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

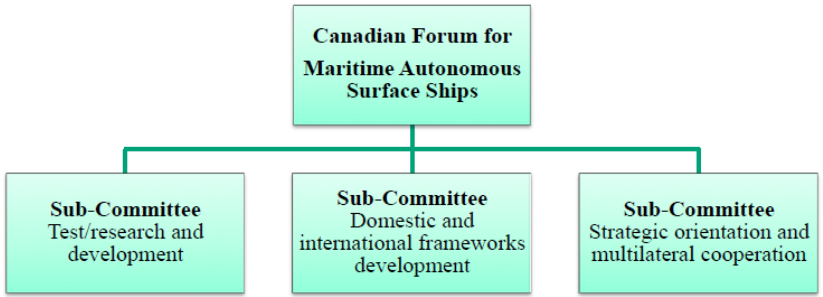
Supply Chain

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

CANADA'S DIGITAL SEAWAY

Creating the world's first digital inland waterway – from the ocean to the Great Lakes

Quebec Saint-Lawrence Seaway: Intelligent Maritime Corridor

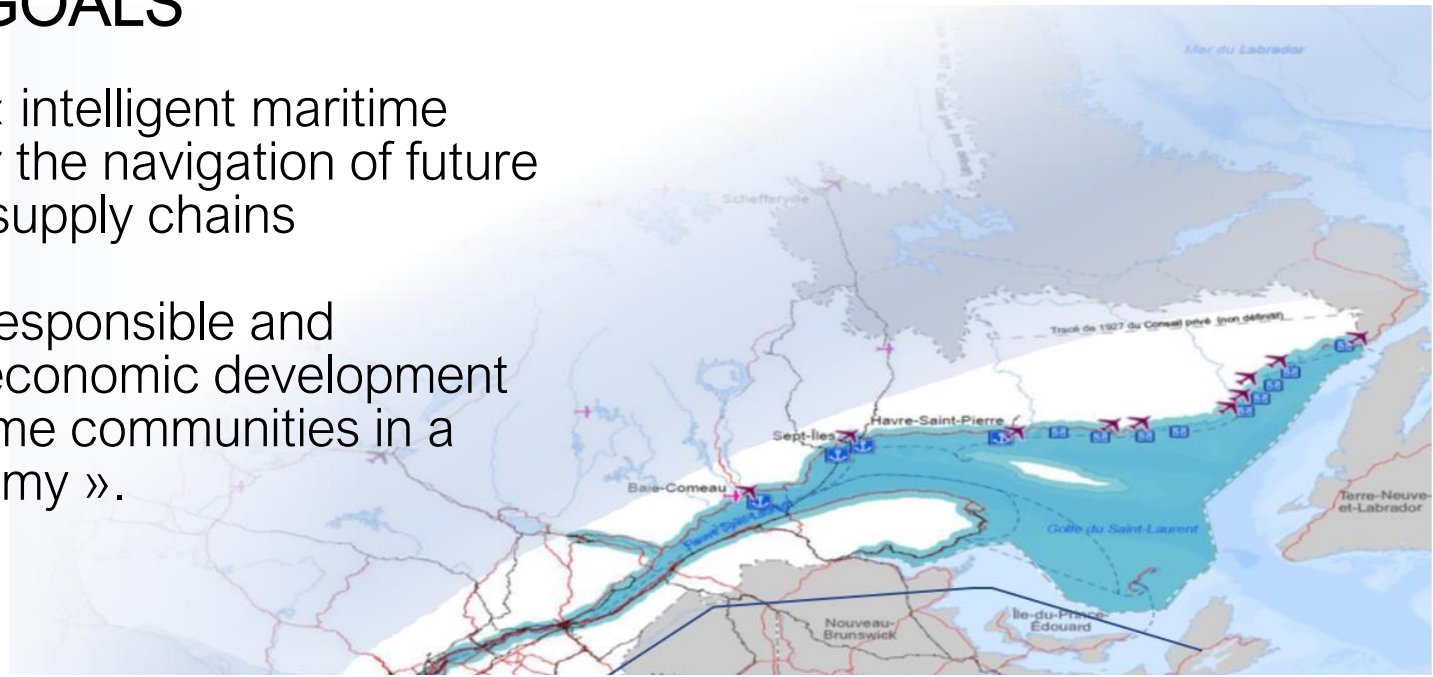
Maritime Vision for Economic, Social Development & Environmental Protection

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

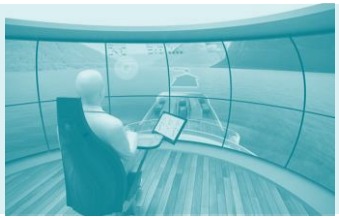
- AI-powered container inspection
- Digital Twin Modelling
- Automated labor dispatch
- Port Security
- Predictive Analytics using Machine Learning

