
INNOVATIVE TECHNOLOGIES
FOR SMARTER, GREENER AND SAFER SHIPS
• One-day Meeting on CISMaRT Projects—
Recent Progress and Future Prospects
• 1.5-day Workshop on Ship Noise Mitigation
Technologies for a Quieter Ocean
NOV 27–29th
2018
Four Points by Sheraton
Halifax, NS
For more information, please visit
www.cismart.ca
or contact
Dr. Wei Qiu | qiuw@mun.ca
CISMaRT
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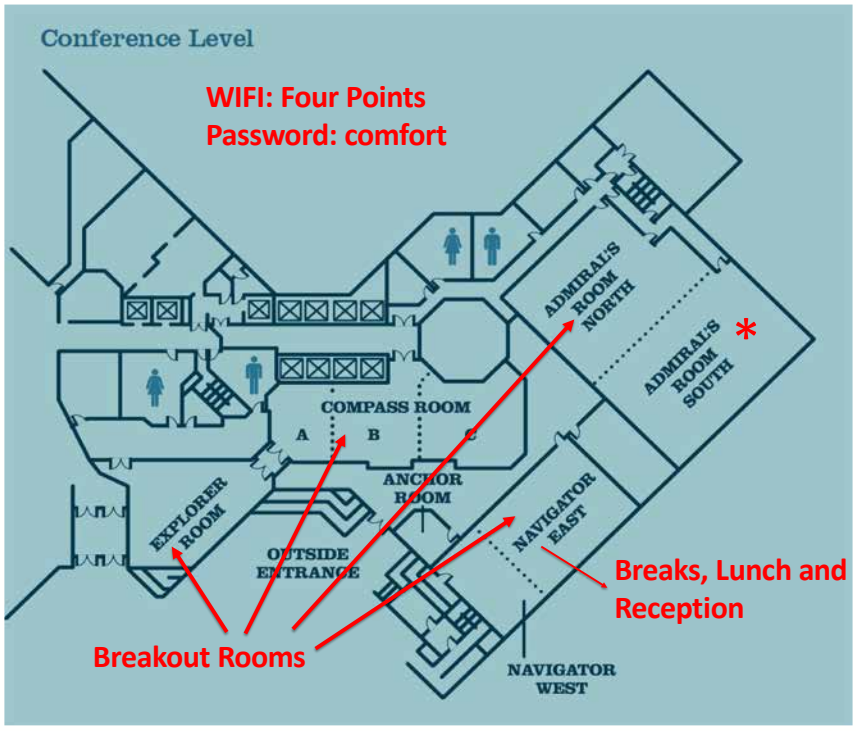
Conference Level
WIFI: Four Points
Password: comfort
ADMIRAL'S ROOM NORTH
ADMIRAL'S ROOM SOUTH
*
COMPASS ROOM
A
B
C
ANCHOR ROOM
EXPLORER ROOM
OUTSIDE ENTRANCE
NAVIGATOR EAST
NAVIGATOR WEST
Breaks, Lunch and Reception
Breakout Rooms

Objectives of the Halifax Workshops

November 27

- To develop collaborative projects in key R&D themes: SMART, GREEN, SAFE and IMPLEMENT.

Objectives of the Halifax Workshops

November 28-29

- to identify technologies in ship design for underwater noise mitigation, including gaps, limits and barriers;
- to inform international discussions on reducing underwater ship noise, and on taking existing IMO Guidelines to the next stage; and
- to propose projects to address the gaps.

CISMaRT Workshop on Key Research Themes – November 27

Morning Sessions

- CISMaRT Overview and Updates
- Technological Challenges Faced by the Canadian Navy Now and in the Future
- Opportunities for Ship Time on CCG Ships
- Autonomous Ships and Uncrewed Workboats
- Progress Reports on Three Pilot Projects

Afternoon Sessions

- Funding Opportunity – IDEaS
- Project Ideas
- Breakout Session and Large Group Discussions on future projects

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Workshop on Ship Noise Mitigation Technologies – November 28-29

November 28 - Morning Sessions

- Canada's Vision and Plan on Marine Noise Reduction
- Short Course on Underwater Noise from Ships

November 28 - Afternoon Sessions

- Overview of European Projects and Findings
- An Operator's Perspective of Underwater Noise from Ships
- Understanding the Underwater Noise Environment off the BC Coast
- Propeller Noise and its Mitigation
- Breakout Session and Large Group Discussions on future projects

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Workshop on Ship Noise Mitigation Technologies – November 28-29

November 29 - Morning Sessions

- Technologies to Mitigate Underwater Noise from Ships
- Breakout Session and General Discussions on Vard Report and Next Steps

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Many Thanks for Financial Support from

Canada NSERC CRSNG Transport Canada Transports Canada MEMORIAL UNIVERSITY

Workshop Organizing Committee

Wei Qiu	Memorial University
Roger Basu	Roger Basu and Associates, Inc.
Abigail Fyfe	Transport Canada
Dan McGreer	Vard Marine
Brian McShane	Innovation, Science and Economic Development Canada
Jon Mikkelsen	University of British Columbia
Neil Pegg	Defence R&D Canada Atlantic Research Centre
Fraser Winsor	National Research Council

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CANADIAN NETWORK FOR INNOVATIVE SHIPBUILDING, MARINE RESEARCH AND TRAINING | RÉSEAU CANADIEN POUR L'INNOVATION DANS LA CONSTRUCTION NAVALE, LA RECHERCHE MARINE ET LA FORMATION

Canadian Network for Innovative Shipbuilding, Marine Research and Training (CISMaRT)

Overview and Updates

Dr. Wei Qiu
Chair of CISMaRT Interim Board

Professor and Head
Department of Ocean and Naval Architectural Engineering
Memorial University

November 27, 2018

Outline

- Mission
- Membership
- Progress made and outcomes
- Key R&D themes
- Next steps

CISMaRT

CISMaRT

- CISMaRT is a ***national*** network formed on September 26, 2016.
- Its research and training priorities focus on engineering and technological aspects important to the marine sector.
- CISMaRT is a unique national network in the marine technology sector complementary to other ocean-science-focused networks.

CISMaRT

Engaging Canada's marine sector

- In developing CISMaRT, the Canadian marine community was engaged to gain their input and a level of commitment to the national network.
  - UBC Workshop on July 6, 2016
  - MUN Workshop on September 26, 2016

CISMaRT

Mission of CISMaRT

CISMaRT is dedicated to being a world-class network within which its members undertake innovative and collaborative R&D in marine technology and improve education and training of highly qualified personnel for Canada's current and future shipbuilding and marine industries.

CISMaRT

Membership

- CISMaRT is membership-based and seeks participation from industry, government and academia.
- The current membership comprises 44 organizations drawn from across Canada representing the broader marine sector including three key stakeholders: industry (27 members), government (10 members) and academia (7 members).
- Visit cismart.ca/members/ for the complete list and the membership form.

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Progress made - workshop on education and training

Progress made - workshop on education and training

- Perspectives on education and training in the marine industry were presented by senior representatives from industry, government and academia.
- The current state of education and training in Canada's marine sector, strategies for addressing the challenges, and potential methods for providing solutions were discussed.
- Recommendations were made for Canada's marine education and training.
- The draft final report is available online (cismart.ca).

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Progress made - workshop on education and training

Key observations and recommendations on education:

- Except for some isolated cases, delegates expressed overall satisfaction with the current state of Canada's naval architectural and marine engineering education.
- Some delegates were concerned by the lack of engineers with marine-related expertise in electrical/electronic engineering.
- Retention of staff is considered an issue where the marine sector competes with the offshore oil and gas industry.

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Progress made - workshop on education and training

Key observations and recommendations on training:

- A general concern about the cost to industry with respect to training technical staff in the latest technologies and regulatory developments. Government-funded programs were noted as a possible way to address this issue.
- The importance of understanding the needs of industry and government in regard to training (short courses and other programs) was emphasized.
- There was general support for using newer technologies, such as webinars, to deliver training although a concern was expressed on how the practical/hands-on elements might be delivered.

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Progress made – Halifax workshops

Progress made – workshop on ship noise

- CISMaRT and Transport Canada are jointly hosting a workshop on Nov 28-29:
  - to identify technologies in ship design for underwater noise mitigation, including gaps, limits and barriers;
  - to inform international discussions on reducing underwater ship noise, and on taking existing IMO Guidelines to the next stage; and
  - to propose projects to address the gaps.
- A short course on *underwater noise from ships* will be delivered at the workshop.

CISMaRT Transport Canada Transports Canada

Pilot projects in progress

- **Operational Capabilities of Low and Non-Ice Class Vessels in Ice**
  - Project value: $1.16M over 4 years
  - Partners: Vard Marine, DRDC, ABS, Memorial, Innovation NL and NSERC
  - Started in September 2018.

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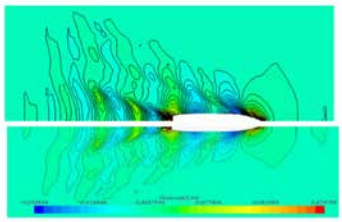
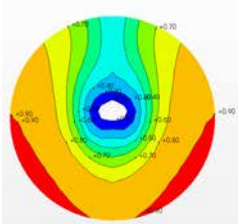
Pilot projects in progress

- **Development of Best Computational Fluid Dynamics (CFD) Modeling Practice for Problems Important to the Marine Industry**
  - Project value: ~$300K over two years (Phase 1).
  - Partners: DRDC Atlantic, Vard Marine, LR, ABS, Robert Allan Ltd., Memorial, UNB, NRC, NSERC and MITACS.





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Pilot projects in progress

- **Effect of Manufacturing Tolerance on Propeller Performance**
  - Objectives: improving propeller manufacturing; reducing propeller induced noise, cavitation/vibrations and their impact on the marine environment.
  - Partners: Dominis Engineering, Transport Canada, DRDC Atlantic, Memorial and NSERC.
  - Initial work supported by NSERC is completed.

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Progress made - CCG ship time

- CCG has agreed to provide ship time as an in-kind contribution to support CISMaRT's R&D.
- The commitment is 35 days per year for five years.

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Progress made - short courses

- **Potential short courses – survey results (not in order of preference)**
  - Basic ship design using digital twins
  - CFD topics
  - FEA topics
  - Fatigue design
  - Risk assessment
  - Introduction to shipbuilding/retrofit
  - Overview of class society rules
  - Weight and cost estimation
  - Underwater noise from ships (*to be offered on Nov. 28, 2018*)

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Pilot projects – short courses (cont'd)

- **Potential short courses – survey results (no order of preference)**
  - Marine corrosion and management
  - Life cycle management and planning
  - Advanced technology in designing Polar icebreakers
  - Marine system design
  - Engineering project management
  - Professional writing
- **Duration: ~3 days**
- **Interest in online courses.**

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Progress made - pilot online course

- **Video based short courses**
  - Hosted by CISMaRT
  - Contributed by members
  - Each course consisting of 20 sessions (about 15 minutes each session)
  - Online self-assessment questions

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Key R&D themes

SMART TECHNOLOGIES
- Autonomous Marine Vehicles
- Communications
- Cyber Security
- Shipbuilding
- Simulation

GREEN TECHNOLOGIES
- Alternative Fuels and Propulsion Systems
- Efficiency Improvement
- Ocean Energy
- Ship Emission and Noise Reduction

SAFE TECHNOLOGIES
- Arctic Engineering
- Harsh Environment Operations
- Human Factors Engineering
- Safety and Risk Engineering

IMPLEMENT DEVELOPMENTS
- Personnel Training and Education
- Policy Advancement in the Public Interest
- Technology Commercialization

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Next steps

- Continue full implementation of the national network (*supported by ACOA, Memorial and NSERC, $300K*).
- Continue the development of more projects by following the collaborative model for the three pilot projects.
- Deliver a pilot online course on Structural Polar Rules**
- Propose projects involving CCG ship time**
- Seek core funding to support major R&D projects **
  - Frontiers in Research Funding initiative
  - IDEaS
  - NSS Value Proposition Opportunities
  - …

** to be discussed in the breakout session.

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Next steps – major funding program

Frontiers in Research Fund

- New tri-agency fund to support high-risk, future-oriented research projects that cross disciplinary boundaries and link to international centres of expertise and have the potential to transform paradigms and impact society.
- $275 million over 5 years starting in 2018-19 and $65 million/year ongoing federal funding.
- Two streams planned:
  - Stream 1: proof-of-concept projects
    - funding up to $1 million over 3 years
  - Stream 2: large projects in cutting-edge interdisciplinary research fields
    - funding up to $20 million over 7 years

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For more information, please visit

cismart.ca

CISMaRT

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CISMaRT

National Defence Défense nationale

CANADIAN ARMED FORCES

Technological challenges facing the Royal Canadian Navy now and in the future

Capt(N) Jacques P. Olivier

Director of Naval Platform Systems
Naval Materiel Regulatory Authority

Presentation to the
Canadian Network for Innovative Shipbuilding, Marine Research and Training (CISMaRT)

Four Points by Sheraton, Halifax, Nova Scotia
27 November 2018

Canada

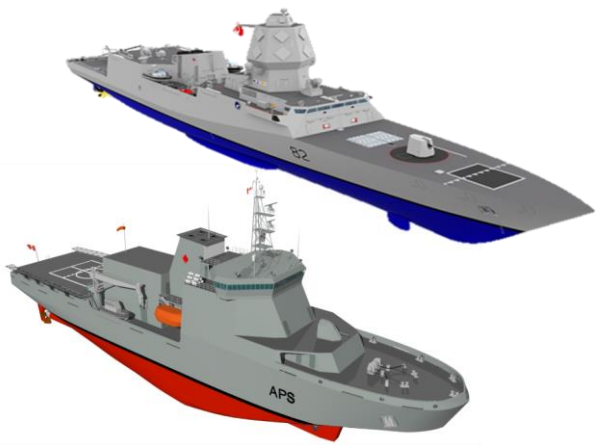
Outline of presentation

- Background
- Naval Materiel Assurance
- Corrosion
- Data analytics
- Cybersecurity
- Environment
- Innovation
- Discussion

Roles and Responsibilities

Provide life cycle materiel management and design authority support to all surface ship classes in the areas of:

- **Ship Systems Engineering**: naval architecture, stability, materials, and survivability
- **Ship Design**: concept design, auxiliary vessel acquisition, acquisition support, human systems integration
- **System Cyber-security Engineering**: cyber mission assurance, vulnerability assessment, penetration test, security risk/assurance
- **Naval Materiel Assurance**: naval materiel regulation and certification, safety and environmental management, configuration management, policy and procedures



Lloyd's Register

ABS

Naval Materiel Assurance (NMA)

There is a corporate responsibility for the RCN to be **self-regulating** to:

- meet the implied intent of national and international acts and regulations (exempted from)
- comply with applicable legislation, regulations and standards
- provide **public confidence** that Canadian naval and auxiliary vessels are, through life:
  - **fit for service**
  - **safe to operate**
  - **environmentally compliant**

Second Royal Canadian Navy ship catches fire while deployed off Europe

Americas Naval

Three Royal Canadian Navy Warships Suffers Series of Technical Issues Over Past Two Weeks

November 11, 2018 DP Staff Writer 0 Comments Canada, Halifax-class frigate, HMCS Edmonton (MM 703), HMCS Halifax (FFH 330), HMCS Toronto (FFH 333), Kingston-class coastal defence vessel, Royal Canadian Navy (RCN)

Three Royal Canadian Navy (RCN) warships have suffered a series of technical issues over the past two weeks causing significant concern on the capabilities of the Navy.

