

National Research Council Enabling MASS in Canadian Waters

Mariners Workshop, January 27, 2022

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- 1. Federal activities**
- 2. NRC activities**

Canadian Forum for Maritime Autonomous Surface Ships (CFMASS) Testing/Research and Development Subcommittee

Initially, Testing Research and Development Sub-Committee Objectives were to:

- Create a Technology Roadmap for enabling MASS in Canadian waterways
- Coordinating all MASS related research activities under CiSMaRT (Research and Technology Theme Lead sits on Board)
- Develop multi-party projects to increase enabling MASS technologies created in Canada
- Long term vision to establish Canada as the global leader in testing and evaluation of MASS technology
 - Physical and numerical modeling across Canadian landscape
- Hold monthly webinars to keep national stakeholders informed and engaged
- Information stored on external collaboration site – permission based

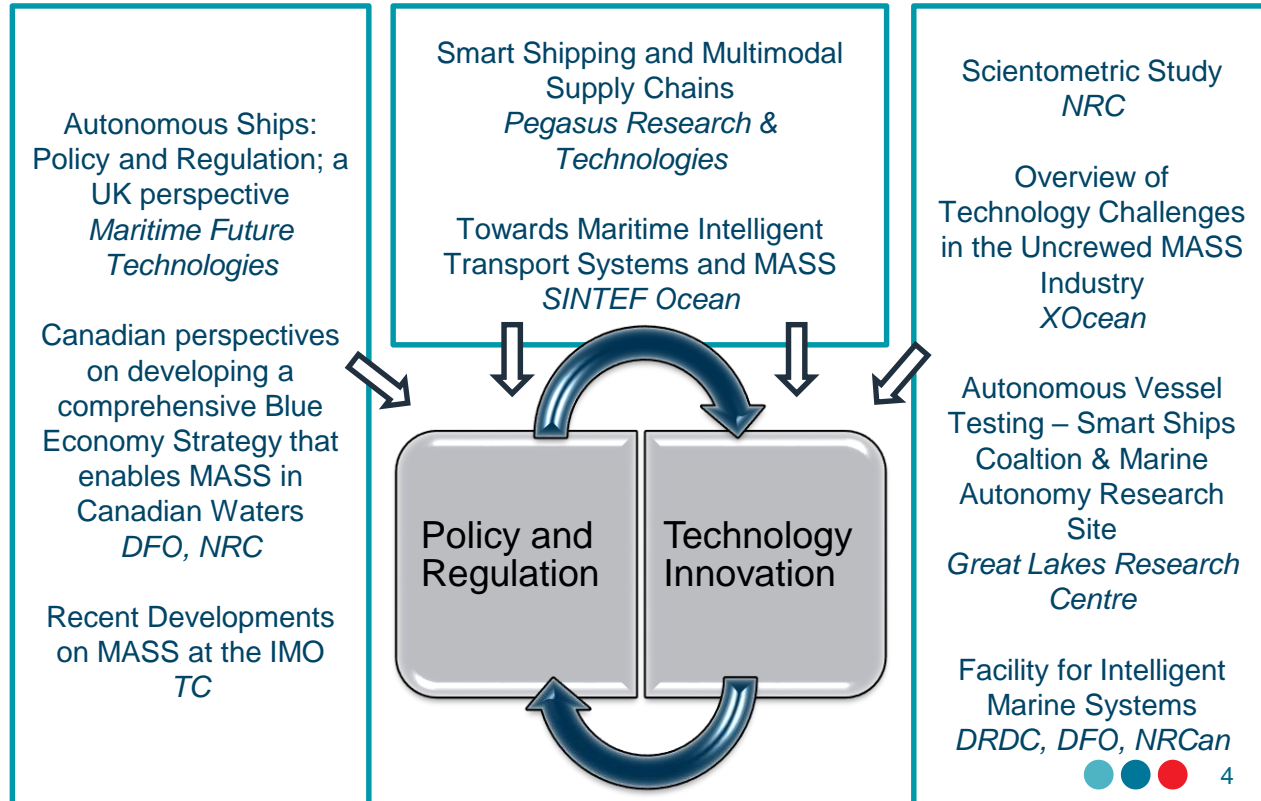
Now, CFMASS a monthly webinar series for bi-directional information exchange only

- All other activities now fall within the Enabling MASS Interdepartmental Working Group

