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Digitizing the maritime eco-system - Improving door-to-door coordination via a digitized transport chain

by

Mikael Lind,[1, 3] Richard T. Watson,[1, 2] Michael Bergmann,[1]
Robert Ward,[1] Niels Bjørn-Andersen,[1] Thomas Jensen,[1]
Sandra Haraldson,[1] Almir Zerem,[1] Michael Rosemann[1, 4]

[1]RISE Viktoria, Sweden, [2]University of Georgia, USA,
[3]Chalmers University of Technology, Sweden, [4]Queensland University of Technology, Australia

A sense of urgency

The maritime transport industry faces strong competitive pressure from other modes of transport with many of them benefitting from entire new infrastructure (for example, China's Belt and Road; autonomous transport systems, and new airports such as in Berlin, Beijing, Mexico City, and Sydney). In order to remain an attractive and contemporary transport option in an increasingly digital economy, the maritime eco-system has to create a new digital infrastructure facilitating the provision of reliable, predictable data on the status of its goods in transit.

Addressing this challenge requires bi-lateral data exchanges between all parties making up the maritime eco-system including hinterland and maritime operators. Ports are the essential connection point in a maritime data supply chain, both as the essential data hub with interfaces to nearly all partners as well as multi-lateral data exchanges within the ports themselves. A port's capability to enhance the predictability of its operations will come only from enhanced data sharing within the port, and between the port and its environment (such as with other ports, ships, and hinterland operators).

To facilitate this data sharing, compatibility between the port call message format (PCMF) and the GS1 and ISO EPCIS and associated CBV standards (ISO/IEC 19987 and 19998) for

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services related to both port call operations and logistics has been initiated[1], building upon combinations of data streams associated with port call operations and goods movements.

About 20 million port visits are conducted every year. Figures for a typical medium-size port indicate that about 20% of all ships have to wait 18 hours prior to entering a port.[2] Summed up, this equals 100s of ship-years of wasted resources (idle capacity) annually as waiting ships cannot commence their next voyage. It also results in a significant additional expense in fuel costs, because the ships might have sailed faster than necessary, or lost cargo carrying time due to the delays in unloading.

Most of the active ports in the world operate on a *first come first served* principle. Thus, to be served first is of course the main concern for a shipping company. However, this goal causes ships to compete for the same infrastructure leading to isolated (ship-specific) optimizations as opposed to an optimization of the entire eco-system's infrastructure. Some of the world's major ports, as well as some of the most used canals and inland waterways, have therefore adopted more sophisticated variants of slot management (for example, the Port of Hamburg[3] and the Panama Canal[4]), which require advanced data exchanges. In the pursuit of sound economic and sustainability goals, it may be worth considering scaling up this approach for the world's top several hundred ports and the interactions between them.

This concept note outlines how an advanced digital maritime supply chain grounded in standardized data exchange can help overcome some of the challenges outlined above. This note focuses on freight transport, but cruise calls[5] and other port call operations related to passengers will also benefit from the concepts explained here.

Port Collaborative Decision Making (PortCDM)

In a competitive global world, business organizations must continually strive to improve their capital productivity and that of their suppliers and customers/clients so that their ecosystem thrives. They must continually seek new means to raise the efficiency of

[1] Lind M., Bergmann M., Watson R.T., Haraldson S., Park J., Gimenez J., Andersen T., Voorspuij J. (2018) Towards Unified Port Communications – from a project format to a global standard, Concept note #9, STM Validation Project
[2] Watson R.T., Holm H., Lind M. (2015) Green steaming: A methodology for estimating carbon emissions avoided, International Conference on Information Systems (ICIS), Fort Worth
[3] https://www.ship-technology.com/news/hhla-launches-new-slot-booking-system-port-hamburg/
[4] https://bookingwp.panama-canal.com
[5] Lind M., Andersen T., Bergmann M., Watson R.T., Haraldson S., Rygh T., Karlsson M., Kinn M. (2018) Coordinated Value Creation in Cruise Call Operations, - the case of Port of Stavanger, Concept note #10, STM Validation Project

resource utilization in their internal operations and those with whom they episodically or regularly interact. Digitization and standardized data sharing to advance interoperability in the maritime industry can generate individual and eco-system gains and should be pursued with vigour and alacrity to maintain the prominence of sea transport in the global economy.