"The safety and security of our sailors is paramount to everything we do and we are investigating each of these issues so that our sailors continue to have complete confidence in our ships and procedures,"

Vice-Admiral Ron Lloyd,
Commander of the RCN

ROYAL CANADIAN NAVY MARINE ROYALE CANADIENNE

/// VESSELS IN SERVICE

HMCS HALIFAX 330
HMCS VANCOUVER 331
HMCS VILLE DE QUÉBEC 332
HMCS TORONTO 333
HMCS REGINA 334
HMCS CALGARY 335
HMCS MONTRÉAL 336
HMCS FREDERICTON 337
HMCS WINNIPEG 338
HMCS CHARLOTTETOWN 339
HMCS ST. JOHN'S 340
HMCS OTTAWA 341

HALIFAX CLASS	MULTI-ROLE PATROL FRIGATE (FFH)		
Standard Displacement	4,770 tonnes	Length	134.1 metres
Beam	16.4 metres	Complement	225 personnel

Armament: Phalanx 20mm CIWS, ESSM SAMs, Bofors 57mm gun, Harpoon SSMs, twin MK 46 torpedo tubes, heavy (.50 cal) machine guns

In 2015, the last of the 12 Halifax-class helicopter-carrying frigates, the core of the Royal Canadian Navy (RCN) fleet, completed the Halifax-Class Modernization project. This involved the installation of state-of-the-art radars, defences and armaments. The armaments combine anti-submarine, anti-surface and anti-air systems to deal with threats below, on and above the sea surface.

HMCS VICTORIA 876
HMCS WINDSOR 877
HMCS CORNER BROOK 878
HMCS CHICOUTIMI 879

VICTORIA CLASS	LONG-RANGE PATROL SUBMARINE (SSK)		
Standard Displacement	2,400 tonnes	Length	70.25 metres
Beam	7.5 metres	Complement	40 personnel

Armament: Mk 48 Heavyweight torpedoes

The Victoria-class submarines are the RCN's "special forces" and some of the Canadian Armed Forces' most strategic assets. Three quiet, stealthy diesel-electric submarines are well armed and capable of patrolling vast distances, while their visibility allows them to perform a wide range of naval missions. Recent upgrades provided the Victoria class with a state-of-the-art bow sonar system and sensors. The Victoria class can operate in the Arctic, Pacific and Atlantic approaches to Canada and significantly extend the navy's tactical and strategic capabilities.

HMCS KINGSTON 700
HMCS GLACE BAY 701
HMCS NANAIMO 702
HMCS EDMONTON 703
HMCS SHAWINIGAN 704
HMCS WHITEHORSE 706
HMCS YELLOWKNIFE 708
HMCS DOCKSTADER 707
HMCS MONCTON 709
HMCS SASKATOON 710
HMCS SHARBOT 710
HMCS SUMMERSIDE 711

KINGSTON CLASS	MARITIME COASTAL DEFENCE VESSEL (MM)		
Standard Displacement	970 tonnes	Length	55.3 metres
Beam	11.3 metres	Complement	37 personnel

Armament: NRWS (sea trials), heavy (.50 cal) machine guns

The Kingston-class Maritime Coastal Defence Vessels are multi-role minor war vessels with a primary mission of coastal surveillance and patrol, including naval mine countermeasures, general naval operations and exercises, search and rescue, law enforcement, resource protection and shores patrols. This class of vessel was designed for a standard crew complement of 37, but has integrated bunking arrangements for up to 45. If a mission requires a larger crew, it can house an additional 6 personnel in an add-on accommodations module.

ORCA 60
RAVEN 61
CARIBOU 62
PINNED 63
WOLF 64
GRIZZLY 65
COUGAR 66
MOOSE 67

ORCA CLASS	PATROL CRAFT TRAINING VESSEL (PCT)		
Standard Displacement	210 tonnes	Length	33 metres
Beam	8.6 metres	Complement	25 personnel

Armament: Heavy (.50 cal) machine guns

The Orca-class vessels operate year-round in British Columbia's coastal waters. In addition to their primary training mission, they support regional community relations by appearing in local festivals and maritime events. While not specifically assigned an operational role, these vessels patrol coastal waters responding to distress calls, reporting suspicious activity, pollution infractions and fishing violations.

/// SPECIAL CAPABILITIES

Explosive Ordnance Disposal (EOD)

Clearance Divers conduct EOD tasks in the RCN. The divers perform a variety of tasks including battle damage repair, Improvised Explosive Device (IED) disposal, naval mine recognition and counter-measures, and underwater demolitions. They are drawn from a variety of naval occupations and are trained in dive physics, physiology, hydraulics, underwater photography, electrical, and welding (surface and underwater). Clearance Divers are familiar with a variety of explosives, and how to deal with them.

Maritime Tactical Operations Group (MTOG)

The MTOG generative Enhanced Naval Boarding Party (ENBP) teams comprised of personnel who receive significant advanced training, and for whom boarding and force protection operations are a full-time duty. Members are trained in hand-to-hand combat, advanced medical training, IED identification, close-quarters battle and tactical shooting.

Naval Security Team (NST)

The NST is composed primarily of naval reservists, and includes a full-time command team to ensure personnel, training and equipment are available for deployment. The teams tasks include port force protection and heat radiation taken, along with support and intelligence requirements in foreign ports. They are trained in the use of force, rules of engagement, advanced weapons training, small boat tactics, communications, deployed logistics and liaison.

/// HALIFAX CLASS
MULTI-ROLE PATROL FRIGATE (FFH)

/// VICTORIA CLASS
LONG-RANGE PATROL SUBMARINE (SSK)

© Irving Shipbuilding Inc. 2016

/// HARRY DEWOLF CLASS
ARCTIC AND OFFSHORE PATROL VESSEL (AOPV)

/// KINGSTON CLASS
MARITIME COASTAL DEFENCE VESSEL (MM)

© Thyssenkrupp Marine Systems Canada Inc.

/// PROTECTEUR CLASS
JOINT SUPPORT SHIP (JSS)

/// ORCA CLASS
PATROL CRAFT TRAINING VESSEL (PCT)

© Federal Fleet Services Inc.

/// iAOR
INTERIM AUXILIARY OILER REPLENISHMENT SHIP (MV) – CONTRACTED SERVICE

/// VESSELS IN DEVELOPMENT

HMCS HARRY DEWOLF 430
HMCS MARGARET BROOKE 431
HMCS MAX BERNAYS 432
HMCS WILLIAM HALL 433
HMCS FREDERICK ROLLITT 434

HARRY DEWOLF CLASS	ARCTIC AND OFFSHORE PATROL VESSEL (AOPV)		
Standard Displacement	6,440 tonnes	Length	103 metres
Beam	19 metres	Complement	65 personnel

Armament: BAE Mk 38 Mod 2 gun, heavy (.50 cal) machine guns

Scheduled for delivery in 2018, the Harry DeWolf-class Arctic and Offshore Patrol Vessels will be ice-capable ships enabling armed sea-borne surveillance of Canada's waters, including the Arctic, providing government situational awareness of activities and events in these remote regions. The Harry DeWolf class, in cooperation with other partners in the Canadian Armed Forces and other government departments, will be able to assert and enforce Canadian sovereignty, when and where necessary.

HMCS PROTECTEUR
HMCS PRESERVER

PROTECTEUR CLASS	JOINT SUPPORT SHIP (JSS)		
Standard Displacement	20,240 tonnes	Length	173.7 metres
Beam	24 metres	Complement	239 personnel

Armament: 2x Phalanx 20mm CIWS, 4x NRWS, heavy (.50 cal) machine guns

Scheduled for delivery in 2022 and 2023, the Protecteur-class Joint Support Ships will offer a wide range of capabilities, including the provision of fuel, ammunition, spare parts, food, water and other supplies; modern medical and dental care facilities, including an operating room; repair facilities and expertise to keep helicopters and other equipment functioning; and basic self-defence functions.

MV ARTEMIS

iAOR	INTERIM AUXILIARY OILER REPLENISHMENT SHIP (MV)		
Standard Displacement	26,000 tonnes	Length	183 metres
Beam	25 metres	Complement	150 personnel

Armament: Heavy (.50 cal) machine guns and small arms for use exclusively by embarked RCN mission specialists.

The Interim Auxiliary Oiler Replenishment vessel will provide capabilities such as at-sea fuel replenishment, aviation support, medical and humanitarian assistance, and disaster relief. Federal Fleet Services Inc. has been contracted to provide this ship and at-sea service.

/// ARMAMENT

MISSILES & TORPEDOS: The RCN's warships and submarines are equipped with torpedoes, surface-to-air and surface-to-surface missiles.

HARPOON
Medium-range anti-ship missile. Capable of sea-skimming or pop-up trajectories. Max. speed: Mach 0.85.

ESSM
The Evolved Seasparrow Missile (ESSM) is a medium-range surface-to-air missile. Uses terminal semi-active guidance system. Max. speed: Mach 3.5.

MK 48
Submarine-launched long-range, wire-guided heavyweight torpedo for use against both surface targets and submarines.

MK 46
High speed, deep diving, active/passive acoustic homing torpedo carried by ships and aircraft for use against submarines.

GUNS: The fleet is equipped with a range of multi-purpose guns and cannon. They can engage anti-ship missiles, hostile aircraft and surface targets.

PHALANX 20mm
Close-in Weapons System (CIWS). Point defence against anti-ship missiles. Automatically detects, tracks and engages targets. Fires 4,500 rounds per minute.

BOFORS 57mm
Dual-purpose medium calibre gyro-stabilized automatic gun. Fires 220 rounds per minute. Enclosed in a low radar cross-section plastic turret.

BAE Mk 38 Mod 2 25mm
This Machine Gun System (MGS) uses a M242 auto cannon, capable of firing at up to 100 rounds per minute. Remote controlled, gyro stabilized, with an EO/IR in control system.

NRWS 50 Cal.
M2 Naval Remote Weapon Station. Used for short range engagement of surface targets. Equipped with a highly sensitive sensor suite for surveillance and tracking of targets in both day and night conditions.

CANADIAN ARMED FORCES — FORCES ARMÉES CANADIENNES

National Defence — Défense nationale

Canada

A brief history of … the RCN surface ships

Class	1980s	1990s	2000s	2010s	2020s	2030s	2040s	2050s
Halifax CPF 	◆ 1st ship launched 1988 ◆ 12th ship commissioned 1996 ◆ 1st ship modernization 2010 ◆ 12th ship modernized 2016							
Kingston MCDV 		◆ 1st ship launched 1995 ◆ 12th ship commissioned 1998						
Harry DeWolf AOPS 					◆ 1st ship launched 2018 ◆ 6th ship delivery 2023			
Protecteur JSS 						◆ 1st ship delivery 2023 ◆ 2nd ship delivery 2024		
Canadian Surface Combatant 							◆ 1st ship delivery mid-2020s ◆ 15th ship delivery mid/late-2030s	

A brief history of … the RCN surface ships

Class	1980s	1990s	2000s	2010s	2020s	2030s	2040s	2050s

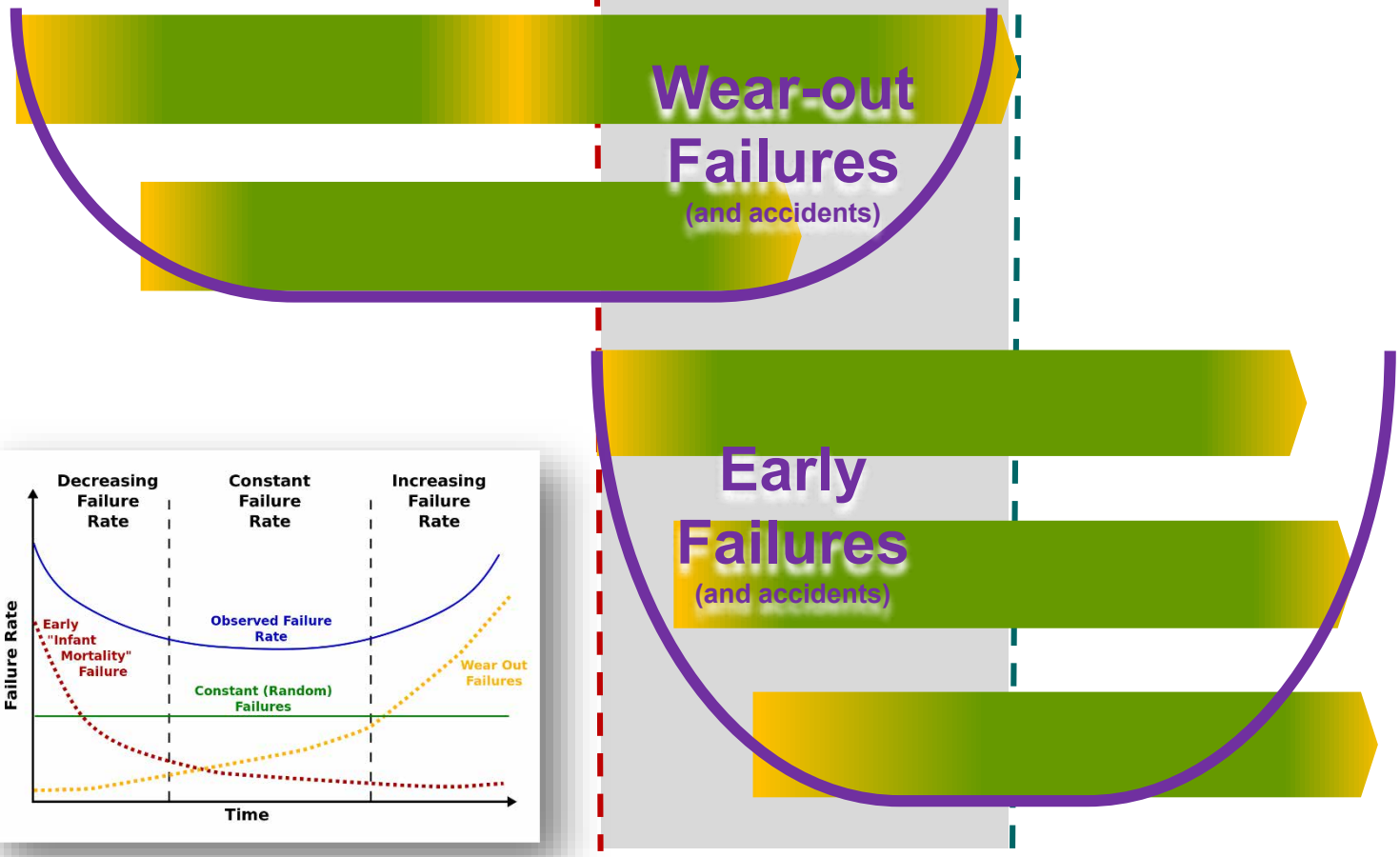
Halifax CPF

Kingston MCDV

Harry DeWolf AOPS

Protecteur JSS

Canadian Surface Combatant



Ref: https://en.wikipedia.org/wiki/Bathtub_curve

Corrosion

Corrosion Material State Working Group – Mission Statement:
Understand, capture and maximize the steel material state of the Halifax Class with a view to offer the RCN predictable and optimized platform availability until end of life

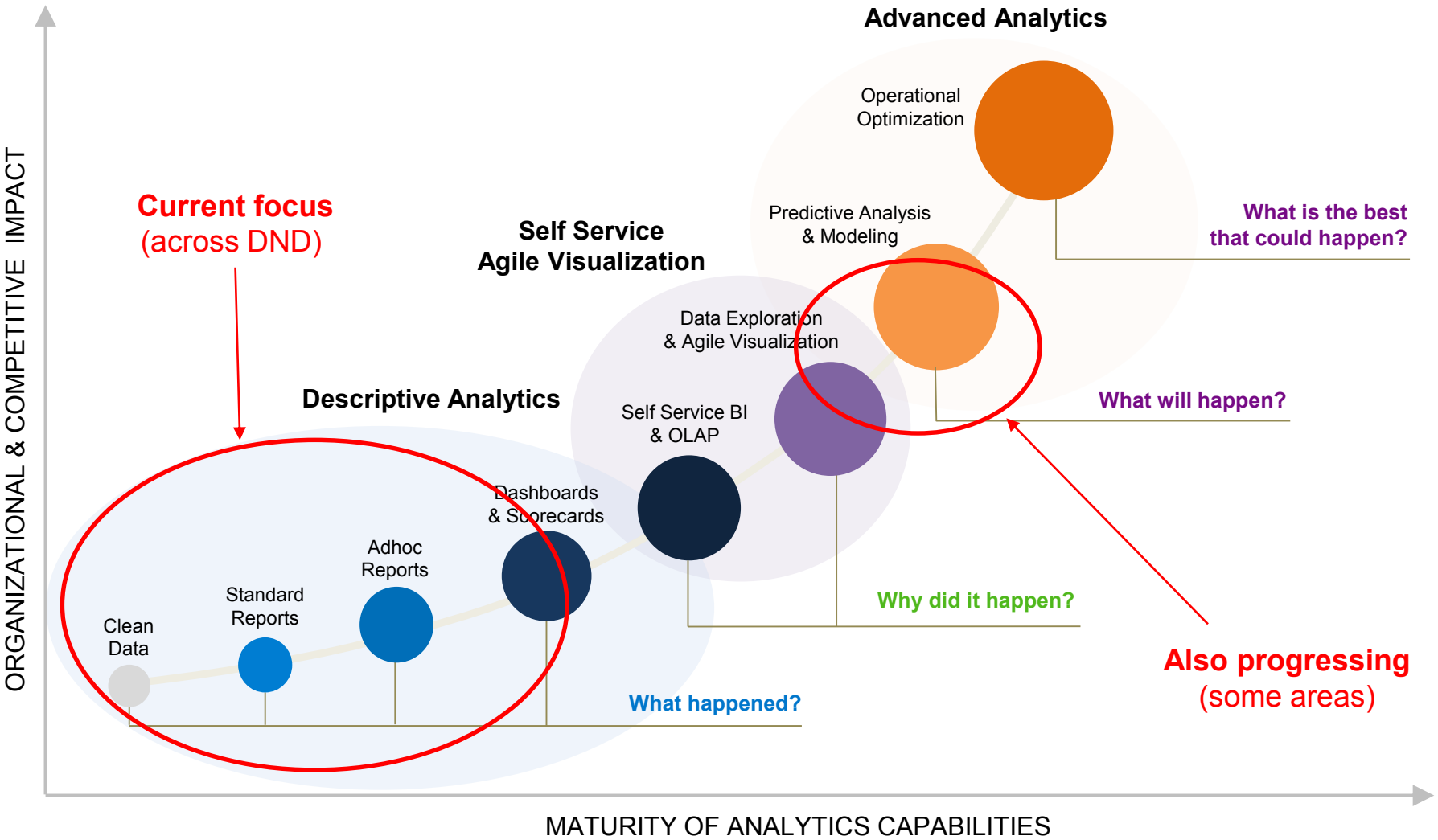
Data Analytics

ADM
(Data, Innovation and Analytics)

Mission:
Provides strategic leadership, governance and guidance to successfully transition Defence to a data-driven organization with people who manage data as an enterprise asset and use it effectively for evidence-based decision-making.

