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(Concept note #6)

Balancing just-in-time operations – Coordinating value creation

by

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The knowledge society

Decision-making is the central activity of modern society, and high-quality decision-making is based upon a trifecta of data, information, and knowledge. A knowledgeable person requests information to enable decision-making. To fulfil the request, data are converted into information. Personal knowledge, which includes expertise, is then applied to interpret the requested information and reach a conclusion, as shown in Figure 1.

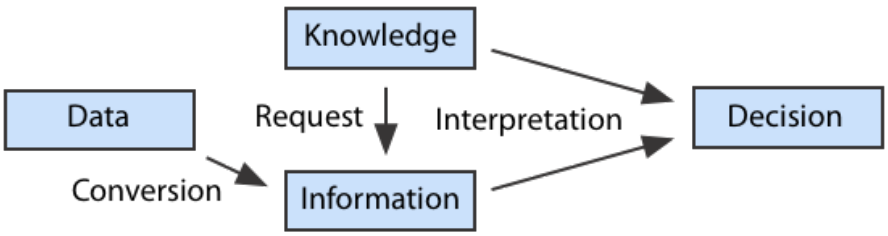

Figure 1: *The relationship between data, information, and knowledge*[1]

The shipping industry has the same need as all participants in competitive economies to make high-quality decisions. However, because it is a self-organizing ecosystem, there can be a lack of data for the involved stakeholders when individual actors don't share plans and outcomes. As a result, the quality of decision-making is lowered.

As elaborated in earlier concept notes in this series, digitization enables the creation of systems of record[2] that others could use to optimize port operations for the benefit of the whole ecosystem. Shared data can also establish a basis for creating flexibility to manage disruptions. High-quality decisions are based upon having adequate data to fully understand and analyse a problem or situation.

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[1] Watson, R.T. (2013). *Data management: databases and organizations* (6th ed.). Athens, GA: eGreen Press.
[2] Lind M., Bergmann M., Haraldson S., Watson R.T., Park J., Gimenez J., Andersen T. (2018) Enabling Effective Port Resource Management: Integrating Systems of Production Data Streams, STM Validation Project

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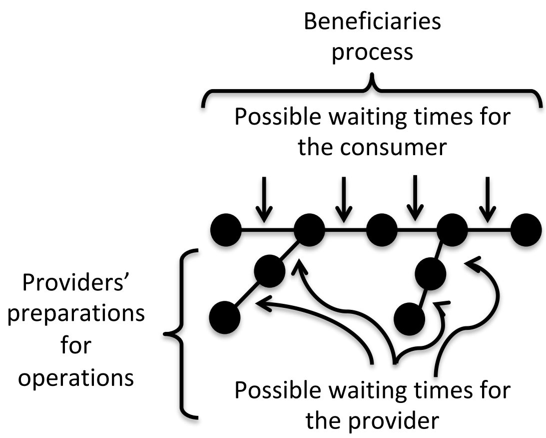
In a self-organized ecosystem, there is no natural leader; each actor is highly dependent on enhanced collaboration among involved actors. In order to cater for a fruitful collaboration, actors need to share their plans with each other to improve each other's decision making for the benefit of the common object of interest shared among the actors.

Port operations is an area where there is an opportunity to pursue enhanced coordination based on a ship's berth-to-berth progress. In such operations, there is often a strong desire to enable short turnaround times for visiting ship, but also for actor's actions alignment in their service operations. Both for the service provider and consumer, there is a need to avoid waiting times. Just-in-time actions enhance consumer satisfaction as well as improve resource utilization.

In this short concept note, we use data from a region in Norway, the Rogaland County, to reveal the improvement potential enabled by Port Collaborative Decision Making (PortCDM) based on actors sharing their systems of record. This analysis shows the direct effects of applying PortCDM as an enabler of Sea Traffic Management (STM) for efficiency, safety, and environmental sustainability in berth-to-berth sea transport.

The two sides of just-in-time operations



A ship is ideally served just-in-time for the different events, episodic tight couplings, that constitute a port visit. Just-in-time operations mean zero waiting times for a ship and the shore stakeholders. Each actor performs its actions/operations just-in-time. This will typically require that the service providers have some slack resources since a port is a system of production, somewhere between a factory and a job shop. The arrival of ships and their service needs will vary, and just-in-time ship handling requires slack resources to handle this variation.

A single port call can be associated to the Toyota Production System when it comes to the desire to cut lost time. Toyota strives to reduce waiting time and has a high focus on process optimization. Port operations should be able to benefit from this way of thinking and by the concept of PortCDM able to reduce "muda", which is a key concept in the

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LEAN process of thinking as well as the KAIZEN concept of constant process improvement.

