International meeting for MASS infrastructure

Tokyo, JAPAN
12-14 February 2020

Executive summary

The international meeting for maritime autonomous surface ships (MASS) infrastructure was held from 12th to 14th February 2020, hosted by the Japan Coast Guard at its Headquarters in Tokyo. The experts on MASS and shore maritime infrastructure including marine aids to navigation from Canada, Finland, Netherlands, Norway, the International Association for Marine Aids to Navigation and Lighthouse Authority (IALA) and Japan participated in the meeting.

The purpose of the meeting was to provide guidance to shore authorities for the development of their strategies that could accommodate safe and efficient MASS operation in future.

The meeting was started with presentations made by the participants on policies, studies, testbeds regarding development of MASS and associated infrastructure in each country in order to exchange knowledge and experience on MASS among participants. Following the presentation, the participants discussed various aspects of infrastructure that enabled safe and efficient MASS operation such as visual, radio, audible and virtual aids to navigation (AtoNs), vessel traffic services (VTS), new infrastructure and radiocommunication. The meeting developed the recommendation to IALA to be attached to this executive summary.

RECOMMENDATION

THE MEETING,

RECALLING that IALA has significantly contributed to safety and efficiency of navigation and protection of marine environment through harmonizing AtoN services and infrastructure worldwide;

RECOGNIZING that there are many studies, projects and testbeds on MASS conducted in the world but mainly focused on onboard systems and automation aids;

RECOGNIZING ALSO that MASS has varying degrees of automation or levels of autonomy from a smart ship with seafarers onboard or a remotely controlled ship to a fully autonomous unmanned ship;

RECOGNIZING FURTHER that human supervision is always necessary for safe and efficient MASS operations regardless of the degree of automation or level of autonomy;

HAVING OBSERVED that in addition to the onboard systems, shore infrastructure including AtoN is also essential for safe and efficient MASS operations;

RECOMMENDS THAT

1. *Existing visual, radio, audible and virtual AtoNs can contribute to forming a suitable platform of complementary and enhanced services for MASS and IALA should initiate studies on the usage of such existing AtoNs with a goal of developing new technologies and policies;*

2. *VTS should retain its principle services for all vessels but enable sharing information with MASS by digitizing and possibly extending the services and IALA should consider revising the Recommendation V-145 "Inter-VTS exchange format service" to include exchanges with MASS shore control centers (SCCs) and other allied services;*

3. *The human-machine interface of the SCC is a key component that is required for safe MASS operations and IALA should study how existing and emerging technologies can satisfy e-navigation user requirements;*

4. *Robust radiocommunication infrastructure is indispensable for MASS and IALA*

should develop guidance materials for the use of VHF Data Exchange System (VDES) and other potential technologies such as 5G, while taking cyber security issues into consideration; and

5. *IALA should consider updating the e-Navigation testbed web-site to include information on MASS operations testbeds to support the development of new infrastructure.*

Report of International Meeting for MASS Infrastructure

1. Overview

The international meeting for maritime autonomous surface ships (MASS) infrastructure was held from 12th to 14th February 2020, hosted by the Japan Coast Guard at its Headquarters in Tokyo. The group of experts on MASS and shore maritime infrastructure including marine aids to navigation from Canada, Finland, Netherlands, Norway, the International Association for Marine Aids to Navigation and Lighthouse Authority (IALA) and Japan participated in the meeting. The participant list is attached as Annex 1.

Photo

2. Opening of the meeting

On behalf of the Japan Coast Guard, VADM TAKASUGI Norihiro, Director General, Maritime Traffic Department welcomed the participants. The photo above shows the participants of the meeting.

3. Presentations

3.1. Canada

Dr. Kevin HEFFNER made a presentation about Canadian MASS development and shore control center as a MASS operator.

The 21st century has been marked by the advent of autonomous ground, air and maritime surface and underwater vehicles. The IMO MASS scoping activity is identifying needed changes to existing regulation while IALA has been developing a set of technical products and specifications that can contribute to the safe introduction of MASS operations as an integral part of the maritime transport industries. E-Navigation is defined as the harmonized collection, integration, exchange, presentation and analysis of marine information on board and ashore by electronic means to enhance berth-to-berth navigation and related services for safety and security at sea and protection of the marine environment. In terms of presentation and analysis of information, E-Navigation specifies the need to employ human-centered design approaches to ensure high usability with the goal of achieving and maintaining shared situational awareness that can adequately inform critical decision-making.

MASS operations will require shore control centres (SCC) where captains and other crew will remotely monitor and operate vessels. SCC will need to establish reliable and well-defined information flows to VTS systems throughout the vessel operation and will also need to provide shared situational awareness to the remote vessel crew while avoiding the situation of information overload.

This presentation considers the human as the decision-maker during MASS operations but allows for varying levels of human supervisory control, made possible using automation. This presentation advocates the use of a 3D immersive virtual environment as an efficient integration platform and visualization system for rapidly creating SCC aimed at supporting the needs of the human decision-maker, first and foremost for testbed validation activities. The acuity and accurate depth-perception are well-suited for activities such as berthing while the ability to pre-configure and dynamically modify the disposition of operational system displays can contribute to improving situational awareness and thereby reduce the risk of human-induced accidents. This technology also could be used for validating new VTS concepts involving higher levels of digitization. Finally, unlike alternate immersive technologies such as headsets and wall displays, the technology presented does not have adverse side effects and provides benefits that render it well-suited for operational use and therefore could be an integral part of future SCC and potentially port operations centers, security operations centers and maritime traffic control centers hosting VTS. The copy of the presentation is attached as Annex 2.

3.2. Finland

Mrs. Kaisu HEIKONEN made a presentation about the situation of MASS in Finland.

In Finland, the Ministry of Transport and Communications is developing a roadmap for Autonomous Traffic. The main goal of the roadmap is to identify the regulatory actions, which would enable their development, but it also identifies some possible requirements for the physical and digital infrastructures and defines short, medium and long-term goals for the development. The draft roadmap also stresses the importance of cybersecurity.

Identified requirements for the infrastructure include further development of AtoN technology in relation to the intelligent fairway concept (e.g. new sensors and functionalities) and the need for increased connectivity in fairways (e.g. 4G/LTE, 5G). The copy of the presentation is attached as Annex 3.

3.3. Netherlands

Mr. Maarten BERREVOETS made a presentation about MASS and VTS in the Netherlands; challenges to beat.

New generation MASS ships (or digitalized to a certain level) will be sailing the world and somewhere someone will keep responsibility for the ship and its behavior. Solutions will have to be found that contribute to make the VTS system even safer with full detection and visibility, interacting objects and advanced decision support.

Ship navigation and vessel traffic services are all about save sea and port passages, including the environmental aspect. VTS of the future will be more about enabling information exchange and interactions than sending messages. Full detection and visibility, interaction objects and advanced decision support are key words.

In the Netherlands we see a difference for sea/coastal MASS and inland MASS.

Two examples:

The Port of Rotterdam started a project called VTS Innovation Lab. Within this program pilots are initiated to gain more information from all kinds of data from CTV camera, LIDAR, AIS and radar sensors and explore the possibilities to get a better object detection and tracking rate within the VTS system.

Rijkswaterstaat, responsible for the inland waterways is now testing the use of floating drones. Drones are unmanned, remote-controlled vessels. One of the goals is to come to data driven corridor management to reduce the waiting time for locks and a better prediction of the ETA. Drones will be used in the future for inspections, both under water and on the water.

Legislation has to be changed, because up to now the use of unmanned ships is not permitted. The copy of the presentation is attached as Annex 4.

3.4. Norway

Mr. Tony HAUGEN made a presentation on Smart Ships, Maritime Autonomous Surface Ships – MASS and the supporting infrastructure.

“The maritime industry is facing a major transformation – new technologies and digital solutions are reshaping what is possible, and supported by new regulations, this will enable smarter, more efficient, safer and greener operations”, making maritime transport operations more competitive.

Smart ships will include the ship into a global logistics chain.

The smart ships / MASS are coming, and we need to adapt to this change with smart infrastructure in order to optimize its operation.

We must ensure that Smart ships / MASS is implemented safely. One incident will be a major set-back.

Infrastructure is needed both to optimise the benefits from MASS transport operations, and very important for the safe introduction of MASS in general. The copy of the presentation is attached as Annex 5.

3.5. IALA

Mr. Minsu JEON introduced the preliminary perspectives of IALA on MASS. He introduced the levels of autonomy and its envisaged possible effects on AtoN and VTS authorities.

Few possible MASS situational awareness enhancement options of conventional AtoN such as optical communication, micro flickering and virtual AtoN were proposed. And he stressed that when GNSS signal is spoofed or jammed, through integrity monitoring, MASS should switch position fix using the landscape and visual AtoN as robust infrastructure.

Communication methods between VTS, SCC, MASS and conventional ships should be discussed and harmonized. He underlined the importance of risk assessment and that VTS would act as a front office to MASS and the VTS centers and operators with MASS testbeds in their jurisdiction may contribute looking to the future. The copy of the presentation is attached as Annex 6.

3.6. Japan

Mr. URANO Yasuhiro from Maritime Bureau, MLIT explained its view that MASS, based on conventional ships, would evolve with the development and introduction of new technologies in a phased manner - specifically, phase 1: systems support decision-making by onboard crews, phase 2: systems propose concrete actions to crews and automatically execute actions under the crews' approval, and phase 3: some functions are conducted automatically by systems without human involvement.

Japan's roadmap of MASS, published in June 2018, was introduced. Along with the roadmap, Japan aims at achieving the realization of phase 2 MASS by 2025 and has started developing domestic safety guidelines to prepare for establishing an appropriate environment for trials of MASS technologies. Taking into account that it would be necessary to collect various data and lessons learned from private companies for developing such guidelines, Japan adopted three projects for trials of MASS technologies, in particular, on autonomous navigation/collision avoidance, remote control navigation, and automated berthing.

It was announced that Japan has published the safety guidelines for remote-controlled small vessels in April 2019 to promote the use of such vessels in various fields by making the application of the current national regulations clearer. Japan mentioned that, besides the three-phased approach, technologies for larger MASS may also evolve from those of such small vessels. The copy of the presentation is attached as Annex 7.

4. Discussion

4.1. Visual, Radio, Audible and virtual Aids to Navigation (AtoN)

The expert from Canada kindly introduced the presentation on virtual AtoN that was originally made by the U.S. Coast Guard and included simulation of the use of virtual

AtoN in MASS operation. The group shared information about the effectiveness of permanent use of virtual AtoNs. They are useful not only for MASS, but also for conventional ships operating under harsh environmental conditions such as extreme weather (ice hazards, high waves, etc.) or geographic features such as deep waters, although there are challenges like cyber security and jamming.

The group recognized that visual, radio and audible aids to navigation were used all over the world. Many new technologies have been developed and enable MASS to detect the aids and the information and signals relayed by these aids, using, for example, thermal sensors, night vision cameras, optical cameras, radars and microphone arrays. But the use of these technologies should consider the environmental impact, such as sound that can be harmful to marine mammals. Integration of these technologies should also consider cyber security risks. It was noted that it may be useful to consider using micro-flickering characteristics of visual AtoNs in order to improve their detectability by MASS. These physical AtoNs could constitute a suitable infrastructure for MASS operations incorporating such technologies and should be the subject of further development.

The group also discussed PNT issues and agreed that radio navigation systems such as R-Mode, e-Racon could be useful for MASS operations. Provision of GNSS integrity information is another challenge. Coastal states should identify ways to provide the service to MASS and conventional vessels using SBAS, DGNSS, or other augmentation systems.

4.2. Vessel traffic services (VTS)

The group discussed the future roles of VTS in MASS operations. The group agreed that VTS should support MASS operations, however VTS should maintain the core purpose of ensuring safe navigation of all vessel traffic in the area. While VTS maintain their core services, the group agreed that it could be useful to share information with MASS to improve the ability to share the common operational picture of the area. In order to facilitate information sharing, VTS should be digitized. In that sense, IALA should consider revising the Recommendation V-145 “Inter-VTS exchange format service” to include exchanges with MASS Shore Control Centers (SCCs) and other allied services. The group also agreed that the VTS authority should perform a risk assessment before conducting MASS trials within their area of responsibility.

4.3. New infrastructure

As for SCC, the group agreed that human supervision is required at all levels of autonomy of MASS and the human-machine interface is a key component for ensuring safe MASS operations. In other words, the human should never be totally absent or act purely as an observer; a human always remains responsible for operations at all times, even if they are highly automated. The group considered that the SCC itself should

become the subject of testbed activities, consistent with the human-centered design approach and user requirement specified as part of e-Navigation.
The group suggested that before defining the requirement for shore-based sensors, it is necessary to perform a risk assessment based on expected traffic in the designated areas. The group also noted that conventional sensors used by VTS, e.g. radar, AIS and cameras, were also useful for developing shore-based sensors for supporting MASS operations.
The group agreed that in order to achieve an efficient logistic chain involving MASS, consideration of intermodal transport modes is important. For this, harmonization of data models of different sectors such as WCO, ISO, UNECE and IMO will be the key. The group also noted that intermodal transport involving MASS operations requires interoperability across transport modes such as sea, rail, road and air, and could include coordination with intelligent transport system standardization initiatives. It was also noted that the port has become a central focus of the logistic chain, e.g. single window, port call optimization toward ensuring just-in-time operation. But the group recognized that integrating the land with maritime transport needed considerable time and effort.

4.4. Radiocommunication

The group agreed that radiocommunication infrastructure for MASS operation should be robust and redundant and IP based communication was important. The group recognized that VHF Data Exchange System (VDES) could be the most feasible at this moment, but new technologies could also provide good technological solutions when higher bandwidth is required. The group noted that VDES was not good at remote control, but good for information sharing. The group considered that for developing radio communication infrastructure, care should be taken concerning cyber security issues and the standardization of communication.

4.5. Any other business

The group considered the use of IALA e-Navigation testbed web page to include various MASS testbeds conducted in the world. While recognizing that IALA website was established for coastal states and shore services, the group considered that such MASS testbeds page could be very useful for developing its policy on AtoN services preparing MASS operations in the future and agreed to recommend IALA to develop such pages.

5. Report and recommendations

The group reviewed the draft report and recommendations, and agreed to submit the outcomes to IALA. The copy of the recommendations is attached as Annex 8.

6. Closing

The RADM AWAI Tsuguo expressed his deep appreciation to all the participants for their active discussion and contribution through the program. He mentioned that all participants have been working together as a team for MASS development and he hoped that they further continue productive discussion. He thanked Commanded Noguchi for his excellent chairmanship as well as hard work of the JCG staff who supported the program in the background. The chair wished participants’ safe back home and closed the meeting.

Annex. 1

Participant list

Dr. Kevin Seth HEFFNER	Canada	Computer Research Institute of Montréal	Associate Director
Mr. Fernando PETRUZZIELLO	Canada	Qube-4D Ventues	Senior Design Engineer
Mrs. Kaisu Anneli HEIKONEN	Finland	Finish Transport Infrastructure Agency	Senior Technical Advisor
Mr. Maarten Daniel BERREVOTES	Netherland	Ministry of Infrastructure and the Environment	Senior Policy Advisor
Mr. Tony Idar HAUGEN	Norway	Norbit Aptomar	Chief Sales and Marketing Officer
Mr. Min Su Jeon	IALA	International Association of Marine aids to navigation and Lighthouse Authorities	Technical operations manager
Mr.URANO Yasuhiro	Japan	Maritime Bureau, Ministry of Land, Infrastructure, Transport and Tourism	Deputy Director
Radm. AWAI Tsuguo	Japan	Administration Department	Deputy Director General
Capt. SHIMURA Tsutomu	Japan	Maritime Traffic Department, Japan Coast Guard	Director
Cdr. NOGUCHI Hideki	Japan	Maritime Traffic Department, Japan Coast Guard	Deputy Director
Lcdr. ANDO Mio	Japan	Maritime Traffic Department, Japan Coast Guard	Section chief

Reconfigurable Control Centres for MASS Testbeds and MASS Operations

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CRIM

IMAGINE 4D

International Meeting for MASS Infrastructure

Hosted by Japan Coast Guard – 12th-14th February 2020

Motivation for MASS & Smart Shipping

- Reduce costs for transportation of humans and goods.
- Increase supply chain efficiency
- Improve maritime safety
- Protect the environment

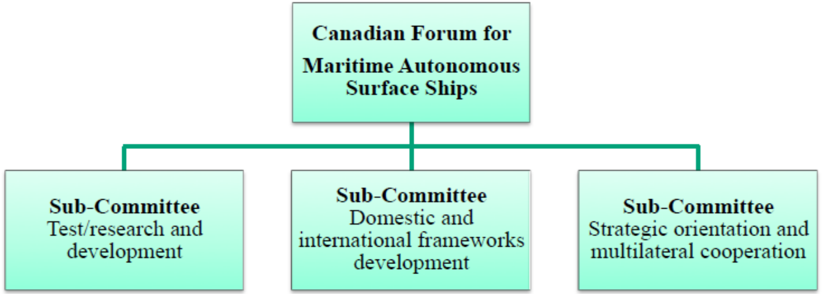
Supply Chain

Canadian MASS & Smart Shipping Initiatives

Canadian Forum for Maritime Autonomous Surface Ships

Canadian Forum for Maritime Autonomous Surface Ships

- Through our engagement efforts, Canadian public and private stakeholders expressed the need for a Forum to:
  1. Foster a Canadian approach to support the MASS development and implementation
  2. Strengthen co-operation among Canadian public and private stakeholders
  3. Be a Canadian consolidated voice
  4. Collaborate and exchange with national/international counterparts fora
- Forum launched on April 11, 2019
- To support the above four pillars, the Forum is composed of three Sub-Committees that have distinct functional areas



Chaired by Transport Canada

Transport Canada

Representation from:

- Federal and Provincial Governments
- Ports & Pilots
- Shipowners & Operators
- Technology Providers
- Research Community

INTER-AGENCY COOPERATION

To support he recommended approach for Canada and MASS

National Research Council Canada
Conseil national de recherches Canada

Canada

Quebec Saint-Lawrence Seaway: Intelligent Maritime Corridor

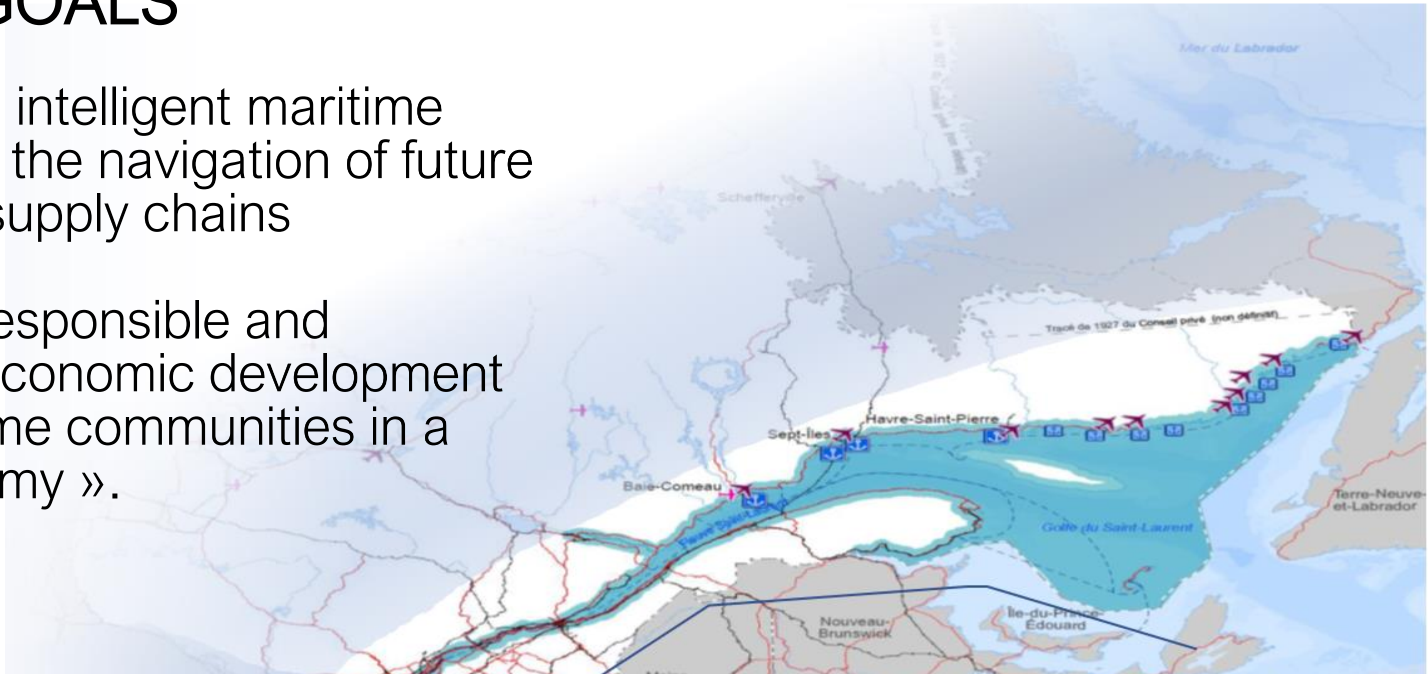
Maritime Vision for Economic, Social Development & Environmental Protection