CFMASS Webinar Series in 2021

Standing Agenda:

- CFMASS and NRC Update
- Transport Canada Update Presentation
- Open Discussion



Federal Enabling MASS Interdepartmental Working Group

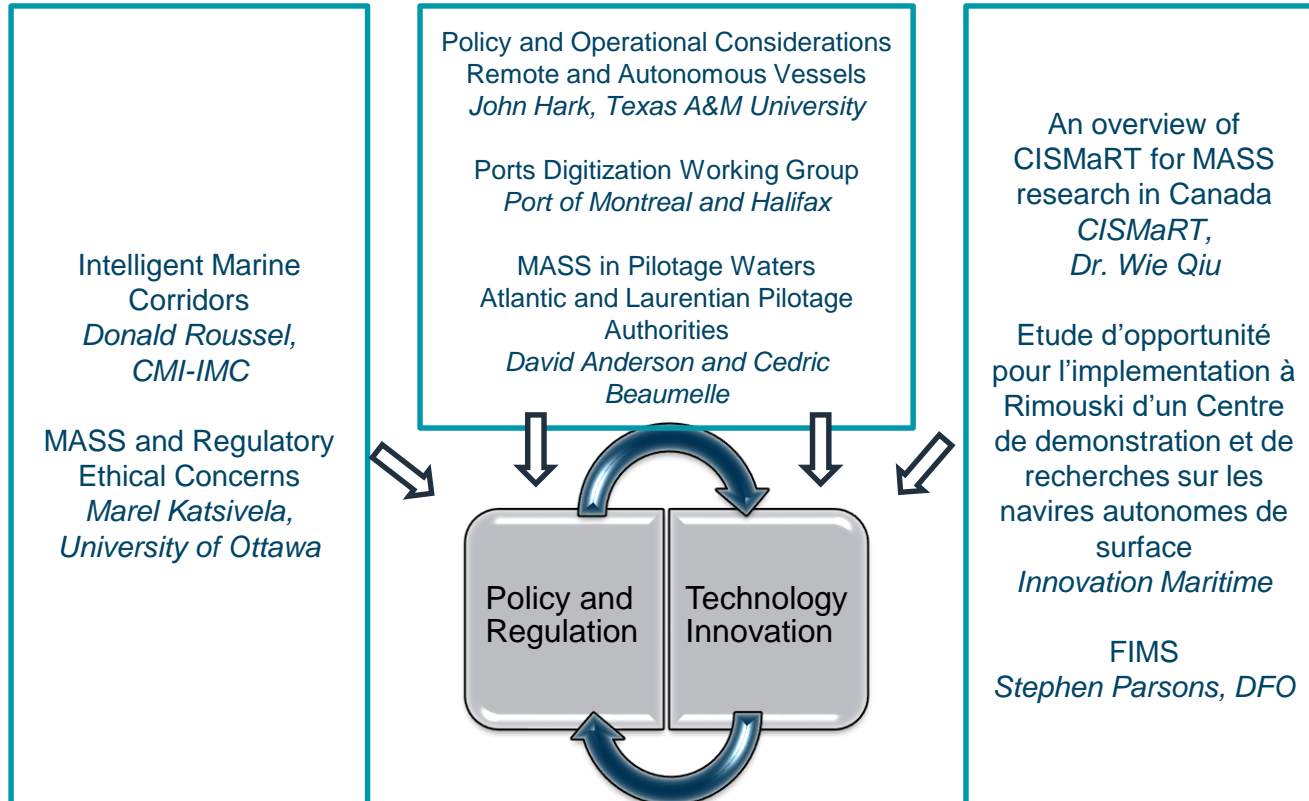
CFMASS activities guided by Enabling MASS Interdepartmental Working Group (eMASS IWG) with participation from:

- Transport Canada (TC)
- Canadian Coast Guard (CCG)
- Department of Fisheries and Oceans (DFO), Blue Economy Strategy Secretariat
- Canadian Hydrographic Service (CHS)
- FIMS (Defense Research and Development Canada (DRDC), Natural Resources Canada (NRCan), DF)
- Canadian Space Agency
- Pilotage Authorities
- Invitation to Ports (regular discussions)

Initiated 5 year technology roadmap for enabling MASS in Canada

- Aligned with federal blue economy strategy

Federal Enabling MASS Interdepartmental Working Group



Roadmap: An All of Government Approach



Technology development and commercialization are important goals

- Control centres will be key to the management and operation of MASS
- Integrated ship-to-port operations (smart ports) is a must; smart ships need smart ports and links to road and rail networks
- Canada can be the leader in the piloted approach for the implementation of MASS – Physical testing, numerical simulation, test beds / ranges needed.