Pilotage, as a part of the port call process, is an illustrative example of enabling just-in-time ship operations. The ultimate goal should be that the pilot is available when a ship arrives at the pilot boarding area. Neither the ship (as the service consumer) nor the pilot (as the service provider) should have to wait for each other. However, this might mean that pilot resources are not fully 100% utilized in order to ensure that ships do not wait.

As the mantra of today's business practice is to put the customer in focus this means that the needs of the service consumer (the shipping company) typically overrides the needs of the service provider. Higher accuracy planning data, timestamps, expressing intentions shared among all actors providing services to the common object of interest, creates the potential for service providers to plan their operations to optimally meet the needs of the service consumer, without any unnecessary waiting times for the consumer. In other words, service providers should aim to minimize their slack resources.

Enhanced data reliability: The core of the PortCDM concept

The concept of Sea Traffic Management (STM) covers data sharing in a berth-to-berth voyage to enhance efficiency, safety, and environmental sustainability of sea transport. STM has brought forward the enabler, Port Collaborative Decision Making (PortCDM) to contribute to enhanced coordination and synchronization of port call operations. PortCDM builds upon sharing time stamps between different port call actors as the basis for:

- providing enhanced accuracy of essential timestamps in the port call process
- providing a basis for each port call actor to align its plans of their operations
- establishing a continually emerging common situational awareness among involved actors

Common situational awareness is a reflection of the content of the current systems of record concerning a particular port call at a particular time. This also means that when the system of records captures plans, or their realization, of events in the systems of production, situational awareness will be updated. By established a communication channel for updating each other in real-time, port actors can maintain an accurate situational awareness.

Since event changes in the system of production are instantly captured and shared in the system of records, it is possible for an individual actor to be notified of desired event

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changes, such as the ship arriving to the pilot boarding area, and also be informed of possible deficiencies in the overall plan of the port call process. Within PortCDM, an indicator system, from which actors can get warnings, has been defined for three different types of states, as configured by the actor:

- missing data, which directs attention towards possible missing data in the system of records based on when they should have occurred in a system of production. One example is a pilotage need requested and confirmed some pre-defined hours before arrival.
- conflicting data, which directs attention towards actor's different conceptions of timestamps. An example is when port authority, the terminal operator, and the captain report different estimated times of arrival to berth.
- unreasonable relationships, which directs attention towards the relationships between different timestamps. An example is when the time between estimated times of pilotage commenced and arrival at berth differ outside a defined range

The case of Rogaland County[3]

Rogaland County is the third biggest maritime economic region in Norway only surpassed by the Oslo-fjord and Bergen region. It is situated on the southwest coast of Norway. Some of the major ports and terminals/terminal operators located in Rogaland are Stavanger, Karmsund, Egersund, Sandnes, Kårstø (Statoil), Westport, NorSea (Dusavik/Tananger), ASCO and Kuehne & Nagel.

We examine conventional cargo operations in Rogaland, and concentrate on the ship types mostly used in those types of operations. The study reports on ship types of "General Cargo Ship", "Ro-ro Cargo Ship", "Refrigerated Cargo Ship", "Palletised Cargo Ship" and "Container ship". Ship types uniquely transporting "Dry bulk" and "Wet bulk" ships are as such also not included in the studies. The case is based on a data sample from 16th of June 2016 till 24th of October 2017 (16 months). These data, containing only notifications done in the 24 hours prior actual arrival, are summarized in the following table.

[3] The case is based on the master thesis "Alternatives for the Development of the maritime business in Rogaland" written by Terje Rygh (To be submitted 26th of March 2018).

	Number of unique port calls in the data sample (captured in NSW)	Early (total in hours)	Late (total in hours)	Total
Arrival *	4691	3311,2	2225,93	5337,13
Departure **	4431	7703,5	4977,98	12680,98
Sum (in hours)				18218,11

* Based on ETA unique message estimates

** Based on ETD unique message estimates

Within the last 24 hours of the Actual Time of Arrival (ATA) there are a total of 21 681 registrations and update messages to the ships Estimated Time of Arrival (ETA) (see figure 2 below). An average berth stay in Rogaland is of around 18 hours, we therefore look the last notification updates of ETD given in the 24h period before arrival adding the time of the average berth stay (42 hours of time line of observations prior to ATD). In the last 42 hours before the Actual Time of Departure (ATD), there are 18 356 estimated time of departure registrations and updates (see figure 3 below).