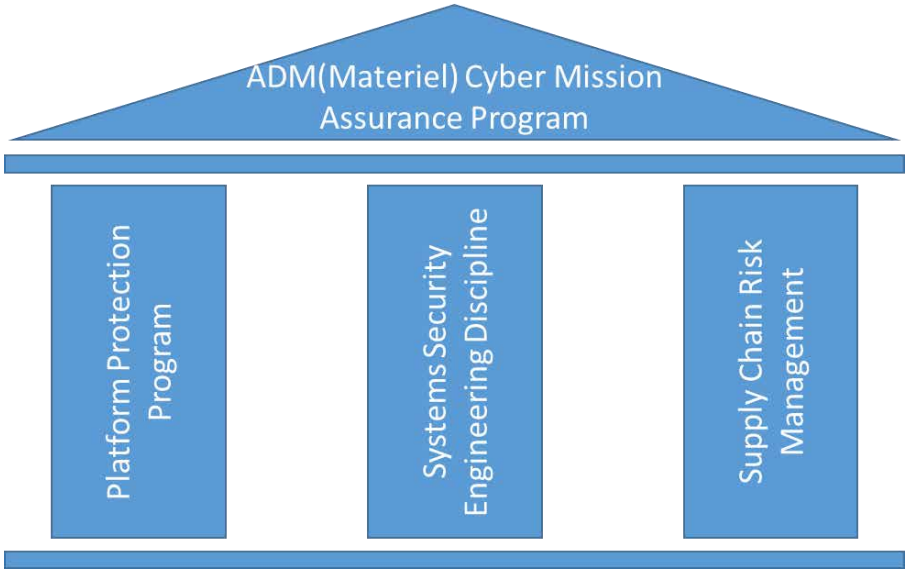
Vision:
Defence embraces a data-driven culture, with trained and capable people across our team who protect valuable data assets and harness them through analytics to drive deliberate decisions and measurable actions to create a more agile and innovative defence enterprise.

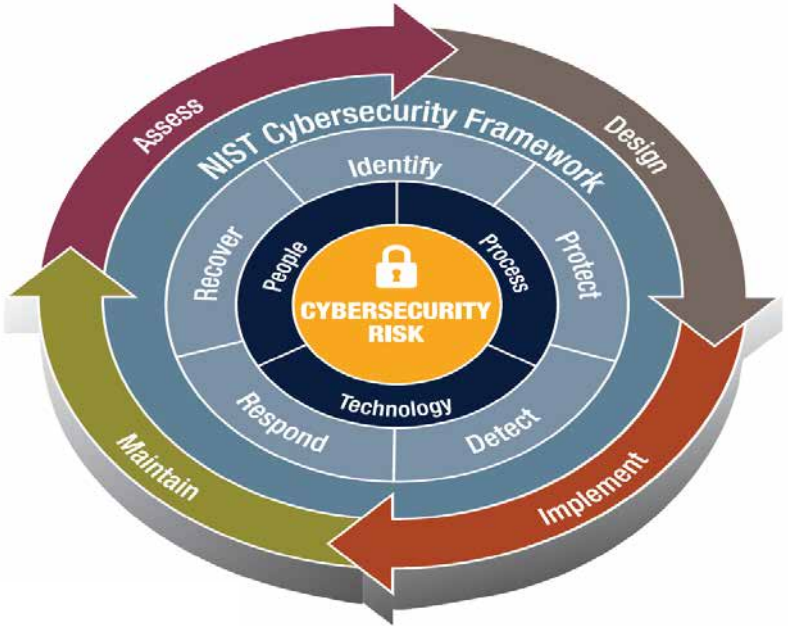
ADM(Data, Innovation and Analytics)



BOBJ Report – Defects, Deviations & Waivers (HFX Class)

System Security Engineering



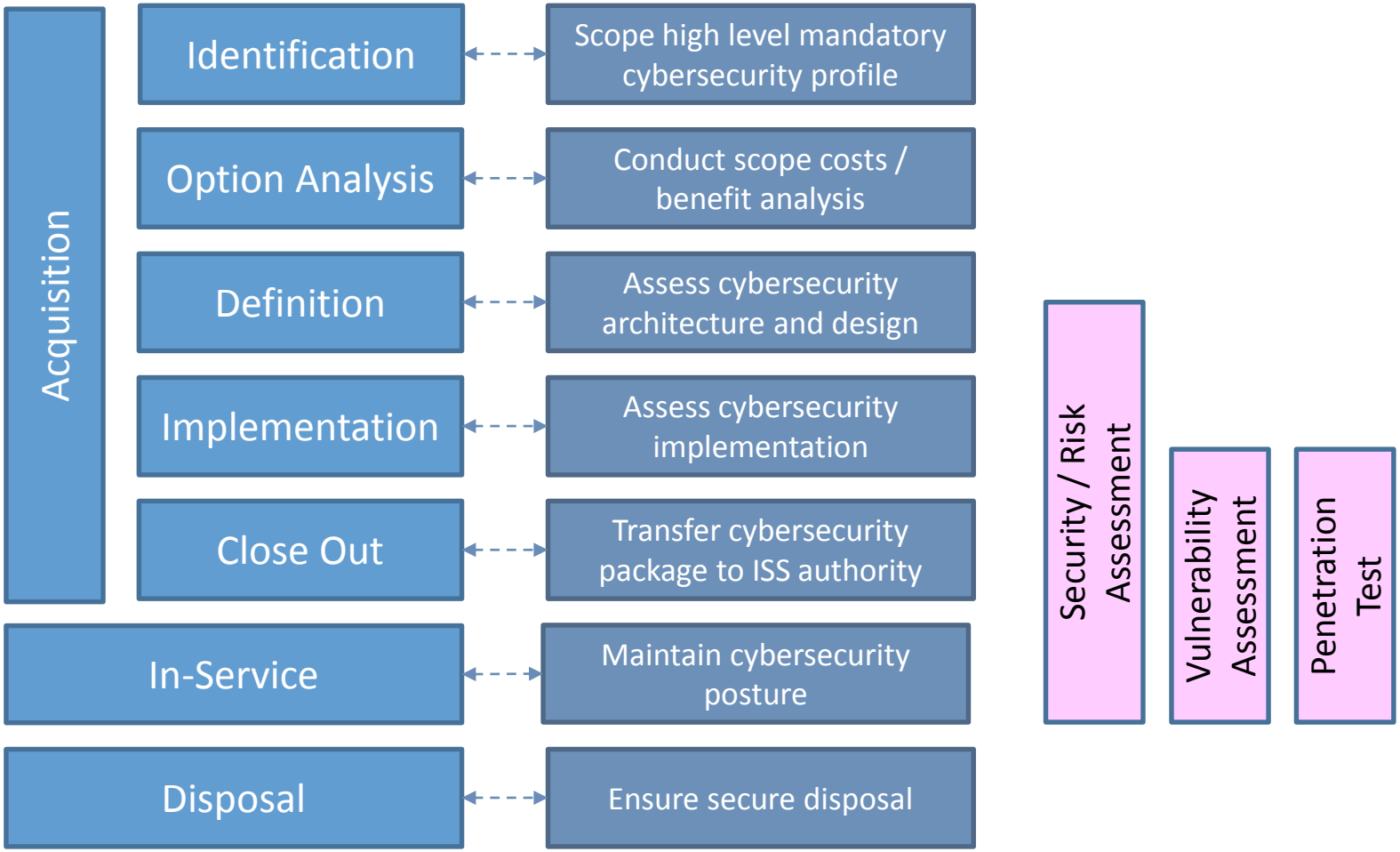


Cyber Mission Assurance (CMA): Ability of an organization, service, infrastructure, platform, weapon system or equipment to operate in a cyber contested operational environment and accomplish its mission

US National Institute of Standards and Technology (NIST) Framework for Improving Critical Infrastructure Cybersecurity

CMA Platform Protection Program

Platform Protection Program (PPP) framework is an overarching risk management framework to address cyber risk and cyber resilience during MA&S lifecycle



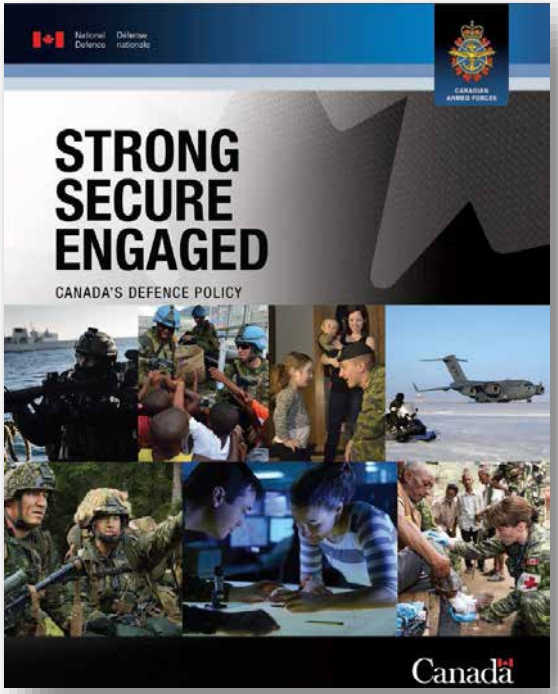
CMA Challenges

Systems Security Engineering Discipline
Systems Security Engineering is a specialized discipline of Systems Engineering that focuses on systems security aspects to deal with possible sources of disruption, either from malicious acts, outright cyber-attacks or misuse.

Supply Chain Risk Management (SCRM)
The SCRM Framework manages risks where an adversary may exploit vulnerabilities in the supply chain to sabotage, infiltrate information, maliciously introduce unwanted function or otherwise subvert the design, integrity, manufacturing, production, distribution, installation, operation or maintenance of a system so as to surveil, deny, disrupt or otherwise degrade the function, use, or operation of that system. Risks could also include the insertion of counterfeits, unauthorized production, tampering, malicious software, loss of confidential government information or poor manufacturing and development practices in the supply chain.

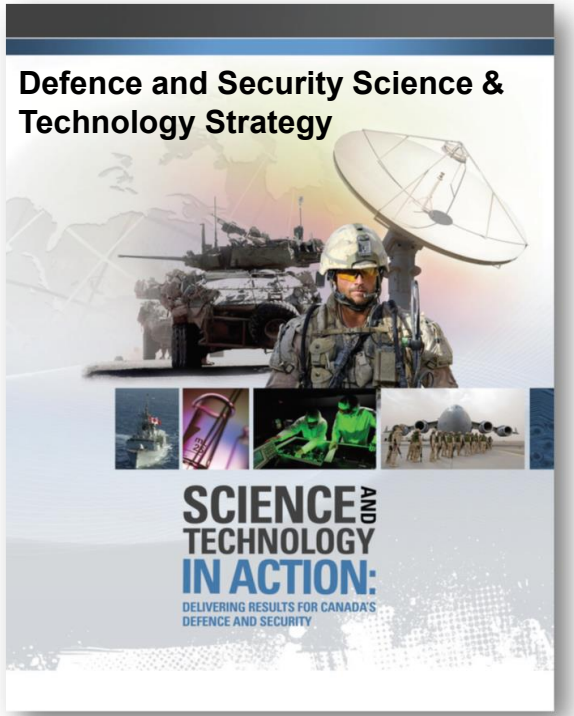
Environment

Policy coverage on innovation



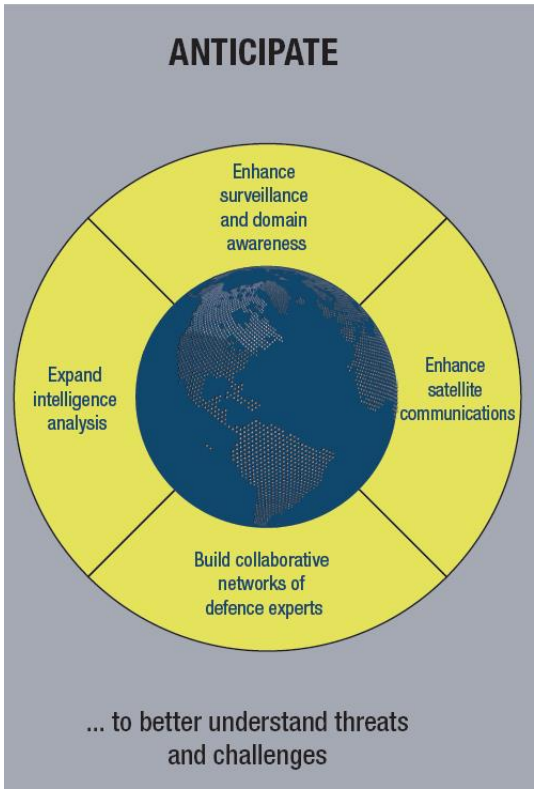
Initiative 105. Implement the new Innovation for Defence Excellence and Security (IDEaS) program, including implementing flexible new procurement mechanisms that allow Defence to develop and test ideas and the ability to follow through on the most promising ones with procurement.

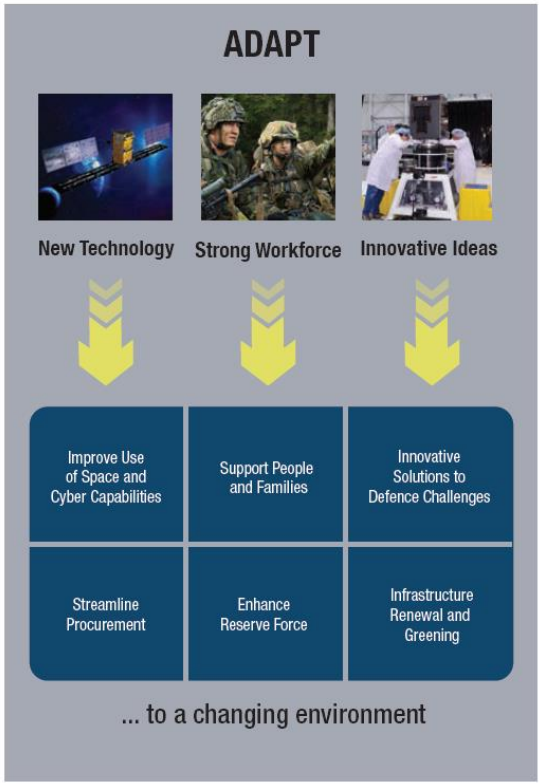
In order to ensure the RCN continues to remain combat relevant and adapts to an ever-changing environment, an RCN innovation programme will be established.