Higher predictability in port operations, as advocated by Port Collaborative Decision Making (PortCDM), provides substantial benefits for the actors involved in the maritime eco-system, particularly shipping companies and port operators, as well as the hinterland operators concerned with optimizing their operations and the utilization of the infrastructure.

Put simply, PortCDM enables actors to share intentions and outcomes as the building blocks for a common situational awareness for actors' alignment of plans and notification of up- and down-stream activities as well as possible disruptions.

PortCDM, as an enabler brought forward within the Sea Traffic Management (STM) concept, has used the aviation sector (AirportCDM) as its source of inspiration. Additionally, informed by PortCDM, StationCDM is now being introduced to the railway sector.

Digitization is the glue for integrating maritime operations

The transport of goods from producer to consumer requires the integration of the logistic and information supply chains across multiple service providers and transport modes. Ideally, this should be an integrated, efficient, and predictable door-to-door process. To achieve these goals, all actors in the full supply chain need to synchronize their activities through timely and appropriate standardized communication. Unfortunately, this is not the case today, where a huge proportion of communication is still based on non-integrated digital systems (for example, e-mails) and even non-digitized communication (such as phone, SMS). These diverse and incompatible communication capabilities among the transport providers severely limit efficiency and predictability.

Maritime transport, as with many other types of transport, is a highly distributed eco-system with many independent and competing operators. In some cases, up to 40 different and economically independent actors might be in one supply chain in the transport

network[6]. As a result, the level of coordination often disappoints customers and causes negative effects, such as delays, especially when compared to other options such as air transport. The reliability of container vessels arriving within +/- one day of the original estimate is below 70%,[7] and too commonly multiple days of delay are experienced. One of the main reasons for the delays (other than weather conditions) is missing or error prone information, such as that contained in the packing list attached to the certificate of origin. It is also notable that transport service providers are generally more concerned about the location and timings of the vessel or its containers than about the individual contents being freighted and as specified in the packing list. Significantly improving standardized digital data exchange is an opportunity to create a higher level of coordination while at the same time preserving the necessary independence of the various actors. As in other transport and delivery chains, digitization and standardization are key to ensuring tighter, timely, and more efficient operations. This will lead to an improved predictability in the maritime supply chain and this reduced variation will have the potential to unlock entire new levels of efficiency (similar to what could be witness with just-in-time or Six Sigma approached in other industries).

Enhanced connectivity, using an agreed digital data infrastructure and standardized data dictionary, for sea transport can enhance operational services, facilitate the creation of entire new (data-intensive) maritime services (e.g., third-party recommender services) and ultimately raise capital productivity. Two significant benefits that can be achieved through enhanced connectivity and appropriate data exchange are:

- increased situational awareness for all the actors thereby enabling improved and accelerated decision-making at sea and in port;
- customers can seamlessly track and trace goods in the sea transport chain.

These two benefits in turn offer substantial savings in operating costs and improved customer satisfaction. They also enhance the possibility of green steaming for just-in-time arrivals and optimized port call operations as well as enhanced coordination in relation to the other means of forwarding and onward transport.

[6] Jensen, T., Vatrapu, R., & Bjoern-Andersen, N. (2017). Avocados Crossing Borders: The Problem of Runaway Objects and the Solution of a Shipping Information Pipeline for Improving International Trade. *Information systems journal*.

[7] The industry average reliability for vessel arrival on-time which is within +/- 1 day compared to estimated time of arrival promised two weeks prior was 67.8% for January 2015 and 69.2% for January 2017. Global top 18 liner carriers are ranked on reliability e.g., by SeaIntelligence www.seaintel.com 20170321

Fundamentals of integrated transport

Different means of land and sea transport are used across different regions. The transportation process starts with the needs of the goods' owner, who might use multiple shippers and modes to move their goods. A principle sketch of the fundamental assignment structures and the logistical flow are visualized in Figure 1 below. In such a scenario, different transportation sub-processes need to be coordinated to enable actors to synchronize their actions and to manage any disruptions.

