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From concept to implementation
- an interplay between research and practice

by

Mikael Lind[1, 3], Michael Bergmann[1], Richard T. Watson[1, 2],
Sandra Haraldson[1], Jin Park[4], Thomas Christensen[5]

[1]RISE Viktoria, Sweden, [2]University of Georgia, USA, [3]Chalmers University of Technology, Sweden,
[4]SNPO/KRISO, South Korea, [5]SNPO, South Korea

The need to move beyond test beds in the maritime sector

When industry or governments are considering new developments - regulations, standards, processes, products or some combination of these – the current best practice is to first define the underlying concept, which can be thoroughly reviewed with key stakeholders and refined through engaged interaction. Once concept consensus is attained, test beds are established to validate the assumptions and confirm that the concept is technically implementable. If successful, test bed results can be used as the basis for full implementation. This process has, for example, been used successfully in aviation to implement SESAR, the “Single European Sky Air Traffic Management Program”. The concept phase ran from 2005 to 2008, the test beds, preparing for implementation, were established and used from 2008 to 2013, and the implementation phase started in 2014 and is expected to be completed in 2020.

Another example is the development of autonomous cars, where we are in test bed phase, both for technical development as well as for legislative enactment.

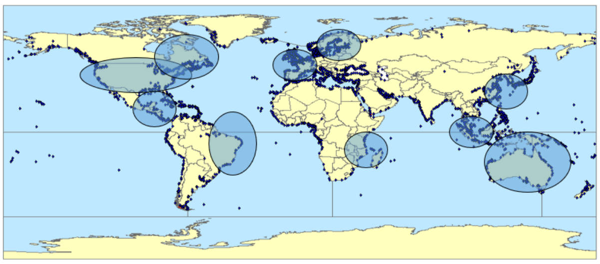

Figure 1: e-Navigation Test-Bed Clusters[1]

As the maritime sector recognizes the need for digitization, improved cooperation, and collaboration through information sharing, various projects and programs have been developed and some are in execution. SESAR and Sea Traffic Management (STM) are examples of holistic concepts that were developed over successive phases, with each phase focusing on a specific aspect of the holistic concept.

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From the IMO e-Navigation Initiative, through projects like BLAST or MONALISA, various stakeholders have formed teams to develop concepts, intended to help the maritime industry to rapidly adopt and implement such innovations.

The last few years has seen various test beds executed in different regional maritime clusters to validate concepts and gain data on how to overcome technical, procedural, and administrative difficulties in implementing them (See Figure 1[1]).

While this migration is a difficult and long-lasting process, the need to push towards implementation is paramount for success. Lessons in other markets show that those who lag in implementation of digital solutions or collaboration might not survive in the modern world. Kodak, for example, pioneered the development of digital photography, but failed to implement the innovation rapidly because it did not want to destroy its existing film-based product and services. Other firms seized the opportunity to destroy the film market with digital cameras, and Kodak was stranded with few customers for an old solution.

Maritime transport might be at a similar junction. Moving from concept to implementation of digitization, data sharing, and collaboration – in essence full utilization of maritime informatics – could be a matter of success or failure for some industry participants. Standstill, protection “the way we always have done it” and denying change as “we never did that” are typically poor survival strategies.

This concept note uses examples, Port Collaborative Decision Making (PortCDM) (initiated by the European Union), and the Maritime Connectivity Platform (MCP) (initiated by a series of EU projects in collaboration with Korean research and public organisations), illustrate the path from concept to implementation. Both, as key components of the concept of Sea Traffic Management (STM), are in various stages of implementation. STM is an example for how to create the new by building on the old paradigm of the maritime industry: Sail where no one sailed before and discover new ways to bring success to the maritime transport industry.

Approach to informed concept development and concept validation

The ultimate goal of bringing new concepts into application is to contribute to better practice. By engaging multiple stakeholders, new concepts can expand organizational boundaries and collaboration. This is especially the case for concepts utilizing

[1] Bergman M. (2016) „e-Navigation Test-Bed Clusters“, DGON-POSNAV, Germany, 2016

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digitization. Naturally, new methods are typically proposed to respond to deficiencies in existing practices or to utilize new technologies or methods, such as digitization, for raising the productivity and efficiency of existing practices and increasing financial benefits and safety.