QUEBEC SHARED MARITIME SERVICES INFRASTRUCTURE

GOALS

1. Develop an « intelligent maritime corridor » for the navigation of future vessels and supply chains

2. Stimulate a responsible and sustainable economic development by the maritime communities in a « blue economy ».



https://www.transports.gouv.qc.ca/fr/ministere/role_ministere/colloques-congres-conferences/tournee-secteur-maritime/Documents/brochure-Strategie-maritime.pdf

Montreal Smart Port Initiatives

Smart Ports: Piers of the Future

Smart Ports: Piers of the Future 2019 | Antwerp | Hamburg | Los Angeles | Montreal | Rotterdam | Barcelona

Port of Montreal receives C$300M funding boost for new container terminal

Montreal Initiates Next Phase of Terminal Expansion

Port of Montreal Joins Maersk Blockchain

Canada Continues Maritime Transformation

ChainPORT Leading world ports gather in Montreal

INNOVATION SUPERCLUSTERS

Supply Chain scale.ai

CANADA'S OCEAN SUPERCLUSTER

CANADA'S DIGITAL TECHNOLOGY SUPERCLUSTER

ChainPORT Projects

- Digital 3D Port Model
- Port Monitor
- Smart Railway Switch
- Sharing Port Information
- Smart Sounding Table
- Road Traffic Simulation System
- Virtual Gates
- Port Links (CO_2 emissions)
- Internet Infrastructure
- Cyber Security Center
- Single Window
- Data Analytics Dashboard
- Surveillance Drones
- Push Communication
- Trucking Portal
- Smart Port Challenge
- River Navigation
- Remote-Controlled Infrastructure
- Barge Traffic System
- Gas Detectors

Some Port of Montreal Focus Areas

- AI-powered container inspection
- Digital Twin Modelling
- Automated labor dispatch
- Port Security
- Predictive Analytics using Machine Learning

Control Centres at the centre of the MASS Ecosystem

Control Centres for future Maritime Transport Operations

Focus on Testbeds & Pilot Projects

OPERATIONS AND CONTROL CENTERS

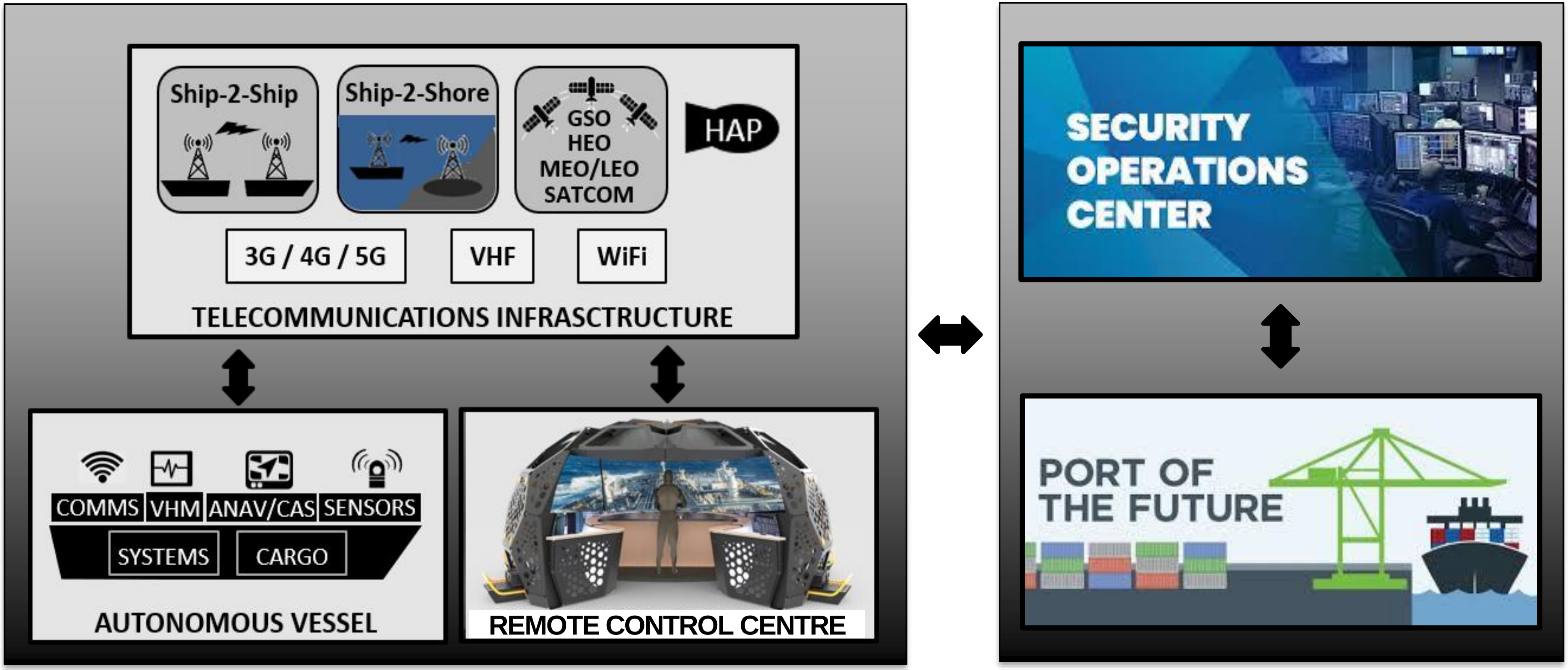
- Remote Vessel Control
- Port Operations
- Security Operations
- Maritime Traffic Control
- Search & Rescue

ACTIVITIES

- Technology Validation
- Concept Development
- Interoperability Tests
- Cybersecurity Automation

MASS Ecosystem Challenges

Securely connecting the vessel to the port and beyond



MASS Ecosystem Challenges

Insurance & Liability Perspectives

Shipowners

1. Overall function unchanged
2. Relation to remote operators
3. Goods, ship & incident Liability

Yards & System Suppliers

1. Services
2. Compliance
3. Maintenance
4. Connectivity
5. Product Liability

Remote Operators

1. Multiple operational concepts
2. Division of existing duties & obligations
3. Operator Liability

Classification Societies

1. Verification & Certification of MASS
2. Drive regulatory development

Insurers

1. Insurability
2. Risk associated with higher levels of autonomy
3. Access to operational data
4. Cyber risk management

MASS Ecosystem Challenges

A Technology Perspective

Sensory Processing → Automated onboard decisions → Data transfer → Interoperability → Human interaction

Smart sensors | AI | 5G, SatCom | Standards | AR, VR

Smart Sensors	LiDAR, Camera Arrays, RFID, GPS Synthetic Aperture Radar	**Shared Data Services**	S-102 Pilot Project, CAN Ice Services ENAV MSP, MRN Registry, MCP KOR SMART e-Nav Services STM Validation Project, Single Window
Ai	Decision Aids, Automation Intelligent Adaptive Interfaces Object/Pattern Recognition	**STD**	IHO S-100 , IMO SIP IALA S-200, MRN ISO TC8 MASS US/Canadian ITS RA
COMMS 5G	LEO Satellites Shore Antenna Arrays Ship-to-Ship, Ship-to-Shore IALA VDES	**AR 360°**	VR Headsets, Walls Domes, Immersion, 3D Enhanced User Interactions

Standardization & Interoperability

What does it mean to the Maritime Transport Industry ?

Organizational Interoperability :

The ability of groups or organizations to work together to achieve common goals.

System Interoperability :

The ability of computer systems or software to exchange and make use of information.

Technical Interoperability :

Ensures the interconnection of systems and data exchange via standardized transmission protocols and data formats.

Government Level	Economic and Regulatory Policies	Political Context
	Aligned Priorities & Focused Objectives	
Enterprise Level	Industry Goals	Organizational Interoperability
	Business Objectives	
	Aligned Processes & Procedures	
System Level	Understanding/Awareness	Syntactic & Semantic Interoperability
	Information Interoperability	
	Data Model Interoperability	
Network & Transport Level	Protocol Interoperability	Technical Interoperability
	Physical Interoperability	

Standardization can contribute to achieving interoperability.

MASS Ecosystem Challenges

Control Centre Requirements

Sensory Processing → Automated onboard decisions → Data transfer → Interoperability → Human interaction

Smart sensors | AI | 5G, SatCom | ISO IEC Standards | AR, VR

Smart Sensors	LiDAR, Camera Arrays, RFID, GPS Synthetic Aperture Radar	**Shared Data Services**	S-102 Pilot Project, CAN Ice Services, ENAV MSP, MRN Registry, MCP KOR SMART e-Nav Services STM Validation Project, Single Window
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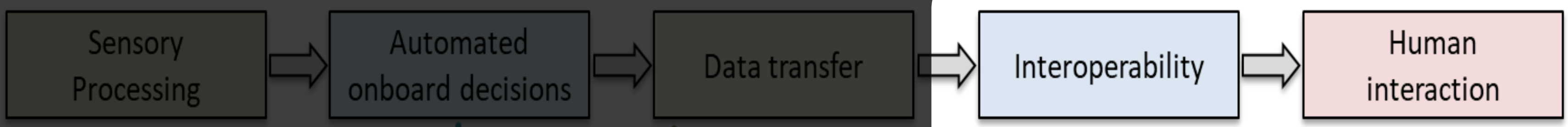
COMMS 5G	LEO Satellites Shore Antenna Arrays Ship-to-Ship, Ship-to-Shore IALA VDES	**AR 360°**	VR Headsets, Walls Domes, Immersion, 3D Enhanced User Interactions

MASS Ecosystem Challenges

e-Navigation Control Centre Requirements



IMO Strategy Implementation Plan for e-Navigation

2 of 5 Prioritized Solutions

S2: means for standardized and automated reporting;

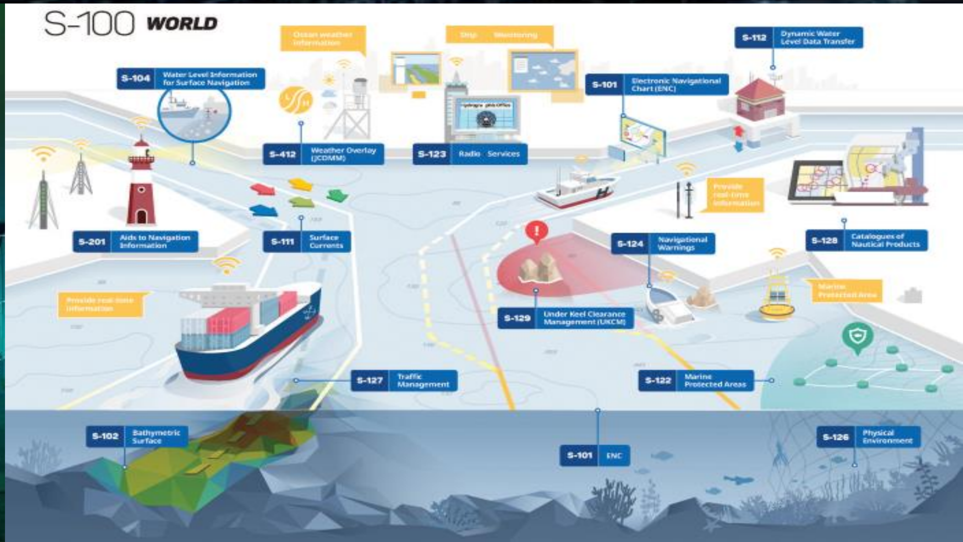
S4: integration and presentation of available information

Related Risk Control Options

RCO 4: Automated and standardized ship-shore reporting (related to sub-solutions S2.1, S2.2, S2.3 and S2.4);

RCO 6: Improved shore-based services (related to sub-solution S4.1.3 and solutionS9);

Digital Twins of Vessels, Infrastructure and Waterways



Digital Twins of Vessels, Infrastructure and Waterways

ASSIST OPERATORS AND STAFF TO PERFORM TASKS

- VTS
- Navigation
- Plan Operations
- Monitor Operations
- Inspection
- Maintenance & Repair
- Evidence-based training & emergency preparedness
- Search and Rescue
- Life-Cycle Management

S-100 Universal Hydrographic Data Model | S-200 Shore Services

Maritime Data Framework

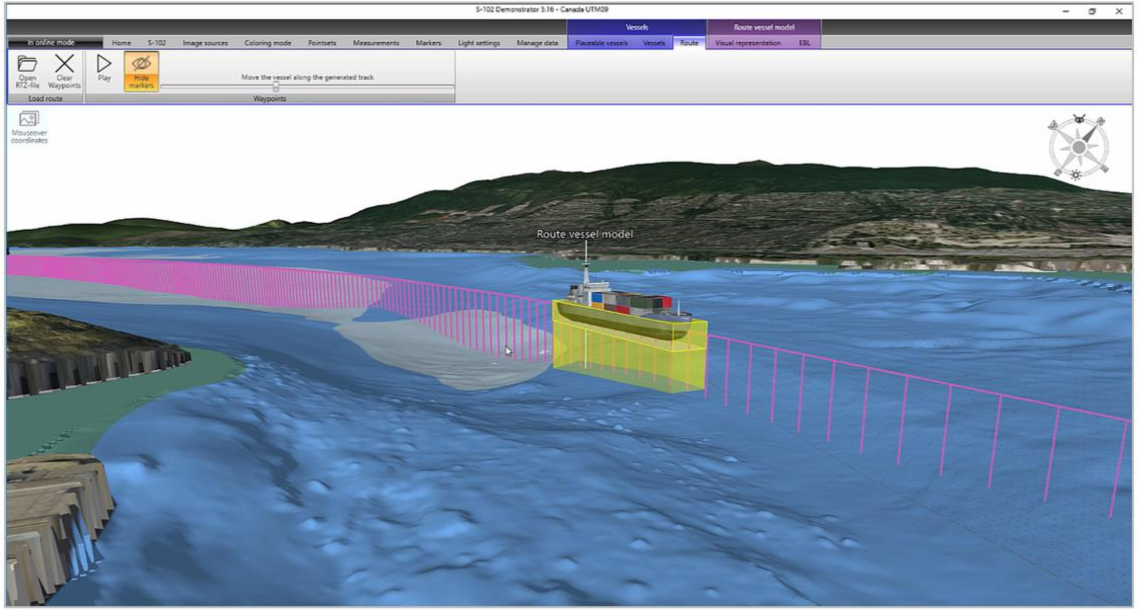
S-100 Universal Hydrographic Data Model | S-200 Shore Services

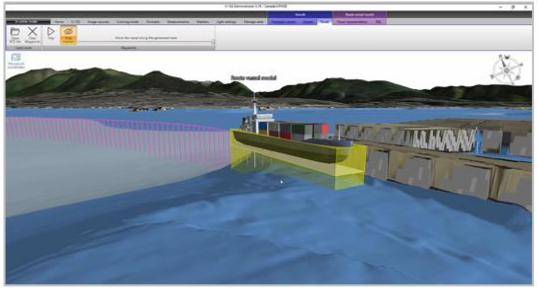
S-102 Bathymetric Data

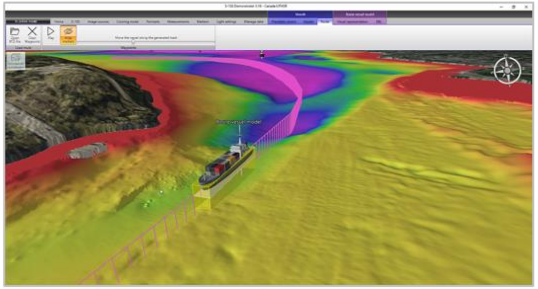
Using Digital Twins for Navigation

DEMONSTRATION SCENARIO – S-102 DATA AND THE POTENTIAL FOR e-NAVIGATION

Vancouver Harbour S-102 Datasets in Kongsberg S-102 Demonstrator







Source: S-102 Bathymetry Data as a Service Pilot Project

The Underlying Problem : Managing Complexity

Three questions :

1. What are the sources of complexity ?

2. How can AI and other technologies help to reduce complexity ?

3. What are the practical limits on using AI for safety-critical applications today ?

Safety-Critical Systems

Sources of Complexity

Operator State Monitoring
Working Environment
Dynamic Space
Operations Context

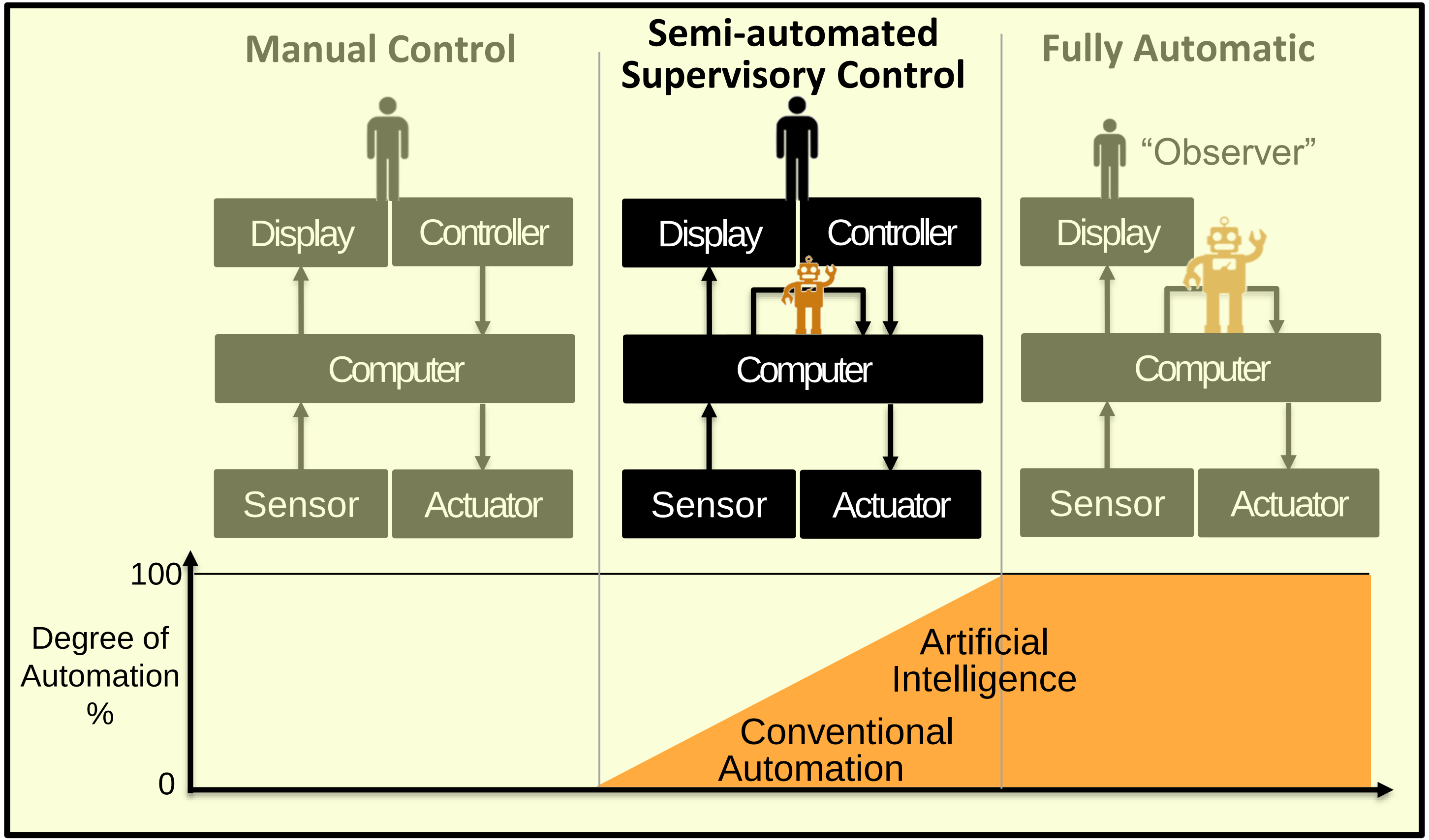
Procedures
Crew/Team Interactions
Tasking & Reporting
Authorizations

Multiple displays
Visual Overload
Excessive inputs
Trust Management

Information Overload
Prioritizing decision-making
Maintaining situational awareness