Maximizing the capacity resident in our own workforce and laboratories, and building partnerships with other departments and agencies, industry and academia, as well as our international allies, to enable the transfer and application of scientific knowledge from the broader innovation community to the end users of defence and security S&T at all levels.

Strong, Secure, Engaged: Anticipate, Adapt, Act





ANTICIPATE and better understand potential threats to Canada and Canadian interests so as to enhance our ability to identify, prevent or prepare for, and respond to a wide range of contingencies.

ADAPT proactively to emerging challenges by harnessing new technologies, fostering a resilient workforce, and leveraging innovation, knowledge, and new ways of doing business.

ACT with decisive military capability across the spectrum of operations to defend Canada, protect Canadian interests and values, and contribute to global stability.

Ready to help, ready to lead, ready to fight

Fit for service

Safe to operate

Environmentally compliant

Autonomous Ships and Uncrewed Workboats

CISMaRT Meeting, November 27-29, 2018, Halifax

Innovative Technologies for Smarter, Greener and Safer Ships

Vince den Hertog – Vice President, Engineering

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Topics

- Robert Allan Ltd overview
- Autonomous ships
- Uncrewed workboats & development areas
- Current and future technology needs
- Opportunities for Canada

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Robert Allan Ltd.

- Founded 1930 in Vancouver; Canada's most senior consulting naval architectural firm
- Recognized internationally as a leading designer of high-performance escort & ship-handling tugs and fireboats
- ~75 employees
- Clients about 50/50: major shipyards or vessel owners

Workboats

- Tugs
- Pushboats
- Crewboats
- Offshore support
- Patrol vessels
- Emergency response

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Uncrewed workboats
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Autonomous Ships
Image credit: Rolls-Royce
Image credit: Kongsberg
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Major Initiatives

Name	Participants	Focus Areas
Maritime Unmanned Navigation through Intelligence Networks (MUNIN) project (2012-2015)	European Commission Other European entities	Feasibility of an autonomous and unmanned vessels Legislation and contracts Economics
Unmanned Multifunctional Maritime Ships Research and Development Project (2012-2015)	China	Technologies
Advanced Autonomous Waterborne Applications (AAWA) initiative (2015-2017)	Rolls-Royce led Other Finnish entities	Technologies Safety and security Legal and regulatory Economics
Ishin Next MOL Smart Ship Project (2016 -)	Mitsui O.S.K. Lines (MOL) led Other Japanese entities	Concept development Technologies

Image credit: Rolls-Royce

Joint industry projects and working groups

Name	Participants
One Sea Autonomous Marine Ecosystem (led by DIMECC)	Finnish organizations including: ABB Rolls-Royce Wärtsilä...
Norwegian Forum for Autonomous Ships (NFAS)	Norwegian organizations including: SINTEF Kongsberg Rolls-Royce DNV-GL...
Smart Ships Coalition of the Great Lakes - St. Lawrence	US and Canadian industrial, government and academic institutions
Unmanned Cargo Ship Development Alliance	Chinese industrial, government and academic institutions, plus CCS, ABS, DNV-GL Rolls-Royce Wärtsilä...

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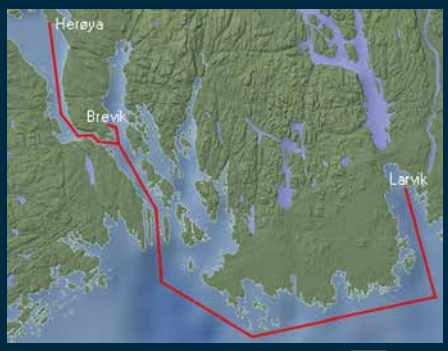
‘Real’ project - Yara Birkeland

- World’s first autonomous and electric container vessel
- YARA, Kongsberg, VARD
- NOK 133.6 million from Norwegian Government
- Delivery Q1 of 2020, Vard Brailia in Romania
- Fertilizer transport
  - Herøya – Brevik (approx. 7 nm)
  - Herøya – Larvik (approx. 30 nm)



Main particulars
- LOA 80 m
- Eco speed 6-7 knots
- Max speed 13 knots

Capacity
- Cargo capacity 120 TEU
- Deadweight 3200 mt

Propulsion
- Azipull pods 2 x 1200 KW
- Tunnel thrusters 2 x 700 KW

Batteries
- Capacity 7 MWh

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Main hurdles

Regulatory and legal
- Rule and guidelines are being developed, e.g.
  - *LR Code for Unmanned Marine Systems (June 2017)*
  - *UK Industry Code of Practice for MASS (November 2017)*
  - *BV Guideline for Autonomous Shipping (December 2017)*
  - *DNV-GL Autonomous and Remotely Operated Ships (September 2018)*
- IMO MSC undertaking regulatory scoping exercise
- Transport Canada developing framework for MASS
- Responsibility, liability and insurance?

Technology
- Situational awareness and collision avoidance
- Communications & cyber security
- Reliability of equipment & machinery

Economics & business case
- Not clear; depends on application

Acceptance

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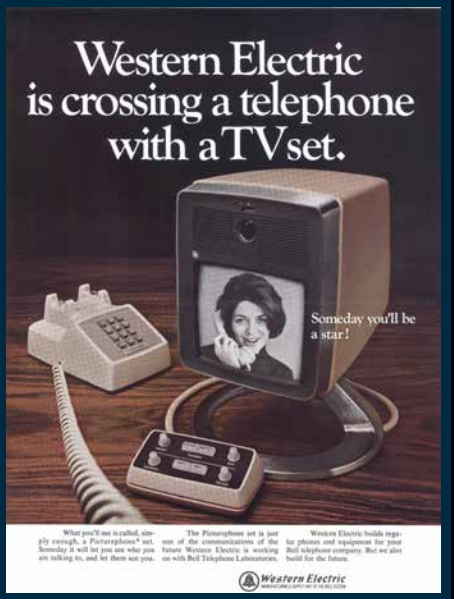
A cautionary message…

If we need autonomous ships, *why don't we have them already*?

A lesson from 40+ years of subsea robotics:

> *"Autonomous vehicles are mission-driven."*
> Dr. James McFarlane, founder and president of International Submarine Engineering and ROV / AUV pioneer behind over 200 unmanned vehicles.

> *Despite the extensive development that went into the AT&T PicturePhone system—more than 15 years of engineering effort and $500 million in development costs—market acceptance of Picturephone service was very poor. Ultimately, AT&T concluded that the videophone was a "concept looking for a market," and service was discontinued in the late 1970s.*
> Videophone telephone, David E. Borth, Encyclopædia Britannica Online



1968 Ad from Western Electric, AT&T's manufacturing subsidiary (courtesy AT&T Archives and History Center.)

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Other Players

SEA MACHINES

- Boston MA
- Autonomous technology company that specializes in advanced control technology for workboats and other commercial vessels

ASV unmanned marine systems

- Portchester UK, Broussard LA, Houston TX
- Supplier of unmanned and autonomous marine systems (recently acquired by L3)
- C-Worker, C-Cat, C-Target, and other C-class designs
- ASView ™ proprietary control system


Image courtesy of ASV Global

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Technology demonstrations

Rolls-Royce and Svitzer demonstrate remote control tug operations with Robert Allan Ltd-designed / Sanmar-built *Svitzer Hermod* in Copenhagen Harbour (2017)


Image courtesy of The Maritime Executive

Towage operator KOTUG operates Robert Allan Ltd-designed *RT Borkum* in Rotterdam via command station in Marseille at the ITS 2018 trade show

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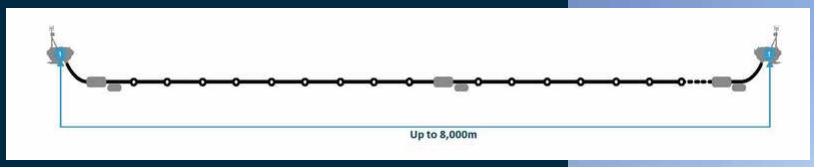
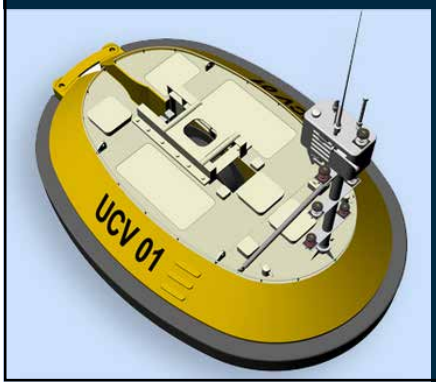
‘Autonomous Recording Vessel’ (2009)





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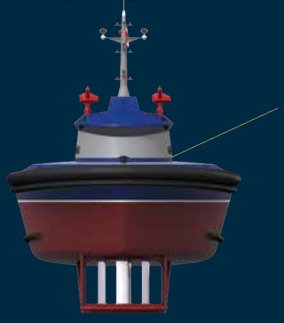
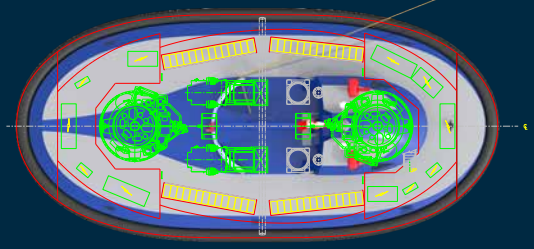
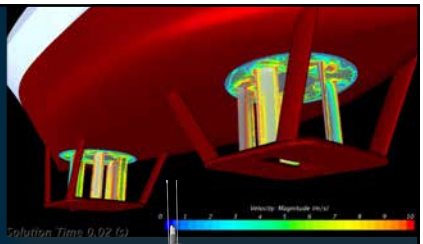
RAmora Tele-operated Ship-handling Tug (2014)





LOA:	25.8 m
Rule length:	23.5 m
Breadth:	12.0 m
Depth:	4.0 m
Draft:	5.5 m
Gross tonnage:	320
Speed:	12 kts
Bollard pull:	55 t



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What is the mission?

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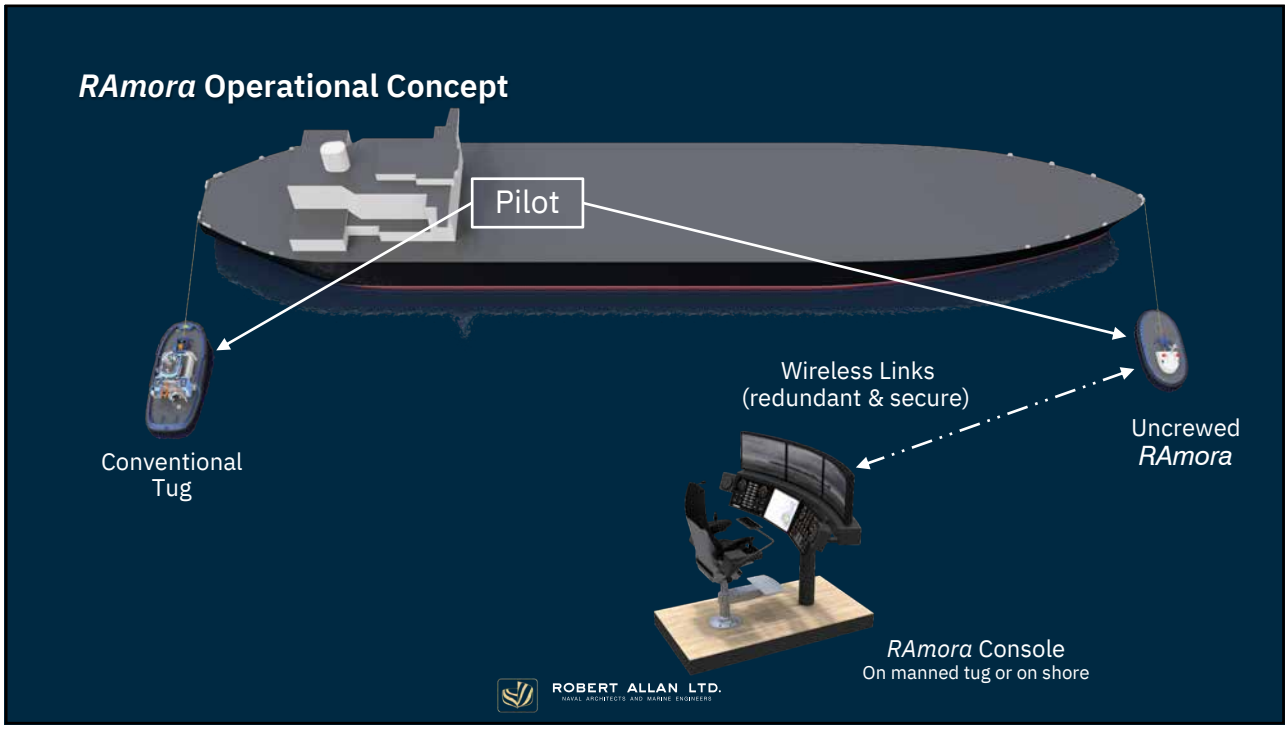
Triple E-Class 18,720 TEU *Magleby Maersk* with Robert Alllan Ltd. designed KOTUG *RAmparts 3200* Class *SD Sparta*

The dangers of ship-handling – and managing them


RAmora Operational Concept
Pilot
Conventional Tug
Wireless Links (redundant & secure)
Uncrewed *RAmora*
RAmora Console
On manned tug or on shore
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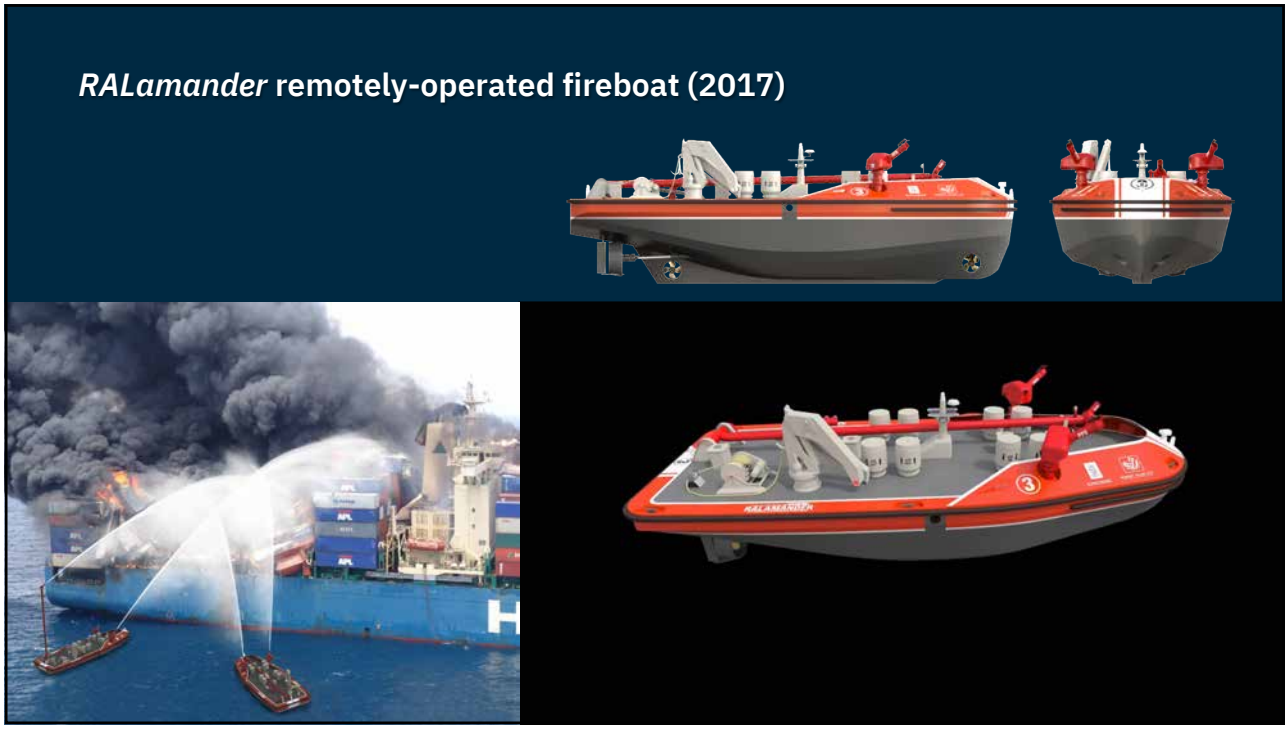
RALamander remotely-operated fireboat (2017)

Two development areas for uncrewed tugs

- Human machine interface design
- Motion-compensated towline transfer system

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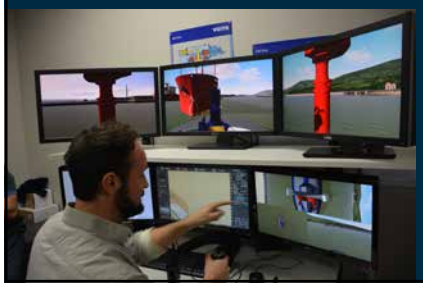
Human machine interface design

- Industry is not ready for fully autonomous operations
- Even with 'driver assist' functions, operation by an licenced mariner may be wanted or required
- Ship-handling requires a high level of situational awareness of ship's bow and towline action
- Non-visual cues are important if 3D depth perception is impaired or not possible, e.g. engine sound, towline tension, motions…



- What kind of controller inputs and driver assist functions are needed?
- What is the most effective 2D environment?
- What about VR and AR?