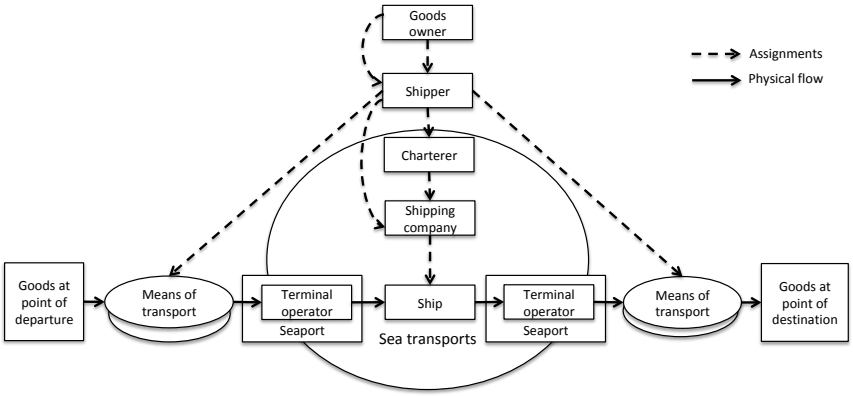

Figure 1: Sea transports in the context of the door-to-door process

As of today, there are two major means of coordination: analysis of historical patterns to determine typical resource needs to satisfy joint needs, and the real-time sharing of intentions among stakeholders acting in co-opetition[8] to handle specific tightly coupled episodes. The latter enhances the planning capabilities of all the actors involved, and thereby creates better utilization of resources for a particular series of interactions through higher predictability of events.

Maritime transportation also typically involves multiple actors, such as agents, terminal operators and other port services, as well as ships, all providing different types of infrastructure for their immediate collaboration partners. However, these interactions are typically not standardized and only electronically integrated to a limited degree. To enable higher predictability of when and where events will occur requires awareness in the transport chain of the intentions of the different actors and their current status. This includes knowing the client's needs for co-utilizing infrastructure. Digitization of all key assets across the common infrastructure creates the foundation for higher predictability.

In an ecosystem of autonomous actors serving the needs of different clients, digital access to relevant information allows individual actors to be more efficient, particularly if they are able to access the intentions and the progress of the other actors in real-time. This can also enable analysing and querying existing patterns of activity to avoid perpetuating

[8] Brandenburger A. M., Nalebuff B.J. (2015) Co-Opetition: A Revolution Mindset that Combines Competition and Cooperation, 9th edition, Crown Business

inherently inefficient processes and habits. Digitization provides a contemporary opportunity to re-think, re-configure, and optimize current business processes. This includes inter-organizational re-engineering by moving operations and decision-making between actors. However, some actors are competing and may be reluctant to share information, especially detailed information. Accordingly to facilitate an acceptable level of information sharing a balance will have to be found between sharing a sufficient amount of decision-relevant information such as status information for the transport unit to facilitate the flow in the supply chain without the need to share detailed information such as packing list at the source[9].

Sea Traffic Management (STM) – enabling sustainable sea transport by enhanced inter-operability

Within the context of the total supply chain process from producer to customer, the STM concept was introduced to provide the various actors with enhanced coordination capabilities. To ensure alignment with multi-modal transportation systems, the scope of STM is berth-to-berth, which combines both a ship and a port centric view of a sea voyage.[10] A digital interoperable infrastructure must support this range of attention. Some of the core principles for establishing enhanced and trusted interoperability are:

- *Share data*
- *Align data streams*
- *Allow for distribution of all necessary information*
- *Enable discovery of information and application services*
- *Ensure credible authentication and data protection*
- *Utilize and/or develop internationally agreed upon standards for message formats, interfaces, authorization principles, methods for deriving situational awareness.*

STM builds upon hub-to-hub communication.[11] The guiding principle is that the data owner determines and provides access to the data recipient. From a holistic point of view, there are three core actors that should be considered; the ship with its different functions, the port with its entities, and the shore centre with its information provision services. These actors can and should be seen as information hubs, and STM builds upon different