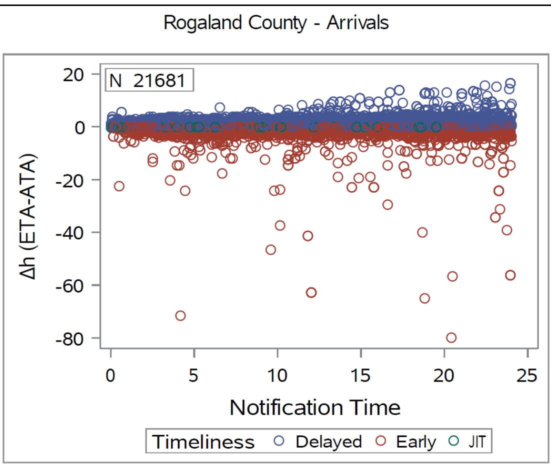

Figure 2: Arrival - Variation of ship voyage updates in Rogaland (all ship types)

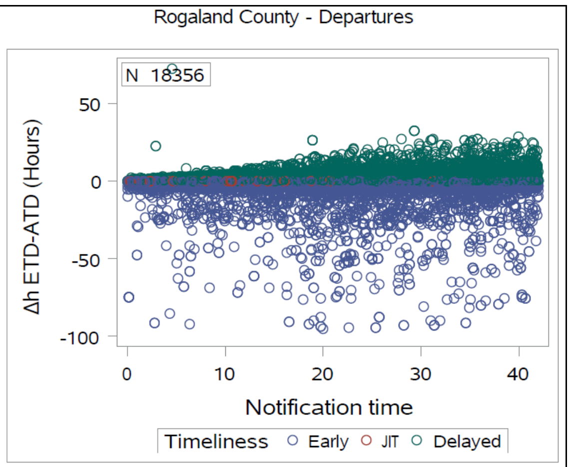

Figure 3: Departure - Variation of ship voyage updates in Rogaland (all ship types)

The two figures show scatter diagrams of ships arriving and departing berths in Rogaland County. They show ships arriving or departing *too early* (negative y-value) or *too late* (positive y-values). As can be seen from the diagrams, there are more than twice as many more instances (hours) of late departures than late arrivals as also the preceding table depicts.

Looking from a terminal operator's perspective, early or delayed ship arrivals or departures have to be managed on a daily if not hourly basis. The goal of the operations

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manager is to manage variance of predictability in port or terminal operations and strive for just-in-time (JIT) operations. To change the execution of one task or a series of operational sequences may be impossible due to variance, and a "bull-whip" effect may occur in the whole value chain down- and upstream. If there are no means to mitigate these variances, they might cause idle resources for the terminal operator. If the next ship in line has to agree to use earlier or later time slots, this in turn may influence other ships and terminals as well as third parties that in turn need to shift their operational plans. The ability to get early notification of late ship arrivals or departures in real time would have a big impact on a port or terminals' ability to mitigate operational variance. If handled well, situational awareness can help them, their customers, and other stakeholders in optimizing their day-to-day business.

> "*Through updated information and use of Slot Time, it`s possible for shipping companies to save up to 75% of port fee. Based on the availability of real-time information about the ship's position, it can enable the port operator to increase the utilization of resource capacity up to 40%*", Kurt A. Ommundsen Managing Director WESTPORT AS

An analysis of the case data reveals an average loss of 5693 person-hours per month (just for the terminal operators which is just one actor group involved in a port call), and the cost of ships arriving late or early lies somewhere between USD 3 049 000 and 5 149 000 per year due to terminal workers having to wait, show up early, not having any capabilities to re-plan, or do work in another sequence. It is reasonable to assume that when taking all actors involved in a port call into consideration, the cost for ill-coordinated operations would likely be much higher for the rest of the value chain (tug, pilot, linesmen, truck drivers, goods owner, warehouses, retailers, and others).

A conservative and sensible approach would thus be to double the average loss by including all actors involved in a single port call, which gives us a saving of 6 – 10 millions USD. This equals a loss per port call off USD 350 -600. If we assume that the numbers can be aggregated worldwide (20 million calls worldwide annually) we have an annual loss of USD 7-12 billion.

For actors, such as Amazon and Alibaba, who both receive and send goods by ships, the quality of ship arrivals (predictability and punctuality) is likely a high priority. They will obviously be concerned when port variance magnifies downstream supply and value chain disruption. We speculate that these will be significant because goods can have many waypoints before their final destination, and variance in one part of the value and

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supply chains may have big impacts on other parts of them. This should be investigated in future studies.

The impact that ship arrival variance has on operational costs, as in the Rogaland case, shows why there needs to be a focus on how to manage variance. The data sample of Rogaland covers about 35% of the port calls in the region for just one actor group, the loss of person hours is significant, and consequently the are substantive possible savings. By using existing standards and tools, reducing these costs should be possible. Better situational awareness using PortCDM, in addition to advanced resource management tools, should enable ports and terminals to improve their performance. For example, using real-time benchmarking with historical data and process control charts, in collaboration with PortCDM, it is feasible to consider reducing variance costs. However, today's terminal and port operation managers do not have all the data and tools they need to make smarter decisions.