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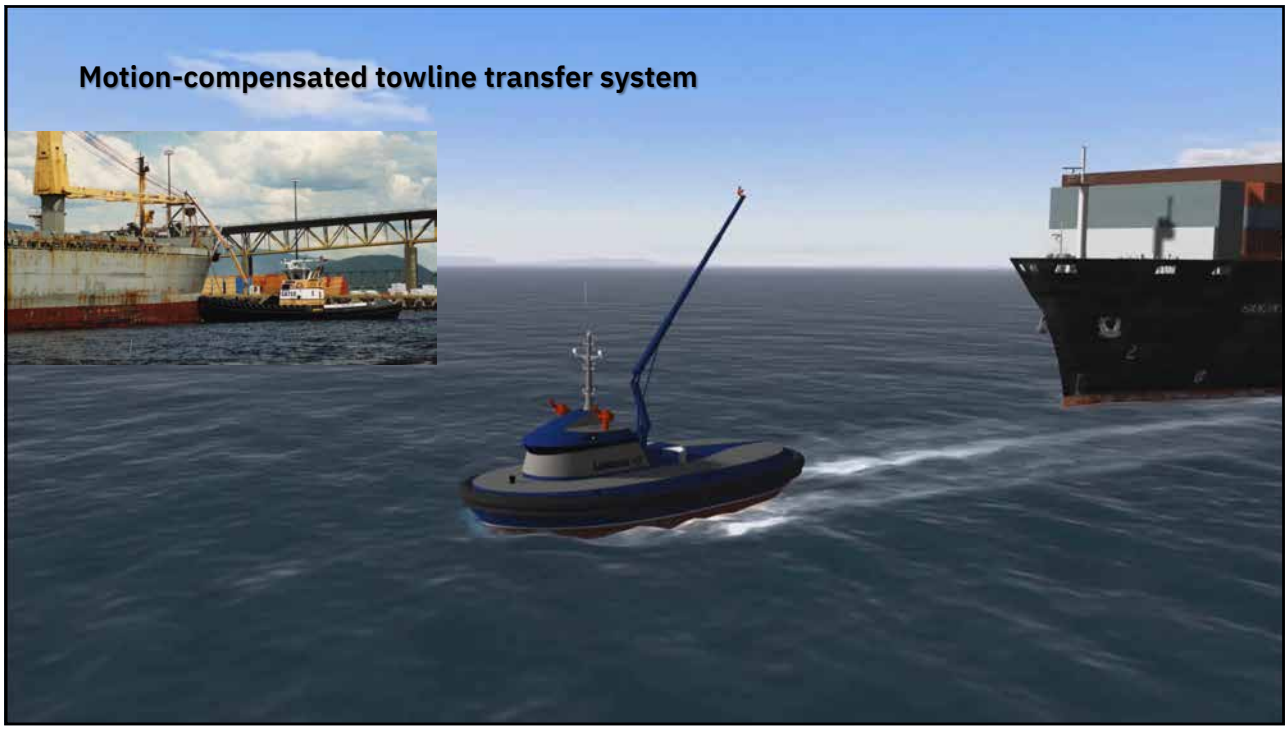
Motion-compensated towline transfer system



Current and future technology needs:

- Computational resources for R&D (mainly CFD)
  - Our high performance computing (HPC) cluster leverages our capability to innovate & compete internationally
  - Demand for HPC resources is growing, but it is expensive!
  - Need affordable HPC resources
- Access to simulator facilities & resources
  - To prove new designs to clients and regulators, need realistic simulation environments like full-mission bridge simulators
  - We can bring high-fidelity mathematical models to the table (win-win)
- Opportunities for uncrewed vessel technology demonstrations
  - Want to demonstrate core technologies related to controls, communications and situational awareness sensors with shipyard, operator and technology supplier partners
  - Europe is ahead of us, both with autonomous shipping and workboat-related demonstrations
  - To keep up will take vision, will and effort… and collaboration for made-in-Canada solutions

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Autonomous ships – Opportunities for Canada

Autonomous ships are not inevitable. We need to ask ourselves:

- Are doors opening to 'missions' that were not possible before?
- What are the missing pieces for Canadian missions?
- Are there Arctic opportunities?

Missions

- Arctic surveillance
  - Roving surveillance & support for aerial drones and/or autonomous underwater vehicles
- Arctic environmental monitoring / pollution response
- Autonomous cargo ships in the Arctic?


Photo courtesy of the RFNC-VNIIEF press service

Enabling technologies

- Ice detection
- Route planning
- High latitude communications
- Survivability / reliability

DRDC Photo

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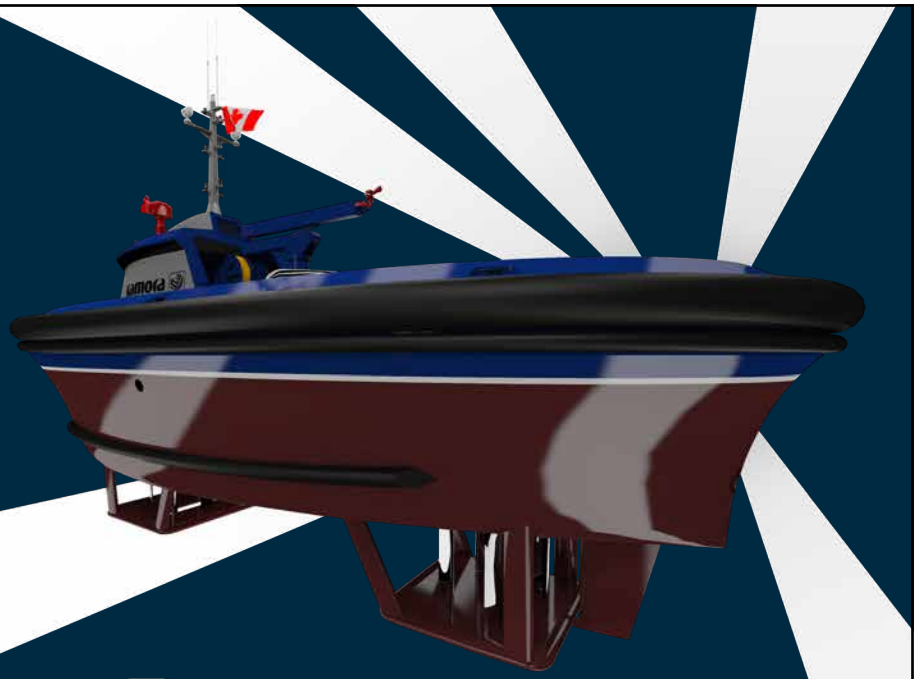
Thank you



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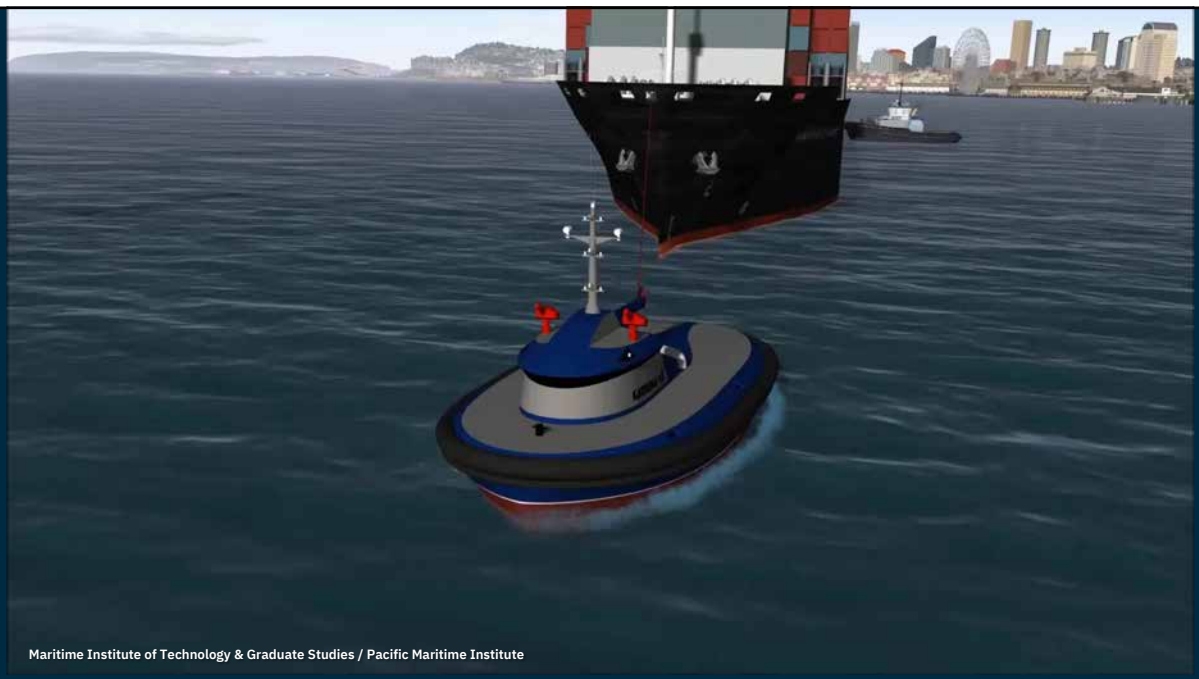

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The dangers of ship-handling at speed

- Interaction effects
- Reaction time, human error
- Towline forces & capsize
- Underwater bulbous bow

November 2010 - Collision & capsize while connecting tow line

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Fisheries and Oceans Canada | Pêches et Océans Canada
Canadian Coast Guard | Garde côtière canadienne

Safety First, Service Always

Use of CCG Ships as a Research Platform

Presentation to CISMaRT Meeting
November 27, 2018

Canada

Introduction

- **The presentation will focus on the logistics of using ship time, including:**
  - Types of ships available
  - Length of deployments
  - Additional costs
  - Other associated requirements

Objective: give you a clear sense of what is possible and what is not.

2

CCG Commitment

- CCG has agreed to provide time on board its fleet to CISMaRT-affiliated researchers as an in-kind contribution to the research network.
- The commitment is for 35 days of sail along time, per year, for five years.

3

Coast Guard Fleet

- 2 Heavy Icebreakers
- 4 Medium Icebreakers (Type 1200s)
- 7 Heavy Endurance Multi-Tasked Vessels (Type 1100s)
- 5 Offshore Patrol Vessels
- 9 Mid-Shore Patrol Vessels
- 3 Medium Endurance Multi-Tasked Vessels
- 4 Mid-Shore Science Vessels
- 2 Channel Survey & Sounding Vessels
- 4 Near Shore Fishery Research Vessels
- 14 Specialty vessels
- 49 SAR lifeboats

4




5

Logistics of Ship Time

- **CCG commitment is for ship time rather than program time (i.e., ride along rather than directing a ship)**
- **Projects can't interrupt normal ship operations**
- **Bandwidth on board CCG ships is limited**
- **There can be last-minute changes to schedule from the CCG side**
  - SAR calls
- **Maximum deployment is 35 days per year for all projects**

6

Additional Costs

- **Personnel carried on board CCG vessels must pay accommodation costs of approximately $100 per day.**

7

Prioritization of Projects

- **CCG proposes that CISMaRT provide an annual list of projects and their relative priority.**
  - CCG priority will be for non-commercial research
- **CCG will review the projects, and evaluate the prioritized list with a focus on the expected or potential impact on vessel operations, either through installation of equipment or while on program.**

8

Q & A

Questions?

9

Defence Research and Development Canada | Recherche et développement pour la défense Canada

Operational Capabilities of Low- and Non-ice-class Vessels in Ice

A CISMaRT Pilot Project

27 November 2018

Dr. John MacKay, Defence R&D Canada – Atlantic Research Centre

Prof. Bruce Quinton, Memorial University of Newfoundland

This document has been reviewed by Defence R&D Canada (DRDC) using the Guide to Canada's Export Controls dated April 2011 and DOES NOT CONTAIN controlled goods.

DRDC | RDDC

Canada

Introduction

The Ship Design and Operational Challenge

- Various ships with limited ice strengthening operate occasionally (intentionally or unintentionally) in ice-infested waters
  - Naval vessels, cargo ships, FPSOs, tankers, etc.
  - Ice damage can occur even for ice class vessels
  - Polar design rules and tools are generally aimed at structurally heavier / stiffer hulls
  - Ship-ice interaction for lighter hulls is not well understood

The Research Challenge

- Enable the design and assessment of the ice-going capability of low-/non-ice strengthened vessels
  - Improve understanding of ship-ice interaction
  - Develop tools to predict ice loads and damage
  - Develop engineering design tools

Kingston Class Maritime Coastal Defence Vessel operating in ice-infested waters

Bulbous bow of a Ice Class 1A cargo vessel damaged in ice near Iqaluit in the summer

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1

Project Participants and Funding

- Collaborative Partners from CISMaRT
  - Memorial University (Project Lead)
  - Defence R&D Canada
  - Vard Marine Inc.
  - American Bureau of Shipping
- Additional Funding Sources
  - Natural Science and Engineering Research Council (GoC) – DND/CRD Program
  - Government of Newfoundland and Labrador
- Project Funding:
  - Total Cash Funding: $810K CAD
  - Total In-Kind Contributions: $350K CAD
  - Total Project Value: $1.16M

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2

Project Overview

- Project Investigators from Memorial University
  - Bruce Quinton, Deputy Head, Assistant Professor
  - Claude Daley, Associate Dean of Research, Professor
  - David Molyneux, Director of the Ocean Engineering Research Centre, Associate Professor
- Project Duration: 4 years (Sep 2018 – Sep 2022)
- Highly Qualified Personnel
  - 9 Masters (MEng) students
  - 4 PhD students
  - 2 Postdoctoral Fellows

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3

Project Overview

Key Project Goals

- Develop and validate software tools for assessing response of non- and low-ice-class hulls to ice loads
- Develop and validate new ice-load hull monitoring techniques
- Advanced material behaviour and fracture characterisation of aged and new ship-building steels
- Assess ice load patterns and effects on warships operation in marginal ice conditions
- Incorporation of moving load effects in hull assessment tools

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Research Project Streams

- (1) Full-scale ice-structure interaction experiments
- (2) Advanced material characterisation of ship-building steel
- (3) Development of ship-ice interaction simulation tools
- (4) Practical engineering design tools for lightly- /non-ice class vessels

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(1) Full-Scale Ice-Structure Interaction Experiments

- MUN's Large Pendulum Apparatus
  - Two pendulum arms in a self reacting frame
  - One side carries an ice feature, the other supports a grillage
  - Total Relative Impact Speed: Up to 6.2 m/s (12 knots) at 60 deg pendulum angle
  - Up to Total Impact Energy: Up to 53.5 kJ