Control Centres at the centre of the MASS Ecosystem

Control Centres for future Maritime Transport Operations

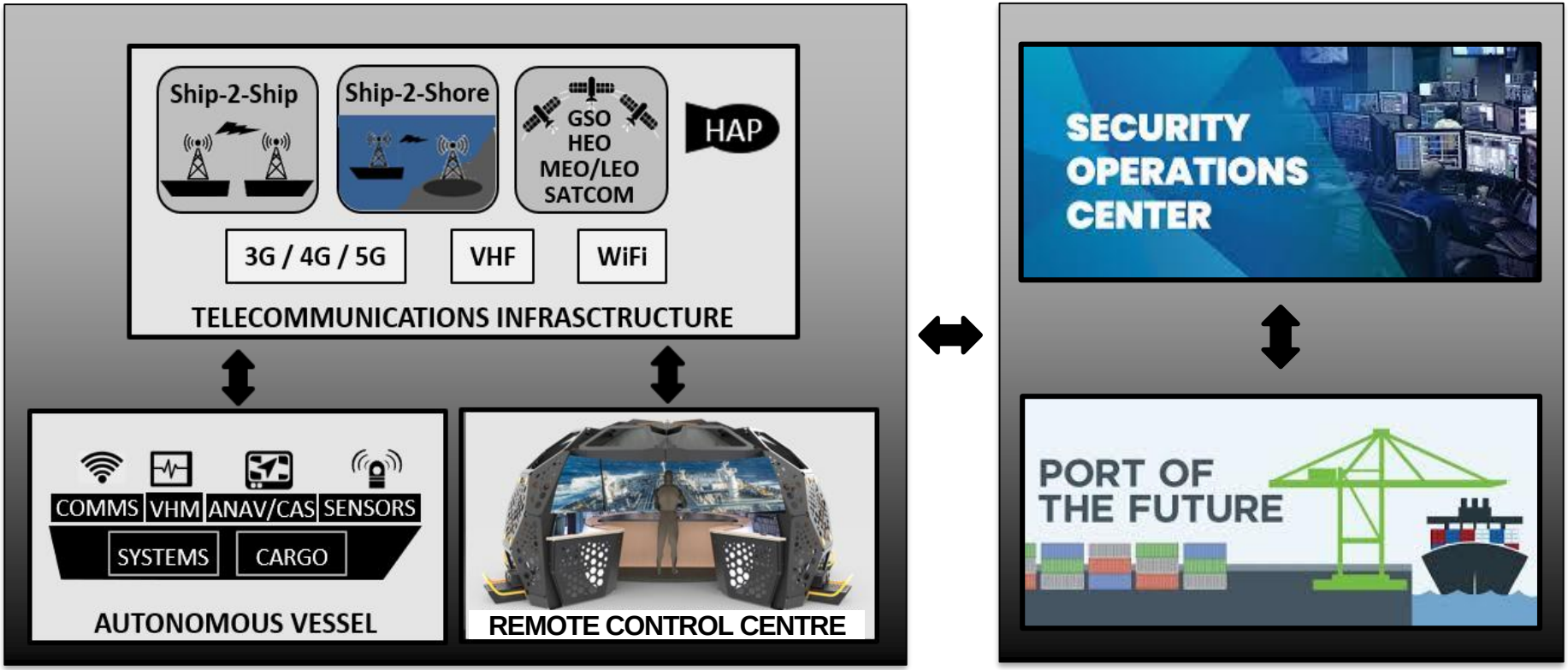
Focus on Testbeds & Pilot Projects

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



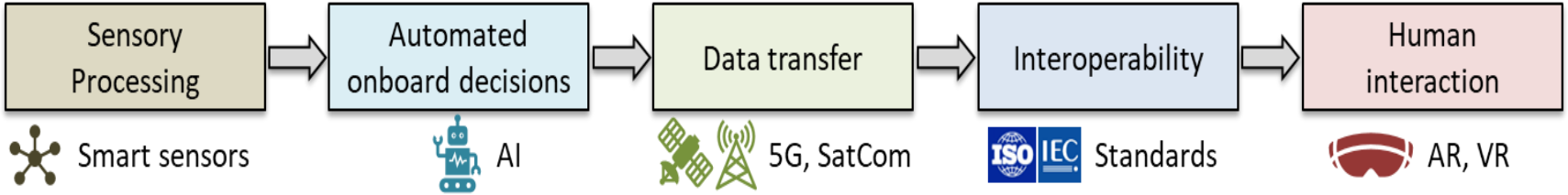
MASS Ecosystem Challenges

Insurance & Liability Perspectives

Shipowners	Yards & System Suppliers	Remote Operators	Classification Societies	Insurers
1. Overall function unchanged	1. Services	1. Multiple operational concepts	1. Verification & Certification of MASS	1. Insurability
2. Relation to remote operators	2. Compliance	2. Division of existing duties & obligations	2. Drive regulatory development	2. Risk associated with higher levels of autonomy
3. Goods, ship & incident Liability	3. Maintenance	3. Operator Liability		3. Access to operational data
	4. Connectivity			4. Cyber risk management
	5. Product Liability			

MASS Ecosystem Challenges

A Technology Perspective



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 :

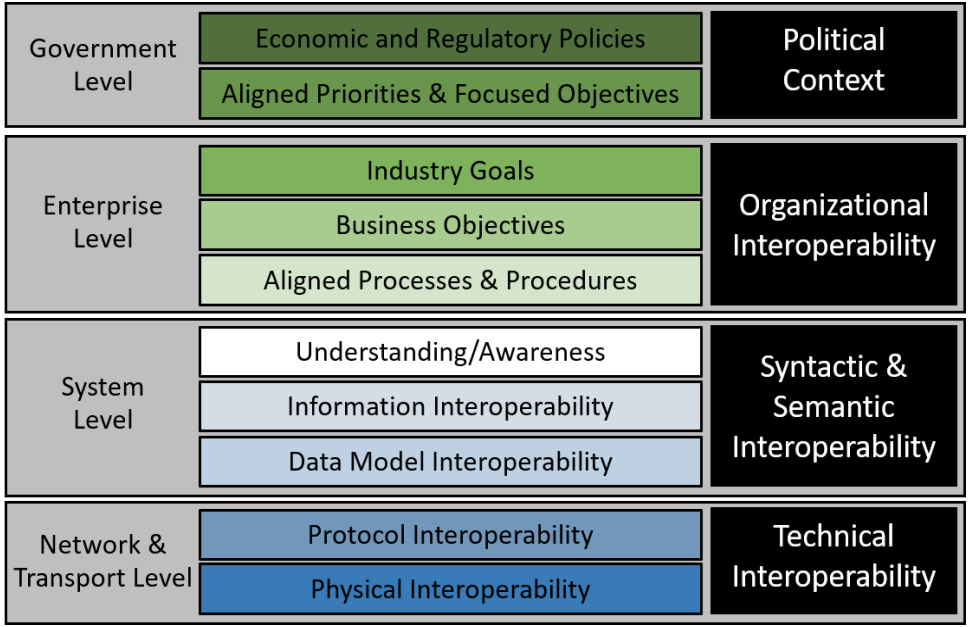
The ability of groups or organizations to work together to achieve common goals.

System Interoperability :

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

Technical Interoperability :

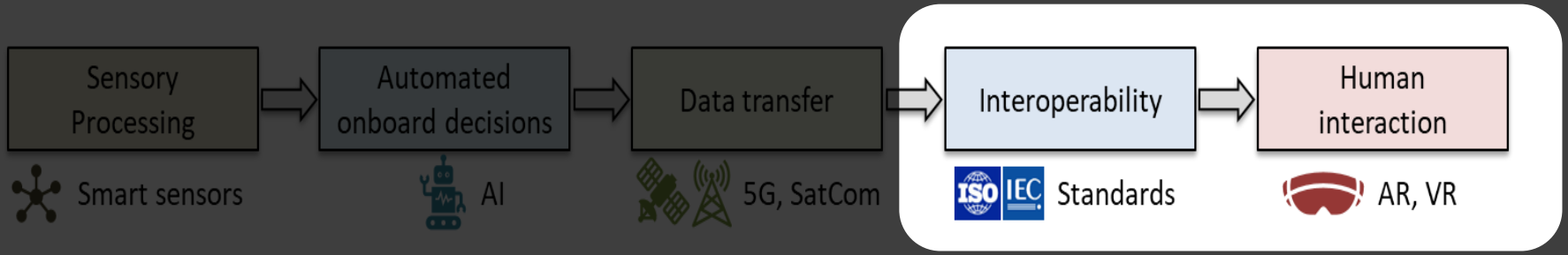
Ensures the interconnection of systems and data exchange via standardized transmission protocols and data formats.



Standardization can contribute to achieving interoperability.