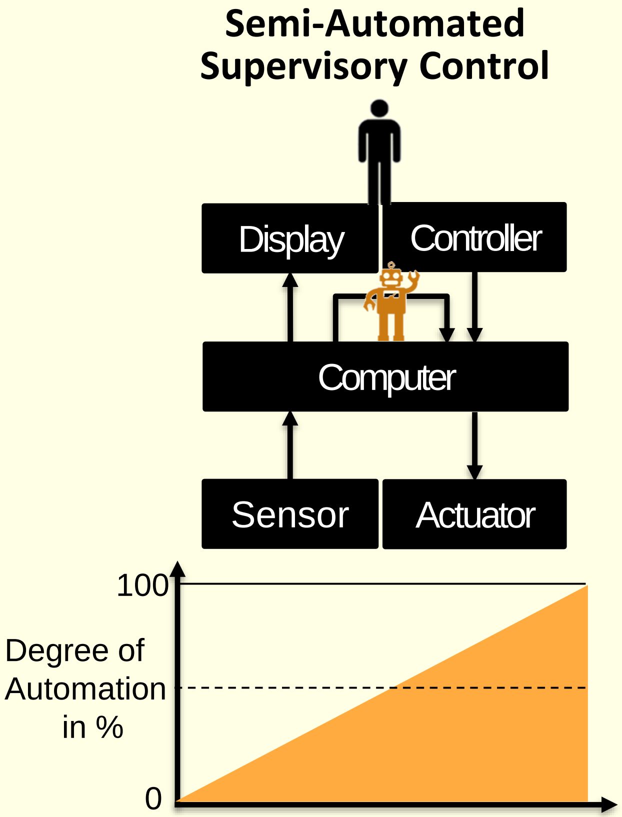
Safety-Critical Systems

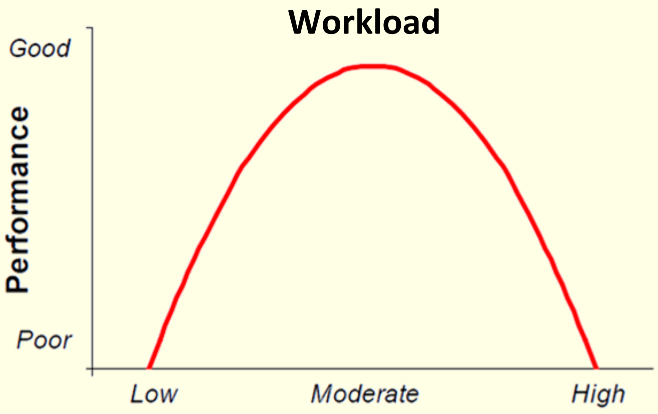
Increasing levels of supervisory control to manage complexity



Safety-Critical Systems

Optimizing human performance for decision-making





AI can contribute to maintaining optimal performance :

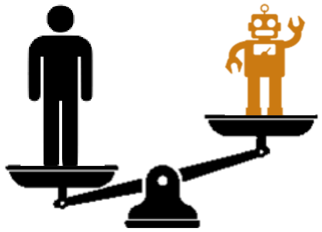
1. **E.g. by dynamically adapting the operators' displays and controls to the operational context while avoiding information overload, and**

2. **E.g. by using digital twins to extract and highlight relevant information in a 3D immersive environment to better inform decision-making.**

Safety-Critical Systems

Judicious use of Artificial Intelligence

- ✅ **Automated information flows**
- ✅ **Object detection, classification**
- ✅ **Enhanced situational awareness**
- ✅ **Predictive analytics**
- ❌ **Automated decision-making**

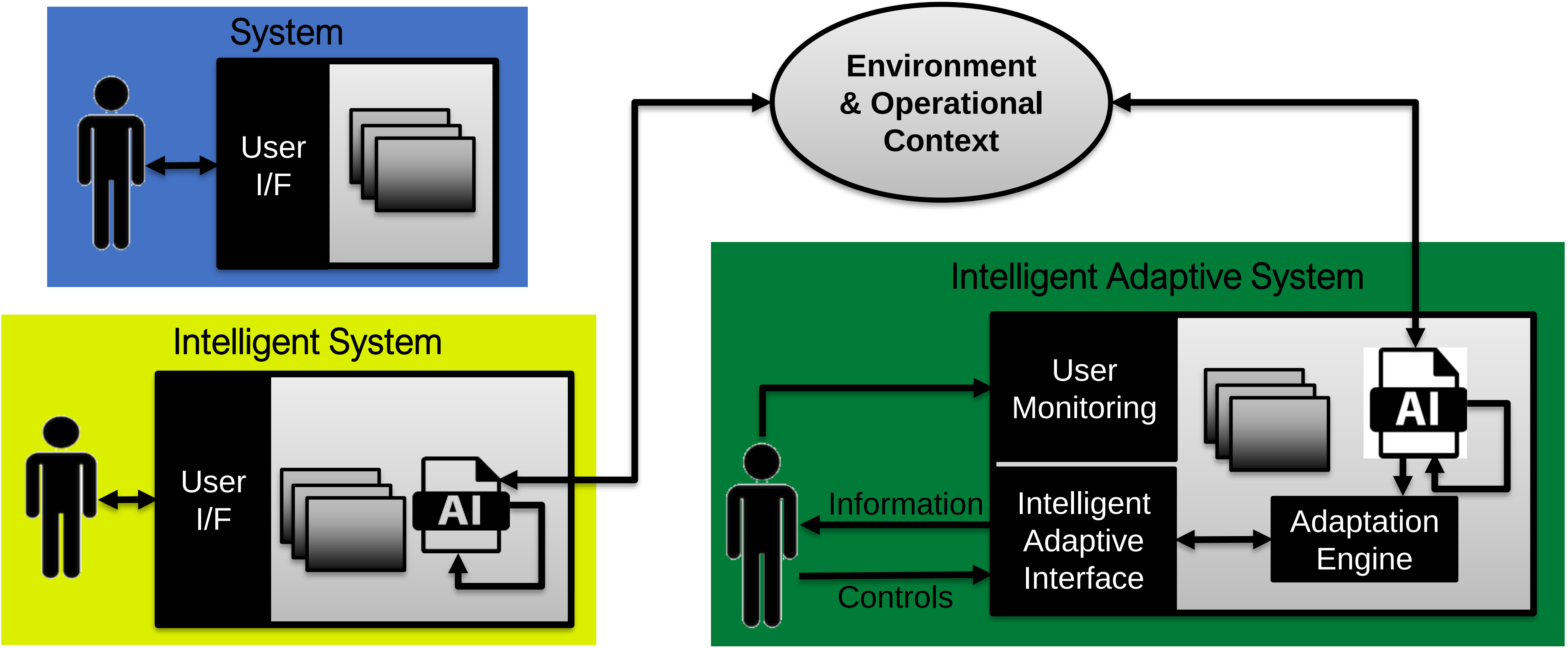


Today: *Humans are better than machines for most complex decision-making tasks.*

Short/Medium term: *Humans will remain primary decision-makers*

But AI can provide valuable decision aids and contribute to improving shared situational awareness.

System | Intelligent System | Intelligent Adaptive System



Systems that can adapt their displays and controls to the human as a function of the operator state and operational environment

MASS Ecosystem Challenges

Human-centered Decision-Making

Shared Data Services

Smart Sensors

Collect & process data,
share information

Exercise control &
make informed decisions

Maintain shared
situational awareness

MASS Ecosystem Challenges: Human Information Overload

The Need to Improve Shared Situational Awareness

EXTRACTING INFORMATION FROM SURVEILLANCE CAMERAS

Live security camera Rejkjavik Iceland
https://www.insecam.org/en/view/802373/

Live security camera Rejkjavik Iceland
https://www.insecam.org/en/view/802374/

Using Virtual Reality & Augmented Reality to improve shared situational awareness

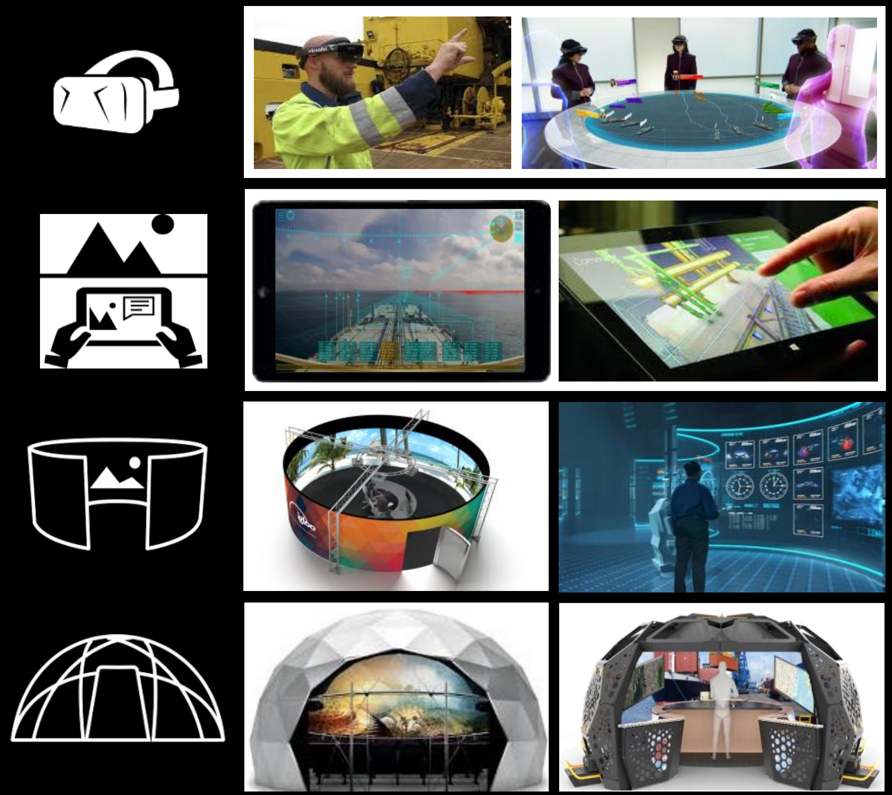
A paradigm shift: *Immersive Safety-Critical Environments for Operational Use*

3D Immersion Value Proposition: Use combination of immersion and virtualization to dynamically adapt environment to dynamic situations, including AI-assisted augmented reality, 2D virtual monitors and 3D interactive digital twins to:

1. Improve Situational Awareness
2. Reduce the risk of information overload
3. Improve operator performance
4. Enable better collaboration and coordination

Virtual Reality (VR) & Augmented Reality (AR)

What is applicable to the Maritime Transport Industry ?



- Already commercially available today
- Ubiquitous, low-cost VR/AR Headsets
- Address many (but not all) needs
- Technology gaps still exist !

SOURCE: readwrite: Feb 6, 2019
https://readwrite.com/2019/02/06/6-ways-to-implement-ar-vr-into-your-business-today/

Virtual Reality (VR) & Augmented Reality (AR)

Do VR headsets really work ?

Yes, for a subset of applications… <u>but</u>

- Depth perception limitations
- Adverse side effects
  - Nausea, headaches, dizziness, fatigue, seizures…
- Limited duration of use < 30 min.

The makers of the most popular VR headsets, the Oculus Rift and HTC Vive, recommend taking "at least a 10 to 15 minute break every 30 minutes, even if you don't think you need it."

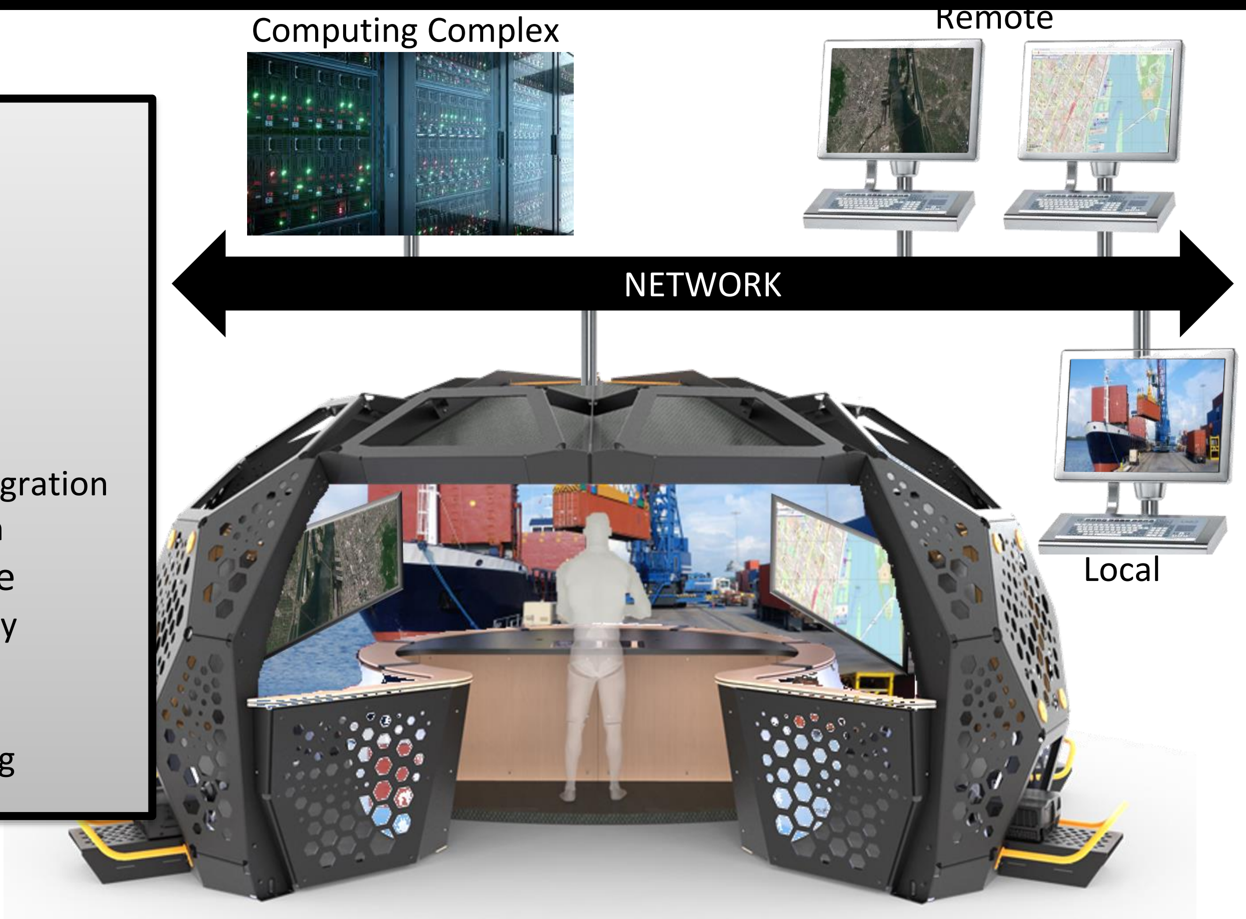
SOURCE: Business Insider, Mar 4, 2018, https://www.businessinsider.com/virtual-reality-vr-side-effects-2018-3

A Reconfigurable Control Center for Testbed Applications

System-System and Human-System Integration

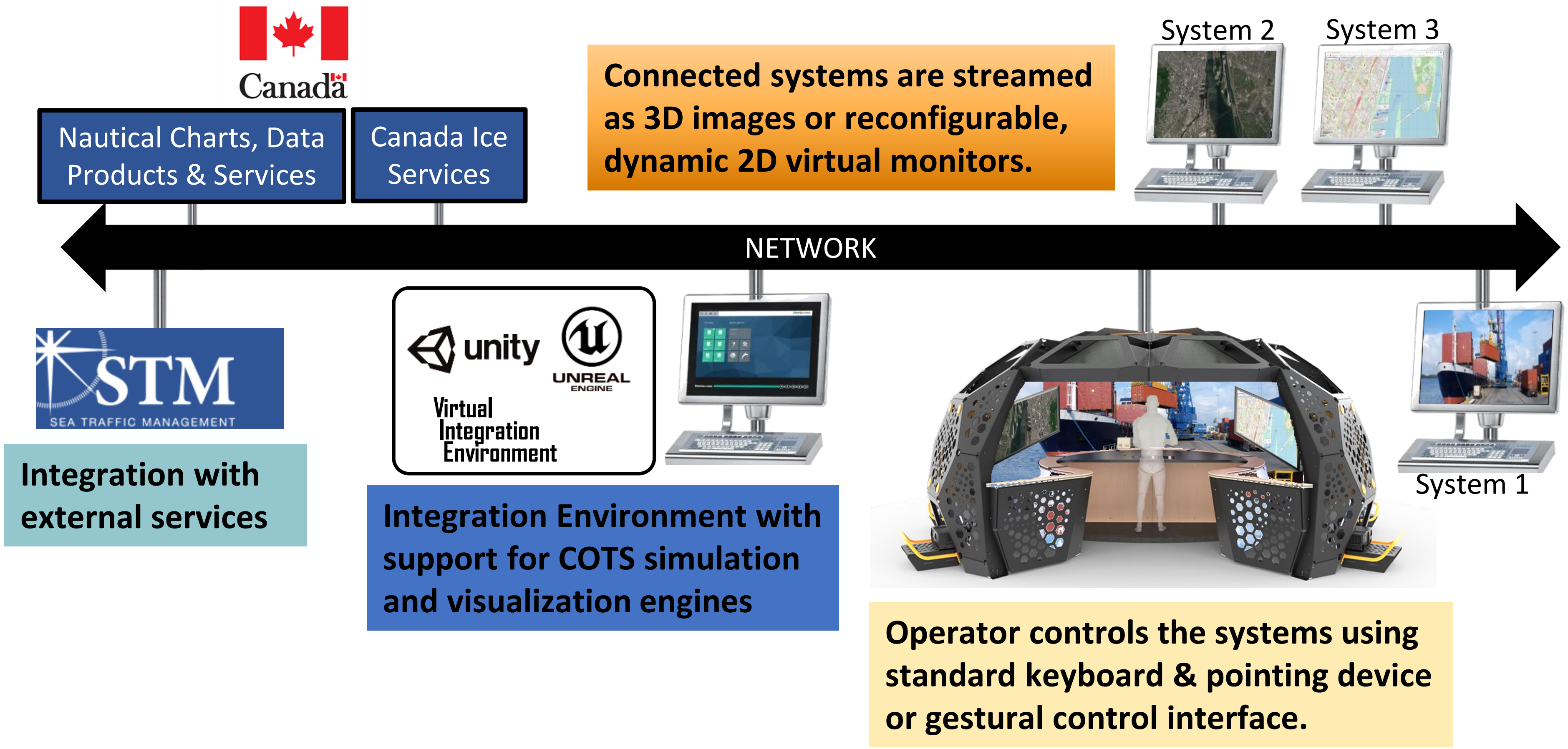
Capabilities

- 3D Immersion
- Simulation ready
- Live streaming capability
- Connected, Networked
- Reconfigurability
  - Black box Plug & Play Integration
  - Modular Operator Station
- Intelligent Adaptive Interface
  - Built-in Augmented Reality
  - Gestural Control
  - Voice Commands
  - Operator State Monitoring



A Reconfigurable Control Center for Testbed Applications

Integration of Simulation, Shared Services and Operational Systems



A Reconfigurable Control Center for Testbed Applications

An Integration Environment Ideal for Validation

- An environment built using an integration platform and immersive visualization system ideal for implementing distributed service-oriented architectures.
- Plug & play integration of standard video outputs and http streams (e.g. CCTV, web applications)
- Support to develop streamable applications using publicly available simulation and visualization engines or customized virtual integration environment.
- Can support stand-alone validation activities involving individual operators or small teams of networked operations scenarios across multiple sites.

A Reconfigurable Control Center for Operations

Are 3D Immersive Environments Suitable for MASS Operations ?

- Pre-loaded certified configurations can be used, as needed, for different types of shore-based vessel control scenarios.
- Vessel control applications can be dynamically adapted during operations as a function of phase of operation, operator state and workload, unanticipated events, unplanned incidents, emergencies etc.
- Reducing the level of strain and effort to process information can contribute to increasing the safety of operations.

Reconfigurable Operations Centre Testbed Summary

- A Reconfigurable Operations Centre Testbed can satisfy requirements for technical validation of key technologies for future MASS operations.
- Testbeds can be used for operational validation of new concepts and procedures for remote operating centres and for the evolution of port operations centres and security operations centres.
- Testbeds can be used to validate interoperability products required to connect Canadian federal, provincial, regional and international initiatives, including e-Navigation and the Canadian ITS RA.
- The Imagine-4D Station IX Visualization System and Integration Platform has the features required for building a state-of-the-art Reconfigurable Operations Centre.

Thank you for your attention.

