Ports of the Future: Bringing Emissions in Port Visits to a Minimum by Collaboration and Digital Data Sharing

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Synopsis

Improving port performance is a key factor in reducing emissions from shipping. Increased utilisation of port infrastructures by ships provides incentives for shipping companies and ports to take joint actions for reducing their carbon footprint. Ports and ships are still not totally 'in-sync' resulting in unnecessary waiting times and/or unnecessary movements. Different initiatives associated to port call coordination / synchronization / optimization do address the potential in aligning the ships arrival and departure with the port's capabilities to serve the ship for the reduction of waiting times and emissions. The smart port of the future needs to be based on synchronization capabilities to enable sustainable shipping. To achieve substantial environmental effects, it is however a need for joining forces among the different initiatives that is brought as tools to be used by maritime transport producers. In this article numerous initiatives are identified, and an approach for bringing those together, as enabler for gaining substantial environmental effects putting the smart port of the future at the core.

Keywords Digitization, Collaboration, Ecosystem, Maritime transports, International Harmonization

1. Introduction

Being environmentally sustainable is a raising concern for all human practices. Shipping is no exception. The global shipping industry is responsible for approx. 90% of the world's trade (IMO, 2012). As it has been reported by IMO, in 2012, maritime transport emitted around 940 million tons of CO_2 annually and is responsible for about 2.5% of global greenhouse gas (GHG) emissions (IMO, 2014). Despite that this was a slight decrease since 2007, in relation to the global GHG emissions, the contribution of shipping to the reduction of global emission has not yet been good enough. Without major changes in technology and policies, shipping could by 2050 account for 17% of global CO2 emissions (Cames et al., 2015) and reports have been made that this industry is a sustainability slowcoach (Cuff, 2016).

There is a number of initiatives to realize the IMO GHG emissions strategy (IMO, 2018), such as new types of fuel, Exhaust Gas Cleaning technologies as well as digital opportunities gluing the actors of the maritime self-organized eco-system together. An unresolved quest, however, building upon the high ambitions set out through the IMO strategy, is how to treat the shipping industry as a holistic system. As of today, dominating the shipping practice, there are

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different efforts that leads to sub-optimization, as e.g., the dyadic charter parties being used for coming to an agreement of stipulating the ship's time of arrival to the port area, without securing that the ship can be served by the port. Following this example, coupled three-party agreements has been proposed to overcome such sub-optimization (c.f. Lind et al, 2018a).

As it has been acknowledged by several (c.f. e.g. Safety4Sea (2019), Lind et al (2019a)), port call coordination/synchronization/optimization is one the drivers behind achieving substantial gains in the reduction of emission driven by just-in-time operations. Due to the self-organizing characteristics of maritime transports, a higher degree of transparency through digital data sharing and collaboration is necessary. This has also been acknowledged by the International PortCDM Council (www.ipcdmc.org) (Bergmann, 2019).

It has been proven that there are a lot of efficiency and environmental gains that can be drawn from enhanced data sharing associated to port operations, including ship operators / ships collaborating and exchanging data with ports on planned and recommended times of arrival (c.f. Lind et al, 2018b). The smart port of the future need to be based on synchronization capabilities to enable sustainable shipping.

The purpose of this article is to elaborate on necessary means to enable substantial reduction of emission from shipping taking a holistic view and reflect some of the contemporary initiatives. Aiming at this goal a lot of the initiatives that have been taken so far addressing what happens at sea, this article takes a port centric perspective while considering what happens at sea. It assumes that today's fleet and port infrastructures are under-utilized why there are still incentives for shipping companies and ports to take joint actions for reducing their carbon footprint.

We will elaborate upon how just-in-time operations could be enabled by the use of digital technologies in self-organized ecosystems. This will be followed by an elaboration on digital data sharing for just-in-time shipping, build upon Port Collaborative Decision Making (PortCDM), a concept that promotes enhanced collaboration and data sharing. We will also elaborate on contemporary initiatives associated to the opportunity of reducing the carbon footprint by enhanced efficiency where many actors share data and benefits. The article is ended by some suggested movements in aligning different ongoing initiatives.