MASS Ecosystem Challenges

Control Centre Requirements



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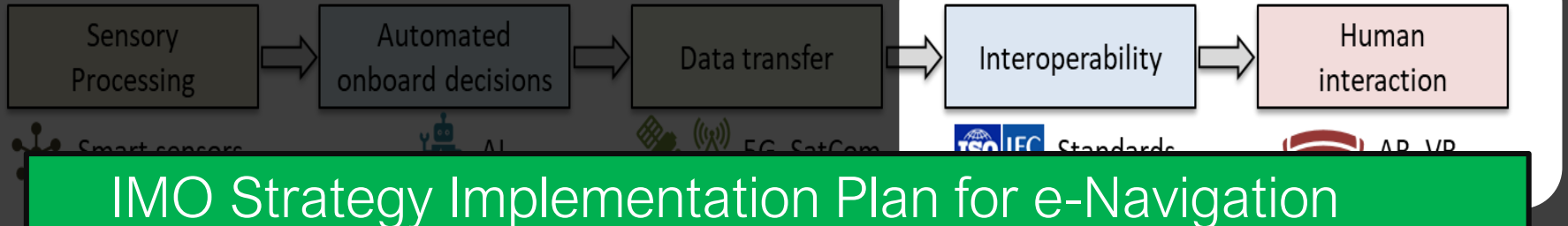
MASS Ecosystem Challenges

e-Navigation Control Centre Requirements



IMO Strategy Implementation Plan for e-Navigation

2 of 5 Prioritized Solutions

S2: means for standardized and automated reporting;

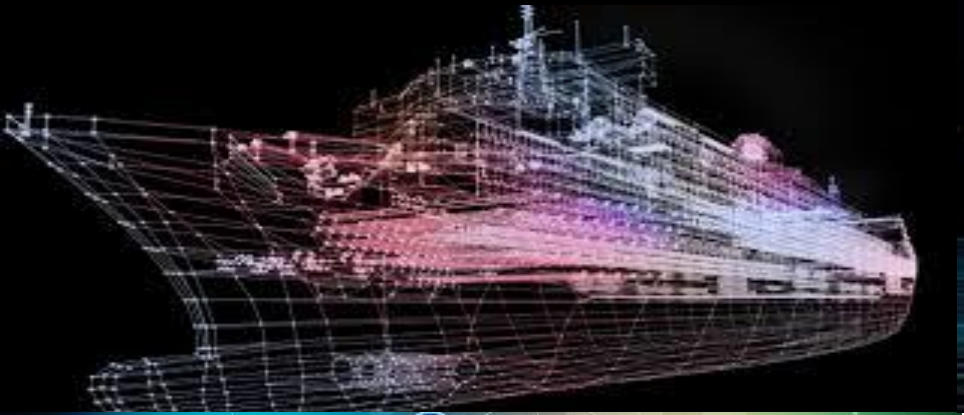
S4: integration and presentation of available information

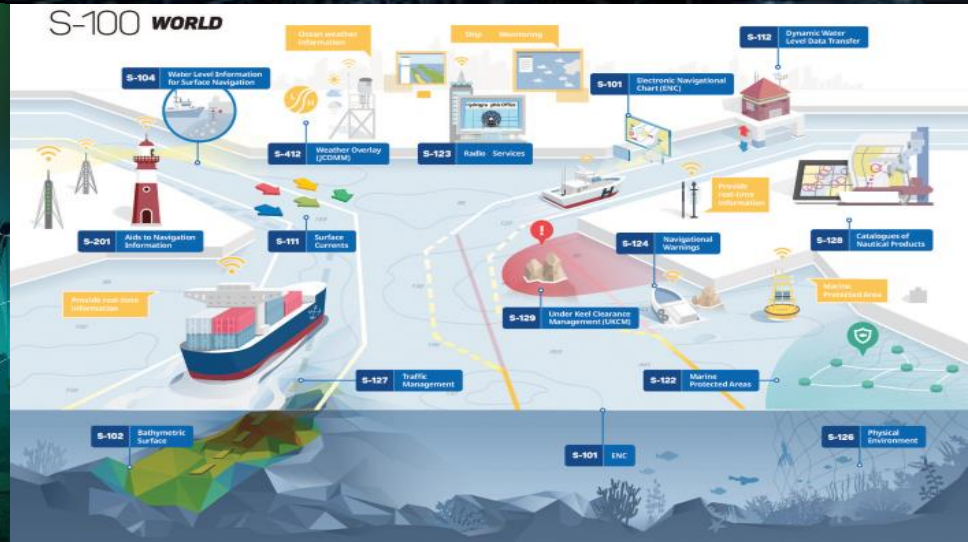
Related Risk Control Options

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

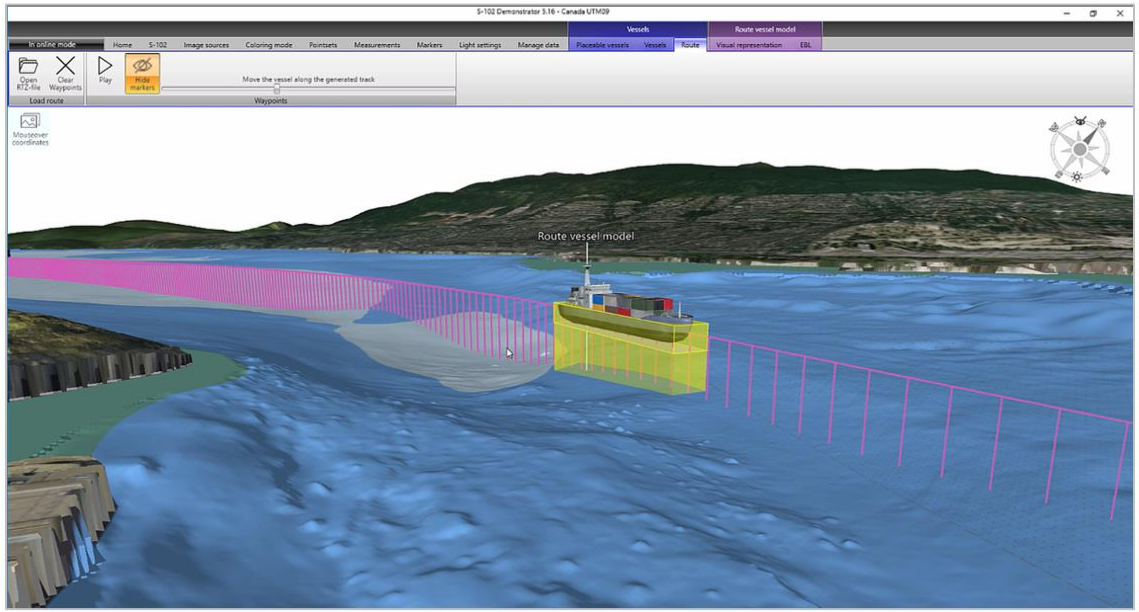
S-100 Universal Hydrographic Data Model | S-200 Shore Services