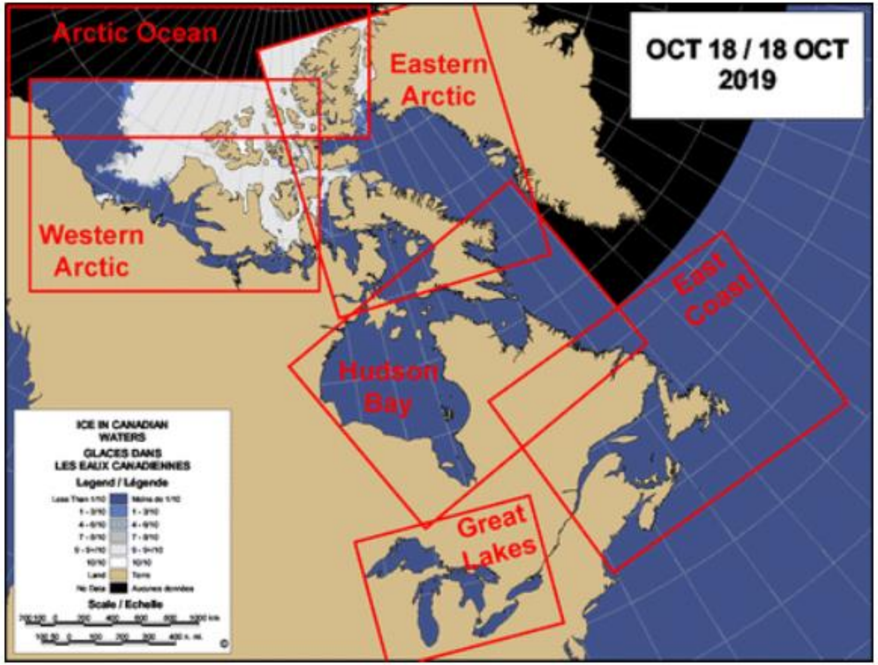
kevin.heffner@crim.ca

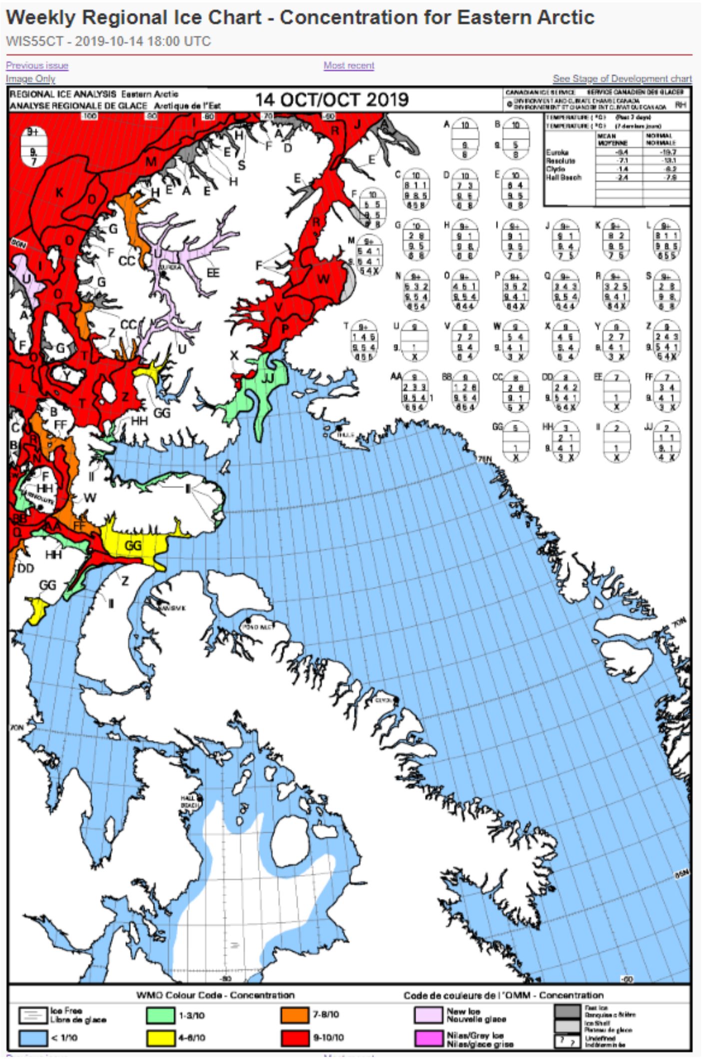
CRIM

Backup slides

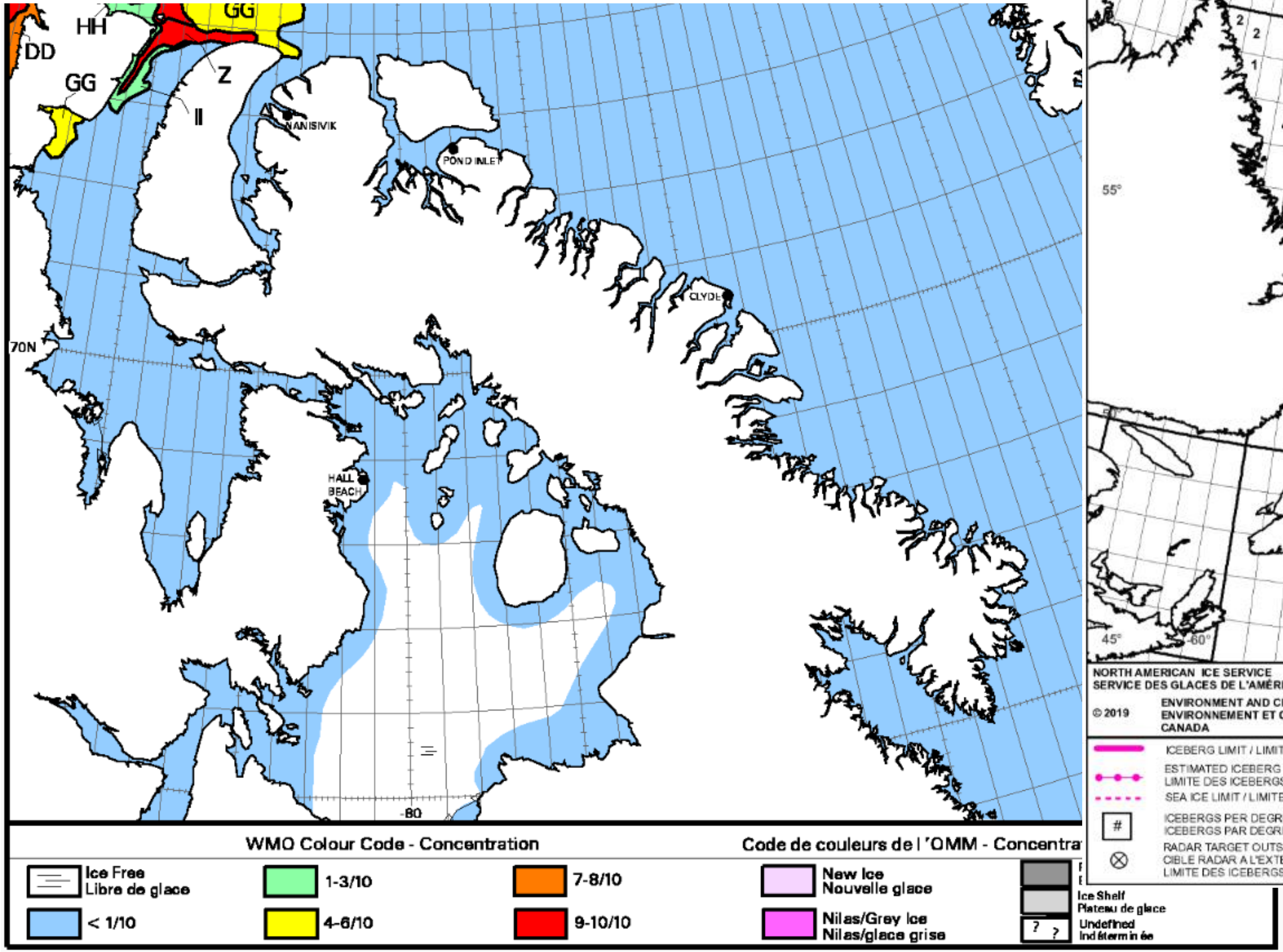
Canada Ice Services

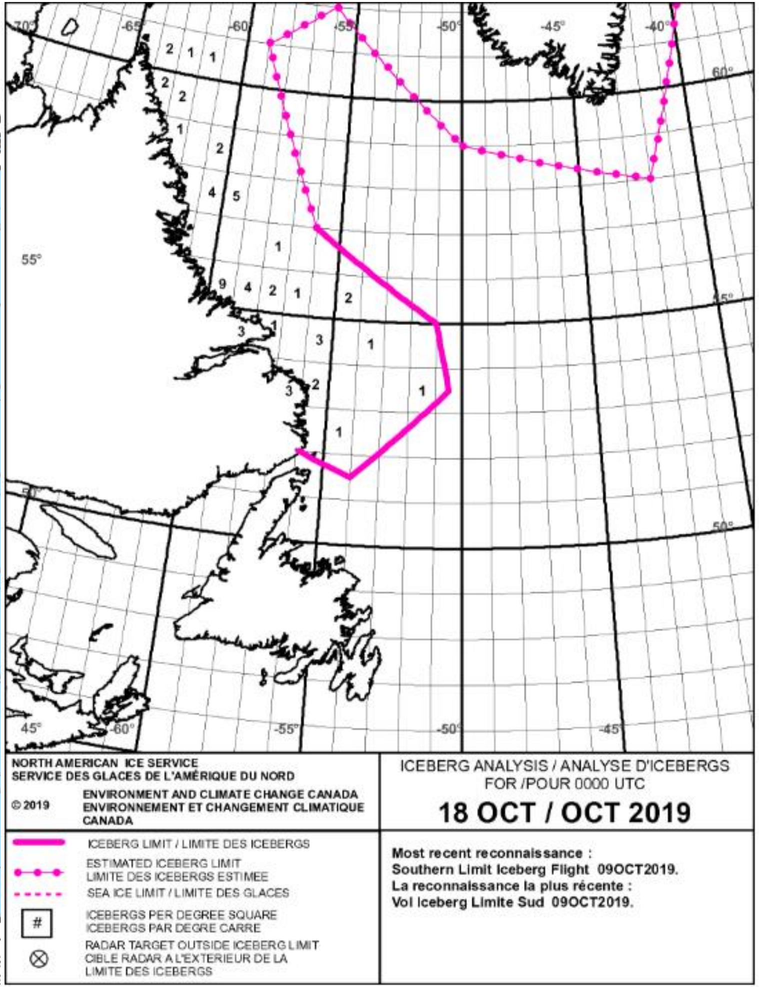
- Daily ice charts
- Regional ice charts
- Departure from normal concentration charts
- Image analysis charts
- Aircraft ice charts
- Iceberg charts
- St. Lawrence River observed ice charts





Canada Ice Services – Iceberg Free Zones



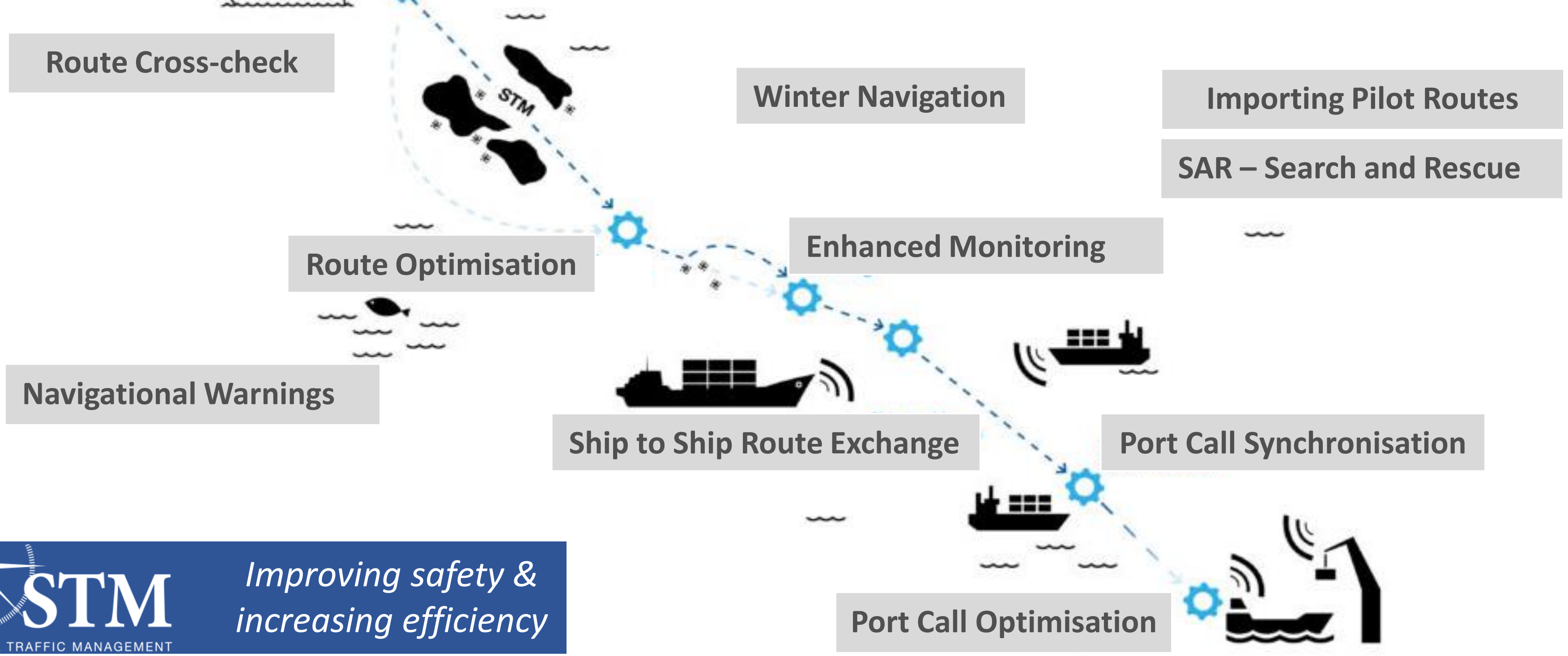


Sea Traffic Management Services

An example of Shared Data Services using IALA e-Navigation Solutions

STM Services

By using standards and creating interoperability Sea Traffic Management is opening up for an endless number of services. Below you find descriptions about the STM services that are being validated in the STM Validation project.



STM SEA TRAFFIC MANAGEMENT

Improving safety & increasing efficiency

Problem statement: How to validate MASS technologies ?

1. Not all technologies for autonomous ships are readily available & validated.
2. No interoperability framework for future Intermodal Maritime Transport Ecosystem.
3. Integration with global supply chain requires better information exchange.

Technology Validation Testbeds can accelerate the development of the ecosystem of autonomous vessels and intelligent ports.

Need

TECHNOLOGY VALIDATION

OPERATIONAL VALIDATION

Experimentation and testing is necessary to validate emerging technologies and technical standards and prepare the transition for new regulations and operating procedures.

Prototyping and operational validation activities will accelerate the evolution of existing security and port operations centres and the development of remote vessel operations centres.

International meeting for MASS infrastructure 12.-14.2.2020, Tokyo

VÄYLÄ
Finnish Transport Infrastructure Agency

Kaisu Heikonen 12.2.2020

MASS activities and infrastructure - Finland

VÄYLÄ
Finnish Transport
Infrastructure Agency

Present MASS related activities

- Draft Roadmap for Autonomous Traffic under development by the Ministry of Transport and Communications
- Industry driven R&D
- Public funded R&D projects

Possible impact on infrastructure

- Physical AtoN
- Communication infrastructure
- Digital Services

Present MASS related activities

Draft Roadmap for Autonomous Traffic (1/2)
- Basic horizontal principles for automated and autonomous traffic

VÄYLÄ
Finnish Transport Infrastructure Agency

1. Development should be human centric
   - respect human rights and privacy
   - increase individual and societal well-being
2. Should increase safety, efficiency and environmental sustainability
   - elimination of human errors
   - optimised transport chains
3. Require high reliability
   - transparent algorithms
   - cyber security
4. Switching to manual control should be possible at any time
   - journey should continue smoothly in case automatic/autonomous operations are not possible
5. Require increased connectivity between vehicles and between vehicles and infrastructure
   - exchange of observations and plans

Draft Roadmap for Autonomous Traffic (2/2)
- Basic horizontal principles for automated and autonomous traffic

VÄYLÄ
Finnish Transport Infrastructure Agency

6. Require better availability of static and dynamic traffic data
   - digital twin
   - more efficient information sharing
7. Should favour universal technologies and enable vendor-independent applications
   - re-use of existing standards and systems
   - use of public mobile networks (4G/LTE, 5G)
8. Require internationally agreed procedures and recommendations as well as national regulation
   - regulative focus on the expected behaviour of the vehicle regardless of how it is being controlled (man or machine)
9. Should enable new business opportunities and economic productivity contributing to the well-being of society
   - development should be industry driven and authorities should take the role of enablers
10. Preparations should start immediately
    - regulation enabling tests and experiments
    - supporting digital and physical infrastructure

Draft Roadmap for Autonomous Traffic
– Goals for maritime activities

VÄYLÄ
Finnish Transport Infrastructure Agency

- Short term goals (2020 - 2021)
  - Intelligent Fairway, further development
  - Remote pilotage, ensuring conditions
- Medium term goals (2022 – 2025)
  - Tests with Ferries on archipelago areas
  - Tests with Cargo vessels on national waters
- Long term goal (2025 - 2030)
  - Baltic test area, smooth transit from one country to another

Intelligent fairways (short term goal)

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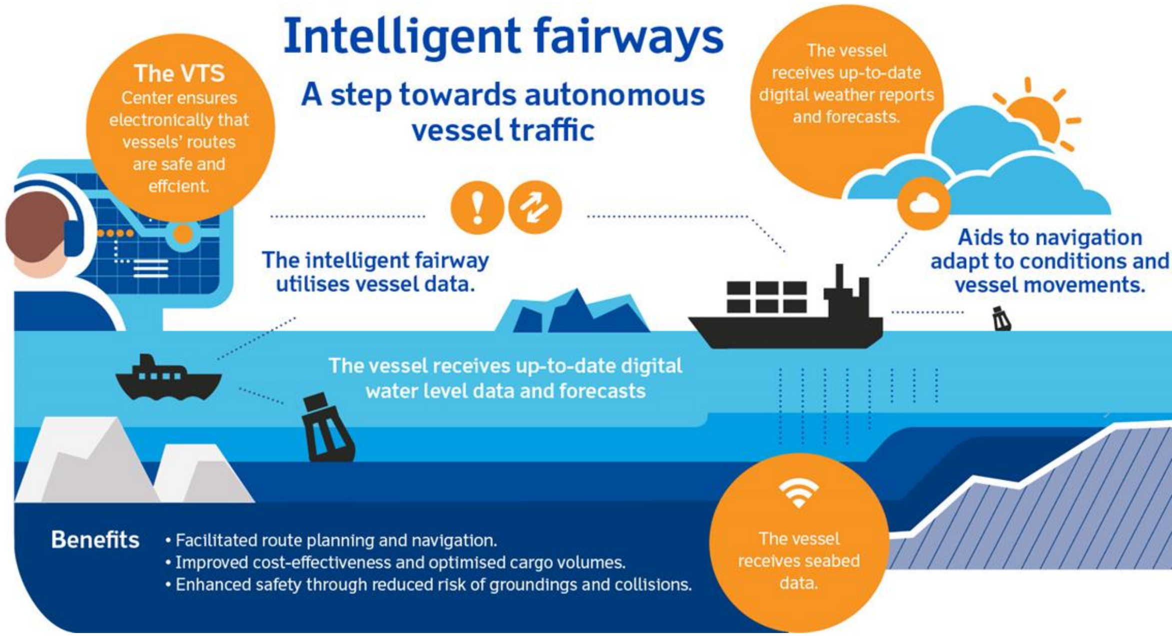
Finnish Transport
Infrastructure Agency

- New sensors added to AtoNs
- Digital services provided
- New functionalities added to AtoNs
- More accurate seabed data provided
- 4G/LTE and/or 5G coverage enhanced
- Additional services from VTS provided



✓Only on selected Fairways

Example: Data from some of the wave buoys is available online via internet:
http://geojson.io/#data=data:text/x-url,https://meri.digitraffic.fi/api/v1/sse/latest

Remote pilotage (short term goal)

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Finnish Transport
Infrastructure Agency

- Provision of reliable, broadband communication link between pilot and vessel on remote pilotage capable fairways (i.e. better 4G/LTE or 5G coverage)
- All relevant data digitally available
    - Environmental (e.g. weather, sea state, water height, ice information)
    - Position and navigational (e.g. vessel’s navigational data, AIS, radar, coastal radar)
    - Infrastructure (e.g. seabed information, depths, fairway and AtoN information)
    - Faults (e.g. AtoN malfunctions, displacements)
    - Route/voyage plans (e.g. vessel’s, pilot’s)

✓ Pilot must always have
- ✓ Shared situational awareness with the vessel’s bridge team
- ✓ Information from ship movement observation systems outside and inside the ship
- ✓ Ability to communicate with all relevant actors (crew, tugs, VTS, port, icebreakers)

Test with ferries, archipelago area (medium term goal)

