, Europe, and Asia. In this way we document specific lessons learned spanning the deployment life-cycle that may contribute to the success of a PCS.

This article opens with a more detailed description of inter-organizational information systems with an emphasis on seaports. Following this description, we present the methodology employed to select, study, and compare specific port community systems. In the fourth section, we describe our findings – centered on four stages of implementation. Finally, we conclude with a brief summary and discussion of future directions.

INTER-ORGANIZATIONAL INFORMATION SYSTEMS
In general, information technologies are applied to trade flows from two fundamentally different perspectives: exploitation and exploration (9). Exploitation in this sense refers to a class of actions undertaken to improve operational efficiency; whereas exploration refers to a class of actions undertaken to discover new possibilities. Presently, most PCSs focus on automating and integrating information flows from different parties with the goal of smoothing or improving the physical flow of goods. In this regard PCS design tends toward automating existing processes
(exploitation) with long-term or eventual goals of discovering improved port operation techniques (exploration). This common evolution from a non-existent or limited legacy system through deployment of an exploitive PCS and subsequently a PCS for explorative purposes can also be seen in the evolution of information system architectures; from bi-lateral construction through to a modular distributed plug and play structure. The selection of an appropriate architecture to match the evolutionary stage and goals of a PCS deployment is important to the success of the system – as such we begin this section with a subsection describing inter-organizational information system architectures. As system design is only a part of the full deployment process, the section as a whole concludes with a subsection on the information system deployment life-cycle.

**Inter-organizational Information System Architectures**

We define the transactional backbone as the technology layer enabling inter-organizational collaboration by connecting two or more organizationally disparate applications. The structure underlying the transactional backbone is known as an architecture. Classically, there are four distinct architectural types. Figure 1 provides an overview of these four architecture types.

<table>
<thead>
<tr>
<th>Architectural Type</th>
<th>Explanation</th>
</tr>
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</table>
| Bilateral (1:1)    | - Point-to-point (P2P) connectivity.  
                    - Direct connection between two trading partners.  
                    - Connectivity in its most basic form.  
                    - Works well for established partnerships.  |
| Private hub (1:N)  | - Hub structure that makes it possible to connect to many partners with minimal linkages.  
                    - Internal applications need only one connection point.  
                    - Standardized access for external partners.  
                    - Generally initiated by a strong party, to link with many smaller parties.  |
| Central orchestration hub (N:M or N:1:M) | - Like a private hub; but generally run by independent operator.  
                                            - Expected to work best in industries without dominant parties.  |
| Modular distributed plug & play architecture (N:M) | - No permanent linkages – plug & connect capabilities.  
                                                  - Parties connect when interaction needed, exchange information and conduct business.  
                                                  - Standardization is critical.  |

**FIGURE 1 Different types of inter organizational information system architectures (adapted from (10)).**

The first type of port information systems that appeared were of the bilateral type; enabling one-to-one connections. This type of integration is relatively cheap when basic communication channels (i.e. phone and fax) are used. Even in cases where Electronic Data Interchange (EDI) is used the integration is relatively easy as no intermediaries are needed, and the two parties can tailor the message format to their needs. When considering EDI, this architecture works well for establishing connections between large parties, with many
information exchange transactions. However, when considering multiple small parties using a phone or fax to access a port terminal this architecture suffers from problems of scalability. In order to connect all $n$ parties with each other, $(n(n-1))/2$ connections are required. This number of connections literally explodes: fully connecting 10 parties requires 45 point-to-point connections; fully connecting 20 parties requires 190 connections.

Hub architectures serve to solve this problem. Each party connects to the hub, and a connection with another party is established through the hub. In this way significantly fewer connections are required – to fulfill the connectivity requirements for 10 or 20 parties requires only 10 or 20 connections to the hub, respectively. In practice there are two different kinds of hubs: private hubs that are owned by one (generally large) party to connect to the outside world and independent central orchestration hubs that do not belong to any of the (traditional) parties in the network. The former type is classified as a one-to-many type whereas the central orchestration hubs are considered many-to-many.

Within hub architectures, the role of a coordinator is important. This role is often played by an information broker. Information brokers provide connectivity, translation services and re-usage of data (as in a central orchestration hub). Furthermore, increasingly information brokers provide more intelligent services on top of the messaging infrastructure, like workflow and operational planning services. While trends indicate a move towards non-brokered information exchange (i.e. modular distributed plug and play), information brokers are expected to play a key role in security related information systems as well. In such a context, the information broker can ensure that the appropriate information is disseminated to the appropriate authorities. The means by which this information is exchanged is another system design issue that must be decided in addition to selecting the architecture.