[9] Jensen, T., & Bjoern-Andersen, N. (2018). Cloud Solutions for the Shipping Ecosystem pose new opportunities. In G. Fitzgerald & J. Malaurent (Eds.), *Information systems, development approaches and qualitative research: a tribute to David Avison.* Paris, France: ESSEC Publishing.
[10] Lind M., Karlsson F., Watson R.T., Bergmann M., Hägg M. (2018) Empowering the chain of operations in berth-to-berth sea transports by digitization, concept note #8, STM Validation project
[11] Lind et al (2014) Sea Traffic Management in MONALISA 2.0, Preliminary findings #2, MONALISA 2.0

physical and organizational components in order to achieve coordination through exchanging data. A continuous flow of data between different entities, within and between hubs, involved in berth-to-berth sea transport becomes an important means for the actors further along the value chain to become informed of progress.

A port is composed of many actors who need to cooperate closely to serve external clients efficiently. Some of the data captured within an information hub can be released, with appropriate authorization, to external parties enabling them to coordinate their operations and also to provide advice. This has the potential to create an entire new entrepreneurial eco-system ('MariTech') which will consist of start-ups attracted to the opportunity of developing attractive applications capitalising on the availability of rich maritime data.

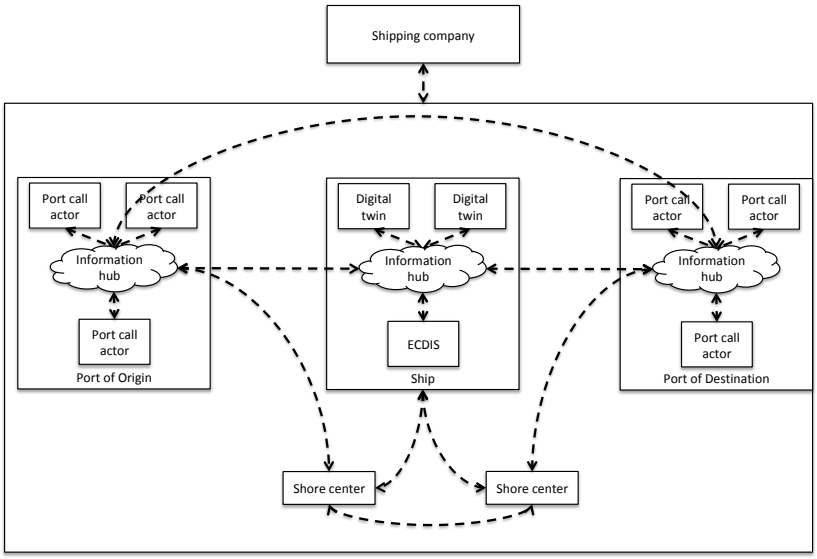

Figure 2: Data exchange within and between information hubs involved in sea transport

Data exchanged within and between hubs, such as shore centres, ports and ships, can be expected to enable involved parties to make better-informed decisions. This will mean that decisions are made less on conjecture (guesstimate) and increasingly grounded in data (evidence). Such a move will enable the use of Artificial Intelligence and Machine Learning as a way to further automate and improve the quality of decisions. In Figure 2 above, the data flow between core parties identified within STM is depicted.

Hubs as connection points for coordination

In order for the maritime sector to work in the larger transportation chain, there needs to be agreement on what is expected from each port's operations. This is especially important for ports moving towards becoming both a trans-shipment and an information hub, such as is occurring in Singapore, Rotterdam, and Limassol.[12]

[12] Lind M., Bergmann M., Haraldson S., Watson R.T., Michaelides M., Herodotou H., Voskarides S. (2018) Port-2-port Communication Enabling Short Sea Shipping: Cyprus and the East Mediterranean, concept note #5, STM Validation Project

The need for a high degree of predictability in all operations is a very important driver for a high degree of efficiency. Two examples are:

- Hinterland operators should not have to wait for all containers from a visiting ship to be unloaded and receive customs clearance before loading them onto a new means of transport.
- Ships should be able to obtain a berth predictably upon arrival thereby allowing for more cost-efficient fuel use during a voyage and to avoid unnecessary fuel consumption at anchor by arriving too soon.

In order for upstream and downstream actors to work efficiently, they need to be fully and promptly informed of upstream disruptions and downstream capabilities.