To propose new concepts, the focus needs to be on desired outcomes. A concept note relies on arguments that implementation of the proposed ideas will raise capital productivity. All businesses, including shipping, aim to create capital by converting it from one form to another or by making an existing form more valuable. For example, a ship (economic capital) creates economic capital by moving goods (economic capital) closer to the final purchaser. A TV set, for example, is worth more in retailer's showroom than in the factory warehouse. Concepts can have a transformative power by creating new opportunities for capital creation or improving the productivity of existing capital conversion processes.

At the same time, concepts might increase safety, protect the environment, and reduce costs. Thus, they can simultaneously preserve human and natural capital while increasing economic capital.

Concept development should be a highly iterative process, where we continually learn about the focal practice and potential innovations. In order for a concept to become a successful response to an existing practice, it is necessary for the concept to address a vision and a roadmap towards capital creation efficiency gains. To gain an understanding of how a concept might work in practice, there is need to demonstrate all or part of the concept. This helps decision makers to understand the implications of proposed changes as well as revealing human and organizational behaviour related to the practice addressed.

Within (maritime) informatics different approaches are applied to ensure that knowledge (and concepts) are of practical relevance, such as action and design research, in which:

- the concept developer is engaged as a change agent acting for the good of the organization(s) sponsoring the assignment.
- technical innovations representing (parts of) an emerging concept engage stakeholders to provide feedback on requirements. In an early stage of a concept development / implementation process, prototypes can demonstrate a concept's constraints and limitations and support its practical validation. Prototypes help cement current requirements and identify new ones.

A concept should provide a concrete vision and holistic view of the problem. It should embrace values, procedures, goals and respond to deficiencies in existing practice and advance opportunities to improve them. It should be based on a well-founded knowledge of practice, facts, and sound business logic for productivity gains.

Exemplifying the process from concept to implementation

Let's look at some relevant examples that illustrate the prior discussion: Port Collaborative Decision Making (PortCDM) and the Maritime Connectivity Platform (MCP), which are parts of Sea Traffic Management (STM) that originated from four interacting sub-concepts. These four sub-concepts (enablers) followed the same phases of definition, validation, and implementation in which different strategies were adopted to realize each phase. The first initiative was in 2009 (MONALISA 1.0), which defined and demonstrated the voyage management sub-concept. MONALISA 2.0 introduced flow management as a new sub-concept building on the RTZ format, an outcome of the same project. MONALISA 2.0 also took a holistic stance in defining STM with its different enablers; voyage management, flow management, PortCDM supported by a maritime digital infrastructure, Sea System-wise Information Management (SeaSWIM), which had components of the MCP. All these components were then brought into the STM validation project, with its approach to validation of the different enablers in isolation and also from a holistic point of view in an integrated manner. The different parts of STM followed a similar procedure in going from concept definition to implementation, but the different sub-concepts are at different maturity levels. When pursuing implementations of this magnitude with their wide geographical spread and large scope, different parts of a concept will naturally be at different levels of maturity. As revealed through the emergence of the STM concept, we see the following actions have been pursued for the different sub concepts:

- Concept innovation based on scientific foundations and in intense interaction with practice
- Use of demonstrators in authentic settings for concept validation
- Use of simulators for concept validation[2]
- Engagement in establishing a digital environment through the MCP
- Procurement, as one strategy, for implementation

[2] This effort also paved the way for the establishment of The European Maritime Simulator Network (EMSN)

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- Industrial partnerships for supporting the implementation of products building on the different enablers of STM

These actions matured the different concepts for implementation. In the following section PortCDM and the MCP are used as illustrative examples to discuss how the journey has been pursued to advance concepts to their current maturity level and also to elaborate on which actions should be pursued to achieve the next level of maturity.

Introducing Port Collaborative Decision Making (PortCDM)

PortCDM was introduced into the maritime sector to improve the productivity of a port call. It is one of the enablers of Sea Traffic Management (STM) concept introduced within MONALISA 2.0 to meet the demands of efficient, safe, and environmentally sustainable sea transport berth-to-berth. This followed the need for ships to be able to communicate with a port for just-in-time arrivals and ensure that the right capabilities were established to serve ships transitioning from voyage management, one of the enablers of STM demonstrated in MONALISA 1.0 (2009-2012).