The last architectural type discussed here is referred to as the modular distributed plug & play architecture. Not yet a truly established category, but a collection of initiatives and developments that focus on realizing fast connect (and disconnect) capabilities within a supply chain. In this new paradigm, system integration should not be a matter of months of hard work, but the result of a few mouse-clicks. Web Services technologies include a technology named Universal Description, Discovery, and Integration (UDDI) encapsulating online discovery systems for seamless connection between two different parties – which do not yet “know” each other. Facilitating this work is research on semantic web technologies and mechanisms aimed at understanding the content and context of messages without human intervention. Although this research creates opportunities, these technologies are not yet commonly included in the daily operations of a port. While purely automatic modular plug & play will greatly ease integration, many hurdles are expected on the road to widespread adoption – especially in establishing the high-level of standardization that such technology requires.

Aside from the architecture underlying electronic communication, the language of communication is an important design decision. Despite many advances in data exchange technology and languages, many ports still favor Electronic Data Interchange (EDI) as a means of communication. This is largely due to the initial investment costs and history of deployment. For example, the ports of Bremen and Bremerhaven initiated a port information system, COMPASS, based on EDI in 1973 (11). Unfortunately, the cost of EDI has inadvertently excluded many small parties (i.e. independently owned trucks calling at the port) from participating in these information systems. New, cheaper, web-based exchange techniques (i.e. eXtensible Markup Language, Business Process Execution Language, Business Process Markup Language, etc) are slowly opening port information system participation to a greater diversity of
users (12,13). As noted above, ports are an interface – a location where many parties come together with the purpose of exchanging goods. As a result, the needs of the many varied parties must be carefully considered when planning an inter-organizational information system implementation.

**Inter-organizational Information System Deployment Life-Cycle**

The process of designing and implementing a PCS can be roughly divided across four stages: project initiation, systems analysis and design, implementation and adoption, and maintenance and growth (4). During the project initiation stage the key challenge is to clearly identify and communicate to all participants the need for an information system. Once the need has been identified the business setting and goals should be analyzed and an appropriate system designed – this includes design of the architecture and selection of the communication language, as described above. Following the design stage the process of implementing the technology, signing on users, and promoting adoption must begin. As with all technology deployments the system must be continually maintained and updated to reflect evolving business practices; practices that may be shifting from exploitation to exploration.

It is important to emphasize the tension that can occur between the level of the individual firm and the collective level of all system deployment participants. At the individual firm level, the participating organizations may differ with respect to expected benefits, available resources (expertise, financial budgets) and negotiating power. However, at the collective level, implementation success depends on long-term commitments of all parties participating in the PCS. A collective of organizations need to agree upon the use of common information technologies, procedures, and standards. As organizations differ with respect to commitment, resources, capabilities, and perceived benefits, the adoption and implementation of information systems may run into lingering negotiations, conflicts or even failures (14). Research shows that resource poverty is a serious problem for small and medium sized enterprises to participate in IOS (15).

Moreover, within a port environment companies do not benefit from participating in PCS to the same extent (termed benefit heterogeneity), which implies that commitments to the PCS adoption may differ from company to company. For example, imagine a small independently owned trucking company that communicates with a port terminal only a few times per day versus the port terminal that must communicate with multiple trucking companies multiple times per day. Thus, sponsors and a change agent are needed to promote the involvement of all parties. Sponsors are those organizations that initiate the establishment of an IOS. They can provide expertise and sometimes financial aid to other companies who benefit less from a PCS. Local port authorities often act as change agents and orchestrators of the PCS adoption and implementation processes.

Addressing the challenges posed by both benefit and resource heterogeneity while orchestrating each stage of the information system deployment life cycle can be a daunting task. In this article, we therefore seek to document lessons learned within each life cycle stage as derived from an international scan of PCS deployments. The next section describes the method employed in performing this scan.

**INTERNATIONAL SCAN METHODOLOGY**

In order to gain insight into implementation success factors in practice, we studied the deployment of information systems at multiple international ports. The port cases were selected based on the knowledge of experienced researchers from three continents – North America,
Europe, and Asia. Within each continent, the cases examined were further selected based on the availability of deployment documentation in the public domain and accessibility to deployment participants. In all, ten different information system deployments were identified and studied. The cases are briefly presented in Table 1.