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6

(1) Full-Scale Ice-Structure Interaction Experiments

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7

(1) Full-Scale Ice-Structure Interaction Experiments

- Experimental Program
  - Six stiffened panels from the Ex-HMCS IROQUOIS
  - Six (at least) exact copies of the Ex-HMCS IROQUOIS grillages
  - Six concept grillages (testing new structural arrangements with similar steel weight)
  - Investigate new hull structural monitoring technologies for ice impact
    - Video strain monitoring (3D DIC)
    - Fibreoptic strain gauges
    - Accelerometers

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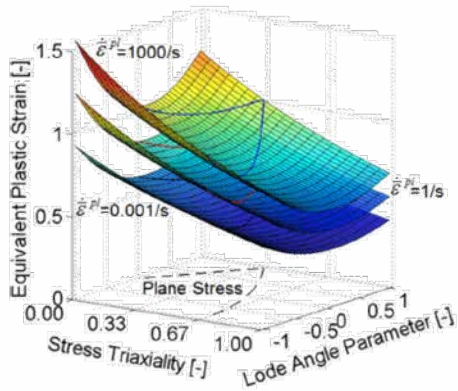
(2) Advanced Material Characterisation of Ship-Building Steel

- Material fracture is difficult to predict accurately with numerical models
- Hull fracture for sliding ice loads is particularly hard to predict
- Conventional "equivalent strain to fracture" techniques are not sufficiently accurate
- This project will investigate the use of the **Fracture Locus** concept for predicting hull rupture
  - "Fracture locus" defines the fracture strain as surface, in Lode and triaxiality space
  - Custom material experiments in combination with FEA
  - Characterise and compare fracture of aged and new naval steel
  - New material data will be used in high-fidelity numerical models of ice impact scenarios



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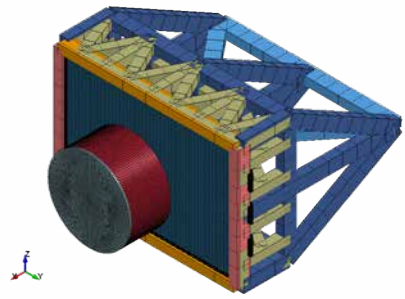
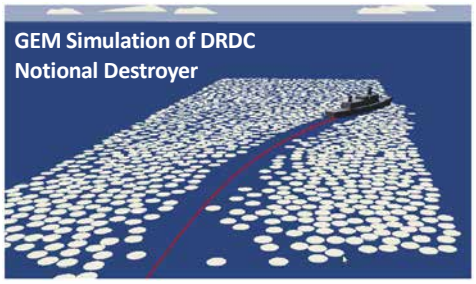
(3,4) Ship-Ice Interaction Simulation and Design Tools

- High-fidelity modeling of hull damage due to ice impact using finite element (FE) models
  - 4D (Ice) Pressure Method – automated application of real or predicted ice loads to whole-ship numerical models
  - Dynamic simulation of ship-ice impact, including ice failure and hull damage and rupture
  - Validation against experiments and sea trials
- Holistic ship-ice interaction simulation
  - Enhancements to the GEM software – MUN's novel Event Mechanics simulation software
    - Predicts ice loads on a hull including floe fracture
    - Provides real-time support for decisions involving pack ice
  - GEM enhancements to include
    - 3D simulation environment
    - Effect of hull deformations on ice load prediction
    - Level ice-breaking capabilities
- Desktop ice-load and hull assessment tools





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10

Project Status

- Project Administration
  - Collaboration agreement (MUN, DRDC, ABS, Vard) signed in Sep 2018
  - Project officially started
- Project staffing
  - 1 PhD and 4 MEng students in place
  - MUN seeking
    - 3 additional PhDs and 1 Post Doc immediately
    - 4 additional MEng students in May 2019
- Research program
  - Design modifications to large pendulum apparatus underway
  - Pre-testing measurements of Ex-HMCS IROQUOIS test specimens underway
  - Large pendulum tests to begin in Spring 2019
  - Database of existing ice trial data being developed
  - Collaboration with NATO partners being planned
    - Additional grillage test specimens from New Zealand
    - Complementary grillage and material experiments in Germany
    - Numerical modeling development with the USA

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11

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SCIENCE, TECHNOLOGY AND KNOWLEDGE FOR CANADA'S DEFENCE AND SECURITY

SCIENCE, TECHNOLOGIE ET SAVOIR POUR LA DÉFENSE ET LA SÉCURITÉ DU CANADA

built on trust

Development of CFD Modelling Best Practices

Dan McGreer/Andrew Kendrick, Vard Marine

Halifax, November 2018

CISMaRT

CANADIAN NETWORK FOR INNOVATIVE SHIPBUILDING, MARINE RESEARCH AND TRAINING | RÉSEAU CANADIEN POUR L'INNOVATION DANS LA CONSTRUCTION NAVALE, LA RECHERCHE MARINE ET LA FORMATION

VARD a Fincantieri company

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Background

- Computational Fluid Dynamics (CFD) analysis is becoming "state of the practice" for a number of aspects of performance prediction and verification.
- There is still a shortage of engineers with in-depth understanding of how to address problems using CFD.
- "Trial and error" modelling is expensive and time-consuming; and does not necessarily give confidence in analytical results.
- Joint project industry/government/academia has been set up to develop and validate best practices for a range of analyses.

VARD a Fincantieri company

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Challenges – Levels 1-3

Level I: CFD software packages are able to solve the physics of interest, but what are the best settings considering accuracy / reliability and solution time / resources?

- Examples of questions at this level include what turbulence model should be employed, how many grids should be distributed on the free surface, and what size of computational domain needs to be used, if a RANS solver is chosen.

Level II: CFD software packages are able to solve the physics of interest. However, there are other model choices. Clarity is needed on the performance of models considering Level I only after the investigation of most appropriate model(s) for a given need and trade-off between models.

- Examples of question at this level include what solvers, RANS, DES or LES, should be chosen for full-scale resistance and maneuvering simulations.

Level III: CFD software packages are not yet able to solve the physics of interest adequately and investigation is needed into new or improved techniques / models. This is undertaken considering level I and II issues, but only following the development and/or refinement of model theory, success with fundamental validation cases, and demonstrated scaling to practical problems.

- An example is ship maneuvering in waves which involves the modeling of free surface flow and ship motions.

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Participants/Funding

Participants and Project Steering Committee:

- Wei Qiu, Memorial University
- Kevin McTaggart, DRDC Atlantic
- Andrew Kendrick, VARD Marine
- Andrew Gerber, University of New Brunswick
- Bart Stockdill, Robert Allan Ltd
- James Bond, American Bureau of Shipping
- Derrick Alexander, Lloyd's Register
- Dong Cheol Seo, NRC-OCRE

Funding Partners:

- DRDC Atlantic,
- Vard Marine,
- PRNL,
- ABS,
- MITACS
- NSERC

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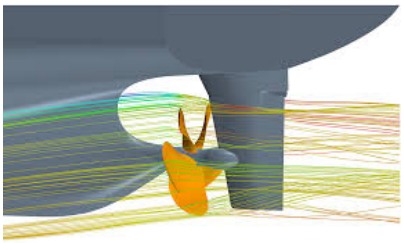
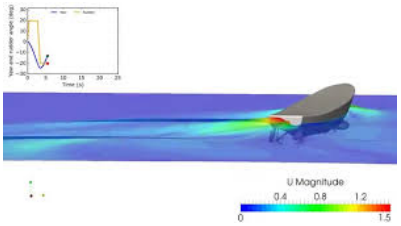
Initial Area of Exploration

1. Prediction of Effective Wake Using RANS Solvers
2. Determination of Manoeuvering Coefficients Using RANS Solvers





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Prediction of Effective Wake

Case: KCS container ship in full scale and model scales

Work will explore:

- Computational domains: 3 domains
- Y+ values: 5 ranging from 1.0 to 500
- Grid resolutions: 4 for stern zone and propeller
- Free surface modeling/grid: 4
- Turbulence modeling:
  - SST k – ω model, k –ε model, SST with LCTM
  - IDDES (only for a small number of unsteady cases)
  - WALE SGS Model (only for a small number of unsteady cases)
- Time steps: 3 Courant numbers for unsteady cases.
- Size and location of inflow: 3 x 3 plane upstream of the propeller

Most work will be undertaken using STAR-CCM+, some cases with OpenFOAM and Simerics-MP+ Marine

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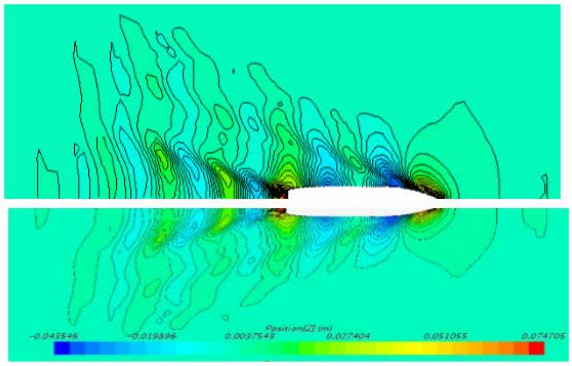
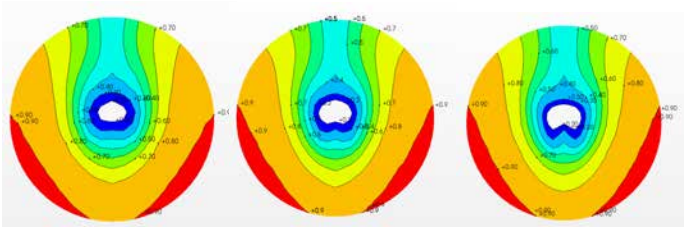
Initial Results

- Coarse mesh
- Comparison of experimental and CFD results



- Wake fields at varying mesh density



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Manoeuvering Coefficients

Studies will be carried out for three ships with and without appendages, including:

- DTMB5415 (destroyer)
- KCS (container ship
- KVLCC2 (tanker)

CFD analyses will be compared with:

- Planar Motion Mechanism (PMM) Simulations for DTMB5415 Bare Hull
- PMM Simulations for DTMB5415 Appended Hull
- PMM Simulations for KCS and KVLCC2 Bare Hulls
- PMM Simulations for KCS and KVLCC2 Appended Hulls

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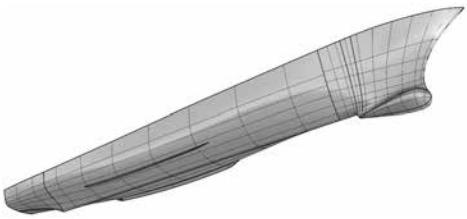
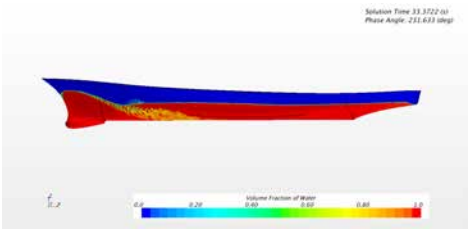
Complex Phenomena (from prior Vard/DRDC work)

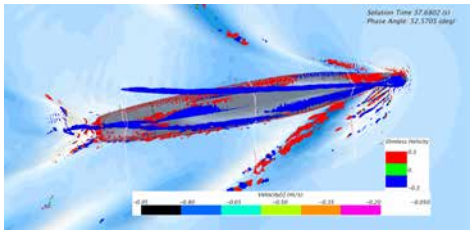
Hull Form





Breaking waves and bubble sweepdown

Flow helicity



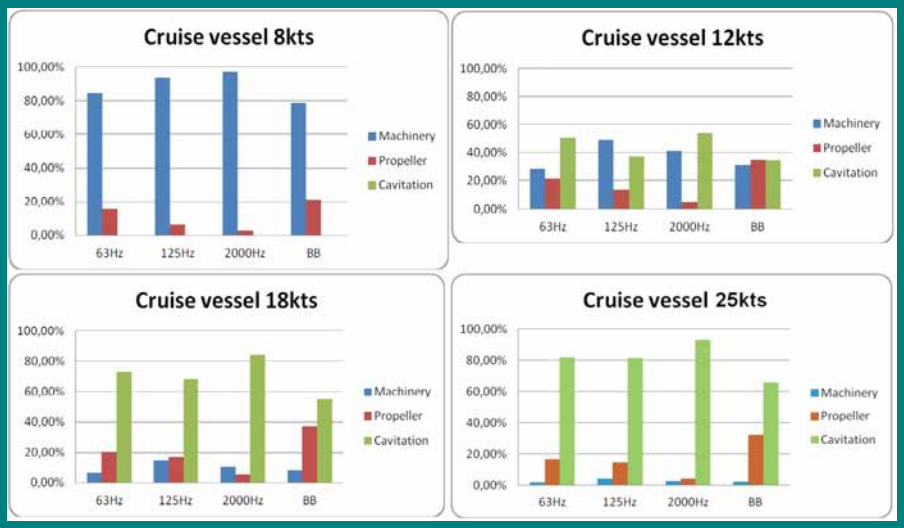
VARD
a Fincantieri company

CISMaRT Workshop
Halifax, 27-29 Nov. 2018

Impact of Manufacturing Tolerances on Propeller Performance

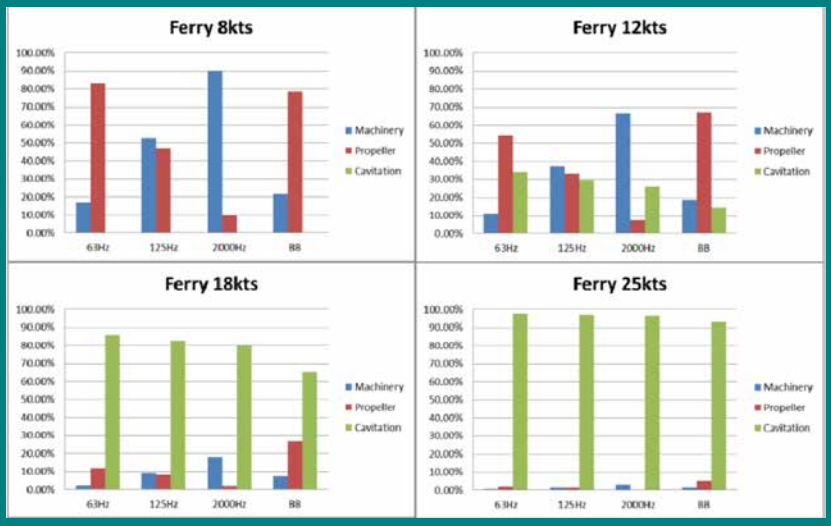
Bodo Gospodnetic
Dominis Engineering

Contribution between, machinery, propeller and cavitation noise for a cruise vessel at different speeds



AQUO Project no. 314227, WP 2: Noise sources, Task T2.5, Report page 22 - 23

Contribution between, machinery, propeller and cavitation noise for a ferry boat at different speeds



AQUO Project no. 314227, WP 2: Noise sources, Task T2.5, Report page 22 - 23

Typical propeller manufacturing process

- Construction of propeller CAD model
- Design and fabrication of fixtures
- CNC programming and verification
- CNC rough machining (in 2 setups)
- Robotic or hand grinding of blade surfaces
- Hand grinding of edges and tip
- Inspection

Process sources of errors

- Robotic grinding: 1. Precision issues
  2. Only flat surfaces
- Hand grinding is: 1. Time-consuming
  2. Error-prone
  3. Non-repeatable
- 2 setups: Back/face positioning errors

MANUFACTURING TOLERANCES FOR SHIP TYPES

ISO 484/1 tolerance class	Ship type
S	Naval vessels such as frigates and destroyers Cruise vessels High speed ferries Research vessels Special purpose merchant vessels
1	General merchant vessels Deep sea trawlers Tugs Ferries Naval auxiliary vessels
2	Low-power craft Low- speed craft Inshore fishing vessels Work boats
3	Similar types as Class 2