2. Theoretical framing: Enabling just-in-time operations by digital technologies in self-organized ecosystems

The notion of just-in-time comes out of the production industry were the system in operation management is focusing on the demand at a particular moment. Pioneered by Toyota, the aim has been to reduce non-profitable activities and make the manufacturing system more flexible, eliminating the associated costs of carrying and maintaining the inventory. As addressed by MBA Skool (2019), there are various methods in which just in time or JIT can be achieved:

1. Elimination of defects & waste
2. Balancing the flow and scheduling the output
3. Multi-skilled labor force to carry out specific operations
4. Maintenance of equipment and machinery for flawless operations
5. Cellular manufacturing i.e. making in small batch sizes.
6. Streamlined design and process flows & layouts

As reported by Memari (2016), a number of researchers have argued that intensive transportation activities through popular distribution strategies, such as Just-In-Time (JIT) could significantly increase carbon emissions within logistic chains. The same author does however claim that there is a need for a systematic understanding how JIT distribution affects carbon emissions in product distribution and transportation at large.

However, in shipping, just-in-time thinking does have a potential of large positive effects due to the distributed nature of shipping, sub-optimization, and the fact that the relationship between carbon footprint and ship's speed through water is exponential. Several reports have been made related of the potential in just-in-time operations associated to ships arrival time to ports, serving the ships at the port, and the ships departure from ports. Delays in the latter, also creates ripple effects for downstream ports. There are reports addressing the challenges of enabling synchronization of ships and port operations (Poulsen & Sampson, 2019).

As the shipping industry is arranged as a self-organized ecosystem with collaborating as well as competing actors, additional challenges are encountered. Each participant in the ecosystem MUST consider their own performance in relation to the port call process as the common interest shared with other participants. In order for each of the actors to optimize operations, arranged in just-in-time patterns, there is a need of being aware of each of the actors' plans and expected outcomes. In this way, upstream progress for the particular instance of interest, serves as the basis for the actors responsible for downstream operations. The methods addressed in the non-exhaustive list above address the need for sharing common situational awareness among the actors. As a single information source might not be reliable, it is also highly recommended to rely on multiple sources.

3. Digital data sharing for just-in-time shipping – the PortCDM approach

Achieving 'Just-In-Time' in ports, requires a collaborative environment, engaging those that are involved in the activities. While today's ports may aim at a collaborative environment, most ports have developed digital capabilities in isolation and with focus on a few key actors.

Planning and communicating about intended actions and progress for all involved actors, throughout the entire ecosystem of sea transports berth-to-berth is however key to enable a successful future.

International initiatives to harmonized collaboration and data sharing has now been formalized through Port Collaborative Decision Making (PortCDM) (www.ipcdmc.org), encouraging involved actors to instantly share data in internationally agreed ways allowing for the emergence of common situational awareness. To facilitate this, S-211 for time stamp data sharing has been introduced as an IHO/CMDS standard endorsed by IALA, allowing involved actors to share data of common business essence, enabling co-opetition.

To manage the complexities of integrated performance of internal and external collaboration, the PortCDM concept, facilitates collaboration to enable the optimal realization of port visits by flexibly balancing capacity utilization and minimize port visit disruptions (Lind, 2018e).

PortCDM, inspired by the aviation sector, supports the port call optimization processes by enabling (Lind et al, 2018d):

- The extension of planning horizons through standardized connectivity to upstream and downstream actors
- The sharing of the timing of future events for the coordination of the port call process
- The combination of multiple sources of data for enhanced predictability
- Machine-2-machine connectivity for instant sharing of data from the source based on agreed message formats
- Shared situational awareness by sharing data on the progress of a port call among internal and external involved actors
- Acknowledgement of discrepancies in the port call process

The concept is governance agnostic, usable for any port, independent of size, geographic location, and role in the maritime and global transport system.

PortCDM aims at establishing common situational awareness and collaboration utilizing compliant tools, and data sharing environments. The port of the future needs to be able to communicate expectations to outside actors of what performance that can be expected from the port. The increased digitization at ships and ports are enabling this exchange.