Obviously, it is important to get information as soon as possible about any disruptions causing delays in the planned port related events. Once this information is received, there is an urgent need to combine different data sources from the actors, such as:

- Downstream ports being informed by upstream ports of the progress of operations related to the port calls that involve them
- Downstream ports being informed when a ship will arrive
- Hinterland operators informing ports of their intentions and capabilities
- Shore centres informing affected parties of possible disruptions in planned arrival or departure times.
- Ships trust a port authority's recommendations
- Upstream ports being aware of the capabilities of downstream ports
- Ships informing shore centres of their intentions and progress at all stages
- Stakeholders informed of contextual information (e.g., whether, traffic)

All of these requirements point to the need for international harmonization.

Two areas of application enabled by enhanced connectivity

<u>Increased situational awareness for informed decisions at sea and in port</u>

STM aims to provide a holistic approach to coordinating global sea transportation as described previously. Key to achieving this goal is ensuring efficiency and trustworthiness in the operations pursued at connection points. For this reason, PortCDM has been developed as an enabler of STM. This also provides integration to the larger transportation system. PortCDM creates the possibility for enabling

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- Situational awareness from multiple sources of spatial-temporal data to create a holistic view
- Collaboration (expressed as when to share data and what to share, related to different events of the port call process)

This is done by providing the following port features:[13]

- Associating data from different sources with the same port call
- Access management and data ownership (within the port and between the port and external actors)
- A unified format for port call messages (S-211) with reference to voyage identifiers
- A set of globally defined KPI's (duration time, waiting times/anchoring times, punctuality, predictability, berth productivity, and capacity utilization)[14]
- A system of indicators and warnings enabling port call actors to coordinate actions and manage any disruptions (conflicting data, unreasonable relationships, incomplete or missing data)[15]
- A governance structure at the global, regional, and local (port) level:
    - Global: Primarily based on broad definitions
    - Regional: Building on the global governance structure by further defining common ground and agreements within a region (e.g., adapting to regional legal conditions)
    - Local: More detailed implementation as needed locally, compliant with the Global and Regional governance framework

Because port call coordination covers both internal (intra-port) and external (port call synchronization among many actors (such as other ports, ships, and hinterland operators)),[16] there is a need for unified and standardized data exchange among all actors.

Importantly, PortCDM is not a product or a service. It is a concept embodying particular principles that will need to be realized in order to enable more predictable timings and operations in sea transport. Predictability is the key both for a synchronized eco-system

[13] Lind M., Bergmann M., Watson R.T., Haraldson S., Park J., Gimenez J., Andersen T., Voorspuij J. (2018) Towards Unified Communication – from a project format to a global standard, concept note #9, STM validation project
[14] Lind M., Haraldson S. (2016) New KPIs will show how ports become more efficient with PortCDM, STM Validation project
[15] Lind M., Rygh T., Bergmann M., Watson R.T., Haraldson S., Andersen T. (2018) Balancing just-in-time operations – coordinating value creation, Concept note #6, STM validation project
[16] Lind M., Bergmann M., Haraldson S., Watson R.T., Park J., Gimenez J., Andersen T. (2018) Port Collaborative Decision Making (PortCDM): An enabler for Port Call Optimization empowered by international harmonization, Concept note #1, STM Validation Project

of maritime transport actors and as a means for improved cooperation among upstream and downstream actors in the larger transport system.

Track-and-trace of goods in the logistic transport chain

Lately, there have been several initiatives announced to the maritime community that connect ship movements with supply chain management concerns. Examples of these are the IBM-Maersk collaboration[14] and the PSA initiative[17]. Both emphasise a need to provide awareness of where goods are and when they will arrive in different locations. Put simply, this means the track-and-trace of goods in the logistical chain, which many would conceive as being one of the most important requirements for successful maritime transportation in the 21st century.

Maersk and IBM have recently formed a joint venture[18] (pending regulatory approval) aimed at connecting all the different global supply chain actors via one neutral, open, secure digital platform for a safe and easy way of exchanging data. The platform will use IBM's blockchain technology, based on Hyperledger Fabric from the Linux Foundation, which among other things ensures that platform participants' information is secure, and any transactions involve only the relevant parties. In a similar way, PSA International recently announced the launch of a new global supply chain platform, CALISTA.