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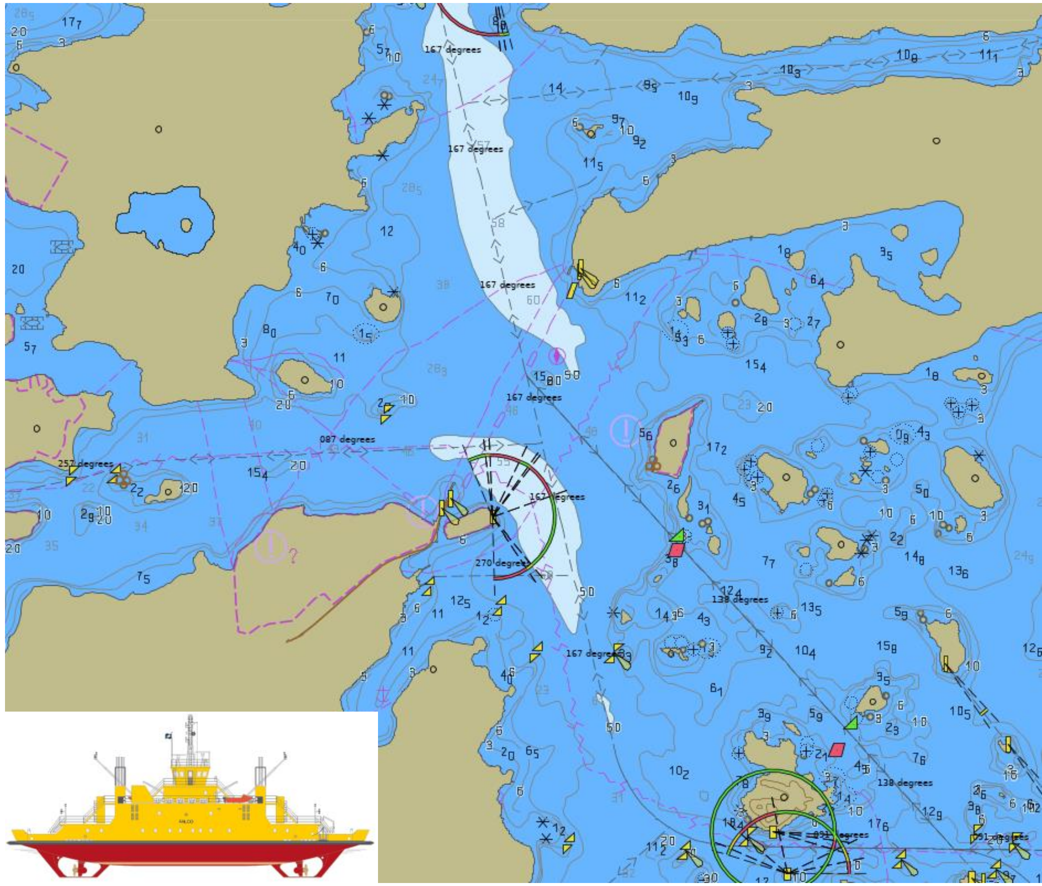
Finnish Transport Infrastructure Agency

- First test conducted already December 2018 (SVAN)
- FALCO, 54m long car ferry, serving traffic between mainland and Nauvo island in the Turku Archipelago
- Equipped with multiple additional sensors providing 3D image of surroundings
  - short-range radar
  - day- and night-vision cameras
  - LIDAR
- 3D image transferred to the remote control centre located in mainland via mobile phone network
- Succeeded to navigated safely among other traffic both in autonomous and remotely operated mode

✓ For this route, existing mobile phone network provided sufficient communication channel

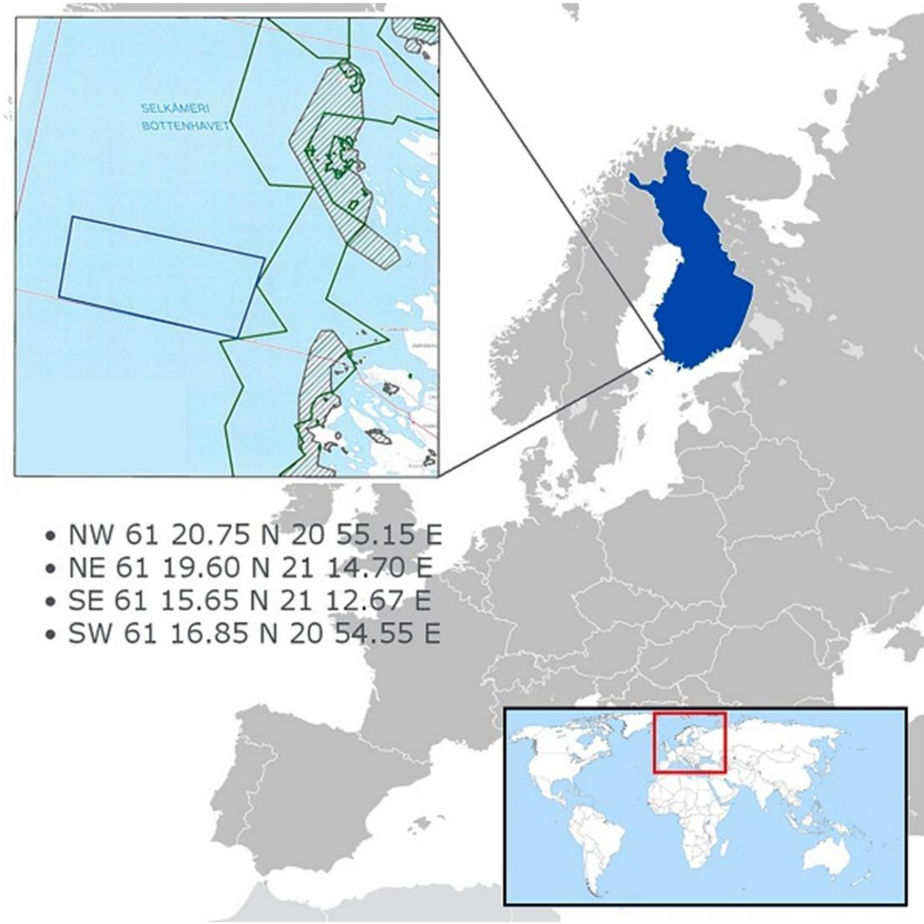


Industry driven R&D

- MASS test Area (www.oneseaecosystem.net)
- Kongsberg Maritime R&D Center, Turku

✓ Development is financed by industry and test results not published openly

✓ Requirements on public infrastructure still unknown



Public funded R&D projects

Finnish Transport Infrastructure Agency

- ISTLAB (https://istlab.samk.fi/)
  - Simulator environment for testing human interaction with various levels of autonomy
- MARITIME AI-NAV (www.maritimeai.org)
  - Testing and validating AI & various sensor technologies in vessel
    - AIS
    - visual images
    - environmental sound recordings
    - RADAR and LiDAR ranging
    - satellite navigation

✓AI-NAV preliminary results indicate low visibility of AtoNs with LIDAR

Possible impact on infrastructure

Physical AtoN

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Finnish Transport Infrastructure Agency

- AtoNs are equipped with remote monitoring equipment and AtoN status information is widely available in digital format (both to vessels and to shore)
- New sensor technologies require changes to AtoN materials or equipment (e.g. additional reflectors for LIDAR)
- Use of physical AtoNs to host additional equipment increases (e.g. environmental sensors, 4G/LTE/5G base stations)
- Increased demand of energy requires changes to AtoN structures (e.g. for hosting more battery capacity)

Communication infrastructure

VÄYLÄ
Finnish Transport Infrastructure Agency

- Communication infrastructure in fairways is enhanced to support:
    - digital communication with VTS
    - provision of digital services
    - remote pilotage
    - remote control of vessels
- Coverage of 4G/LTE or 5G is extended as much as possible, with reasonable cost
- VDES communication channel is provided in coastal areas

Digital Services

- VTS starts to communicate and exchange information with remote operation centers and remote pilots in addition to communicating with vessels (e.g. distribution of vessel routes and maritime picture)
- Intelligent fairways provide digital information (e.g. AtoN status, seabed information, environmental information and forecasts) to vessels and shore users
- The providers of digital services can be identified and authenticated

➢ Increased need to harmonise digital information exchange interfaces towards:
  - vessels
  - shore users

VÄYLÄ

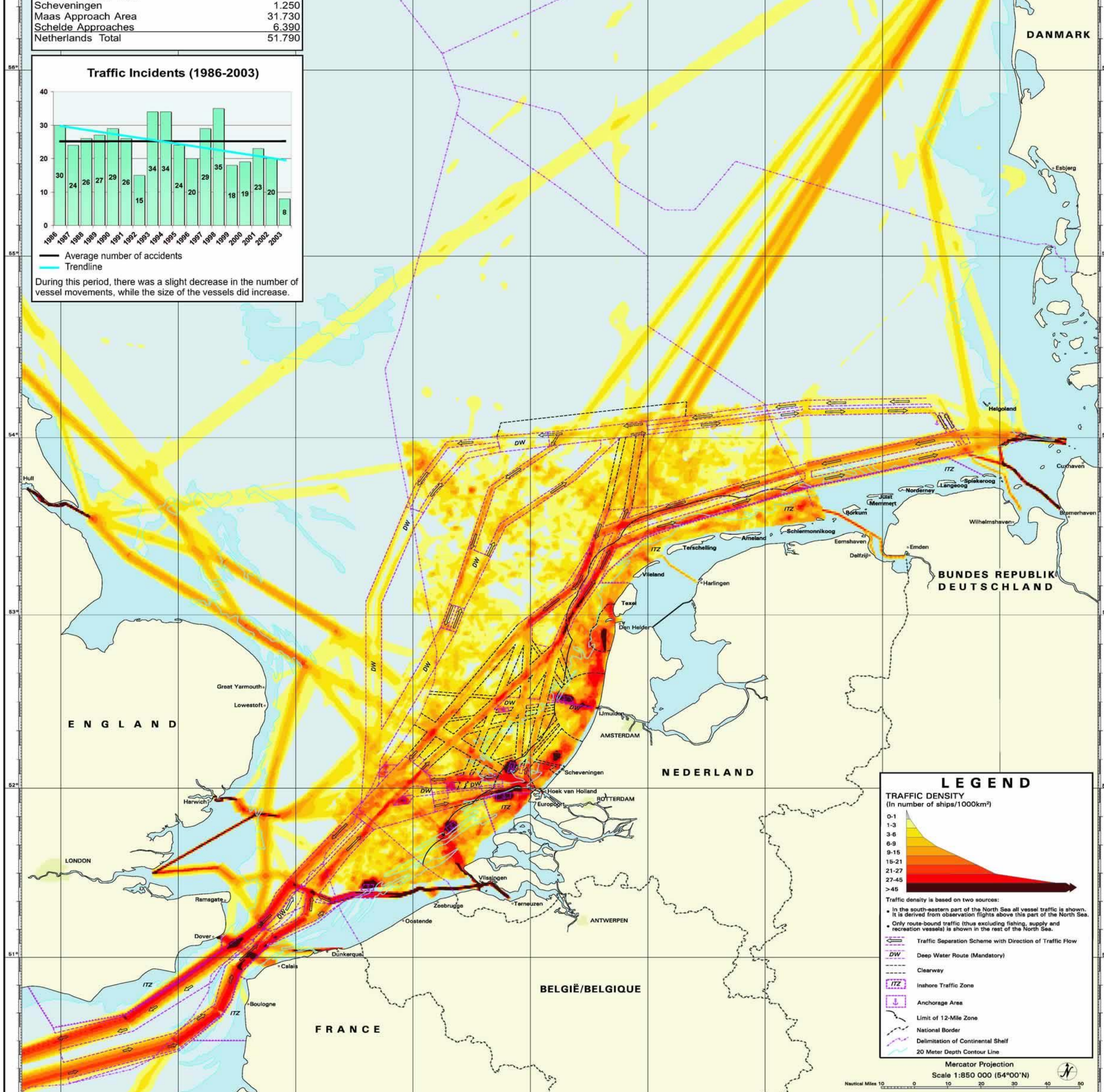
MASS and VTS

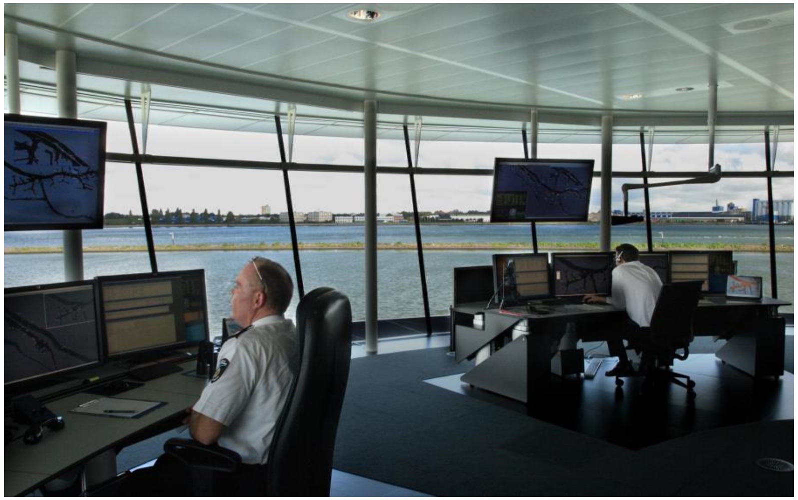
Netherlands

Maarten Berrevoets
Dept. Head Seaport division
Ministry of Transport and Water Mangement


NORWAY
SWEDEN
FINLAND
ESTONIA
LATVIA
LITHUANIA
DENMARK
IRELAND
UNITED
KINGDOM
BELORUSSIA
POLAND
GERMANY
UKRAINE
CZHEK
REPUBLIC
SLOVAKIA
FRANCE
SWITERLAND
AUSTRIA
HUNGARY
MOLDAVIA
ROMANIA
ITALY
CROATIA
PORTUGAL
SPAIN
BOSNIA
SERVIA
BULGARIA
KOSOVO
MACEDONIA
ALBANIA
GREECE
designed by freepik.com

Scheveningen	1.250
Maas Approach Area	31.730
Schelde Approaches	6.390
Netherlands Total	51.790





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Groningen
Veendam
Delfzijl
Den Helder
Meppel
Alkmaar
Zwolle
Almelo
Hengelo
Utrecht
's Gravenhage
Europoort
Rotterdam
Dordrecht
Nijmegen
Emmerich
Moerdijk
Vlissingen
Zeebrugge
Terneuzen
Bergen op Zoom
Antwerpen
Dunkerque
Gent
Willebroek
Venlo
Lille
Avelgem
Liège
La Louvière
Namur
Charleroi
Münster
Hamm
Lünen
Dortmund
Wesel
Duisburg
Gelsenkirchen
Mülheim
Düsseldorf/Neuss
Dormagen
Köln
Bonn
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Halle
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Poses
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Nanterre
Gennevilliers
Issy-les-Moulineaux
Ivry-sur-Seine
Vitry-sur-Seine
Corbeil-Essonnes
Bonneuil-sur-Marne
Boissise-la-Bertrand
La Brosse
Grande Paroisse
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Vinneuf
Persan
La Fère
Reims
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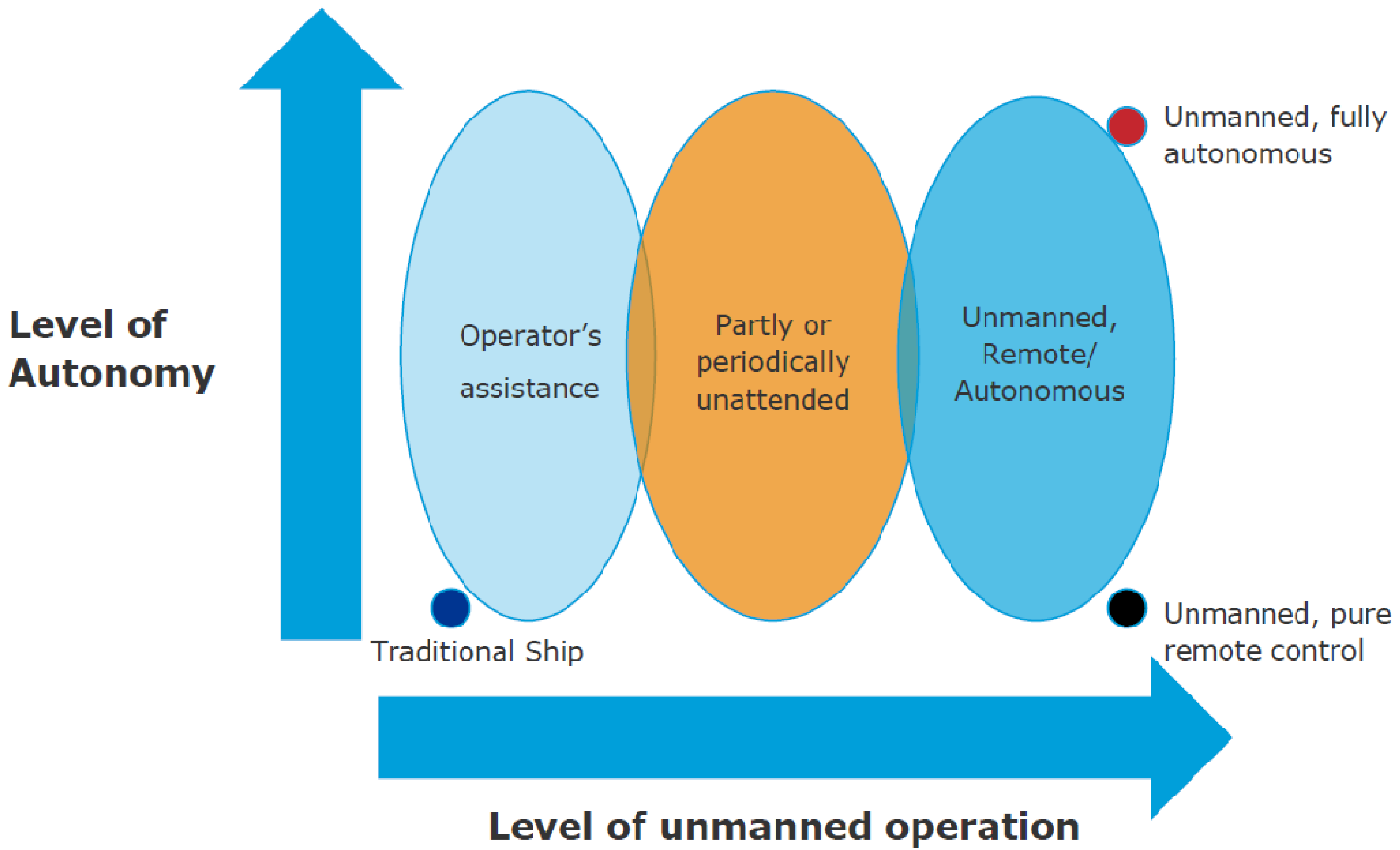
Mondelange
Metz
Völklingen
Saarbrücken
Dillingen
Merzig
Mertert
Trier
Nancy-Frouard
Neuves-Maisons
Strasbourg
Kehl
Colmar
Breisach
Ottmarsheim
Mulhouse
Bingen
Wiesbaden
Mainz
Offenbach
Frankfurt
Hanau
Aschaffenburg
Wertheim
Würzburg
Ochsenfurt
Schweinfurt
Bamberg
Erlangen
Fürth
Nürnberg
Kelheim
Worms
Ludwigshafen
Mannheim
Speyer
Germersheim
Karlsruhe
Wörth
Heilbronn
Stuttgart
Beinheim
Fort-Louis Stattmatten


Level of Autonomy
Operator's assistance
Partly or periodically unattended
Unmanned, Remote/ Autonomous
Unmanned, fully autonomous
Traditional Ship
Unmanned, pure remote control
Level of unmanned operation


PRIMA HOOR, DIE KUNSTMATIGE INTELLIGENTIE...
MAAR NU DENKT ONZE COMPUTER DAT WE EEN VLIEGTUIG ZIJN!
WE MOETEN SNEL ETHISCHE BESLISSINGEN NEMEN!
DGLM

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Smart Ships,
Maritime Autonomous Surface Ships – MASS
and the supporting infrastructure

Norbit Oceans, Tony Haugen

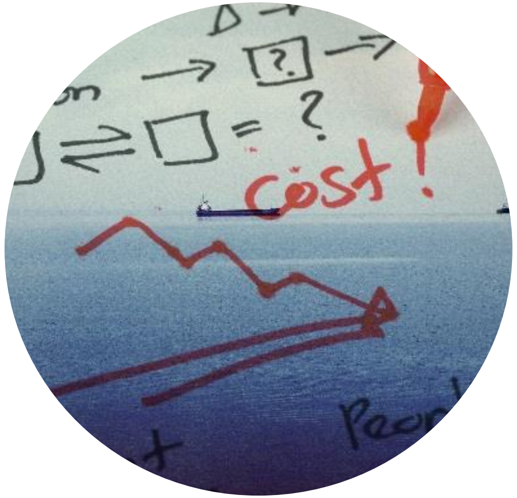
Background


1 NO POVERTY
2 NO HUNGER
3 GOOD HEALTH
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 RENEWABLE ENERGY
8 GOOD JOBS AND ECONOMIC GROWTH
9 INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE AND JUSTICE
17 PARTNERSHIPS FOR THE GOALS
THE GLOBAL GOALS

A maritime industry in transformation

ACCELERATED TECHNOLOGICAL DEVELOPMENT

Digitalization, new vessel concepts and new business models



INTENSIFIED COMPETITION, INCREASED FOCUS ON SECURITY AND ENVIRONMENTAL FOOTPRINT

Fit for purpose, low cost, higher efficiency, optimisation, sustainable and environmental friendly, increased level of standardization

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Accelerated technological development

INTEGRATED SOLUTIONS

DIGITALISATION

REMOTE SERVICES

AUTONOMY

Digitalization

BREAK THROUGH OF DIGITAL TECHNOLOGIES

Enabling technologies:

- Data- and analysis capacity
- IoT - “Internet of Things”
- AI and Machine Learning
- Data Connectivity

Source: Maersk

COST FOCUS AND SUSTAINABILITY DRIVES THE DIGITAL TRANSFORMATION AND DISRUPTION

- Fuel (46%)
- Port Charges (21%)
- Personnel (10%)
- Repairs (10 %)
- Insurance & Others (13%)

Future

- Environmental Footprint (? %)

Image: Kongsberg Digital

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Smart Ships

Image: Kongsberg Digital

What is a smart ship?