PortCDM supports the coordination and collaboration between the ship, directly or via ship operation centres, and the port to allow an optimization of the sea voyage. The ship voyage speed can be optimized with focus on efficiency and emission reduction as there is no need to arrive as early as possible to be first in "first-come-first-serve". With reduced waiting time on anchor, emissions are reduced, and the port environmental footprint is improved. Within the port, ship emissions can be reduced as well. As PortCDM will support the shortening of ships' total turnaround time, less time on hot ironing where no cold ironing is available will be achieved. If a port uses cold ironing, the high predictability of estimates allows for better planning of this process and as such reduces the time the ship still needs to stay on hot ironing (Lind et al, 2018c).

But same as ships are actors within ports, the ports are often also embedded in the port cities and the surrounding community. An increasing number of port cities are actively working to get greener and positively contribute to the reduction of pollution. Being an integral part, ports are increasingly pushed to reduce their contribution of the city's emissions. With the above-mentioned capabilities of increased predictability of port activities like cargo handling, the port can provide the city with better suggestions on when trucks or other subsequent transport modes are needed. As the ports connect with the city, the traffic systems can be optimized and pollutions due to traffic congestions or waiting trucks can be reduced.

4. Contemporary initiatives for efficiency and environmental gains

There is a lot of attention directed to the role of digitization for connecting different maritime transport producers, providing a thought basis for higher efficiency and reduced carbon footprint. Examples of such different contemporary initiatives have surfaced of which a call for joint actions has been made are (c.f. IntelligentCargoSystems, 2019):

- ChainPort (www.hamburg-port-authority.de/en/themenseiten/chainport/)

providing a platform for knowledge sharing among different ports

- GloMEEP (www.glomeep.imo.org) an IMO initiative aimed at supporting the uptake and implementation of energy efficiency measures for shipping for reduced greenhouse gas emissions,
- The Digital Shipping Container Association (DCSA) (www.dcsa.org) gathering major shipping companies by paving the way for interoperability in the container shipping industry through digitalization and standardization.
- The Global Industry Alliance (GIA) (www.glomeep.imo.org/global-industry-alliance/global-industry-alliance-gia/), under the framework of the GloMEEP Project, bringing together maritime industry leaders to support an energy efficient and low carbon maritime transport system.
- The International PortCDM Council (IPCDMC) (www.ipcdmc.org), with its global reach, establishing the overarching guidelines, processes and procedures to make PortCDM a successful international concept to improve maritime transport as it relates to Port operations and interaction with ships. IPCDMC maintains the S-211 time stamp data sharing standard.
- The International Port Community Systems Association (IPCSA) (www.ipcsa.international) gathering port community systems providers supporting smooth transport and logistics operations at sea ports, airports and inland ports
- The Maritime Connectivity Platform Consortium (www.maritimeconnectivity.net), provision of guidelines and standards for efficient, secure, reliable and seamless electronic information exchange among maritime stakeholders using available communication systems
- The Port Call Optimization Task Force (www.portcalloptimization.org) where shipping companies and ports are working together promoting "Port Call Optimization through improving quality and availability of master and event data which will deliver benefits to ports, shipping lines, terminals, service provides and society"
- The Sea Traffic Management (STM) validation project (www.stmvalidation.eu), a large-scale testbed connecting and updating the maritime world in real time, with efficient information exchange. STM used the PortCDM as one of its enabling concepts
- The SESAME Straits project (www.straits-stms.com), a large-scale testbed for the Secure, Efficient, and Safe maritime traffic Management in the Straits of Malacca and Singapore by the exchange of marine information onboard and ashore by electronic means, during the entire voyage of the vessel i.e. "berth to berth"
- The Smart Maritime Network (www.smartmaritimenetwork.com) providing a forum to promote the benefits of enhanced integration and data sharing among stakeholders within the maritime and transport logistics sectors.
- The SmartNav (www.SmartNav.org), providing additional services for Non-SOLAS ships such as fishery boats, coastal vessels and ferries.