**TABLE 1 Summary of Case Studies.**

<table>
<thead>
<tr>
<th>Nr</th>
<th>Name</th>
<th>Type of IS</th>
<th>Location</th>
<th>Key objectives</th>
<th>Founded</th>
<th>Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Port Infolink</td>
<td>Port Community System</td>
<td>Rotterdam, Netherlands, Europe</td>
<td>Port process coordination with extension to supply chain</td>
<td>2004-2007</td>
<td>~1200</td>
</tr>
<tr>
<td>2</td>
<td>Synchron8</td>
<td>Barge Synchronization System</td>
<td>Rotterdam, Netherlands, Europe</td>
<td>Planning and coordination of barges</td>
<td>2005</td>
<td>~70</td>
</tr>
<tr>
<td>3</td>
<td>Informore</td>
<td>Datahub</td>
<td>Netherlands, Europe</td>
<td>Supply chain coordination</td>
<td>2000</td>
<td>5-10</td>
</tr>
<tr>
<td>4</td>
<td>Secure Logistics</td>
<td>Cargo Card (smart card)</td>
<td>Netherlands, Europe</td>
<td>Authentication and authorization of truck drivers and terminal visitors</td>
<td>1998</td>
<td>~700</td>
</tr>
<tr>
<td>5</td>
<td>Dakosy</td>
<td>Port Community System</td>
<td>Hamburg, Germany, Europe</td>
<td>Port process coordination</td>
<td>1981</td>
<td>~1500</td>
</tr>
<tr>
<td>6</td>
<td>Seagha</td>
<td>Port Community System</td>
<td>Antwerp, Belgium, Europe</td>
<td>Port process coordination</td>
<td>1986</td>
<td>~800</td>
</tr>
<tr>
<td>7</td>
<td>Freight Information Real-Time System for Transport (FIRST)</td>
<td>Port Community System</td>
<td>Port of New York and New Jersey, USA</td>
<td>One-stop-shop’ for freight and port information, providing real-time information</td>
<td>2001-2002</td>
<td>&lt;1% of Registered Port Trucks</td>
</tr>
<tr>
<td>8</td>
<td>Freight Information Highway (FIH)</td>
<td>Supply Chain Orchestration</td>
<td>Federal Government Initiative, USA</td>
<td>Pilot of system to minimize the number of data-exchanges between the multiple transport providers in a containerized freight supply chain</td>
<td>2000-2003</td>
<td>20</td>
</tr>
<tr>
<td>9</td>
<td>Portnet Tradenet</td>
<td>Port Community System</td>
<td>Singapore, Asia</td>
<td>Port process coordination Paperless government applications</td>
<td>1984-1988</td>
<td>8000 2500</td>
</tr>
<tr>
<td>10</td>
<td>OnePort Tradelink</td>
<td>Port Community System</td>
<td>Hong Kong, China, Asia</td>
<td>Port process coordination Paperless government applications</td>
<td>2003-1988</td>
<td>800 53000</td>
</tr>
</tbody>
</table>

Once identified, all relevant literature for each case was reviewed. This review was done with a particular focus on the port environment context of the project initiation; the system analysis and design; the implementation and adoption process; and the maintenance and growth of the system. While most of this information was successfully garnered from publicly available documents, experts and deployment participants were interviewed to fill in missing information. To track this data collection process, a summary paper was written for each case and a comparative table was maintained for all cases. The comparative table allowed for quick
visualization of the similarities and differences of each system. (To view all summary papers and the full comparative table, the reader is referred to \("10\).) We identify key success factors in a number of stages that are formulated along the lines of the information system development lifecycle. The success of the deployment appears to be correlated to specific practices undertaken within each of these stages. The next section describes these stages in the context of ports and highlights the associated success factors as lessons learned utilizing the ten port cases as illustrative examples.

**FINDINGS**

The success or failure of an information system is not a function of any one feature or flaw, but rather the interaction of many features and flaws. In studying the ten different information system deployments four distinct deployment stages, as noted above, emerged as common across all deployments. From the studies we could further identify specific tactics or strategies, features or flaws that most likely induced the success or failure of the deployment in that stage. We now proceed stage by stage formulating lessons learned as illustrated by features of successful deployments and contrasted with flaws in less successful deployments.