A smart ship is basically a ship that have become digital with a higher degree of automation than a conventional ship.

Several degrees of smartness (level of Autonomy). Bureau Veritas has defined 4 main categories of smart ships:

- A1 Human directed
- A2 Human delegated
- A3 Human supervised
- A4 Full automation

Some “key benefits”:

- Advanced sensors and equipment monitoring
    - Predictive maintenance
- Advanced decision support
    - Voyage optimisation
- Automatic reporting – single window
- Optimised operations
    - Just in time arrivals
    - Fuel optimisation
    - Crew reduction
    - Cargo traceability

- **Integrations into global logistic chain**

Is this a smart port?

Smart Ports

What is the concept of Smart Ports?

The Smart Port concept entails the use of technologies to transform services at ports into interactive systems in order to meet the needs of port users with a greater level of efficiency, transparency, and value.

A smart port can be measured in it's ability to develop a collaborative approach and to be more attractive, more competitive and more profitable. Efficiency is more Important than size.

- Higher degree of automation
- Cleaner and greener
- Safer and more secure
  - ISPS focus on physical threats only and not the digital ones
- Improved processes

Integrated part of the global logistics chain

A smart ship has nothing to do in a stupid port

The key word is collaboration rather than competition. The port infrastructure must adapt to the smart ships

Image: Kongsberg

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Smart Shipping

“Ships, ports and stakeholders are connected into one global system and operated in an optimal way”

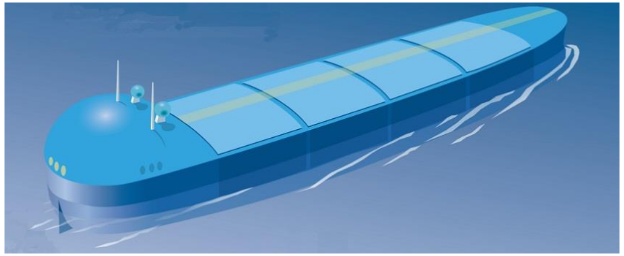
Ship Owners
Optimal timing of arrival and port operations
Reducing:
- Waiting time
- Fuel consumption
- Environmental footprint from transit and operations

Port Owners
Optimal timing of arrival and port operations
Reducing:
- Port congestions
- Needed warehouse capacity
- Environmental footprint of port operations

Consumers
- More goods available for lower prices
- Reliable delivery of goods
- A cleaner and greener world

Image: Kongsberg Digital

Fully unmanned gives most cost benefits



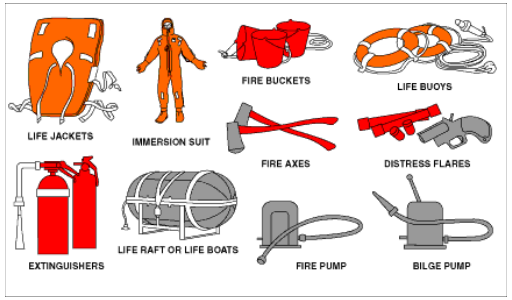
No accommodation

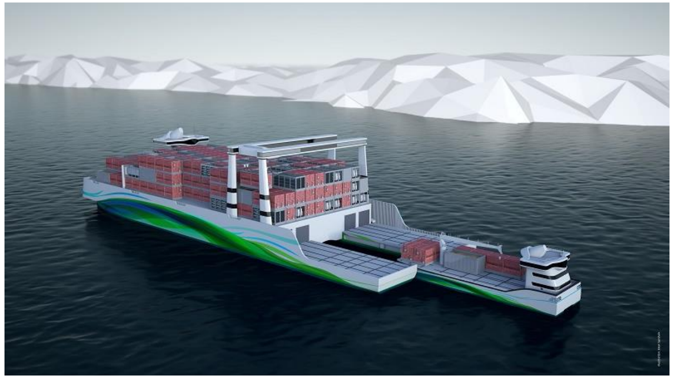
Less power

More cargo

No safety equipment

New constructions





NCE Maritime Clean Tech & NCL

Enables completely new transport system concepts

No crew

No crew related costs

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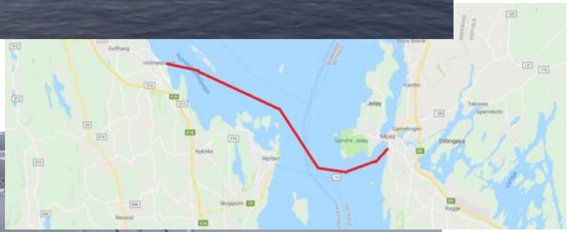
New Autonomous Transport Operations



Focus on the infrastructure

imat

Integrated Maritime
Autonomous Transport Systems

The main purpose is to define the minimum shore-based infrastructure, in order to conduct safe and cost effective integrated maritime transport operations.

Project focus areas:

- ❑ Verification and integration of land-based sensor data with sensor data from autonomous vessels.
- ❑ Adaptation of land-based surveillance technology for data fusion and automatic transfer of navigation data between infrastructure installations, control centres and vessels.
- ❑ Ensure the human-in-the loop when implementing new technology.
- ❑ Standardization of messages and technology, interaction procedures, robust technology for digital information exchange between the systems and parties.
- ❑ Development of new guidelines for interaction, new regulations and standards for information exchange.

Operation monitoring and control / sensor infrastructure

- Even with a fully autonomous transport operation the human need to be in the loop
- Emergencies needs to be communicated fast and effectively
- AI / algorithms able to detect and predict unwanted incidents
- SCC should also contribute to more effective operations as well as collaboration with other stakeholders
- Sensor infrastructure independent of the MASS is needed for independent decisions

New digital ecosystems

- A digital infrastructure for:
  - Fleet management
  - Operation optimisation
  - Logistics

- Connecting stakeholders with the ships

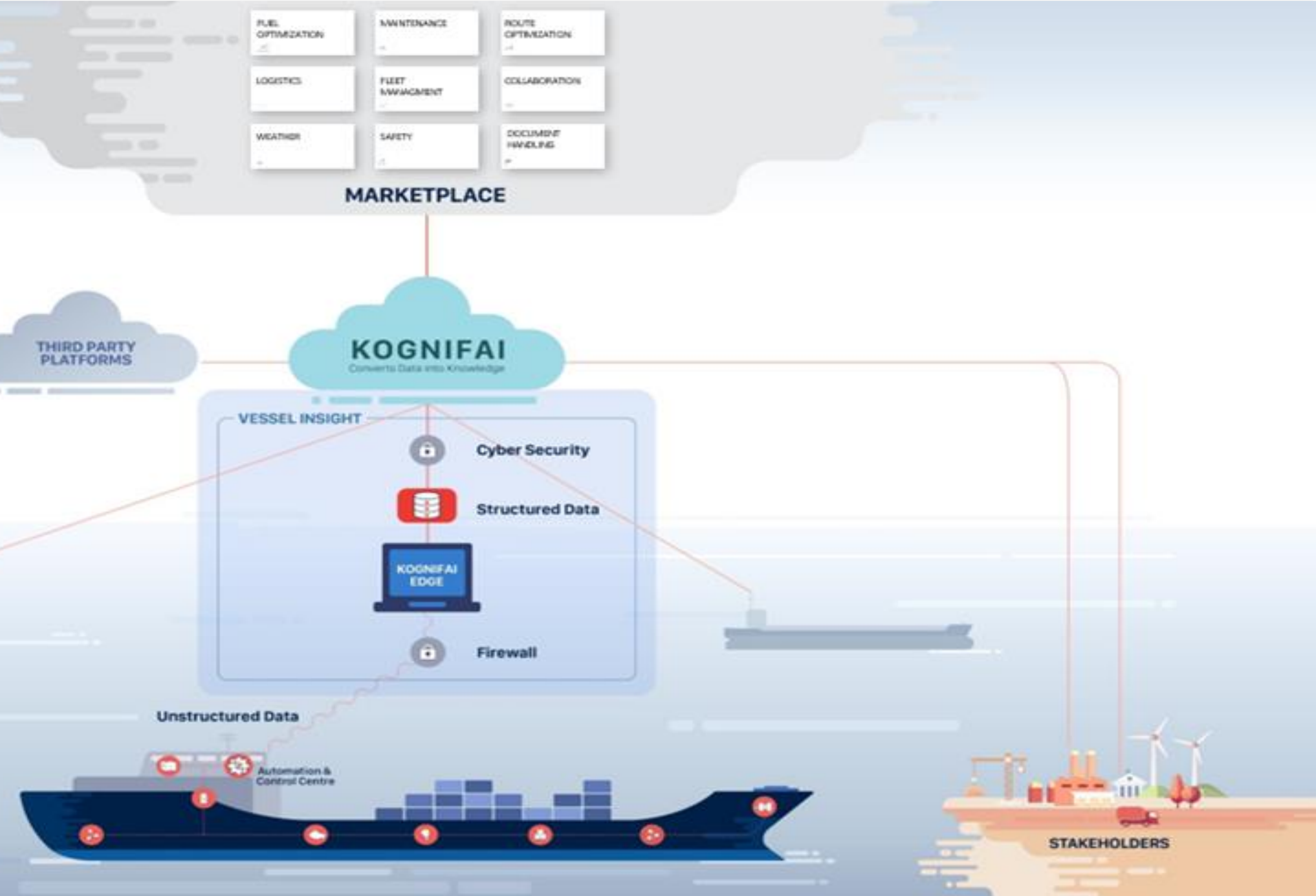


Image: Kongsberg Digital

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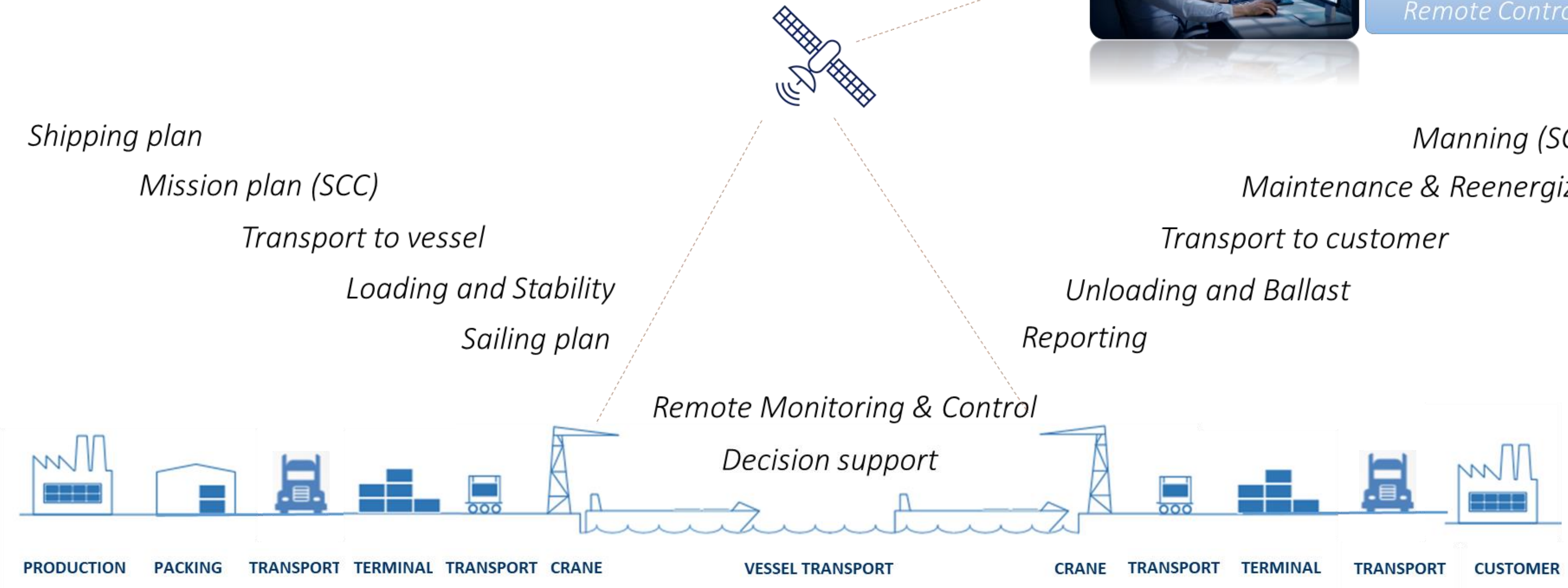
Integrated Maritime Transport Systems

Onshore Systems

Ship Systems

Remote Control



NORBIT
- explore more -

Conclusions

Image: Kongsberg Digital

“The maritime industry is facing a major transformation – new technology and digital solutions are reshaping what is possible, and supported by new regulations, this will enable smarter, more efficient, safer and greener operations”

The smart ships / MASS are coming

We need different types of infrastructure to adapt to the transformation

A smart ship / MASS requires a smart infrastructure in order to optimize its operation

We must ensure that Smart ships / MASS is implemented safely. One incident will be a major set-back

Infrastructure is needed both to optimise the benefits from MASS transport operations, and very important for the safe introduction of MASS in general

NORBIT
- explore more -

Thank you for your attention!

tony.haugen@norbit.com / www.norbit.com

The Yara Birkeland example

Movie: Kongsberg Maritime and Yara

MASS; ATON PERSPECTIVE

Minsu JEON, Technical Operations Manager

IALA

CONTENTS

Autonomous Ships Will Be Great

Doing away with sailors will make the high seas safer and cleaner.

By Adam Minter

34 16 May 2017 23:00

London Times – "We'd Be Lost Without GPS Says Royal Institute of Navigation"

December 5, 2017

Blog Editor's Note: The British government has been actively addressing this issue. See the economic impact analysis they did earlier this year. We understand additional work...

Read More

Space technology to drive autonomous ships

December 1, 2017

ESA will improve satellite-based ship identification and tracking in partnership with the European Maritime Safety Agency and exactEarth to meet the requirements of users, particularly those of government agencies such as coastal administrations. Credit: European Space Agency

ESA Director General Jan Wörner signed a Memorandum of Intent with Rolls-Royce today, as the two entities agree to investigate how space technology can be used to develop autonomous and remote-controlled ships.

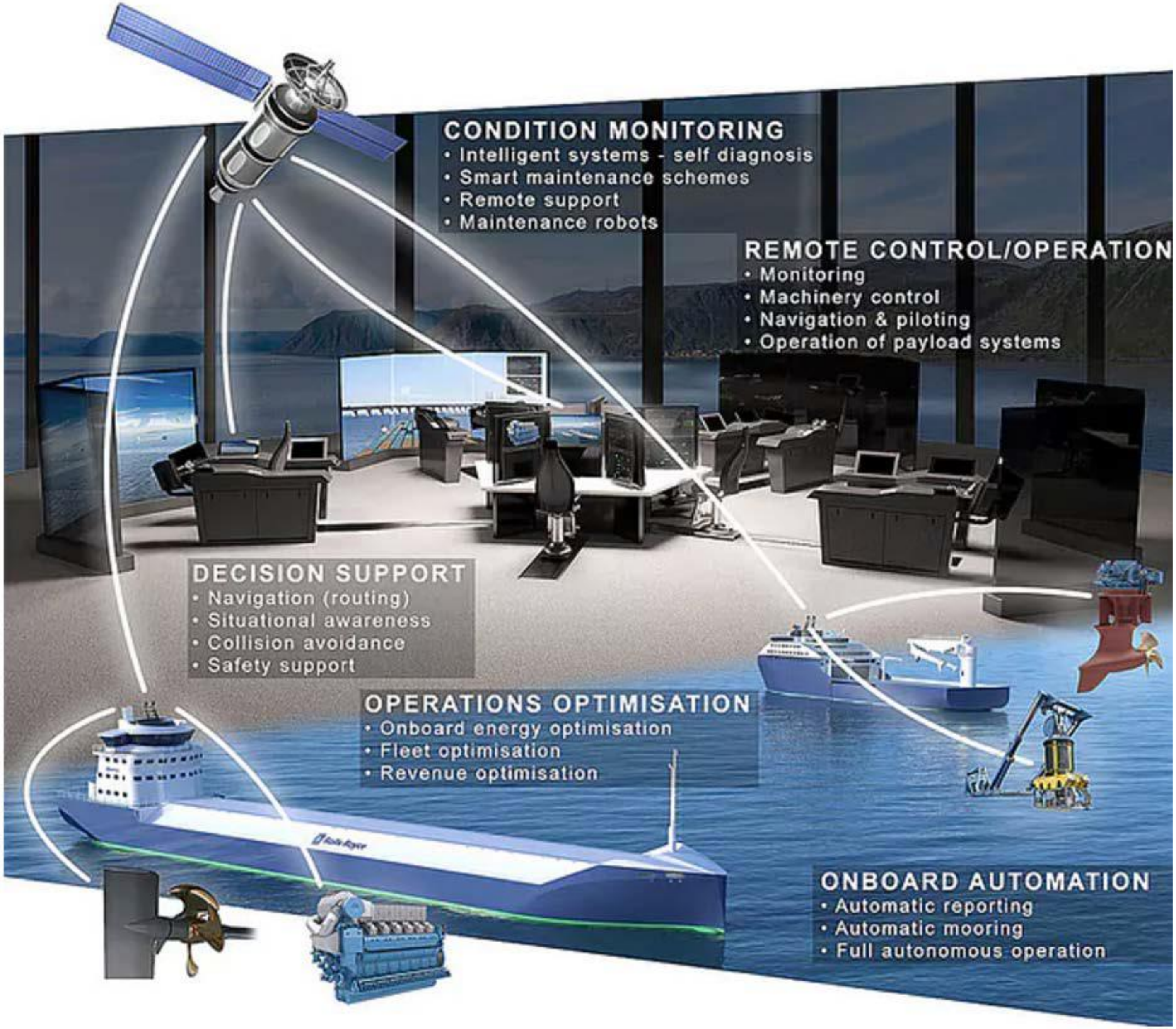
About Sea Traffic Management

STM – THE NEXT STEP FOR A SAFER, MORE EFFICIENT AND ENVIRONMENTALLY FRIENDLY MARITIME SECTOR

Route plan exchange format - RTZ

Route plan exchange is used in conjunction with ECDIS to IEC 61174.

THE PORT CDM CONCEPT – A FINALIST FOR INNOVATION AWARD


CONDITION MONITORING
• Intelligent systems - self diagnosis
• Smart maintenance schemes
• Remote support
• Maintenance robots
REMOTE CONTROL/OPERATION
• Monitoring
• Machinery control
• Navigation & piloting
• Operation of payload systems
DECISION SUPPORT
• Navigation (routing)
• Situational awareness
• Collision avoidance
• Safety support
OPERATIONS OPTIMISATION
• Onboard energy optimisation
• Fleet optimisation
• Revenue optimisation
ONBOARD AUTOMATION
• Automatic reporting
• Automatic mooring
• Full autonomous operation

MASS environment

Drivers and enablers

- Technology (AI, 5G, sensors, big data) makes it possible
- Commercial cost and benefit (CB)
  - Seems feasible for short and simple routes
  - Reduced crew labor and safety cost (STCW)
- Political will
- International initiatives (UN SDG)
- Environmental impact

Challenges and risks

- Cost (initial investment, operation, maintenance)
- Public acceptance (ethics)
- Technical issue (cybersecurity)
- Regulations
- Etc.

What MASS means to Marine Aids to Navigation

Navigational accident

- Collision
- Grounding
- Capsizing
- Contact
- Etc.

Non-navigational accident

- Fire
- Explosion
- Flooding
- Cyber attack
- Sensor failure
- Information error
- Piracy
- Etc.

- MASS is new type of vessel which has **risks** in terms of safety of navigation
- In emergency cases, VTSO talk to the vessel or the Shore Control Center?
- Can kind of information VTSO could expect from MASS and unmanned vessel?

Levels of autonomy -IMO

.1 ***Ship with automated processes and decision support:*** Seafarers are on board to operate and control shipboard systems and functions. Some operations may be automated.