Success requires:

- Canadian stakeholders must recognise how Enabling MASS is relevant to them
- Collaboration with private sector and academia
 - Role for academia – R&D and training
 - Role for industry – Naval architecture and shipbuilding and technology developers
 - Regulations and technologies must mature in parallel



Roadmap: An All of Government Approach

Establish 3 – 6 MASS Living Labs (physical test facilities / ranges or Regulatory Sandboxes)

- In discussions with Halifax, Rimouski/Les Escoumins and Port of Montreal
- Once framework established migrate to West Coast

Living Labs linked to digital lab/digital twin

Link MASS related to work to clean and quiet vessels

Resilient supply chains from destination to destination; smart ports, smart cities



Galvanizing Innovation with Living Labs

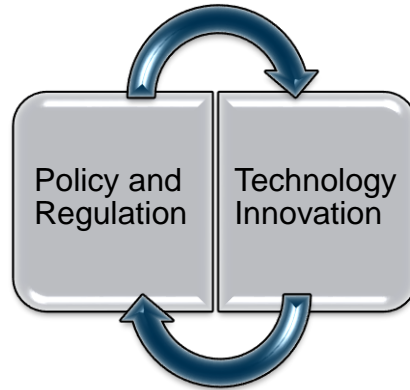
Living lab: Geographically contained location where innovators can develop and test new technologies along side those who are affected by/will use said technologies.

- For shipping:** Innovators – those looking to profit from new technology
- Industry, academia, citizen scientists (early TRL)
 - Incubators play an important roll
 - Government researchers (NRC and SBDs)
 - S&T aligned with federal priorities
 - Regulators
 - Sharing infrastructure, data and information to guide research and inform policy
 - Ports/harbours
 - Transportation system hubs, bringing together all relevant parties (intermodal, customs, security, data exchange, etc...)
 - Mariners (pilots/crew)
 - Subject matter experts and users of shipboard and communications technologies
 - Coastal communities/port cities
 - Canadians whose quality of life is the purpose of innovation

Living labs provide a place, regionally bound, where relevant stakeholders can come together to enhance the innovation process. It is an internationally recognized innovation best practice

Roadmap: An All of Government Approach

- Liability laws
- Seafarer status
- Seaworthiness
- Protection and indemnity
- Ethical application



- Automated information exchange/bandwidth
- Remote centres
- Smart ships/Smart ports
- Ship physics
- Autonomous ships
- Technical operations and maintenance
- Cyber-security
- Decarbonisation
- Quiet vessels
- Supply chain efficiency and resilience



2. NRC Specific Activities

NRC's Ocean Program Responsible for MASS related activities

Ocean Program has Technology Theme dedicated to Intelligent Marine Assets

- Research and Technology Lead (R&T Lead)
 - Fraser Winsor (fraser.winsor@nrc-cnrc.gc.ca)
- Focus on improving operations in ice and harsh environments and longer term environmental prediction
- Primary Sector: Ships and Shipping to enable MASS: Clean, Quiet and Connected

At the end of the program

- NRC will have supported the development of technology that has improved operating costs by a measurable amount
- In-situ facilities for testing/research and development will be available to stakeholders; digital twins will also be available
- 10 new technologies for *clean, quiet and connected* will be developed



INTELLIGENT MARINE ASSETS

Improved operational
performance of marine assets

Autonomous asset operation
in harsh environments

Long-range environmental
prediction and digitalized seaways

Marine renewables in
harsh environments

MASS *Must* Link to Clean, Quiet and Connected

Research and technology needs and trends across the shipping sector are similar or the same

- NRC's researchers work with industry and academia to further these technologies along the innovation spectrum

Clean	Quiet	Connected
Sensor/sensor fusion: sonar, lidar, image, video		
Communications for speed, bandwidth and latency: 5G, LTE, Bluetooth, Wifi, etc.		
Earth observation: hardware and software for sensor payload and payload processing		
Cybersecurity		
Enhanced and augmented reality		
Modeling and simulation		
Alternative fuels		
System performance		
Bi-directionality		
Improved hull and ship design		
Coatings		
	Navigation	
	Collision avoidance	