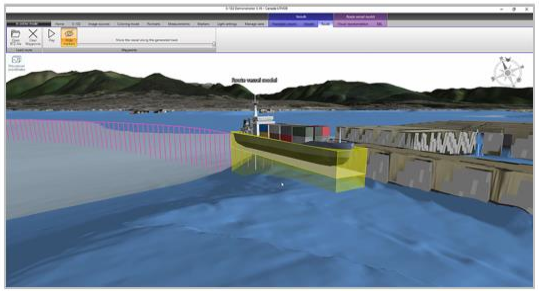
S-102 Bathymetric Data

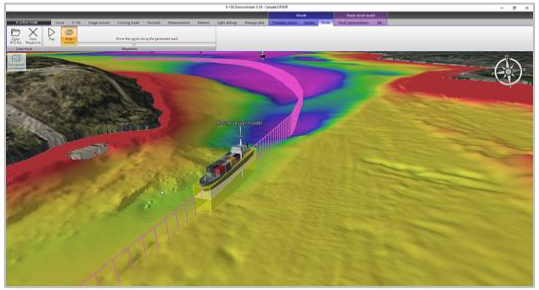
Using Digital Twins for Navigation

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

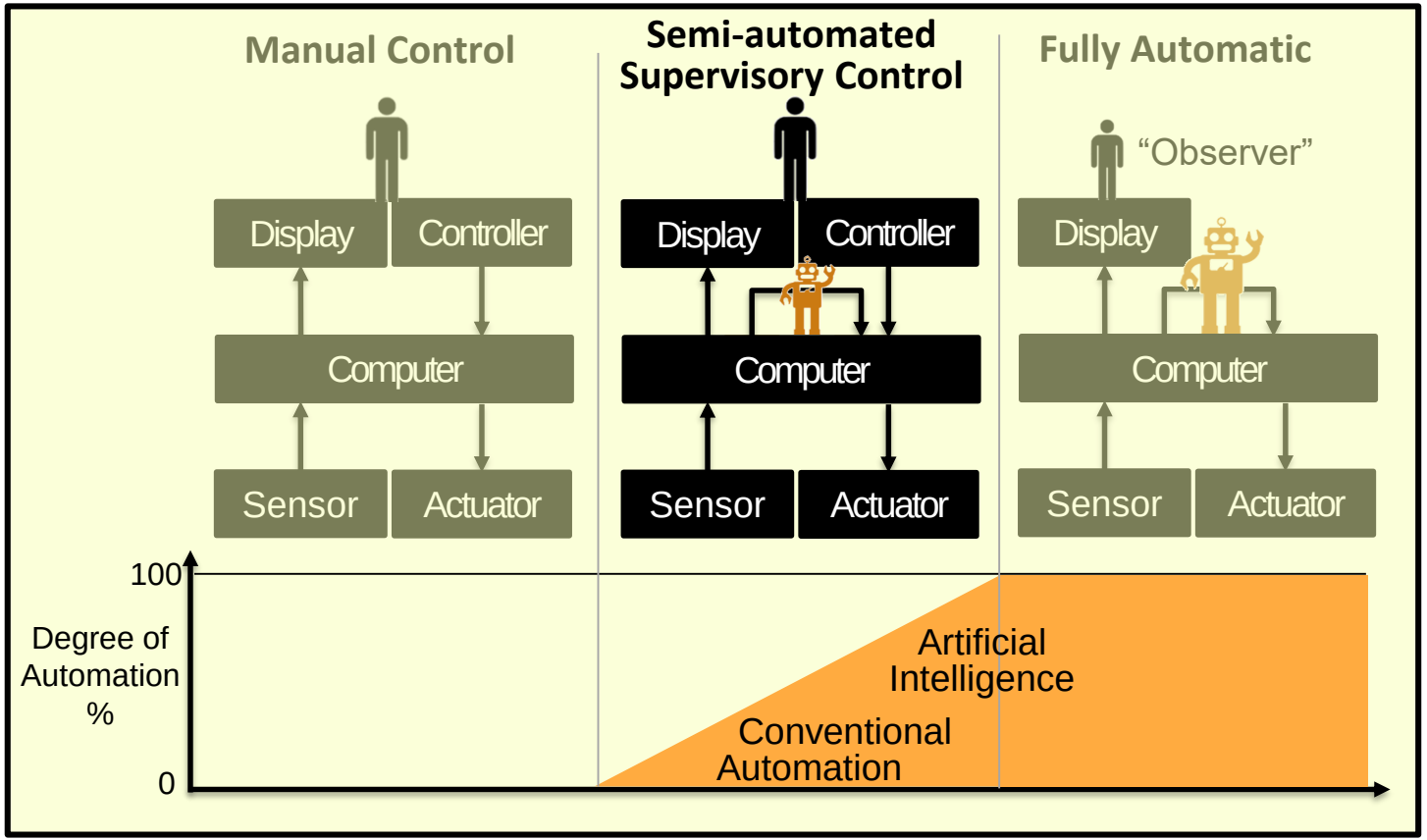
Procedures
Crew/Team Interactions
Tasking & Reporting
Authorizations

Multiple displays
Visual Overload
Excessive inputs
Trust Management

Information Overload
Prioritizing decision-making
Maintaining situational awareness

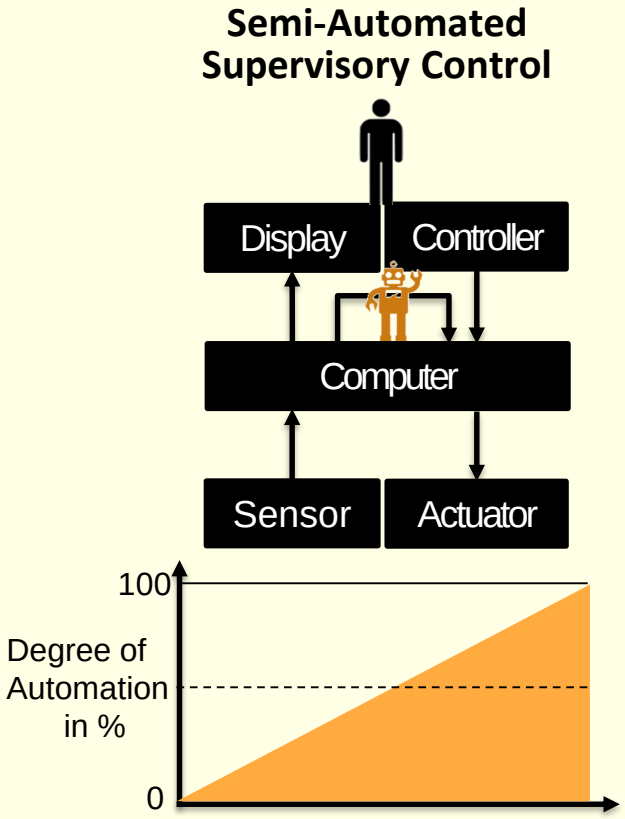
Safety-Critical Systems

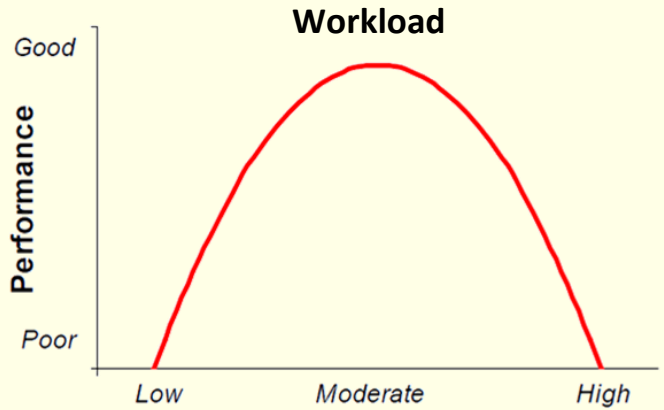
Increasing levels of supervisory control to manage complexity