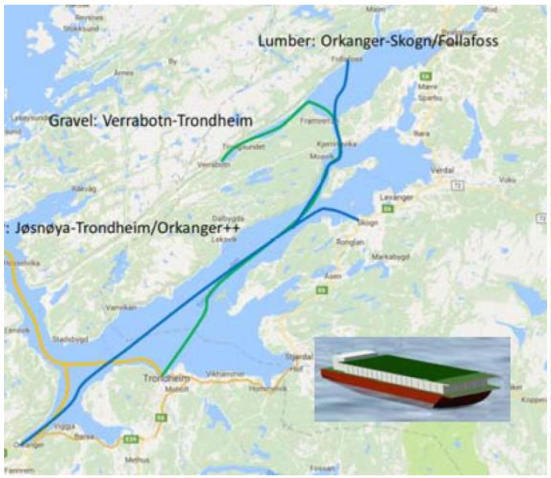
.2 ***Remotely controlled ship with seafarers on board:*** The ship is controlled and operated from another location, but seafarers are on board.

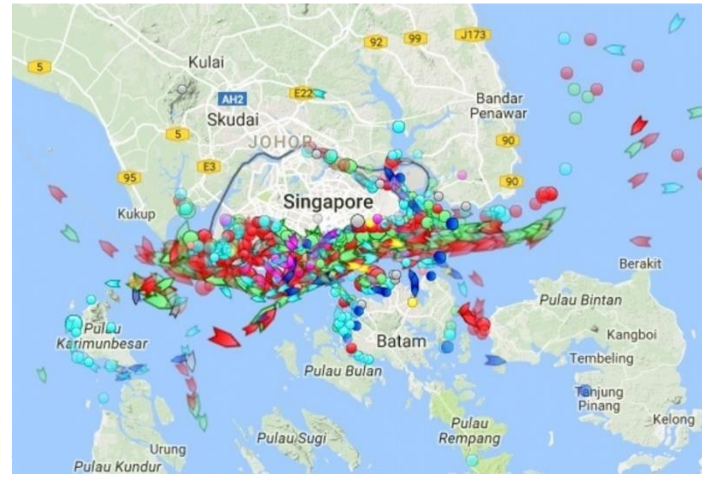
.3 ***Remotely controlled ship without seafarers on board:*** The ship is controlled and operated from another location. There are no seafarers on board.

.4 ***Fully autonomous ship:*** The operating system of the ship is able to make decisions and determine actions by itself.

1	AtoN, VTS		Crew		System
2	AtoN, VTS		Crew SCC		System
3	AtoN, VTS		SCC		System
4	AtoN, VTS		SCC		System

MASS – coastal, ocean and international navigation

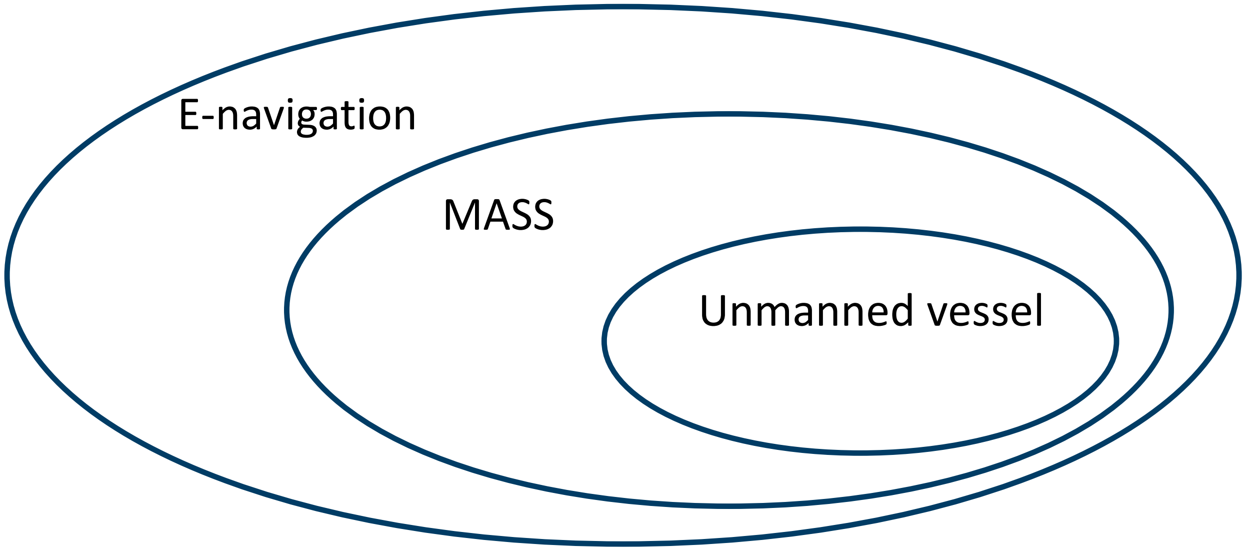




- Different requirements between coastal , ocean and international navigation
- Density of traffic of the area
- Cultural barrier

MASS and e-Navigation

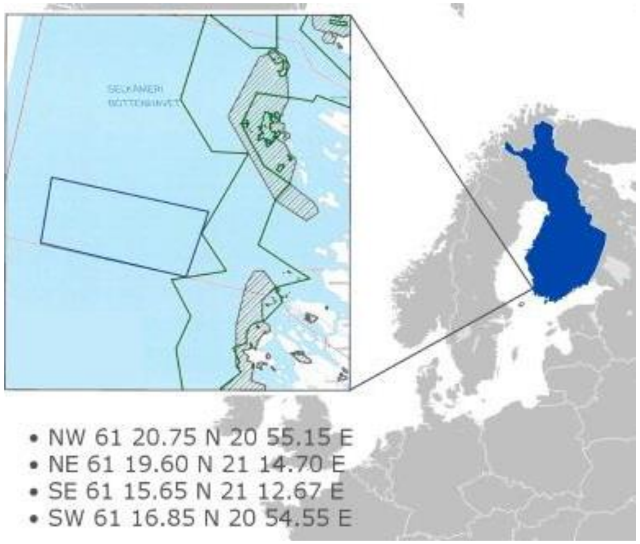
- Automation and digitalization



- Car = 1,000,000,000 * 1 man * benefit = 1,000,000,000 benefit
- Airplanes = 4,000,000,000 * benefit = 4,000,000,000 benefit
- Ships = 53,700 *10 men * benefit = 537,000 benefit

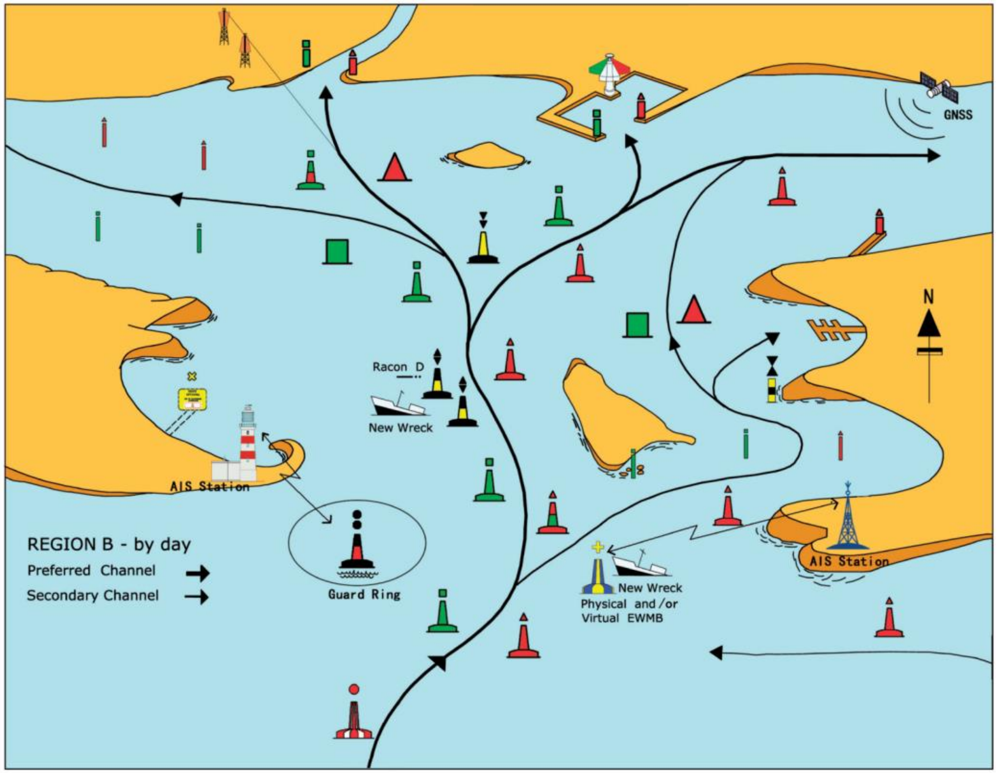
MASS testbed

Country	Year	remark
Norway (Trondheimsfjord)	2016	
Norway (Stofjorden)	2016	
Norway (Horten)	2017	
China (Zhuhai, Guangdong)	2018	
Finland (Jaakonmeri)	2019	



AtoN authority perspective

Conventional AtoN – Visual



- Improve the existing systems, or investigate new systems?
- Enhance the maritime situational awareness via AtoN

imat

Integrated Maritime Autonomous Transport Systems

Project focus areas

- Verification and integration of land-based sensor data with sensor data from autonomous vessels.
- Adaptation of land-based surveillance technology for detection of solutions for data fusion and automatic transfer of navigation data between infrastructure installations, control centres and vessels.
- Ensure the human-in-the loop when implementing new technology.
- Standardization of messages, interaction procedures, robust technology for digital information exchange between the systems and parties.
- Development of new guidelines for interaction, new regulations and standards for information exchange.

massterly KONGSBERG SINTEF NTNU

imat

2
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N63°42'
N63°30'
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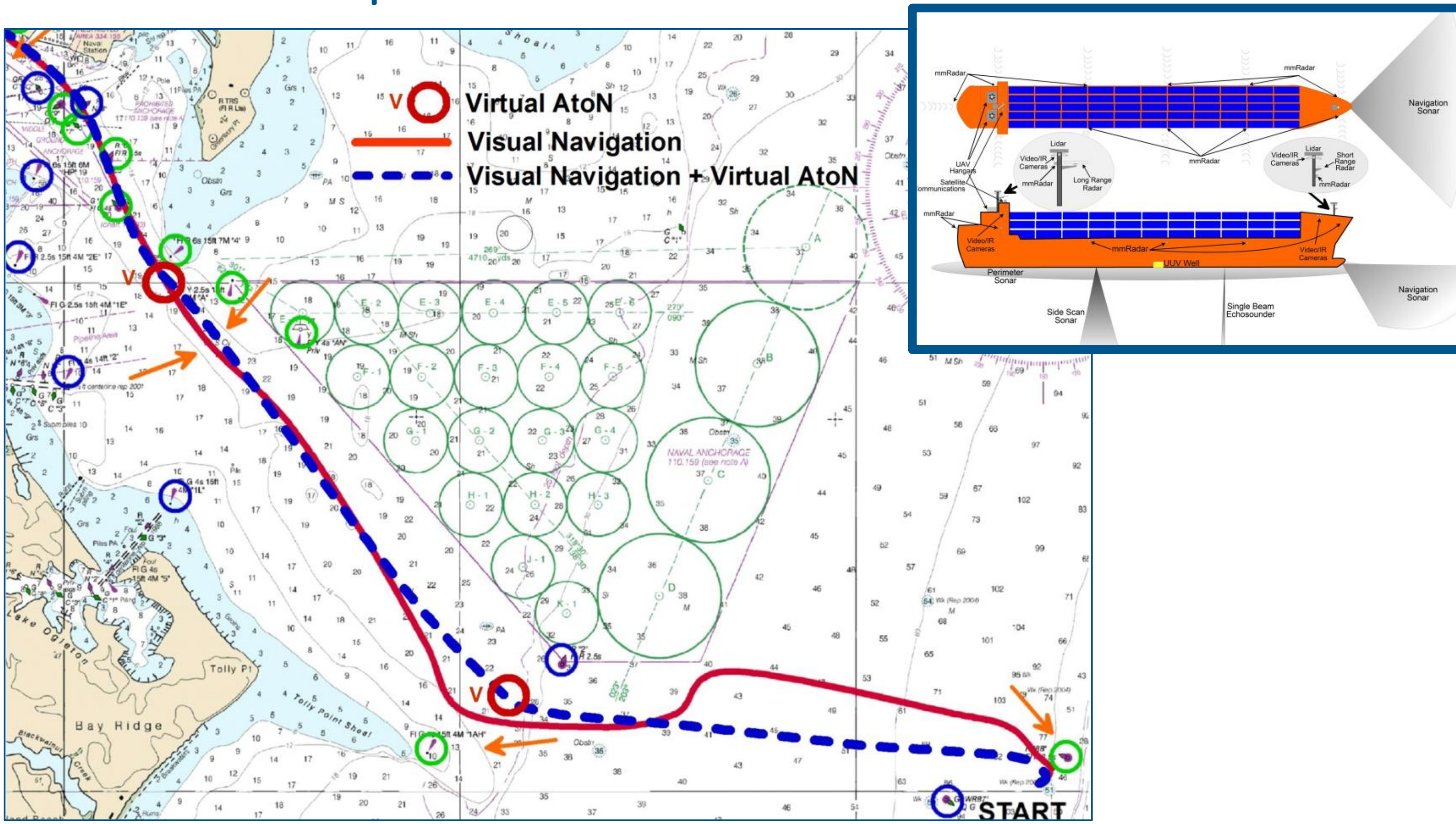
Steinkjer
Verdal
Trondheimsfjorden
Stjørdal
Trondheim
Trondheimsleia
Google Earth

Virtual AtoN experiment with MASS



Glenn Wright, DMATEK

Enhanced AtoN

- Improving the delivery of AtoN service

AtoN		Advanced AtoN
Visual Audible	Perception Daymark Lights Photometry Intensity Color Character Retroreflecting	MASS could see the visual AtoN?
Radio PNT	AIS VDES Marine radiobeacon	Position accuracy Integrity
Complementary use		Communication relay Data collection and relay station Sensors (MET, envir.)

Conventional AtoN – Marine radiobeacon

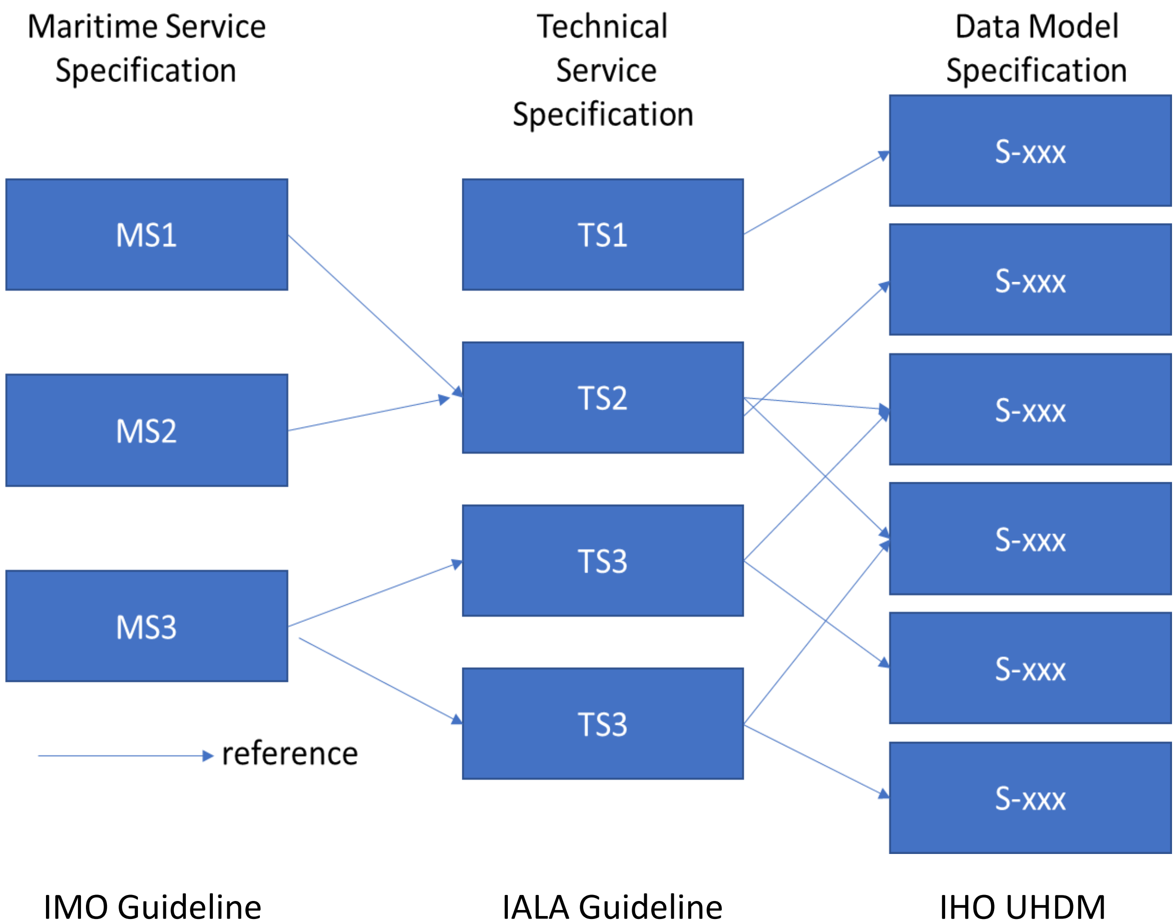
- IALA recognises the important need to inform the mariner, in a clear and timely manner, when GNSS and AIS are compromised and unrealible.

- GNSS < Physical AtoN

Integrity scenario		Hazardous Error (exceeds alarm limit)	
		Exists	Does not exist
Integrity alarm	Alarms within TTA	Genuine alarm	False Alarm
	Does not alarm within TTA	Missed detection	Good Data

e-Navigation - Interaction between different service levels

MS 1-3 VTS
MS 4 PSS
MS 5 MSI
MS 6 Pilotage
MS 7 Tug
MS 8 VSR
MS 9 TMAS
MS 10 MAS
MS 11 NCS
MS 12 NPS
MS 13 INS
MS 14 MIS
MS 15 RHEIS
MS 16 SAR
MS 17 AtoN
MS 18 PNT

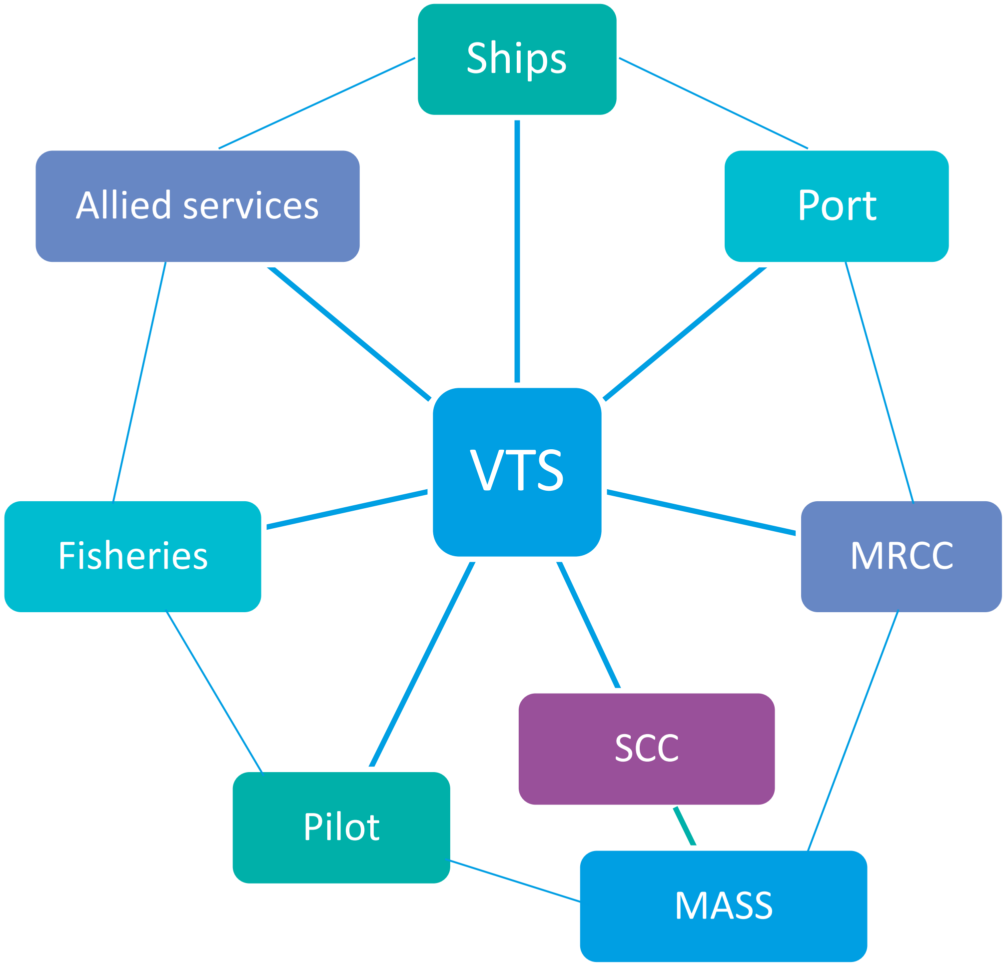


MASS impact on AtoN

- **Enhanced MASS situational awareness using virtual and conventional AtoN** should be further studied. It was tested in the US, existing AtoN and virtual AtoN enhanced the effective movement of MASS.
- Sending a situational image (Ladar, Radar) from shore-side station to MASS had stated.
- When GNSS signal is spoofed or jammed, through **integrity monitoring**, MASS should switch position fix using the landscape and visual AtoN.
- Need to learn from trials and testbed and other industry such as road and railroad.