Enhanced data reliability and sharing creates business value

Accurate timestamps enable higher precision planning. This in turn drives the service provider to optimize its operations for resource utilization. A very tempting goal is optimization of berth utilization. It is common that some terminals adopt a strategy where the visiting shipping company pays the price for a 24-hour slot, when it often requires less than 24 hours to complete the service. A reasonable approach is that booking is for shorter time frames and that the client pays, possibly a higher price per hour, for the time it takes to complete the operation.

Such a change will require higher reliability timestamps throughout berth-to-berth sea transport. By adopting solutions enabled by PortCDM, actors within the self-organized ecosystem could gain higher reliability and predictability of port call events. This is also a driver for gaining more business for the port.

High quality data for decision-making is necessary for managing the trade-off between making commitments to clients versus having flexibility for managing disruptions. It is rarely sensible to plan all resources for 100% utilization, but on the other hand planning means that commitments need to be made so that the client's, expectations can be met as well as enabling service providers to ensure that their resources are aligned with those of each other to ensure an efficient port call.

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Value creation starts with data for better decisions

Just-in-time operations for ships can be achieved when the various parties have sufficiently accurate data of the necessary scope to make high-quality decisions. It starts by establishing a system of records to capture the spatial and temporal dimensions for planned and actual physical movements and service provisioning[4] throughout the value-creation process and directed towards the service consumer. Such systems of record need to capture major events in the systems of production, the value creation process, and these records need to be shared as needed to enable the journey from data to decision-making.

> *"Looking at a call as a production process, the port has a key role in delivering its own services, but also in facilitating other partners in the port. Data availability will not only increase port call efficiency, it will also be a step towards increasing predictability"*, Vidar Fagerheim, CEO, Shiplog AS"

Ports as systems of production

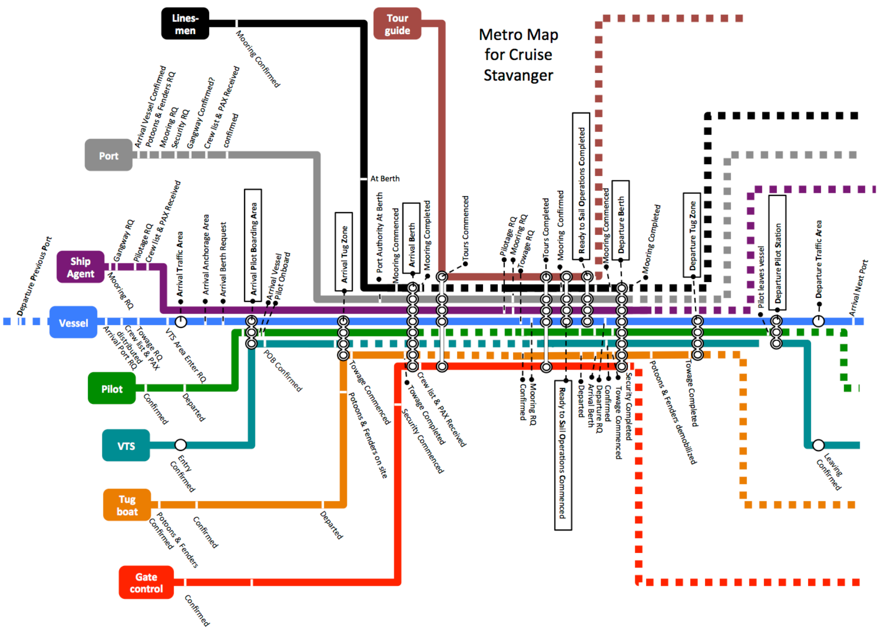

Figure 4: The port call process as a system of production[5]

A port is a collection of systems of production, one for the pilot, one for the tugs, one for the terminal, and so forth. A port visit is a sequenced dependency of each of these systems of production, and thus we can also think of the port as a system of production. A production perspective inspires thinking about methods that factories use to improve productivity and quality. Japanese manu-

[4] Lind M., Bergmann M., Haraldson S., Watson R.T., Park J., Gimenez J., Andersen T. (2018) Enabling Effective Port Resource Management: Integrating Systems of Production Data Streams, STM Validation Project

[5] *Lind M., Haraldson S., Karlsson M., Watson R.T. (2016) Overcoming the inability to predict - a PortCDM future, 10th IHMA Congress – Global Port & Marine Operations, 30th May – 2nd May 2016, Vancouver, Canada*

facturers apply six sigma principles and lean manufacturing to raise their efficiency and quality. Goldratt's Theory of Constraints has led to significant improvements in a range of systems of production.[5] It is, we assert, time to apply management principles honed in some of the most productive manufacturing companies in the world, to ports and shipping to improve decision making and efficiency.

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[5] See Cox, J.F., & Schleier, J.G. (2010). *Theory of constraints handbook*. New York, NY: McGraw-Hill for many examples of its practical applications.

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