5. Contemporary digital tools for port call / cargo flow coordination / optimization

Being in line with the initiatives listed above, there are also numerous digital tools, mostly coming out of a single port with a desire to engage others utilizing the tool, providing opportunities for integration throughout the supply chain. Some of the acknowledged initiatives, as to be conceived as complementary, are (inspired from IntelligentCargoSystems (2019)):

Initiative	Source
CargoMate	intelligentcargosystems.com
Integration products by YourEDI	YourEDI.com
Multiple services by Teqplay	Teqplay.nl
Navis N4	Navis.com
NxtPort	nxtport.com
Perseus	Marine-Fields.com
PitStop	maersk.com/news/2018/06/29/the-quest-for-the-perfect-pit-stop
Portcall.com	portcall.com
PortChain	portchain.com
PortView	Shipsfocus.com
Pronto	portxchange.portofrotterdam.com
TradeLens	tradelens.com
Xvela	xvela.com

Building upon the assumption that

1. nothing substantial related to environmental concerns would happen without engaging a multitude of maritime transport producers;
2. there will not be one party in the world providing a tool to all 3900 active ports of the world;
3. it must be possible for the port to choose among different solutions meeting their needs; and
4. the different solutions need to be based on standards on message formats and APIs that enable data sharing among the actors' tools (as e.g. by the utilization of S-211) reducing the

number of links to a minimum for maintainability reasons

integration opportunities arise that enable inter-operability throughout the maritime supply chain, that is inter-operability built upon integration between the tools addressing the same domain as well as inter-operability built upon integration between different tools used along the maritime supply chain covering different domains. As for integration within the *same type of domain* it is meant that different tools (addressing the same domain), being in use in different geographical areas are, connected to each other by capabilities of data sharing, such as e.g.

- a port utilizing a particular tool for their port call coordination, exchange data, possibly via a data sharing platform(s), with another particular tool used in another port. Such integration would cater for the possibility for a larger set of the maritime community to share data between each other which is necessary for expanding the planning horizons for the particular port, and
- a port utilizing a particular data sharing platform for sharing time stamps among the port call participants exchanging data with other data sharing platforms in use in other ports

Exchanging data between *different tools* would bring opportunities to enhance the capabilities of the particular tool through exchanging data within and/or outside the domain that is addressed in a limited (geographical) setting by the particular tool. The different tools identified above may be both positioned as either pure platforms and/or tools with front-end capabilities addressing different domains, such as having a supply chain focus and/or a port call focus.

A majority of the surfaced tools do put focus on shipping containers. This is surprising since just a approx. 30% of the different types of maritime trade is related to containers why we need to assure that solutions are provided not only for the optimization for container transports, but also for other types of trade. This is of special concern due to the fact that ports in general normally manages multiple types of trade using the same infrastructure and resources. However, as to be noted many of the tools identified above do most likely have some generic characteristics that would be applicable for different types of trade contributing to supply chain visibility.

6. Combining different initiatives – towards a community of tool providers

The review of the different tool initiatives reveals different focus and scope that would suit possible users in different ways. Assuming that most tools do have ambition to be implemented at large scale within its respective domain, it is unlikely that neither of the tools would cater for managing the end-to-end visibility in supply chains that incorporates all different operations. Therefore, the following different integration scenarios, representing different levels of ambition and complexity, may be identified:

1. exchange of data between different data sharing platforms (addressing different domains), as e.g. the exchange of cargo status data within the logistic domain and time stamp data associated to the transport chain within the transport domain
2. exchange of time stamp data between tools for port call optimization and terminal optimization across multiple ports and carriers
3. exchange of data between different tools for fleet optimization, vessel traffic monitoring, port call optimization, and terminal optimization utilizing one/several platform(s) for time stamp data sharing across multiple ports and carriers connecting to one/several platform(s) for goods status data sharing (see figure below)