Guiding principles for Dominis manufacturing processes

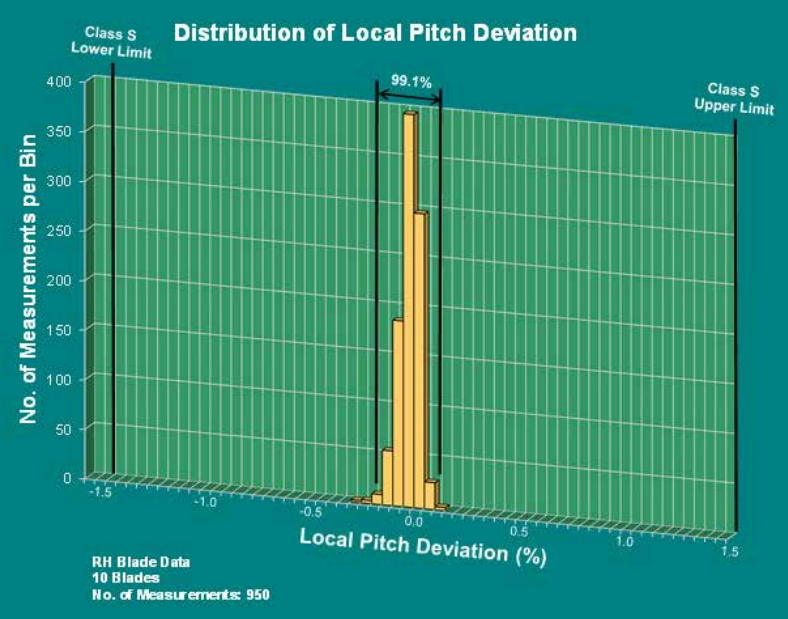
- LE and TE must be CNC machined integral to pressure and suction sides of propeller blade
- All hydrodynamic surfaces must be CNC machining to “final form and finish”
- One setup finish machining
- No hand grinding
- Lights out, unattended operation

Achievements at Dominis

- Improvements to manufacturing process
  - Custom designed cutting tools
  - Surface smoothing and blending software
  - Complex tool-path computation
- Results
  - Accuracy achieved is much better than Class S
  - Surface roughness after milling of 0.8 μm
- Conclusion
  - ISO 484 is seen as unnecessarily lenient

Dominis processes are proven in production

- Process for CP propeller blades
  - used in production of spare CP blades for CPF
- Process for monoblock propellers
  - used in production of propellers for EFMC
- Process for water jet impellers
  - used in production of impellers for LCS



OPERATIONAL CHARACTERISTICS VS. PROPELLER PARAMETERS

Operational characteristics	Propeller parameter	Consequences
Cavitation inception	Leading edge form (critical) Local section pitch Section thickness General section form (camber) Section chord length Blade form and relative location	Underwater noise
Cavitation extent	Local section pitch Mean pitch	Underwater noise
Power absorption	Diameter Mean pitch General section form (camber) Surface finish	Increased fuel consumption
Blade strength	Section thickness	Fatigue failure
Vibratory loads	Static balance Blade form and relative location Rake and axial position	Negative effects on bearings
Blade section drag	Surface finish	Increased fuel consumption

Preliminary investigation

Leading edge form (critical parameter)

- LE geometry is very susceptible to manual grinding errors and also to errors in positioning after flipping from face up to face down
- Dominis manufacturing processes have a specific advantage in the LE definition
- Basic 2D foil theory points to the sensitivity of the LE pressures to geometric variation

Preliminary investigation

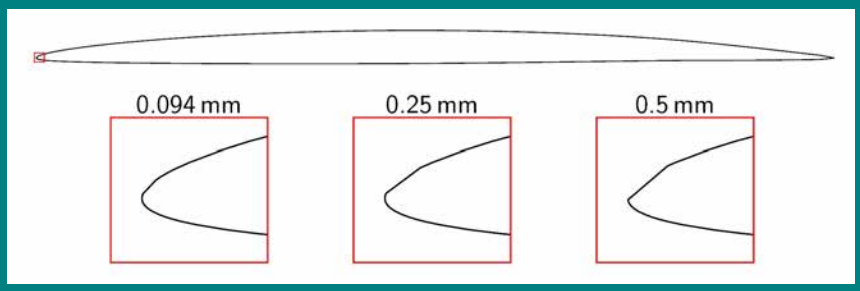
CFD simulations: David Hally, DRDC – Atlantic

2D airfoil:	NACA 66 (mod)
Chord length:	1 m
Thickness:	4.16 cm
Camber:	1.4 cm

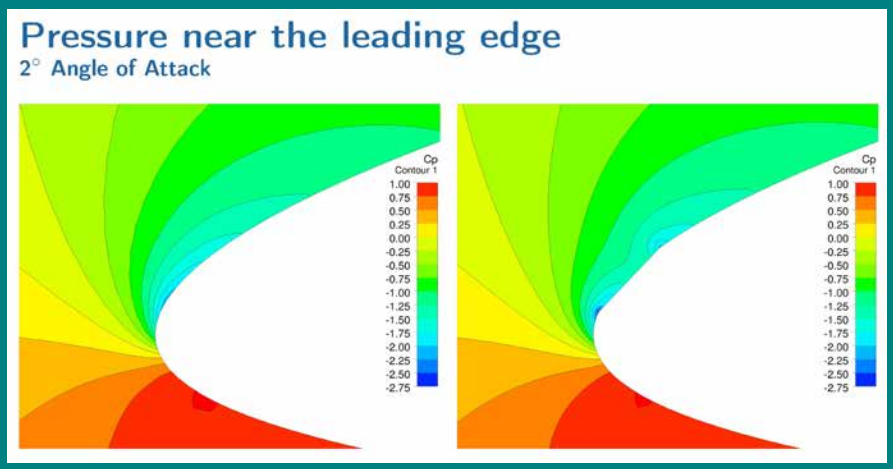
a, 2D airfoil “as designed” with tolerance ±0.000 mm
b, 2D airfoil “as built” with flat deviations, 0.094 mm, 0.250 mm and 0.500 mm from design

Preliminary investigation

NACA 66 with flat defects at leading edge

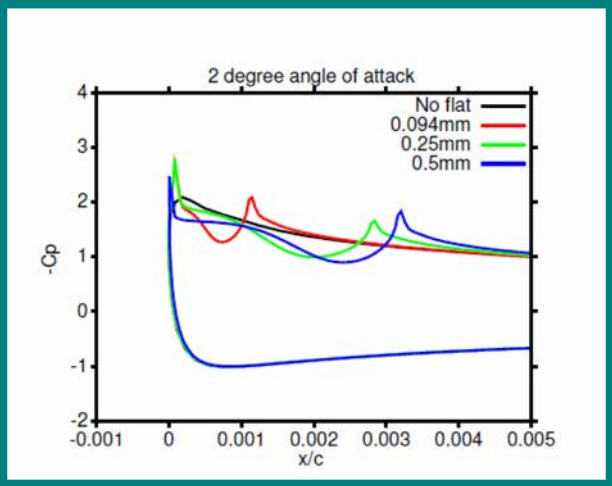


Preliminary investigation



Preliminary investigation

Pressure near leading edge



Preliminary investigation

Preliminary conclusions:

1. Even very small defects significantly smaller than ISO 484 tolerances can have a detrimental effect on the flow near the LE.
2. Location of the defect relative to the maximum pressure is important.
3. A defect causes flow separation at lower angles of attack.
4. Manufacturing tolerances specified by ISO 484 should be thoroughly investigated.

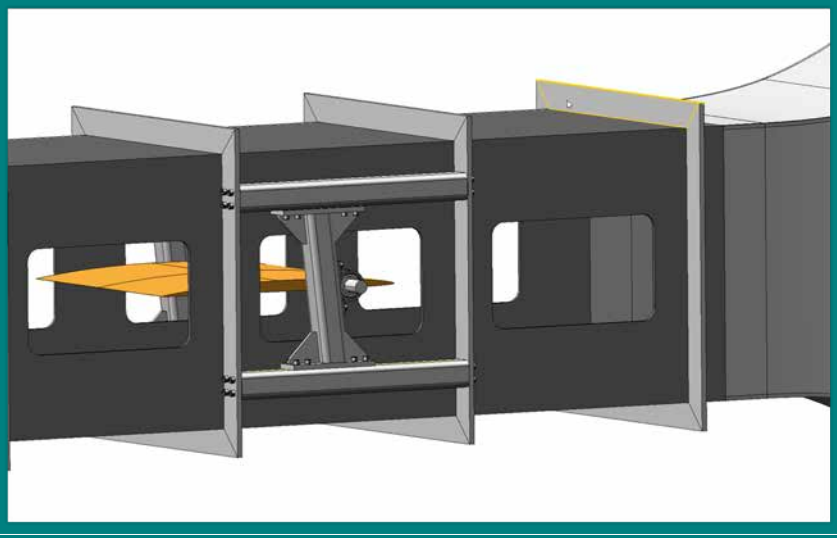
Research program: Impact of manufacturing tolerances on propeller performance

Research team: Dominis Engineering
DRDC – Atlantic
Memorial University

Current research activities:

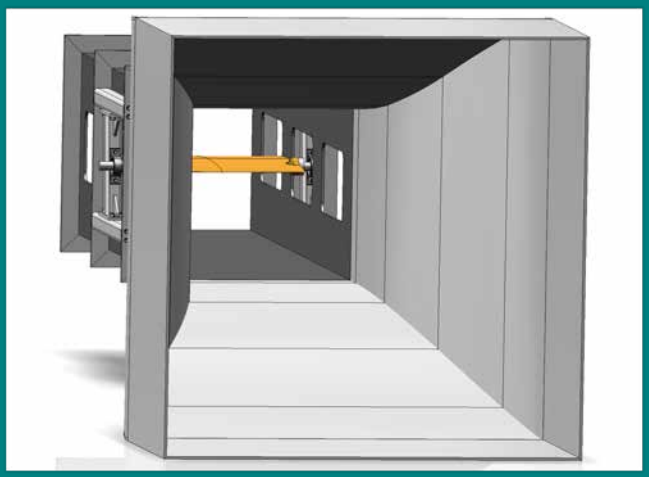
- Analytical studies to determine impact of tolerance on performance
- Fabrication of models for cavitation tests
- Cavitation tests to validate analysis are being arranged

2D airfoil in the cavitation tunnel



19 Dominis

2D airfoil in the cavitation tunnel



20 Dominis

Project objectives

To determine cavitation performance degradation between an ideal geometry propeller “as designed” and compromised geometry propeller “as built”.

Tolerances: Starting from ISO 484-1 class S

Propeller parameter: LE form,
sharp-edged LE flats

Scope of research

1, Investigations to be carried out using CFD simulations

2, Results of CFD simulation will be validated by running experiments with models in a cavitation tunnel. Same scale for CFD and for the models will be used.

Description of research

All investigations will be done at 3 levels of propeller geometry complexity:

1, 2D airfoils in rectilinear flow
- CFD simulations with multiple airfoils
- one 2D airfoil model in cavitation tunnel

2, 3D wing plan-form in rectilinear flow
- CFD simulations with multiple plan-forms
- one 3D wing plan-form model in cavitation tunnel

3, 3D full propeller in rotation
- CFD simulations

Project Deliverables

- Compendium of cavitation effects due to small geometry variations
- Advice to ship-owners on tolerances necessary to meet cavitation requirements
- Recommendations to ISO

Thank you

New Defence Perspective

Innovative technology, knowledge, problem solving *are critical for Canada and its allies to mitigate new threats, stay ahead of potential adversaries, and meet evolving defence and security needs, while generating economic benefits for Canada.*

Strong, Secure, Engaged

Canada's Defence Policy 2017

In SSE, DND announced the
Innovation for Defence Excellence and Security (IDEaS) program and
will invest **$1.6 billion over 20 years**

Defence & Security Science &Technology (S&T)

- The complex and constantly evolving nature of conflict and crises requires that S&T address **potential threats and risks**, such as:
  - **Space, cyberspace**
  - **Natural disasters, major accidents, crime**
  - **Emerging disease, pandemics**
  - **New and unpredictable adversaries (e.g. ISIL)**
  - **Unstable and failing states**
  - **Terrorism and technology**
  - **Globalization of S&T and pace of technological development (e.g. quantum, synthetic biology, artificial intelligence, etc.)**
- In this new environment, **IDEaS** is an augmentative approach to accessing innovation allowing Canada's military to better tap into extraordinary talent and ingenuity resident in Canada.

The Innovation Imperative

WHY WE MUST INNOVATE

- **Nature of conflicts and threats** is rapidly evolving and changing as new technologies, players and domains emerge;
- To **enrich defence capabilities** that address current and emerging challenges;
- To **stay ahead** of rapidly evolving technology;
- To **inform** future decisions; and
- We must innovate to **remain economically competitive**.

HOW WE CAN INNOVATE

- **Recruit** more of the Canadian innovation ecosystem to partner in the delivery of S&T for defence and security;
- Foster a **technologically advanced** and **innovation-driven** defence and security sector capable of addressing evolving threats and generating economic benefits;
- **Increase partnerships** and collaboration to foster and build on emerging S&T developed across the innovation ecosystem; and
- **Leverage government buying power** to target sectors that have the most innovative solutions.

Aligning with Allies

- In 2014, the **U.S.** launched its *Third Offset Strategy* (U.S. $3.6 billion) aimed at leapfrogging the conventional R&D process by tapping into civilian efforts and improving collaboration with innovative private sector enterprises.

- In 2016 **Australia** launched the *Next Generation Technologies Fund* ($730 million over 10 years) and a *Defence Innovation Hub* ($640 million over 10 years) to undertake collaborative innovation activities from initial idea, through testing to application.

- In 2016, the **United Kingdom** in support of Innovate UK, launched the *Defence Innovation Initiative* (£800m over 10 years).

Innovation Lessons Learned

Canada has learned from its allies as well as from organizations at home and abroad. These principles form the foundation for the design and operations of IDEaS.

INNOVATION PRINCIPLES

- Agile business process proposal, selection and engagement
- Multidisciplinary teams
- Learn fast through frequent trials
- Hardest problems attract best ideas

In 2018, Canada announces the Innovation for Defence Excellence and Security (IDEaS) program ($1.6 B over 20 years)

Program Mandate

RECRUITING INNOVATORS	SUPPORTING INNOVATION	MATURING INNOVATIVE IDEAS INTO PRODUCTS
Experts and entrepreneurs engage in **ideation** sessions to gain new insights on defence and security problems **Innovation networks** build S&T expertise across academia, industry, and government defence **Mobility** of experts allows a sharing of experience and proficiency	Supporting **projects** to foster development of promising ideas and solutions Create **contests** to support demonstrable solutions **Sandboxes** assess the applicability and effectiveness of a prototype	Procure limited quantity for **assessment** by operators Provide support to mature solutions using **integrators** and transition to operators
Vibrant innovation community	Open competition of ideas	Validated innovative solutions

Elements may be used independently, or in support of one another, to access and foster innovation

INNOVATION FOR DEFENCE EXCELLENCE AND SECURITY **(IDEaS)** 7

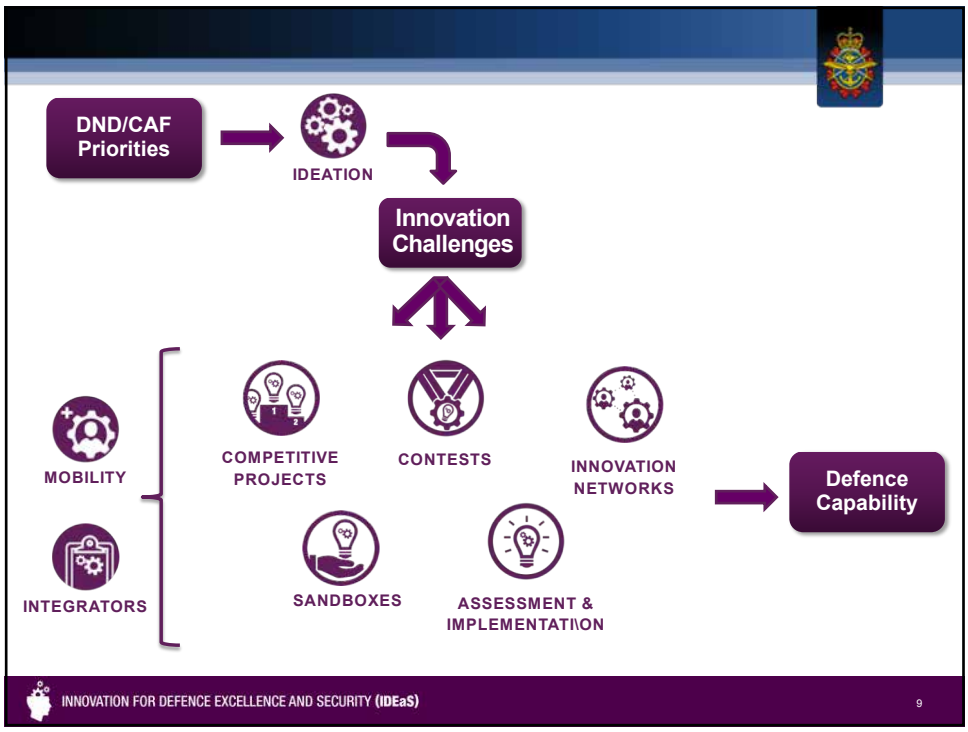
Program Elements

INNOVATION NETWORKS | CONTESTS | COMPETITIVE PROJECTS | SANDBOXES | ASSESSMENT & IMPLEMENTATION

Innovation Enabling Elements

MOBILITY | INTEGRATORS | IDEATION

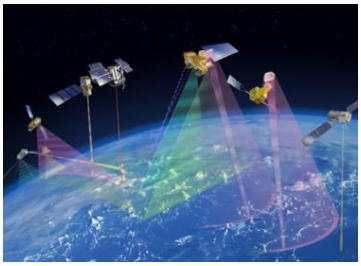
INNOVATION FOR DEFENCE EXCELLENCE AND SECURITY **(IDEaS)** 8



IDEaS in action

Hard Problems turned into Innovation Challenges

- Detection and Classification of Objects of Interest
  - How to augment the ability to detect, recognize, track and identify persons or objects using seamless information sharing across a decision network?
- Autonomous systems
  - How can operators trust and work effectively with autonomous systems?
- Persistent Maritime Surveillance
  - How can offshore waters be monitored to detect underwater threats by using rapidly deployed, persistent, autonomous, solutions?
- Enhancement effectiveness of space-based capabilities
  - How do we develop a Common Operating Picture of space assets to improve situational awareness?