Safety-Critical Systems

Optimizing human performance for decision-making





AI can contribute to maintaining optimal performance :

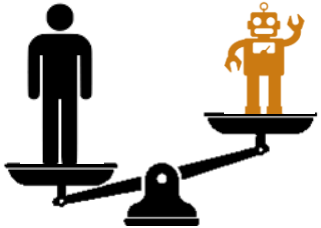
1. **E.g. by dynamically adapting the operators' displays and controls to the operational context while avoiding information overload, and**

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~~

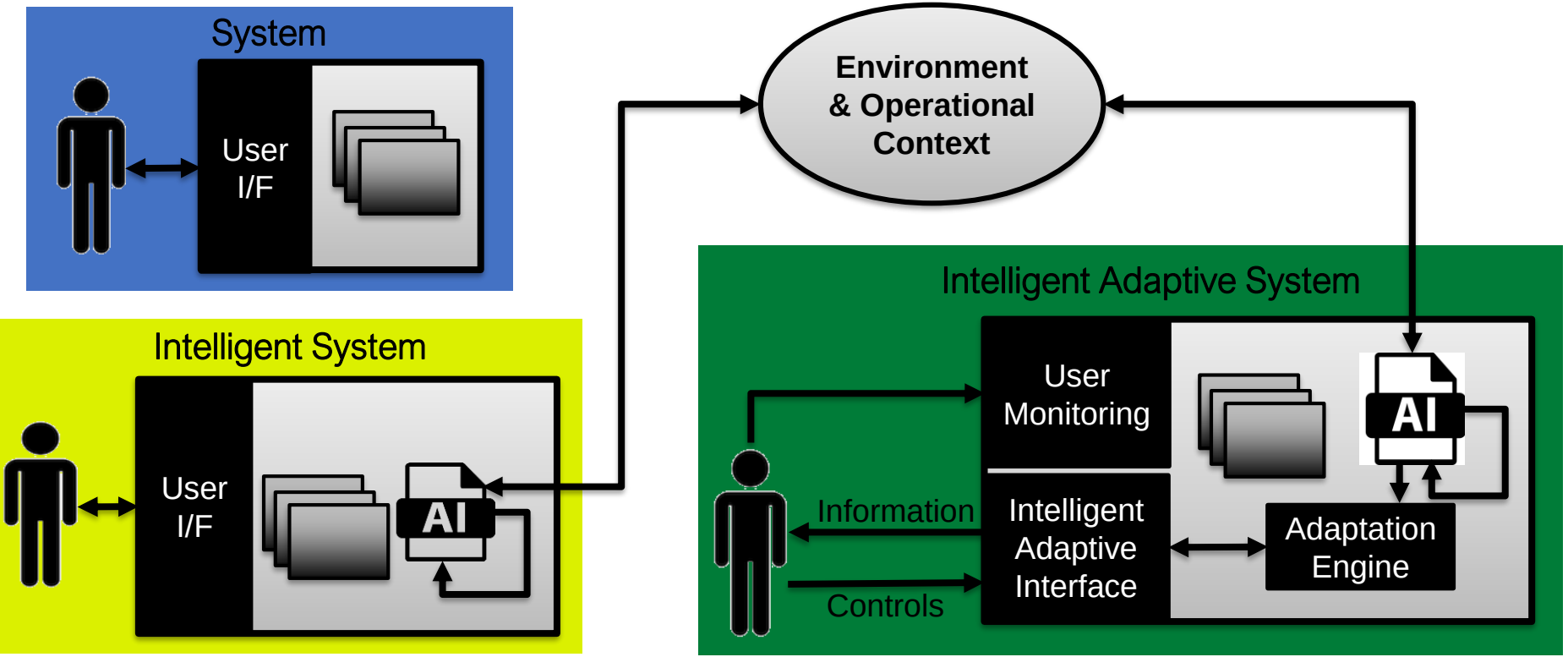


Today: *Humans are better than machines for most complex decision-making tasks.*

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

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

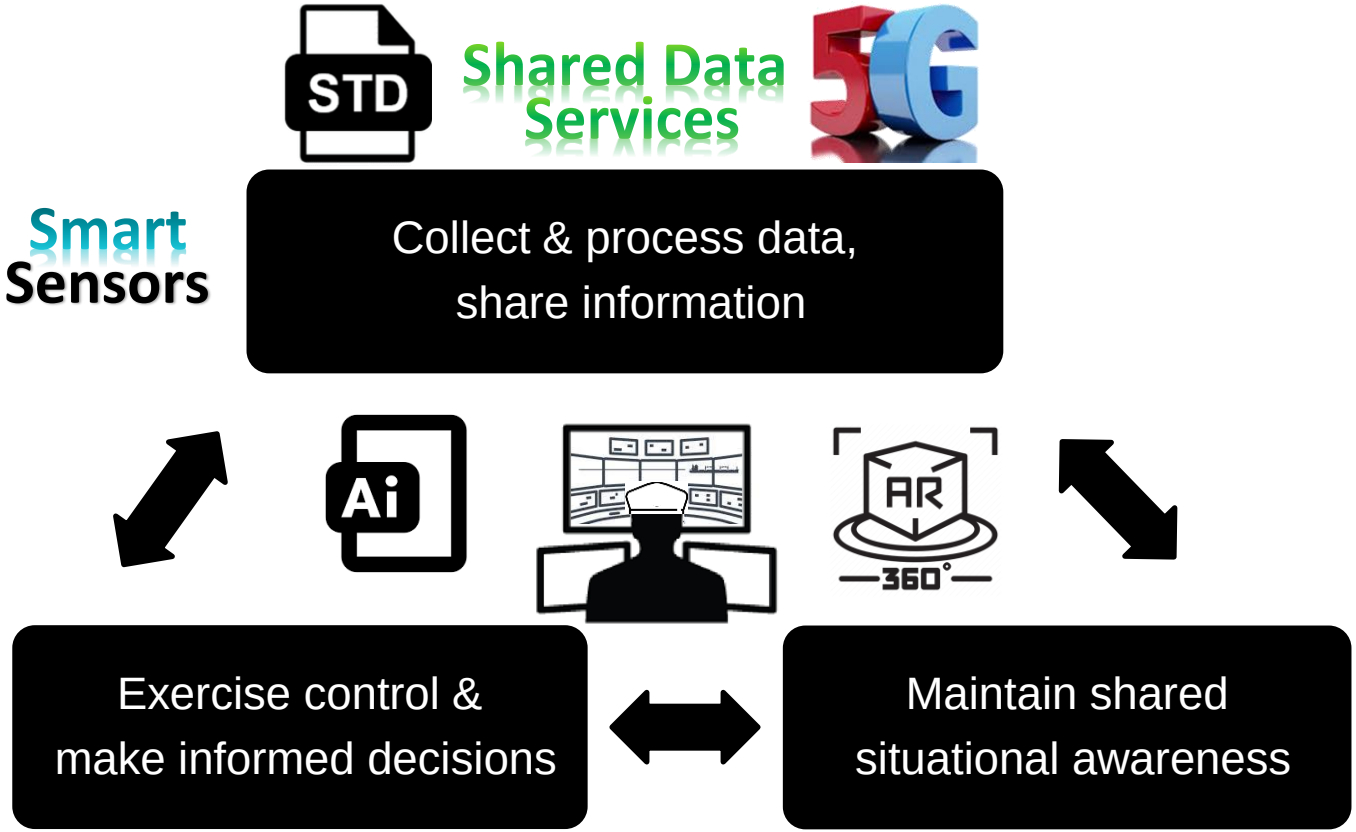
System | Intelligent System | Intelligent Adaptive System