**Stage 1: Project Initiation**

The collective goal of an inter-organizational information system is to intelligently process and re-distribute information to organizations that participate in the inter-organizational information network. The network participants cannot achieve this collective goal individually. The success of an inter-organizational information system depends on the willingness to financially contribute to the set up and maintenance as well as the willingness to exchange company information with other partners in the supply chains traversing the port. In this regard, the deployment of an inter-organizational information system may be viewed as a collective action. As such the new system must have the widespread support of all parties. In the project initiation stage, stakeholders need to be identified and involved in formulating the underlying problems while setting the project objectives and scope. Also in the initiation phase all parties must understand the costs they and others (including government agencies) will bear. Within this stage we present lessons learned pertaining to both problem formulation and sponsorship.

*Lesson Learned: Problem Formulation*

One method to garner support is to clearly specify the problem(s) that the system will address and fairly assess the urgency of the problem(s). While this may seem like an obvious approach, some care must be taken in identifying the problem. A port information system will most likely solve more than one problem and those problems will most likely be viewed as more or less urgent depending on the participant. Thus selecting an appropriately salient problem to address may be the first key to a successful deployment.

In the port of Rotterdam there was general discontent with the state of the existing port information systems by the end of the nineties. There was a shared understanding that a new system was urgently needed. Port Infolink, a private company wholly owned by the Port of Rotterdam, was set up to develop the new PCS. It began by identifying the most critical problem hampering the efficient flow of goods through the port – the import processes and it was able to leverage the existing dissatisfaction of the Harbor Master and Customs in order to promote a paperless import process. As the two main parties agreed on the problem and saw it as urgent, the first services of the new PCS were developed and implemented successfully.
On the other hand, identifying a problem that is not salient to the systems users can be a serious detriment to gaining critical mass in terms of users. For example, the Freight Information Real-time System for Transport’s (FIRST’s) primary source of funding was the United States Department of Transportation Congestion Mitigation and Air Quality (CMAQ) Improvement Program (5). As a result, the system, designed to serve as a ‘one-stop-shop’ for information related to the Port of New York and New Jersey, was marketed to users as a means to improve air quality and mitigate congestion. Unfortunately, these are very intangible issues and as such the participants never realized an urgent need for the system.

Lesson learned: Sponsorship

Unfortunately, port information systems do not come free. They require significant investment of both time and money. The ability and desire to make these investments can vary significantly across all stakeholders in the port. The ability to invest in a port information system is largely related to the resources that the firm has. It is well documented that resource (time, money, and expertise) poverty is a serious problem for small and medium sized enterprises to adopt and implement information systems (15). Given the resource heterogeneity of port stakeholders careful consideration should be given to the investment required by all parties with possible compensation to small enterprises from larger enterprises or port authorities.

The desire to invest in a port information system stems largely from the benefits that each player expects to realize from full implementation. Often it is larger companies with significant resources that initiate or sponsor information system implementation. As such, a gap can develop between the sponsors (i.e. large enterprises) and the adopters (i.e. smaller enterprises). For the most part sponsors have a history of investing in technology and tend to be more cognizant of the initial cost and the length of the pay-back horizon. Adopters or smaller enterprises, on the other hand, tend to expect immediate results (6). Furthermore, the benefits of using a messaging system often accrue with the number of messages sent. As such, larger firms will often benefit more than smaller firms. Hence, small firms tend to be more skeptical of the benefits that a port information system can bring and thus lack the desire to invest (even if the resources are available).

At a general, abstract level the benefits of port IOS’ are clear to all parties. However at the concrete firm-level these benefits are not always so self-evident. Most benefits are indirect and can only be realized in the long term. The most important pre-condition for the long term realization of benefits is achieving critical mass of participants. The more parties are involved, the more and accurate information can be processed, the higher the rate of re-use of information, the more and the higher quality information services can be provided to the participants. In order realize these network effects most initiators and sponsors of inter-organizational information systems were aggressively trying to get as many companies as possible involved.

Given the heterogeneity of both resources and benefits of a port information system, funding or sponsorship activities must be very carefully planned to ensure that all participants are playing on an even field. One technique that emerged as common in the case studies was government sponsorship. The provision of external funds and motivation served to level the playing field in many cases. It should, however, be noted that not all government sponsored port information systems were equally successful. From the studies it appears that the key to successful government sponsorship lies in the nature and duration of the funding and the commitment of parties involved.