After the initial definition of PortCDM within MONALISA 2.0 (2013-2015), the idea was demonstrated at the ports of Gothenburg and Valencia. This paved the way for a larger demonstration effort within the STM Validation project (2015-2018), the largest ever e-navigation project. During this project, PortCDM has been further validated and refined to meet the desires and demands identified by the shipping and port communities.

PortCDM focuses upon standardized collaboration, on operational and technical levels, to create a common situational awareness within four interaction areas (ships and port, between ports, between port call actors, and between ports and hinterland operators). Among other deliverables, PortCDM introduced a proposed port call message format for sharing spatial-temporal planning and actual data among these four interaction areas. The development of this format has been substantially informed by use of the PortCDM demonstrator, a prototype that enables stakeholders to explore the use of PortCDM and give feedback. Successively, more and more features have been built into the demonstrator, and thereby informed concept development, bringing the demonstrator to an appropriate technology readiness level for achieving an industrial uptake during the implementation phase.

During the STM Validation project, different industrial players, both as potential customers and providers, have shown a strong interest in PortCDM. A major concern, however, is to ensure a robust governance structure that ensures efficiency gains from

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the solutions developed and produced, Also, it should verify that expected benefits are highly future proof and internationally adaptable. As part of the work packages of the STM Validation project, an international PortCDM council, with representatives from many large organizations (associations, authorities, ports, and industrial players), was established.

Introducing the Maritime Connectivity Platform (MCP)

The birth of the MCP dates back to the EU project, EfficienSea (2009 – 2012). This was one of the first large projects to focus on e-navigation, as conceived by the IMO a few years earlier. The philosophy of the project was that e-navigation would have a huge impact on the maritime domain and all its stakeholders. Therefore, the aim of the project was to begin early development of e-navigation in order to prepare its participating organisations for this change, and to facilitate the actions required to harvest the benefits of e-navigation as early as possible.

During the course of the project a number of different prototype e-navigation services were developed, as was an E-navigation Prototype Display (EPD) for using these test services.

During this work of practical development and promulgation of prototype e-navigation services, it was realised, that in order for e-navigation to be efficiently implemented world-wide, a global communication framework was needed. This was the clue to the concept of the MCP (or the Maritime Cloud as it was initially called). A description of the MCP can be found at www.maritimeconnectivity.net.

After the end of the EfficienSea project, the development of a prototype instance of the MCP was included in new projects focusing on e-navigation, most notably the ACCSEAS project and MONALISA 2.0 project with collaboration with KRISO (Korean Research Institute of Ships and Ocean Engineering) and KMOU (Korean Maritime and Ocean University). At this phase, the MCP was also proposed as the operational part for the interoperable digital infrastructure to be used in the test beds in the forthcoming STM validation project.

The next big step in the evolution of the MCP was the establishment of three large projects; the EfficienSea2 project (EU), the STM Validation project (EU) and the SMART Navigation project (South Korea). From the beginning, it was decided that all projects would base their services on the MCP and that they would collaborate on the development of the MCP. This brought the MCP to a very mature state as an advanced

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prototype global testbed for e-navigation services. Stakeholders outside the projects (such as China MSA and Australian AMSA) were also given access in order to make experimental developments of e-navigation services on the platform.

Having achieved prototype maturity, the next inevitable and most difficult step is making the MCP operational. At the highest level, this requires two things to be in place;

1. An operational instance of the MCP
2. A trustworthy governance structure for the MCP

As the project owner of the SMART Navigation project and a strong supporter of the MCP, the Ministry of Oceans and Fisheries of Korea (MOF) has vowed to establish an operational instance. Furthermore, members of international organisations (such as IALA, CIRM and BIMCO) will be invited to get access to this MCP instance, thus opening of for the possibility of the MCP becoming the de-facto platform for information exchange and service provision in the maritime domain (i.e. e-navigation, e-maritime and beyond).

Governance has been to a topic of many difficult discussions over the years. Several organisational constructions for taking over the governance of the MCP after the aforementioned projects, has been proposed. Different ambition levels have been discussed, ranging from forming a MoU between organisations dealing with the MCP, to establishing a MCP foundation or getting an existing international organisation to take the responsibility. The organisations behind the platform have decided to aim for the establishment of a consortium as a practical and feasible compromise of these different possibilities. It is the intention to form the consortium with a structure similar to the World Wide Web consortium (W3C).