NRC Roadmap: Clean, Quiet and Connected

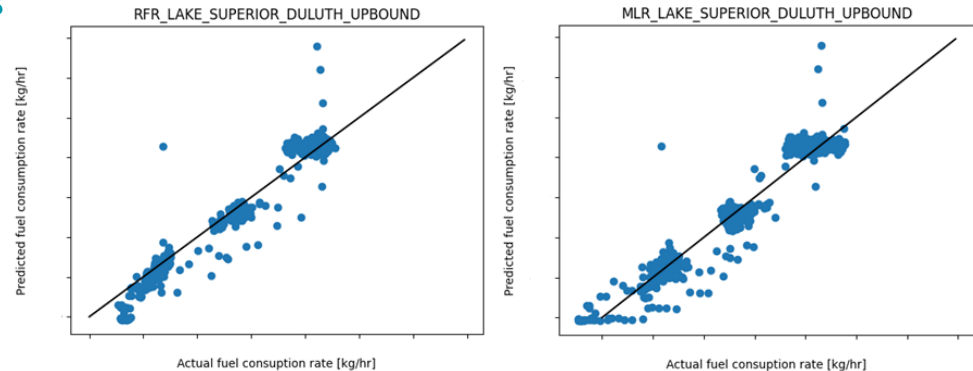
Develop decision support systems (DSS) to enable smart and autonomous vessels to adjust their operations based on real-time conditions

- Marine Performance and Evaluation
- Situational Awareness
- Ice Water Resources

Develop full understanding of potential low to no carbon fuels for Canadian operated fleets

Resilient supply chains from destination to destination; smart ships, smart ports, smart cities

- Develop knowledge, technologies and sustainable solutions (including nature-based solutions) to ensure that ports and harbours are resilient to ocean hazards and disturbances in the changing climate
- Bio-remediation of ports and harbors



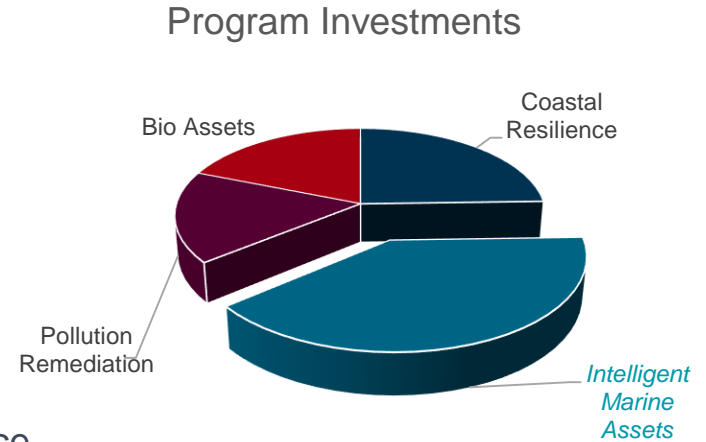
NRC MASS Activities: Clean, Quiet and Connected

NRC Research

- 20% internal NRC projects related to MASS
 - \$3.7 million in G&C's for collaboration
- 18% direct support of other government departments
- 62% industry directed

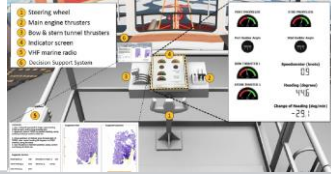
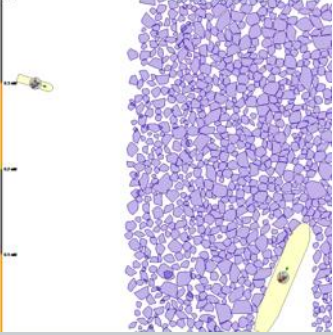
Co-funding 2 PhD student (OFI/OGEN):

- Machine learning method to support shipping operations in ice (applications to tactical voyage routing and strategic)
- Autonomous Fleet for Ice Management via reinforcement learning