For example, in the case of Port Infolink in the Port of Rotterdam, the port authorities decided to bear the initial investments in the Port Community System services, which were most important to preserve the competitive position of the port. Furthermore, users were not charged
for the operational costs in the start-up phase. Customs was involved as one of the lead users. More recently, a charging structure has been introduced – to cover the operational costs of the PCS and the extension with new services, whose benefits can be more directly allocated to specific port actors.

In contrast, some systems are funded by the government only in their initial phase. For example, the Freight Information Highway was funded by the United States Department of Transportation as a pilot recommended by a public-private partnership, the Intermodal Freight Technology Working Group (7). The funding was designated for the purpose of administering an information system pilot for a full transport chain including a major ocean carrier, port terminal, rail facility, and trucking company. The idea was that the government funded pilot would demonstrate a favorable cost-benefit ratio and thereby serve as a catalyst for adoption and investment by users. The pilot served to demonstrate that the technology worked. Unfortunately, due to poor levels of system use a realistic cost-benefit ratio could not be measured in a way that was convincing to system users. As such, without the investment of users, the system did not continue past the end of government funding.

Finally, not all support from external sponsors must come in the form of financial support. In some instances the government’s primary purpose is to instate legislation that favors electronic submission of documents. For example, the OnePORT and Tradelink services in Hong Kong were primarily developed and funded by private shareholders. The use of the systems gained a large boost, however, from a series of legislation passed by the Hong Kong government. The legislation set cut off dates for the exchange of paper trade documents. To ensure a fair trading environment with these regulations the Hong Kong government has spurred competition in the electronic documentation service by ending Tradelink’s exclusive service license in 2004 and extending a license to Global e-Trading Services Ltd.

**Stage 2: System analysis and design**

In the system analysis and design stage, system requirements based on the business context are transformed into an information system model. This model serves as the basis for design of the information system architecture and selection of the communication language and format. The primary lesson learned within this stage of the deployment life cycle pertains to the design of the system architecture. Specifically, the system architecture should mirror the organizational context. A system that reflects the current operational environment will be seen less as a radical change and more as an automating or facilitating technology.

Many ports have been using some form of communication technology (i.e. phone, fax, EDI) for many years. This communication has primarily grown organically as port stakeholders have implemented specific point-to-point systems. For example, a port might have a well established system for transferring trade data from the ocean carrier to the port terminal and another system between the terminal and customs. These systems, referred to as Type I Port Community Systems, are almost exclusively for the purpose of simple messaging with no intelligent support layer. The next generation of port systems, termed Type II Port Community Systems, is envisioned as central hub systems with intelligent decision support functionality (10). Type II PCS provide more possibilities for data-integration and agility in offering new services and communication channels. Older IT architectures (Type I PCS) have a more complex structure, which leads to higher maintenance costs and experience difficulties in extending and expanding with new services and communication channels. As such the transition from Type I to Type II does not occur easily or rapidly, especially given the conservative attitude towards change in the maritime logistics community.
Parties that are used to directly exchanging information with their business partners may feel that going through a central hub is unnecessary – especially if doing so requires a change in technology. Furthermore, the success of a central hub type system is highly dependent on all parties contributing and using the trade data. This requires a significant level of trust in both intent and competence (16). Trust in intent being a trust that the other organizations will not abuse the information that will be exchanged and trust in competence being a trust in the other organizations’ ability to keep their promise to participate. In reviewing the case studies it became clear that the system design itself – the form of the transaction architecture – can serve to mitigate many of these issues of trust.

For example, Initi8, a software developer and consultancy based in Rotterdam, The Netherlands, was tasked with tackling the problem of planning and coordinating the barges at the Port of Rotterdam. The problem was salient and urgent to all parties – barges picking up containers at the port often suffered delays, long waiting times, unreliable plans and frustration on the part of both the barges and the terminals. From a technological standpoint, a central hub solution would work perfectly to coordinate all parties. Such a solution would, however, depend on significant levels of trust; the time required to garner this trust would invariably kill the project. Rather than force a change that was not ready to occur, Initi8 studied the current method of operations and recommended an agent system architecture. In such an architecture, each terminal and each barge operator are represented by a virtual agent. The virtual agent can cull information from the barge or terminal databases, but does not directly share this data with any other agent. Instead all agents meet in a type of virtual market place where the barge agents negotiate with the terminal agents for appointments. In this way, the system design mirrors current point-to-point communication and negotiation practices, but improves the speed at which they occur. While this solution may not generate an optimal solution, it generates a feasible solution which in itself is a significant improvement.