It is planned that in 2018, both an operational MCP instance and the MCP consortium (MCPC) will be established.

From concept definition to implementation – an interplay between research and practice

As can be revealed from the two cases, there are some necessary efforts to advance concepts towards implementation. In both cases the research conducted has been influenced by:

- innovation on scientific foundations, engagement with practice through action and design research, and
  implementing concepts in concert with intense interactions with customers and suppliers reporting the effects of putting concepts into practice in testbeds

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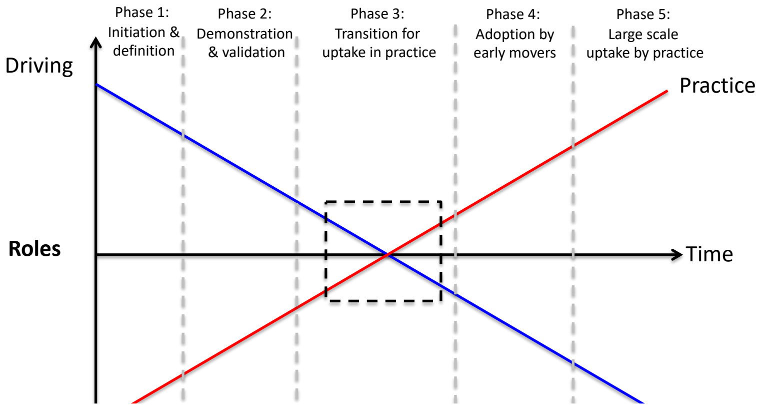

Figure 2: Division of the process from concept idea to implementation as an interplay between research and practice

The two cases show how arguments have been provided for the different concepts by a strong engagement by research organizations. These initiatives can be divided into five phases (see the figure 2 on left).

As shown in the figure, it is appropriate for a research organization to undertake a driving role in the beginning and a more advisory and evaluative role at the end of a project following different phases. These phases constitute the definition/validation/ implementation effort, in which different actions are taken and adopted for bringing the Sea Traffic Management concept into practice.

A crossover occurs when research and the practice shift roles. The research champion hands over the responsibility to the practice, and it then explores new capital creation opportunities provided by elaborating the concept or associating it with other concepts. In this phase, it is also important that structures are created to create long-term assurances for key stakeholders and developers. The MCPC and the international PortCDM council are two examples of such institutions. In the table below, actions pursued and planned for are captured for each of the two cases. The different phases are related both to "Technical Readiness Levels" (TRL) as well as "Operational Readiness Levels" (ORL). Both in combination define the phases or maturity levels PortCDM and the MCP pass through during their implementation.

Phase	PortCDM	MCP
Phase 1: Initiation & definition	Definition and first demonstration in MONALISA 2.0 (2013-2015)	Concept coined and described at the end of the EfficienSea2 project around 2011.
Phase 2: Demonstration & validation	Validation by use of a demonstrator in authentic settings and concept refinement in STM Validation project (2015-2018)	First prototype developed, tested and demonstrated in ACCSEAS and MONALISA 2.0 projects and in collaboration with KRISO (Korean Research Institute of Ships and Ocean Engineering) and KMOU (Korean Maritime and Ocean University)

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Phase 3: Transition for uptake in practice	Establishment of International PortCDM council, standardization of the port call message format (S-2xx), early adopters showing interest (2017-2018)	Establishment of the MCDF (Maritime Connectivity platform Development Forum). This forum consisted of partners/organizations collaborating on the development of the MCP within three projects; EfficienSea2, STM Validation project and the SMART Navigation project. A mature prototype of MCP was developed in this phase as part of a global digital maritime testbed.
Phase 4: Adoption by early movers	First industry players are building tools based on the concepts developed so far and plan to update those as soon as more details are agreed upon. First ports are working on implementing the PortCDM concept.	Establishing the Maritime Connectivity Platform Consortium (MCPC). Implementing MCP Infrastructure on a limited scale.
Phase 5: Large scale uptake by practice	Expectation is that IALA will adopt a S-2XX standard for Port Call Messages. IEC is considering referencing this standard in IEC standards. This will enable broad scale implementation in tools for ship and shore. At the same time it is expected that more ports will engage in PortCDM through the provision of different solutions by the industry.	Possibly establishing the Maritime Connectivity Platform Foundation or having an existing international organization taking over the MCP, if deemed beneficial or necessary. Implementing MCP Infrastructure for international use.