Intelligent Marine Assets

	Improved Operational Performance	Autonomous Asset Operation	Long range prediction and digitalization
NRC Research	Ship as a sensor –ship to determine sea state		Ship as a sensor –ship to determine sea state
Collaboration	Determine engine performance of a series of fishing vessels		Determine emissions based on voyage
NRC Research		On board decision support tools	
Collaboration		<ul style="list-style-type: none"> • AI Assist • Dataset for ship situational awareness in ice <ul style="list-style-type: none"> • Motion planning in ice 	
NRC Research		Ice prediction and maneuverability	
Collaboration		<ul style="list-style-type: none"> • Seasonal ice prediction on St. Lawrence Seaway <ul style="list-style-type: none"> • Model prediction and monitoring systems <ul style="list-style-type: none"> • Tactical routing 	
NRC Research	Supply Chain Efficiency, Resilience and Fluidity Living Labs Cybersecurity Zero-impact shipping		
Collaboration	<ul style="list-style-type: none"> • Interoperability <ul style="list-style-type: none"> • Cyber • Remote operations • Pathways to zero-Impact Shipping 		

Equipment Investments for Clean, Quiet and Connected

Collaboration Space with MUN

- High Compute Capacity
 - Complements numerical expertise and enables collaborators to access digital services
- Upgrade to Explorer
 - Farther, deeper missions for sensor payloads
- Equipment to study noise from ships
 - Allows for better understanding of underwater radiated noise for improved shipping



NRC Research Open Call for Collaboration

Call for Expression of Interest for Collaborative Research: CISMaRT Fall 2020

Areas of NRC Research:

- Use of Machine Learning for Identification and Characterization of Vessel Operational Best Practices
- Digital Twin Technology for Autonomous Operation in Harsh Environment
- Prediction of Ice in the St. Lawrence Waterway Using Artificial Intelligence
- Ship Situational Awareness in Ice
- St. Lawrence Seaway Autonomous Marine Testbed
- Extension of Driving Automation Research Activities at NRC to the Marine Use Case

CISMaRT Call for Proposals

\$866,348 allocated to 6 projects

- Enhancing autonomous ship self-awareness and maneuverability via lateral-line inspired design
 - Queen's University
- Model predictive controller and monitoring systems for MASS
 - Memorial University
- Developing requirements for MASS cybersecurity research infrastructure
 - Memorial University
- Concept development for autonomous vehicle cooperation to facilitate navigation in ice
 - York University
- Enabling MASS situational awareness through autonomous monitoring of St. Lawrence Seaway using trusted crowdsourced bathymetry
 - CIDCO
- Fusing aerial and seaborne sensor data to facilitate MASS navigation in ice
 - SEATAC

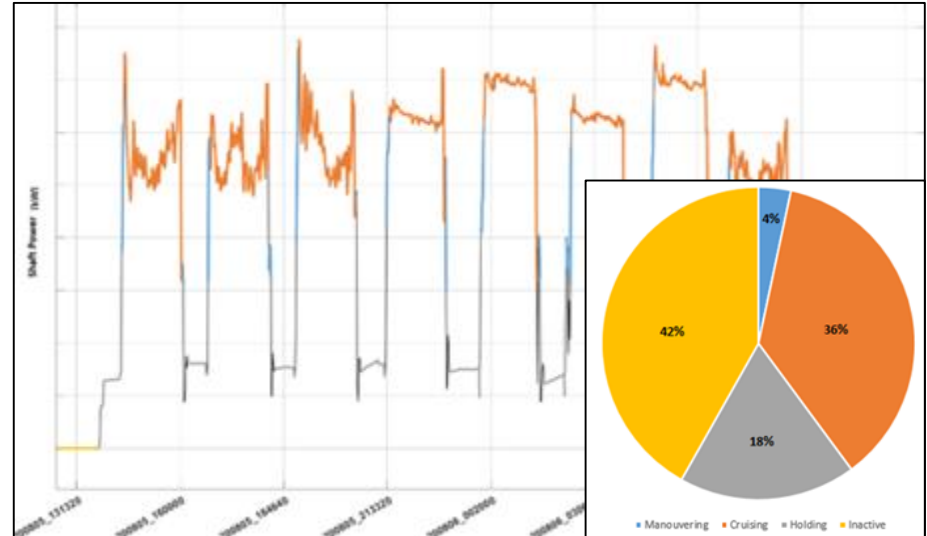
Next Steps: Healthy waterways that support life and trade

Develop 5 year technology development roadmap

Establish Living Labs with stakeholders

Develop capacity to support industry seize the MASS opportunities

- Control centres
- Digital labs
- Decision support tools
- Efficient, resilient supply chains
- Efficient and resilient ports



Thank you