Similarly, if the port environment and culture is already premised on a system of central control, then a central hub architecture may be preferable. For example, in Singapore, where both businesses and public officials have a long history of working towards the vision of an “Intelligent Island”, the TradeNet and PortNet systems have met great implementation success (11). PortNet began in 1984 and moved to an internet environment in 1999. The system serves as a central orchestration hub for myriad of port related services including online ordering of services (berth application, stevedoring, yard crane booking, etc), fulfillment facilitation (pre-gate services for trucking, stowage planning, etc), tracking and tracing, documentation management, data repository, and financial services. TradeNet has a similar history as it began in 1986 and became fully operational in 1989. The focus of trade net is to serve as a platform for trade related communication with the Singaporean government. In short, the size and culture of Singapore have served to foster the successful implementation of a centralized system design (17).

Just as the system design can help foster trust and yield success, it can also hinder deployment. If the system architecture is too much of a radical departure from current operations the system sponsors will have a hard time overcoming issues of trust and resistance to change. For example, Vos Logistics a third party logistics service provider sought to implement an information system to improve the transport of maritime containers between a hinterland terminal in the north of The Netherlands and the Port of Rotterdam (18). The idea behind the system was to provide all parties involved with accurate and timely status and location information in an effort to improve efficiency. The system Vos envisioned was a centralized hub architecture in which all players in the container transport chain would participate. As many of the companies participating
in the transport chain were used to communicating directly with their business partners they did not immediately see the need to start communicating via a central hub. This compounded with the fact that many participants had little or no computer experience led to the demise of the system deployment.

**Stage 3: Implementation and Adoption**

Until implementation begins, the development of an information system largely remains a mental exercise of speculating about the benefits and costs, advantages and disadvantages of such a system. Information system implementation is the stage during which an organization alters its business practices and applications in order to interface with the information system. In a network of organizations, the decision made by each individual organization to start actively using the information system constitutes the adoption process. The primary lesson learned from this stage of deployment is that a modular implementation strategy will likely yield a successful “start small and add” deployment.

As port information systems are often large and designed to connect a network of partners, this stage is likely to see some turbulence between the individual enterprise and the network. A lack of resources at the enterprise level might lead to the withdrawal of an organization from the implementation; this in turn may have direct negative impacts on the benefits of all the other network participants. Thus, the system implementation must be properly phased to ensure the continued interest and support of all parties.

One method to achieve this is via a modular implementation strategy in which each module has clear objectives and quickly realized tangible benefits for all parties involved. This is the approach adopted by many of the longer standing port community systems in practice, including the Dakosy system in Hamburg, Germany (initiated in 1979), the Portnet and Tradenet systems in Singapore (initiated in 1984 and 1986, respectively), and the Seagha system in Antwerp, Belgium (initiated in 1986). Furthermore, newer systems such as the Port Infolink system at the Port of Rotterdam, The Netherlands, have also seen success in using a modular implementation approach. On the other hand, systems that try to accomplish too much in the first phases of implementation may face significant hardship as evidenced in the Vos Logistics and FIRST cases.

**Stage 4: Maintenance and Growth**

Deployment of a port information system is not a one time event it is a continuous process. In order to synchronize system specifications with customer requirements, continuous change is necessary to maintain high system usage levels. The agility to evolve is the basis of the lessons learned from this stage of development. The ability of the information system to evolve in order to seize emerging opportunities enables the system’s continued success.

Due to continuous change both inside and outside all organizations and within the port community, performance gaps between the participants and the technology will arise. Furthermore the factors that initially influenced adoption and implementation are expected to shift. In this respect port community systems tend to follow the documented stages of IT redesign from automation of existing procedures to a redesign of procedures (19). In the context of the port, this is a shift from electronically exchanging previously paper documents to intelligently combining or redistributing data from the documents, orchestrating central workflow, providing active alerts, and data mining. Therefore, in order for a system to remain beneficial to the community that deployed it, the system must continue to evolve with the needs of all parties.
The initial scope of the Secure Logistics’ cargo card in 1998 was using pre-announcements of truck arrivals at the container terminal and driver identification to make administrative procedures at the terminal more efficient and secure. The company Secure Logistics has been established in 2003 with the objective to safeguard the knowledge and experiences from the cargo card implementation for the long term. The introduction of the International ship and Port Safety (ISPS) code and some technical enhancements accelerated the adoption of the cargo card. In the initial phase, the card was used for internal optimization of terminal processes, but after the introduction of the ISPS code, the card supported the implementation thereof. In the future, the range of applications of the card could be extended to other ports, and other link in the transport chain.