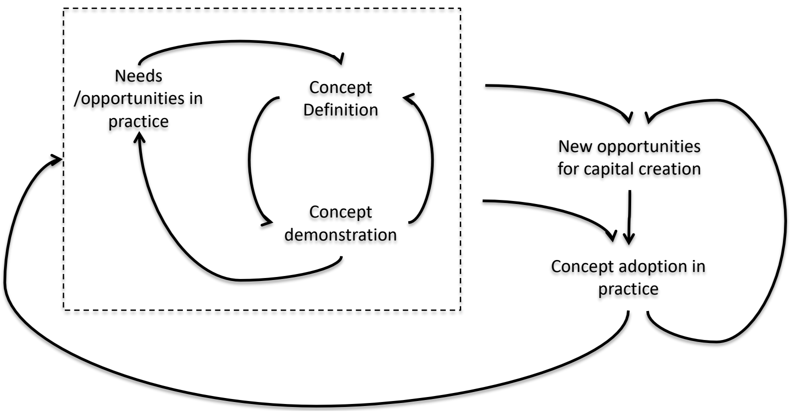

Figure 3: Continuous development of concepts informed by the use of demonstrators in authentic settings and needs from the adoption in practice

In figure 3, the concept development process is elaborated from the identification of different needs toward qualifying the concept as contributing to new opportunities of capital creation in practice. Demonstrators in authentic settings (such in test beds) are highly important to both provide interest and arguments for an uptake by the practice. A testbed is a real-life environment in which actors collaborate to test concepts. A demonstrator is a software prototype of concepts under testbed validation.

The process of this integrated interaction between concept development, identifying the needs and opportunities in practice, and concept demonstration informs further development of the concept until there is a sufficiently robust argument for concept introduction. Many times, demonstrator development is done to generate a level of technology readiness level (see table above) for practice to take over and bring forward by its own resources. At the point when the concept is adopted in practice, it also becomes highly important that the integration between research and practice is kept alive for the continual concept refinement. This would be pursued in roles such as the practice providing feedback on use to research as well as research taking an advisory role to organizations that adopts the concept.

Final words – innovation through concept development

PortCDM, and the MCP, as concepts, would not have been accepted by industry if they did not meet their requirements and create value by improving capital productivity. Both have now sufficiently progressed so that industry is encouraged by their further possibilities. This enhancement in maturity of the two concepts is necessary to enable the realization of synchronization between the different pieces of STM.

The concepts discussed have established a sufficiently solid foundation to encourage the transition to the next phase. Even in the latter phases there will be a need to continue the interplay between research and practice. As one example, inspired by other actions for moving STM towards implementation such as when bridge simulators were used, there is an opportunity to enable ports to explore PortCDM's impact before making major investments. If we were to build a port simulator and use AIS data related to a port as input, we could simulate different rules for operating a port's services and assess productivity changes. Port operators could participate in joint simulations, so they can learn the impact of their decisions on other actors. Rules tested would be grounded in theory related to logistics and constraint management to make simulation testing efficient and fruitful. Another area of further concept development is expansion towards hinterland operations as well as adopting the same concept for other modes of transport / transportation hubs. Moving PortCDM forward in this manner is another illustration of how the roles of research and practice can vary over time to continually strive for efficiency, sustainability, and safety in maritime transport berth-to-berth.

Within the MCP, a similar interplay between research and practice will be exercised in the future. This will be particularly visible because the different modules of MCP are at different maturity levels. Thus, some modules will still have a heavier research

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component, whereas others are more mature, and further development is more dependent on practical use and feedback from actual users and industry implementers.

STM as a whole, as well as PortCDM and the MCP are means for raising capital productivity in the maritime sector by enhanced connectivity and information transparency among stakeholders. Concepts being developed need a solid design vision and a road map for implementation in the maritime industry. This needs to take into account both the current state of the maritime sector and the gains from implementing the new concept. The study of concept maturity and implementation can reveal the behavioural patterns of individuals and organizations in the self-organizing ecosystem of the maritime sector. This knowledge is needed to increase the success rate of the intended implementation of concepts and to ultimately increase capital 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

Thomas Christensen, SNPO; MCP point of contact, +45 40 92 31 30 or thomas@dmc.international

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