By enabling alignment and situational awareness based on ship movements *and* the progress and capabilities of the ports involved, the precision and reliability of such track-and-trace data is possible. It is, however, vital that the standards used for sharing intentions and outcomes of movements and services involved in the berth-to-berth sea transport chain are aligned with the standards for capturing the logistical flow.

Implementation strategies – towards connected maritime transports

Currently, some important baselines have been established, including standardization (for example, RTZ as an IEC standard and S-211 as a standard for the port call message format), the establishment of governance bodies (such as the international PortCDM Council), for the industrial uptake of solutions providing enhanced connectivity to major actors involved in sea transport. In the on-going rollout of STM strategies, adopted by different stakeholders in the maritime community, plans are evolving for

[17] http://www.portstrategy.com/news101/world/asia/PSA-platform-first-phase-comes-in-at-$15.1m
[18] Maersk announcement 16tt January 2018: https://www.maersk.com/stories/maersk-and-ibm-launch-digital-joint-venture , IBM press release 16tt January 2018: https://www-03.ibm.com/press/us/en/pressrelease/53602.wss

- managing non-STM ships connecting with STM ports (i.e., ports adopting the principles of PortCDM) by utilizing already established ship reporting points and adding additional data to mandatory ship reporting
- managing non-STM ports visited by STM ships by utilizing STM data available to the STM ship to improve reporting to non-STM ports

While both of those aspects do not establish the full capabilities of STM, they create improvements and increase capital productivity.

The aviation Industry has implemented the Airport CDM (A-CDM) concept successfully by rolling it out in phases, starting with one airport (Munich) and expanding in Europe. The A-CDM Impact Assessment Final Report of EuroControl[19] shows that the measured annual savings for just 17 A-CDM airports were:

- 34,400 Tons of Fuel
- 238,000 delay minutes (Air Traffic Flow Management - ATFM)
- 2.2 million minutes of ground taxiing,
- € 26.7 million on fuel
- € 15.5 million in ATFM

Further an environmental impact has measured savings of

- 120,700 tons CO_2 and
- 28,700 Kg SO_2.

This phased-in approach shows substantial benefits, both economically as well as ecologically. Full implementation should provide additional significant gains for air transport.

As in the aviation industry, a phased implementation approach for STM should provide early implementers with gains and even greater benefits to follow with a complete rollout. Phased implementation will allow different operators, shipping companies, ports at different sites, in different regions to incrementally adopt STM principles.

To avoid sub-optimization, fragmentation, and to ensure that investments in the shipping industry create value for transportation actors outside the industry, it will be essential that a holistic view is maintained to inform all involved about ongoing developments and progress and avoid isolated optimisation, such as:

[19] EuroControl, March 2016, A-CDM Assessment – Final Report

- Ships sharing their intentions and progress, but ports are unable to provide (reliable) information about the port call and trustworthy recommendations
- Ports developing optimization capabilities, but ships not being connected and able to take advantage of the services
- Intermodal ports with low operational predictability

Major customer-oriented businesses, such as Amazon and Alibaba, continue to succeed by streamlining their complete supply chain and by providing ever increasing transparency of the current position and planned delivery dates to their customers. We expect that they will soon demand that the maritime industry meets their standard practices. If the maritime sector is unable to comply, these commercial giants could well consider establishing their own fleet of vessels to gain greater control of the supply chain. Disruptive businesses do not respect legacy practices, they only respect greater productivity.

For more information, contact:

Mikael Lind, Activity Leader PortCDM testbeds, RISE Viktoria, +46 705 66 40 97 or Mikael.Lind@ri.se

Sandra Haraldson, Activity Leader PortCDM testbeds, RISE Viktoria, +46 707 61 88 14 or Sandra.Haraldson@ri.se

Ulf Siwe, Communications Manager, Swedish Maritime Administration, +46 10 478 56 29, or Ulf.Siwe@sjofartsverket.se

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STM connects and updates the maritime world in real time with efficient information exchange. In the 60s the standardised container revolutionised shipping. The next revolution is the containerisation of information – creating a safer, more efficient and environmentally friendly maritime sector.

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