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



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

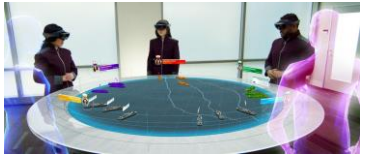
A paradigm shift: *Immersive Safety-Critical Environments for Operational Use*

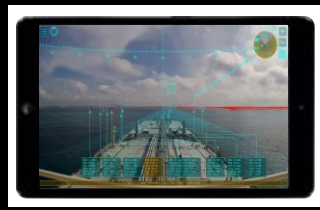
3D Immersion Value Proposition: Use combination of immersion and virtualization to dynamically adapt environment to dynamic situations, including AI-assisted augmented reality, 2D virtual monitors and 3D interactive digital twins to:

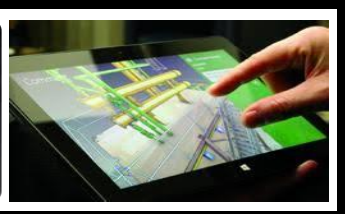
1. Improve Situational Awareness
2. Reduce the risk of information overload
3. Improve operator performance
4. Enable better collaboration and coordination

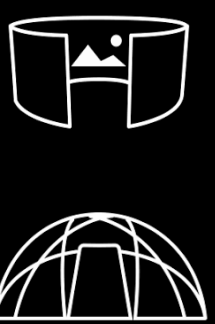
Virtual Reality (VR) & Augmented Reality (AR)

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… **but**

- 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."

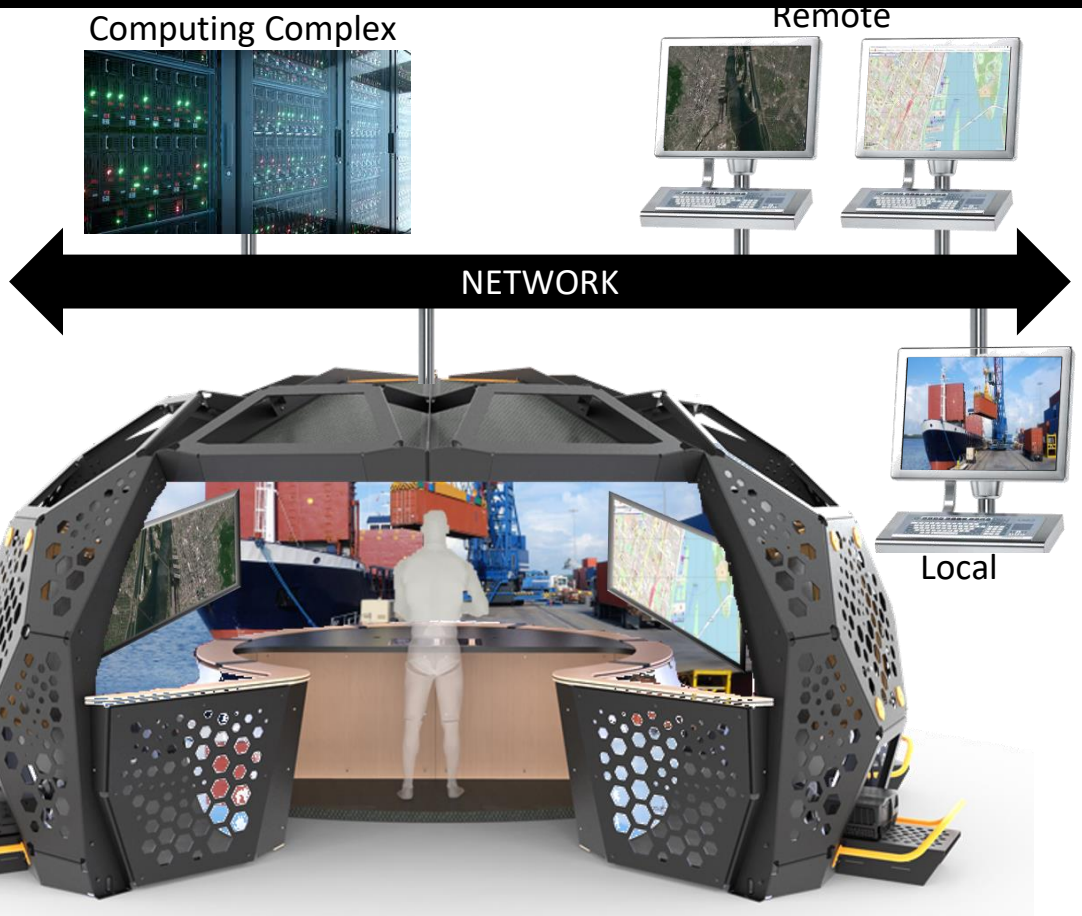
SOURCE: Business Insider, Mar 4, 2018, https://www.businessinsider.com/virtual-reality-vr-side-effects-2018-3

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

Canada

Nautical Charts, Data Products & Services

Canada Ice Services

Connected systems are streamed as 3D images or reconfigurable, dynamic 2D virtual monitors.

System 2

System 3

NETWORK

STM
SEA TRAFFIC MANAGEMENT

Integration with external services

unity

UNREAL ENGINE

Virtual Integration Environment

Integration Environment with support for COTS simulation and visualization engines

System 1

Operator controls the systems using standard keyboard & pointing device or gestural control interface.

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.