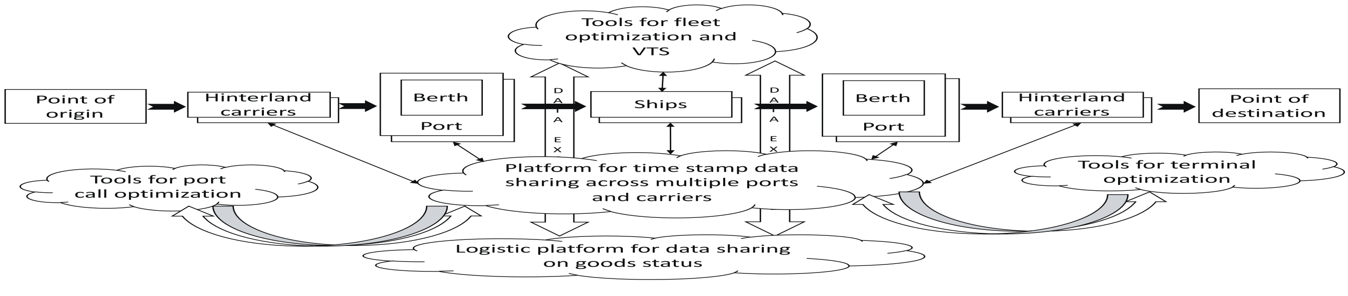

Figure: Integration between the same and different types of front-end tools by exchanging time stamp data and goods status data for supply chain visibility using several platform tools (of the same) of different type

Port call coordination / optimization / synchronization builds upon accessibility to data along the supply chain. It has been noted that trust and reliability in the self-organized ecosystem of shipping needs to rely on two things (Lind et al, 2019d; Hvid Jensen, 2019); 1) that data is made available from multiple sources within the same domain, and that 2) the planning horizon is expanded by not just relying on that ships masters / operators / agents report on their estimated time of arrival to the port. There is thus a need for data sharing within ports, between ports, between ships and ports, and between ports and hinterland operators. S-211 has been developed to cater for such different data sharing use cases.

Any of the tools, presumably relying on its own data sharing platform, will not surface as THE solution for all ports in the world since it is presumed that each port would like to be in charge of its own capacity building. However, if the companies behind contemporary tools, together with initiatives pursued by each port on local level, would join forces by positioning their tools in relation to each other by agreeing upon a limited set of standards on message formats and interfaces (APIs). This might actually contribute to enhanced efficiency and environmental sustainability at large scale for shipping. Data sharing platforms as intermediaries, not associated to particular front-end tools, would suit such purpose, giving room for optimization tools to enhance its capabilities. In the table below, different challenges and opportunities enabled by platforms for integrating different domains across geographical regions is elaborated upon.

Type	**Challenge**	**Opportunity from intermediaries**
Logistic platform	Data associated to port call progress and carrier movement not incorporated in the platform All logistical flows are not captured	Data sharing intermediar(ies) would enable interchange of port call data and cargo data
Tools for port call optimization	The same port call optimization tool not being in use in the chain of ports visited by the ships	Data sharing intermediar(ies) would enable interchange of port call data between different tools, within the same domain, in use at different ports
Tools for terminal optimization	The same terminal optimization tool not being in use in the upstream and downstream terminal	Data sharing intermediar(ies) would enable interchange of port call data, ship movement data, and terminal operations data
Tools for fleet optimization and VTS	Data associated to port call progress is not captured in the tool	Data sharing intermediar(ies) would enable interchange of port call data and ship movement data

This is a call for different tool suppliers to explore the opportunity to join forces by e.g. utilizing the fact that one tool provider would be situated in one port acting as a door-opener for intermediaries, and intermediaries acting as an enabler for enhanced capabilities for the used tool. This is a call for putting capabilities of diverse tools and platforms on the agenda within diverse associations with the purpose of aligning those initiatives for bringing enhanced efficiency and environmental sustainability to shipping.

7. Conclusions

In conclusion, the paper explored how enhanced collaboration and data sharing among port actors, visiting ships, hinterland operators, and upstream ports allows for improved efficiency and reduction of CO_2 emissions in ports thus allowing a longer time for technology to be developed and eliminate the need of short-term solutions based on trade economics to regulate the emissions, by introducing the concept of collaboration instead. This debate is associated to just-in-time shipping which recently also surfaced within IMO. It is obvious that the smart port of the future need to upgrade its data sharing capabilities, to align actors within the port as well as aligning with actors along the supply chain, both associated to what will / has happened at sea, what will / has happened in upstream ports, but also what will / has happened in transport operations outside the maritime domain. In this paper, an approach has been proposed allowing different tools and data sharing platforms to exchange data enabling enhanced opportunities for optimization and supply chain visibility, building upon that contemporary tool providers join forces for the contribution of environmental effects that are substantial for the shipping industry.

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