VTS authority perspective

VTS communication



MASS uses VHF

Technology	Coverage	Max. Data rate (kbps)	Service
HF	More than 500km	0.1 kbps	DSC
MF	Up to 500km	18 kbps	NAVDAT
VHF	Up to 100km	9.6 kbps (AIS, ASM, DSC) 300 kbps (VDES)	DSC, AIS, VDE, ASM
GEO Satellite	Global, except polar regions (>76°)	50 Mbps	Inmarsat, VSAT, etc.
LEO Satellite	Global	130 kbps	Iridium
WiMAX	15km (coast)	6 Mbps	comm. services (Singapore)
LTE / 4G	25km (coast)	7 Mbps	comm. services
Long range WiFi	55km (coast)	3 Mbps	comm. Services (proposal for India)
LTE-Maritime	100km (coast)	1 Mbps	comm. Services (proposal for South Korea)

U.S. Navy Wants its Unmanned Vessels to Make VHF Calls

The U.S. Navy / DARPA autonomous vessel Sea Hunter (file image)

The maritime executive

MASS VTS authority

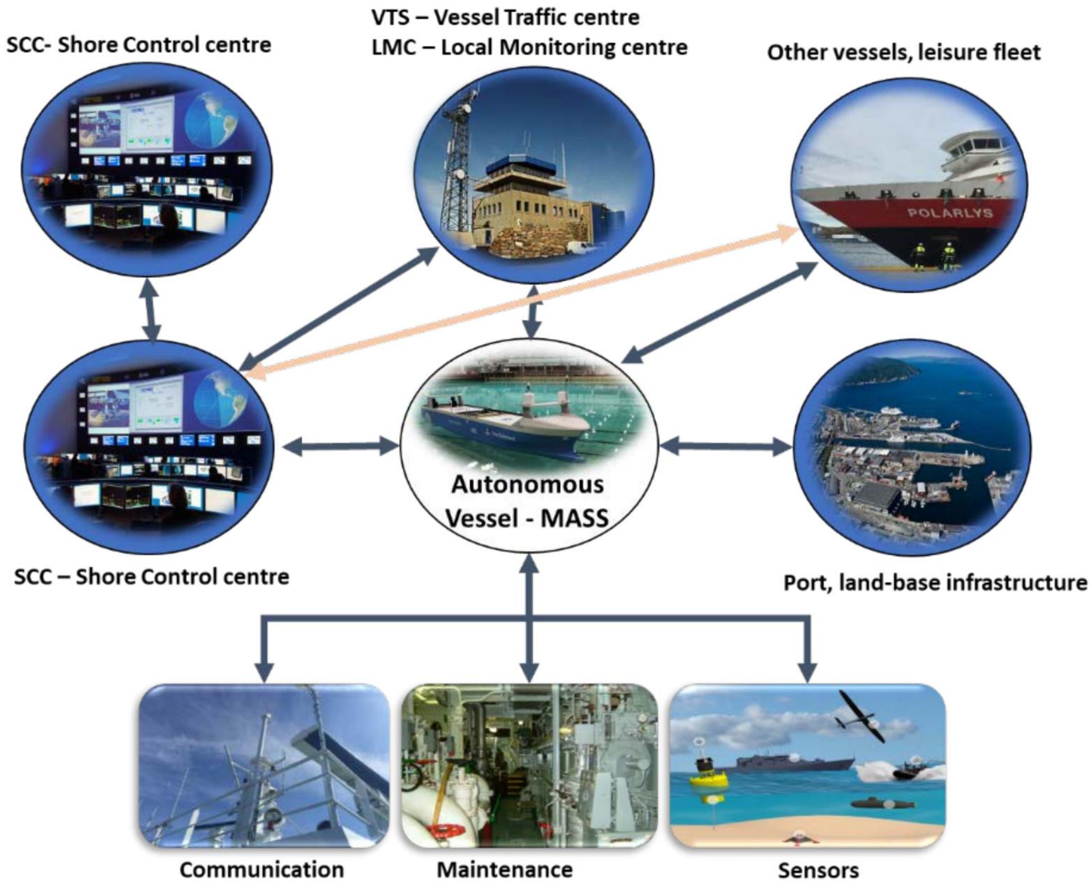
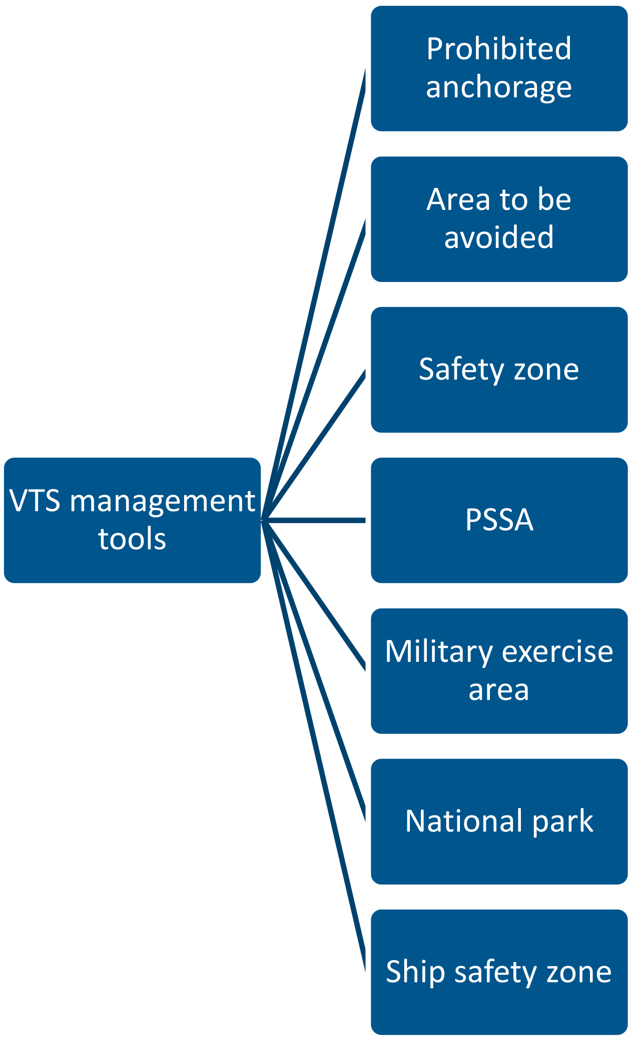


Figure 1 - Integrated Maritime Autonomous Transport system

VTS role in managing restricted or limited access area (G1070)



Management tools

Surveilance measures (radar, CCTV..)
Visual Aids to Navigation
Navigational warnings (NtM)
Coast Guard vessel and aircraft

Impact on VTS

- **Communication** between VTS, SCC, LMC, MASS and conventional ships should be **discussed and harmonized**.
- VTS may be not involved in controlling MASS, but, in an emergency case, **how VTS could stop the maneuvering** of the vessel (emergency stop button).
- Need to learn from the trials and tesbed
- The **VTS centres and operators** (Norway, China, Finland) where have **MASS trials** in their area could contribute peeping into the future.

Role of IALA

Technical Committee Leadership for 2018-2022

- Aids to Navigation Requirements and Management Committee (ARM):
  - Chair: Captain Phil Day, Northern Lighthouse Board, UK
  - Vice Chair: Mr. R David Lewald, US Coast Guard
- Engineering and Sustainability Committee (ENG):
  - Chair: Mr. Simon Milliard, Trinity House, UK
  - Vice Chair: Mr. Michel Cousquer, Cerema, France
- e-Navigation Information Services and Communications Committee (ENAV):
  - Chair: Commander Hideki Noguchi, Japan Coast Guard
  - Vice Chair: Mr. Jorge Arroyo, US Coast Guard
- Vessel Traffic Services Committee (VTS):
  - Chair: Ms. Monica Sundklev, Swedish Maritime Administration
  - Vice Chair; Mr. Dirk Eckhoff, WSV, Germany

IALA Committee Roles in e-Navigation and MASS

IALA's Work in e-Navigation and MASS

- **ARM**
  - Future Role of conventional AtoN
  - Conduct risk assessment
  - MS 17, S-200 PS and Portrayal
- **ENG**
  - MS 18, RPNT and e-Navigation
  - Smart fairways
- **VTS**
  - A.857 Revision and Future VTS
  - Digital VTS services PS
  - Emergency response plan
  - MASS Legal aspect
- **ENAV**
  - Technical service, and harmonised data model
  - Digital Communi-cations, Ship to ship, ship to shore, shore to shore VDES, 5G
  - Cyber security and new technologies

Way forward

- IALA needs to give attention to the development of MASS and conduct a **risk assessment including legal aspect**.
- The role of conventional AtoN with MASS regarding **ship integrity** should be further studied in the frame of e-Navigation
- It is expected that **VTS** will act as a **front office to MASS** between the SCC, LMC and other ships. IALA should closely involved in developing the **communication and data model.** For this, VTS centers which are close to MASS field test (Norway, Finland, china) should be involved in this development.
- The outcome of these studies should be reflected in the IALA recommendations and guidelines.

QUESTIONS ?

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国土交通省

Japan's policy on autonomous ship

Yasuhiro Urano
Deputy Director, Ship Safety Standards Office,
Safety Policy Division, Maritime Bureau, MLIT

Gradual Development of Autonomous Ship

MLIT

- Autonomous ships would evolve in a phased manner, based on conventional ships, along with the development of technologies and their practical application.
- The areas of autonomous decision-making by systems gradually expands.

Conventional Ship

Phase I

✓ Machinery and equipment connected to network
✓ Big data from various onboard sensors
✓ **Simple Decision support**
  -proposing optimized routing
  -engine failure alarm etc.

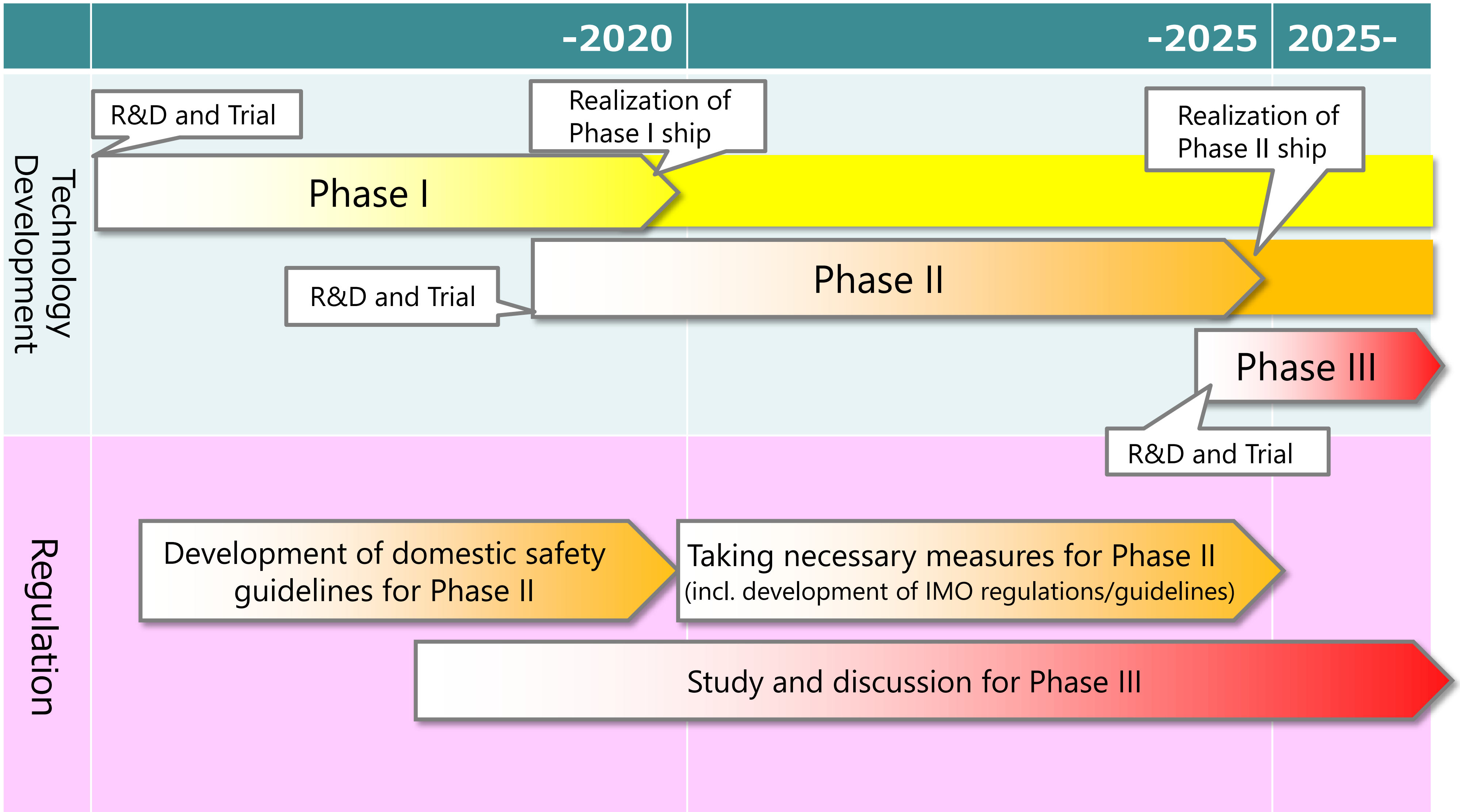
Phase II

✓ **Concrete action planning and proposals** by systems to seafarers (proposal of collision avoidance path, fault detection and predictive maintenance of equipment etc.)
✓ **Specific action would be performed automatically by a system under the approval by seafarers.**
  (manned bridge with autonomous navigation etc.)
✓ **Manned bridge with shore-based remote control**

Phase III

✓ Systems with **high level of autonomy** for some functions (e.g. navigation)
✓ Functions are performed in all normal weather and sea conditions.
✓ Broad **regulatory and liability issues need to be addressed.**

Japan's Roadmap (Three-Phased Approach)

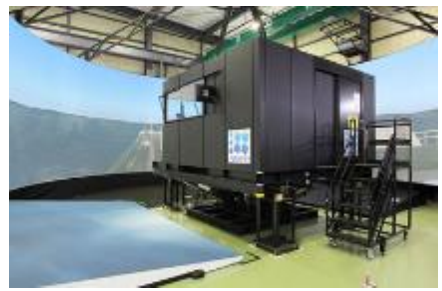


Demonstration Projects of Autonomous ships

- Toward the realization of Phase II ship by 2025, MLIT adopted 3 projects for trials of autonomous ship technologies.
- Through these projects, various data and lessons learned are expected to be collected for future regulatory consideration.

Autonomous Navigation/Collision Avoidance

- ✓ Simulation test and trials at sea
- ✓ Development of generic method to verify the safety of autonomous navigation algorism



Remote Control Navigation

- ✓ Simulation and trials at sea
- ✓ Identifying necessary quality and quantity of information and data which is exchanged between ship and shore control station

Automated Berthing

- ✓ Simulation test and trials at sea
- ✓ Development of generic method to verify the robustness of automated berthing function

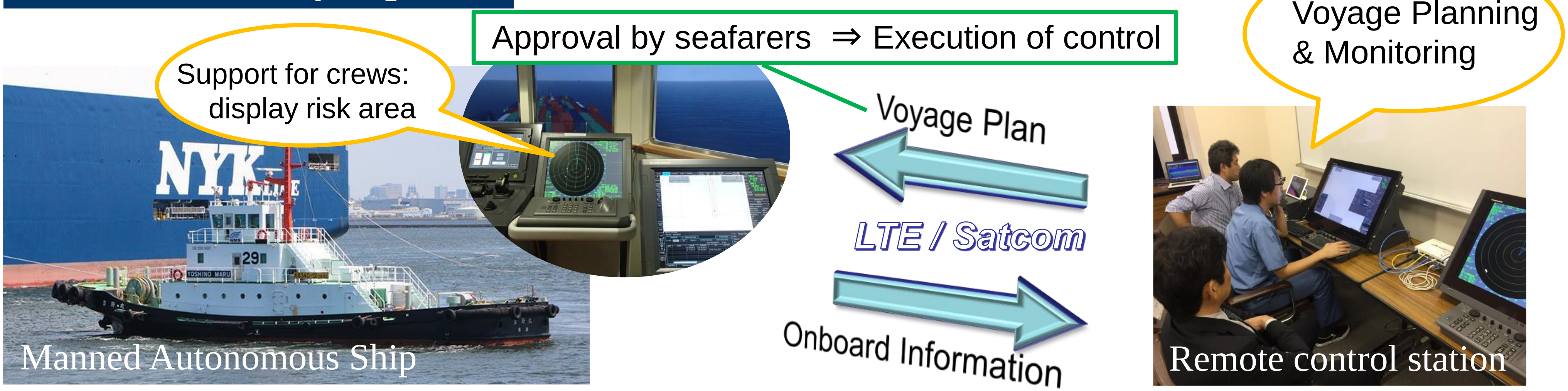
Remote Control Navigation (NYK et al.)

- NYK Group and other manufacturers launched a demonstration project utilizing ship maneuvering support functions and remote control in 2018.
- As part of MLIT's project, trials for remote control navigation will be conducted to identify technical and regulatory issues and to verify the safety of the system.
- During the trials, NYK is also verifying their operational concept, such as support of crews onboard by calculating index for collision risk judgment and displaying risk area.

Objective of Remote-Control Navigation

- <u>Reduction of workload and support for decision making onboard</u> with additional information and advices for the seafarers
- Taking control of a ship in emergency

Demonstration by Tug boat

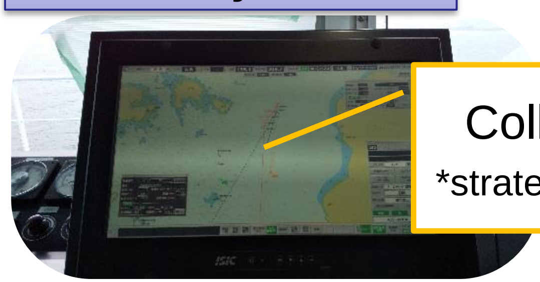


Autonomous navigation/collision avoidance (Oshima shipbuilding)

- "e-Oshima," a battery-driven vessel with automatic maneuvering system for collision and stranding avoidance, was built on June 2019 by Oshima Shipbuilding.
- As part of MLIT's projects, the risk assessment of the navigation system was conducted by NIPPON KAIJI KYOKAI (Class NK).

© Oshima Shipbuilding Co., Ltd.

COLREG-compliant Nav. system



Collision avoidance trajectory

*strategies involving both path and speed

→ Without the "rejection" of the onboard crew, the system automatically executes control.

Main Particulars of the ship

LBDd	35m x 9.6m x 3.8m x 2.6m
Gross Tonnage	340 GT (domestic)
Motors	220kW x 2 (Azimuth Propeller x 2)
Battery	600 kWh
Max Speed	10 knots (350kW)
Capacity	・50 passengers ・8 cars (or 1 bus and 4 cars)
Sensors	Radar and AIS LiDAR (in the future)

Safety guidelines for remote-controlled small vessels

- MLIT has published the safety guidelines for remote-controlled small vessels in April 2019 to make the application of regulations clear.
- It is expected to promote the use of such vessels in various fields (e.g. survey, research).

Points of the guidelines

＜Operational requirements＞

✓ **Unmanned operation is permitted** provided that the **operational manual** is approved by the Minister

Contents of operational manual

- Remote controller's knowledge and skills for navigation (licensed etc.)
- Planned sea areas of operation
- Watch systems (who is a look out etc.)
- Emergency communication plan

etc.

＜Technical requirements＞

✓ **Additional requirements for remote operation**

- Function to control engine and steering via radio communication
- Measures to mitigate safety risks in case of the disruption of radio communication for control

✓ Operated only within **visual line of sight**

- 3 NM from a controller (in principle)

✓ Exemption for vessels with zero capacity

- No need to carry life-saving appliances, chart etc.

Thank you for your attention.