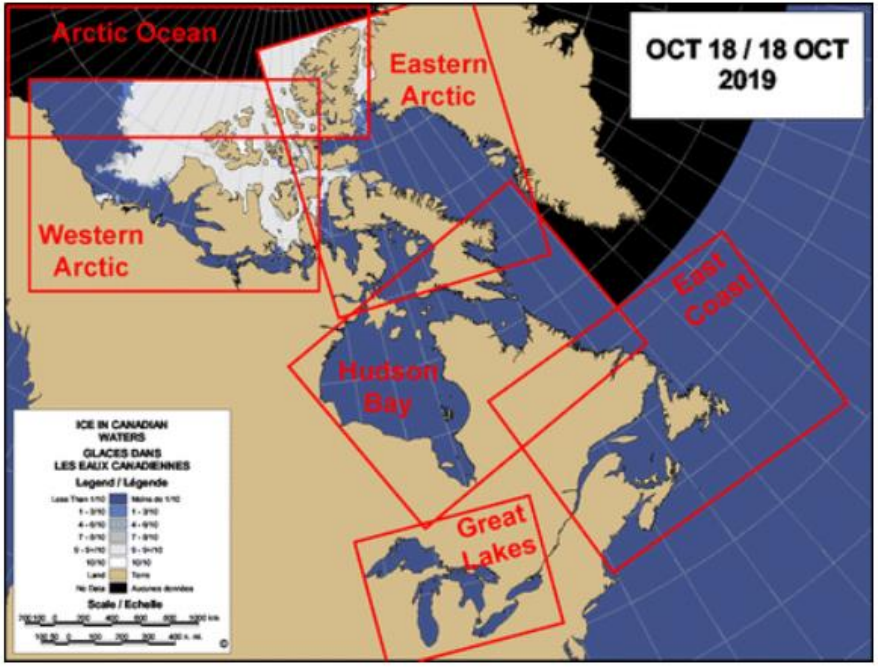
kevin.heffner@crim.ca

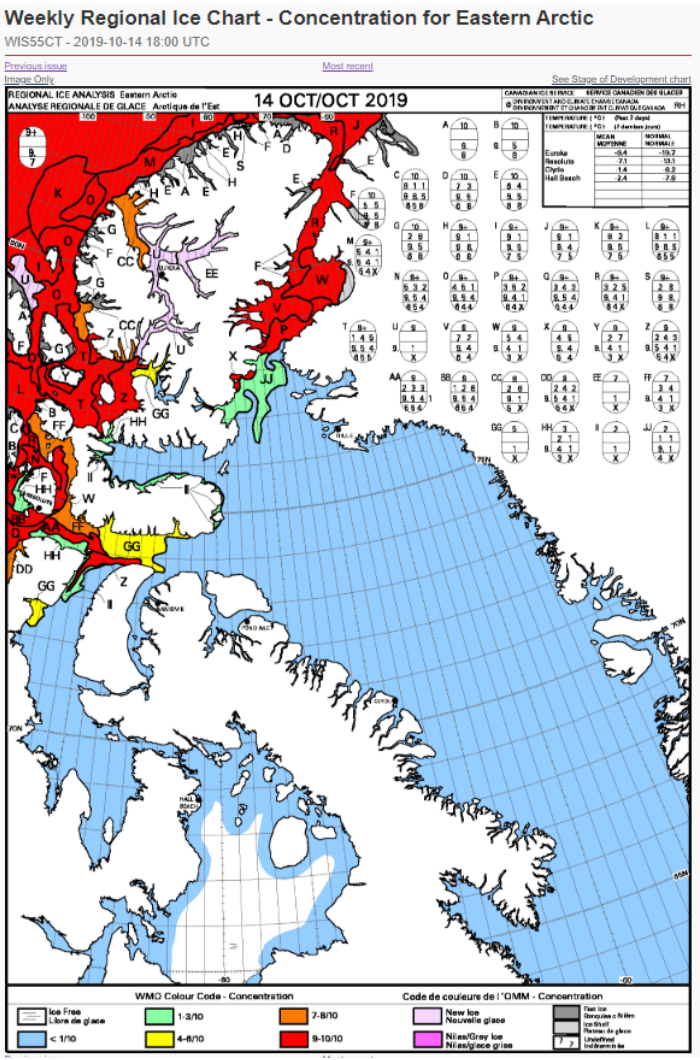
CRIM

Backup slides

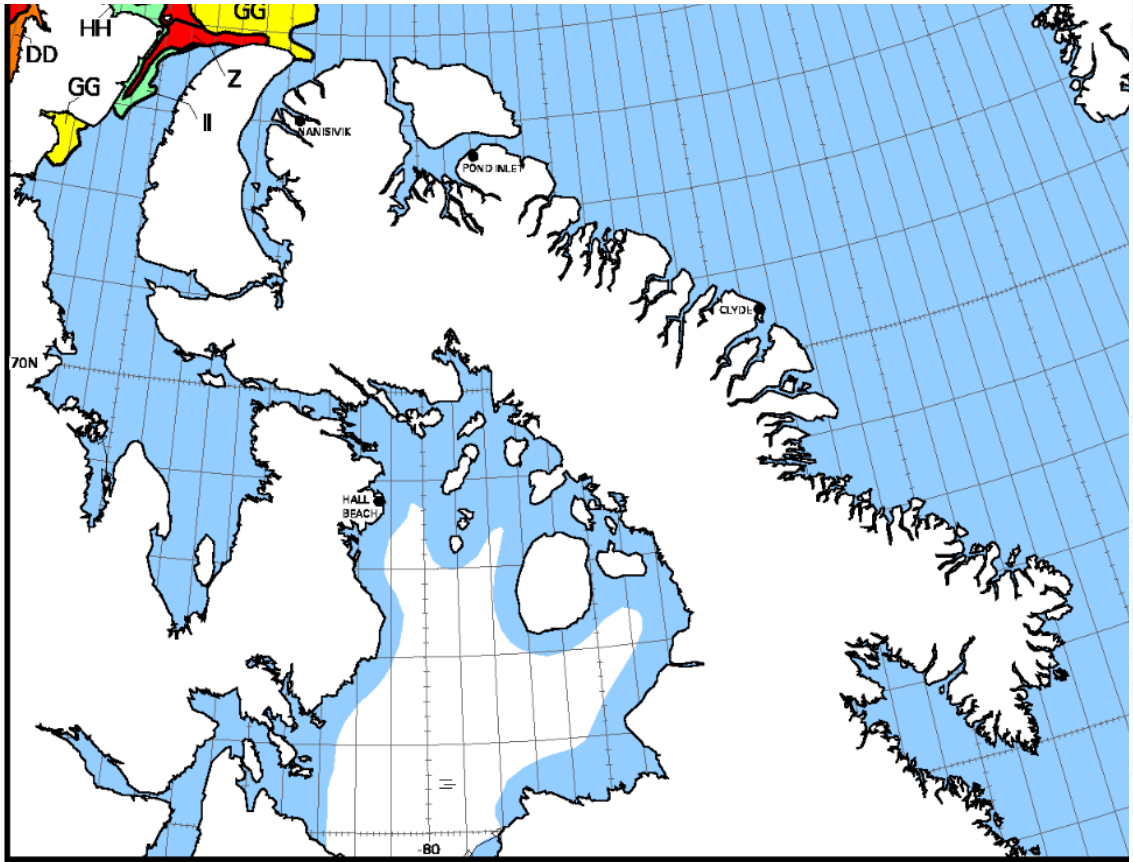
Canada Ice Services

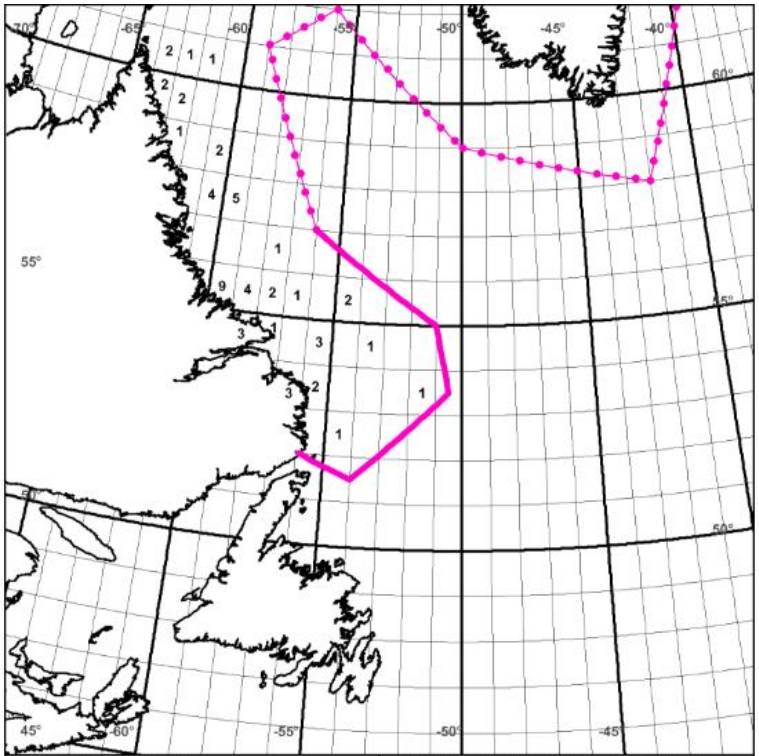
Daily ice charts
Regional ice charts
Departure from normal concentration charts
Image analysis charts
Aircraft ice charts
Iceberg charts
St. Lawrence River observed ice charts





Canada Ice Services – Iceberg Free Zones





NORTH AMERICAN ICE SERVICE
SERVICE DES GLACES DE L'AMÉRIQUE DU NORD

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ENVIRONMENT AND CLIMATE CHANGE CANADA
ENVIRONNEMENT ET CHANGEMENT CLIMATIQUE CANADA

ICEBERG ANALYSIS / ANALYSE D'ICEBERGS
FOR /POUR 0000 UTC

18 OCT / OCT 2019