Port Infolink has developed a number of service packages that constitute the PCS. Each of these modules has been developed in a project with continuous customer involvement. The services are based on a platform providing common facilities and data stored in a central database. New customer requirements can be met by defining new service packages or new versions of existing service packages.

**SUMMARY AND FUTURE DIRECTIONS**

In studying PCS deployments worldwide it is clear that the trials and tribulations of PCS deployment are not unique to any one geographic area. In many cases the success or failure of the system deployments reviewed was due to specific issues encountered in distinct stages of system development. From these cases, spanning three continents, we can learn many lessons about successful development practices. These lessons learned and the relevant PCS examples are summarized in Table 2.

**TABLE 2  Summary of Lessons Learned.**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Lessons Learned</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Project Initiation</td>
<td>Support is most easily gained when the problem(s) and goal(s) are clear and urgent for all parties.</td>
<td>Port Infolink; FIRST</td>
</tr>
<tr>
<td></td>
<td>Sponsorship should be carefully considered in terms of both type (i.e. financial or legislative) and timing.</td>
<td>Port Infolink; FIH; OnePort/TradeLink</td>
</tr>
<tr>
<td>2 System Analysis and Design</td>
<td>The system architecture should mirror the organizational context.</td>
<td>Synchron8; Portnet/Tradenet; Infomore</td>
</tr>
<tr>
<td>3 Implementation and Adoption</td>
<td>A modular implementation strategy will likely yield a successful “start small and add” deployment.</td>
<td>Dakosy; Seagha; Infomore</td>
</tr>
<tr>
<td>4 Maintenance and Growth</td>
<td>The ability of the information system to evolve in order to seize emerging opportunities will enable its continued success.</td>
<td>Secure Logistics; Port Infolink</td>
</tr>
</tbody>
</table>

Early in the project a specific, salient, and tangible problem should be identified and recognized as urgent by all parties. Once the problem is clear and the port stakeholders agree to work towards a technological solution, the system architecture must be carefully designed to match the technological capabilities of the participants and mirror the existing port environment and culture. Gaining sponsorship is key to funding the project, but can also work to the detriment of the project if the nature or timing of the funding does not match the business environment. Furthermore, sponsorship need not always be financial, but can also be regulatory. To ensure that the implementation is successful, it must be properly phased – small modular components should be rapidly deployable with benefits immediately realized by all parties. Finally, the port
information system must be able to grow and be sufficiently agile to evolve with the needs of the port stakeholders.

These lessons learned were extracted from a review of publicized PCS experiences worldwide. Thus, while the lessons identified are consistent with the information systems deployment literature, verification of our findings in a broader spectrum of port environments should be undertaken. Specifically, our proposition that the system architecture should reflect the port environment and culture warrants further investigation via a standardized broad-based survey of many ports.

The cases examined also highlight the role that ports serve in global supply chains. While the port itself may be geographically bounded, a PCS does not need to be similarly bounded. Port community systems can pass information up and down the supply chain and around the world. Extending the coverage of port information systems provides the opportunity for chain-wide (visibility) services and overall workflow orchestration.

To capitalize on a port’s unique role in supply chain goods and information flows, several challenges must be addressed. First, many PCS were deployed to establish a competitive edge. If all systems are linked via the supply chain what might the impact on competitive advantage be? For example ports currently in competition with each other (i.e. Hamburg, Germany and Rotterdam, The Netherlands) may be less willing to implement a conjoined PCS than ports in more disparate locations (i.e. Rotterdam, The Netherlands and Singapore). Understanding the dynamics of port competition is essential to understanding the potential PCSs have in rationalizing global supply chains. Second, the role of standardization should not be overlooked or taken lightly in developing extended PCSs. This will require adapting the services and message exchange protocols currently used in local procedures with local authorities to regional or even global standards. Just as the ancient Phoenicians developed the alphabet as a means to standardize recordkeeping in their network of Mediterranean ports, globally standardized port community systems may be the key to coping with trade volume increases and facilitating the globalization of supply chains.

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