ICEBERG LIMIT / LIMITE DES ICEBERGS
ESTIMATED ICEBERG LIMIT
LIMITE DES ICEBERGS ESTIMEE
SEA ICE LIMIT / LIMITE DES GLACES
ICEBERGS PER DEGREE SQUARE
ICEBERGS PAR DEGRE CARRE
RADAR TARGET OUTSIDE ICEBERG LIMIT
CIBLE RADAR A L'EXTERIEUR DE LA LIMITE DES ICEBERGS

Most recent reconnaissance :
Southern Limit Iceberg Flight 09OCT2019.
La reconnaissance la plus récente :
Vol Iceberg Limite Sud 09OCT2019.

WMO Colour Code - Concentration

Code de couleurs de l 'OMM - Concentra

Ice Free
Libre de glace

< 1/10

1-3/10

4-6/10

7-8/10

9-10/10

New Ice
Nouvelle glace

Nilas/Grey Ice
Nilas/glace grise

Ice Shelf
Plateau de glace

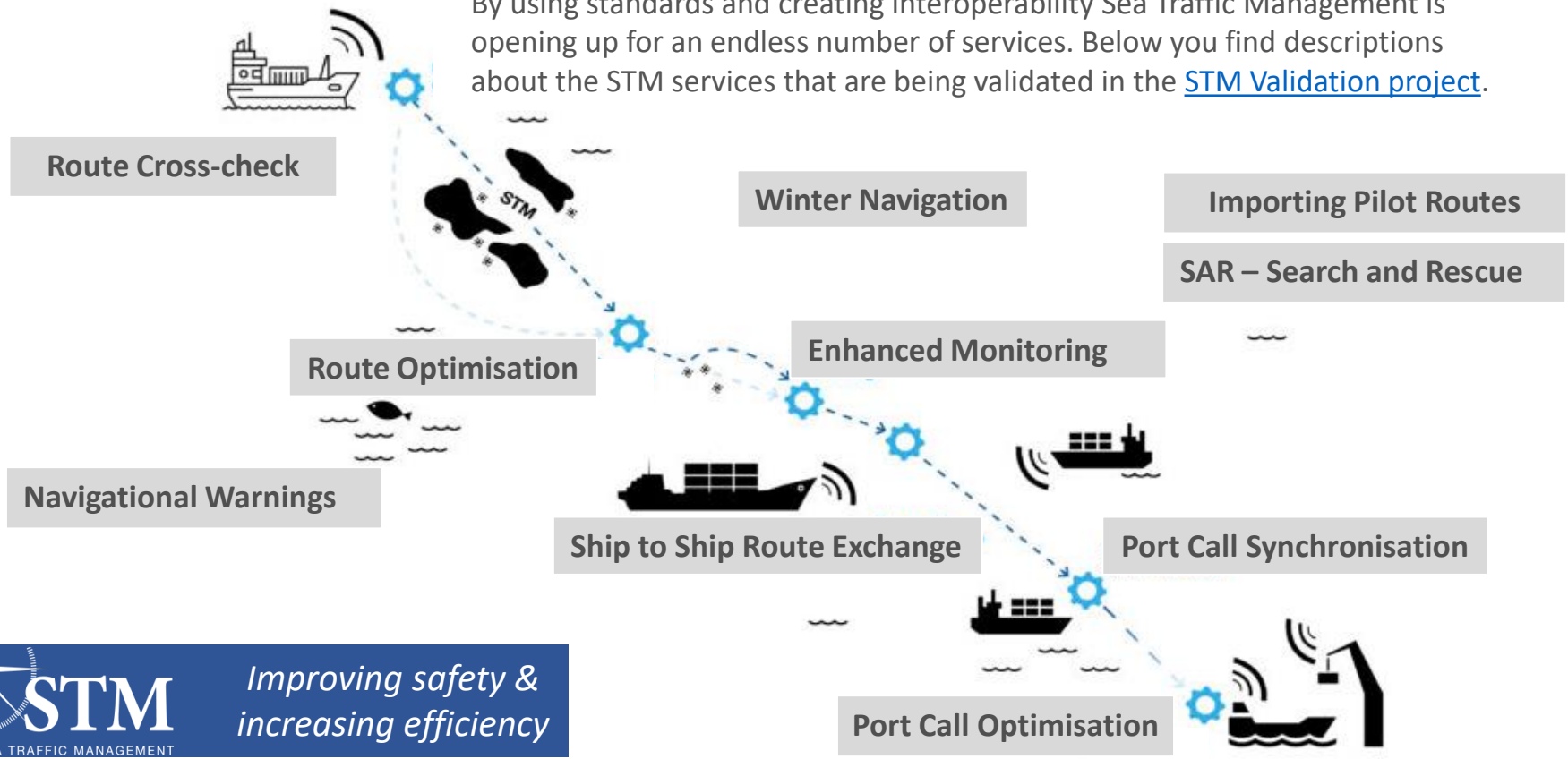
Undefined
Indéterminée

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.