Enhancing Domain Awareness and Joint ISR

IDEaS Elements Solving Innovator Challenges

Networks to Build Capacity
- Make innovators aware of Defence needs for Artificial Intelligence(AI) ideas (**Ideation**)
- **Innovation Networks**
- Embed experts (**Mobility**)

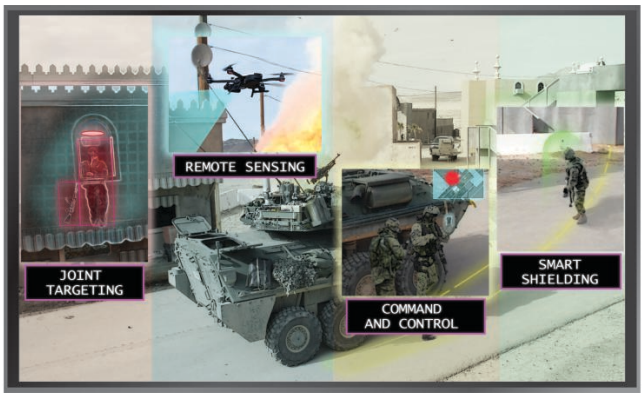
Incentivize Competitions
- Provide multiple funding options to orient the best research towards innovation challenges (**Competitive Projects, Contests, Sandboxes**)

Validation
- Provide expertise, guidance, feedback (**Integration**) and opportunity for solutions to be validated in a realistic setting (**Innovation Assessment**)

Through IDEaS, future capabilities will be available sooner and more diverse

IDEaS in Practice: Building Defence Capability

Using Artificial Intelligence as an example: IDEaS elements can help achieve maximum potential from Unmanned Air Vehicles, sensor arrays, command & control solutions, etc



Competitive Projects

Innovators are awarded Contracts or contribution funding for their defence and security solutions

- The first CFP with 16 challenges was launched on April 9th 2018 and closed June 7
- The contracting process generated more than10 contracts per Challenge, for a potential maximum of 160; out in October/November
- The second CFP was launched on October 18th 2018
- Multiple CFPs each year

Innovation Networks

Increase innovator engagement in defence and security challenges to build capability

- This element of IDEaS has been launched with its first Call for Proposals to establish micro-networks
- Topic: Applications of Advanced Materials (camouflage and protection)
- Two phase process, with a Letter of Intent and a Full Proposal
- Second CFP also launched in early July – Autonomous Systems
- They are both in the Phase 2

Sandboxes

Curated trial opportunity for innovators to receive feedback on a potential solution

- Launched on August 21st; closed on September 24th
- Two-phase process by which we propose a series of Challenges to the innovators to interest and the solicit applications
- Multiple instances/year starting in late 2018 / early 2019

Contests

Incentivize innovators to develop demonstrable solutions

- Under final development
- Some Challenges are ready to be used and submitted to the Canadian innovators
- Multiple instances/year (4-8) starting in December 2018 / January 2019

Innovation Assessment & Implementation

Innovator solutions are evaluated by IDEaS, DND and CAF

- Under final development
- Some Challenges are ready to be used and submitted to the Canadian innovators
- Multiple instances/year starting in early spring 2019

Funding Eligibility *

- Educational institutions chartered in Canada;
- Canadian not-for-profit organizations or associations;
- Provincial/territorial or municipal government organizations;
- Canadian for-profit companies, organizations or associations;
- Individuals;
- International S&T collaborators partnered with an eligible Canadian recipient; and
- Any group composed of eligible recipients above

* Identified within each call for proposals

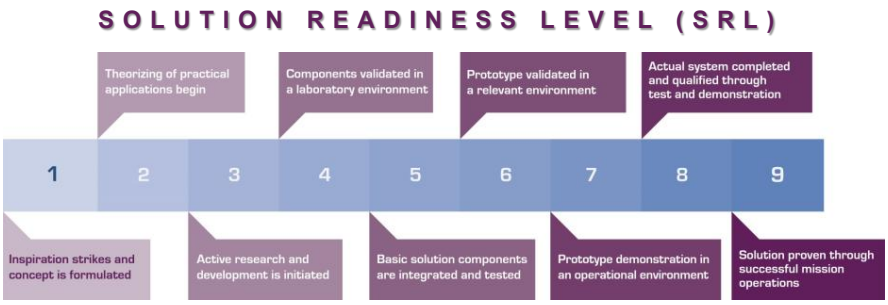
Intellectual Property (IP)

- Innovators will own the IP they develop under this program; and
- The Crown may license any of the IP generated under IDEaS to use for defence purposes.

Contact Us

- E-mail: **DND.IDEaS-IDEeS.MDN@FORCES.GC.CA**
- Web: **Canada.ca/defence-ideas**
- Follow us on Twitter **#DefenceIDEaS**

Innovation Continuum



IDEaS Elements

Competitive Projects

Innovators are awarded Contracts or contribution funding for their defence and security solutions

Innovation Networks

Increase innovator engagement in defence and security challenges to build capability

Contests

Incentivize innovators to develop demonstrable solutions

IDEaS Elements

Sandboxes

Curated trial opportunity for innovators to receive feedback on a potential solution

Assessment and Implementation

Innovator solutions are evaluated by IDEaS, DND and CAF

IDEaS Enablers

Integrators

Link between external innovators and the defence and security community

Ideation

Multidisciplinary collective brainstorming process to refine challenges and explore solution

Mobility

Enables the exchange of expertise between organizations

"Where will our knowledge take you?"

Research Ideas

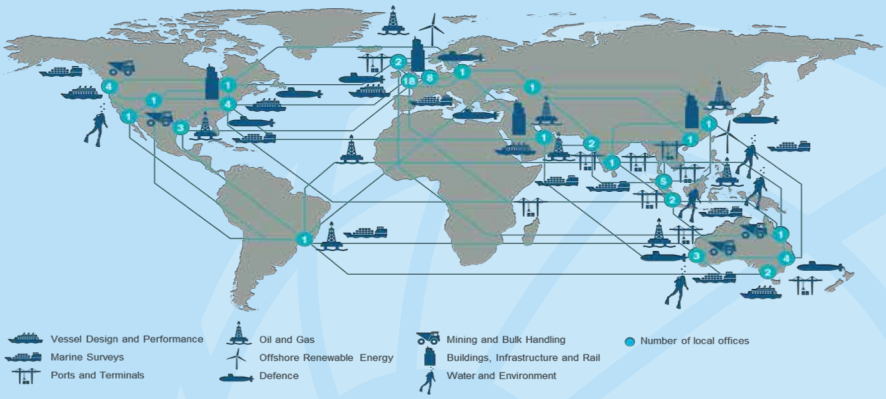
CISMaRT 2018 Workshop

Charlie Nisbet, BSc, MSc, CEng, FRINA
Engineering Director, BMT Canada Ltd

BMT Group

BMT Group

DEFENCE ENERGY & ENVIRONMENT TRANSPORT



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BMT in Canada

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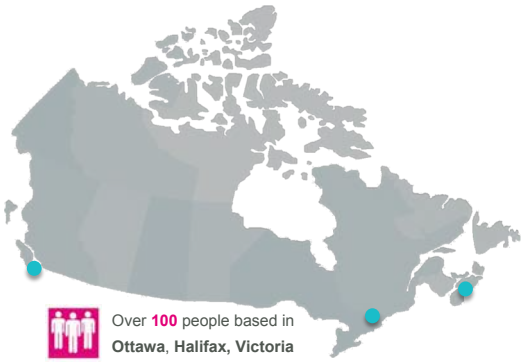

Over **100** people based in
Ottawa, Halifax, Victoria

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RESEARCH IDEAS

BMT

Where do we go from here?

Previous research for the marine and adjacent industries has developed many results and theories.

- Many good research reports completed and filed.

The marine community has not implemented all of these findings, because:

- Marine community is cautious at adopting new technologies
- Research results are not ready to implement, OR
- Marine community is not aware of the research results

Decades of past research and product development is trapped in files for posterity

Often new research is unaware of the archived legacy work resulting in the innocent repeat, re-run and recreation of past research.

BMT

Proposed Solution

Road Map Production

- Perhaps a non-university task
- Identify previous work to define state of knowledge
- Identify gems and gaps

This work will be used to

- Identify easy wins . . . . Implementable (high TRL) results
- Near misses and path to complete . . . (Path to increase TRL)
- Identify gaps in state of knowledge . . . (Research ideas)

Results will be used

- Assign priorities
- Identify industry stakeholder champions for next steps
- Identify researchers interested in projects

BMT

Proposed Application

The approach can be applied across a range of subjects;

- Material Selection for Cold Weather Application
- Production Practices to ensure Fatigue Resistance
- Application of Composite, Hybrid Structural advances
- Power Generation, Storage, Distribution and Consumption
- Conventional and next generation Propulsion Configurations
- Marine support Systems, Component and Product development
- Technology "push & pull" to and from adjacent Transport Sectors
- Impact of Global + Regional, Legislative and Regulatory driven change
- ……no known boundaries

An Opportunity to learn from the past need driven Knowledge and Experience.

BMT

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Thank You

Copyright Statement

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Aligned with your needs.

Real World Application of Noise Control

27 November 2018

ALION
SCIENCE AND TECHNOLOGY

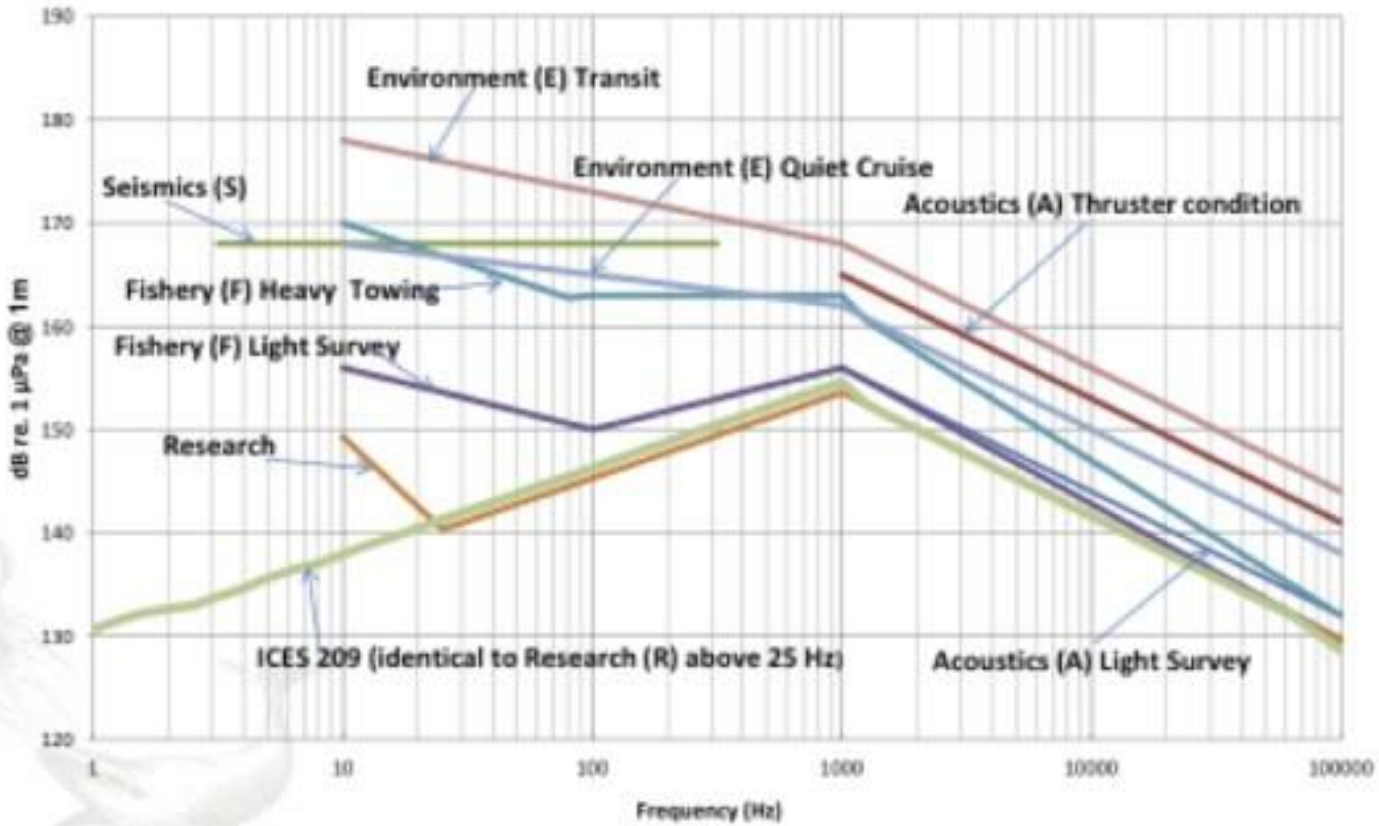
Alion Science and Technology

- Alion (formerly JJMA) is the largest naval architecture and marine engineering company in the United States
- Since 1957, Alion has led or supported hundreds of ship design efforts from concept through detailed design and construction
- Staff includes over 1,400 professionals providing all phases of research/survey, combatant and naval auxiliary vessel design, engineering, and acquisition.
- Provided design and engineering services for every US Navy oceanographic ship over the last 30 years

Alion Research and Survey Vessel Experience

				
T-AGS 60 CLASS SURVEY SHIPS	T-AGS 63 CLASS SURVEY SHIPS	R/V THOMPSON AGOR 23	NOAA Ship RONALD H. BROWN	T-AGS 66 SURVEY SHIP
				
NOAA FISHERIES SURVEY VESSEL	OCEAN CLASS AGOR	REGIONAL RESEARCH VESSEL	USCGC HEALY RESEARCH IB	AGOR 24 R/V REVELLE
				
T-AGS 51 - 52	USNS WATERS	R/V ATLANTIS (AGOR 25)	T-AG 195	R/V KILO MOANA (AGOR 26)

DnV Silent notations, Summary of criteria, Band levels vs ICES 209



Considerations For Selecting and Meeting an Underwater Radiated Noise Level

- Select an URN based on vessel's planned operational use
- Noise control is not cheap: can be 20%+ of the budget
- Understand what drives the signature
- Comprehensive Noise Control Plan Needed
  - Design, Construction, Testing
- Use Of Accurate 3-D Noise Modeling, Including Empirical And FEA Tools
  - Treatment Types And Areas Of Coverage Optimized
  - Improve Effectiveness
  - Reduce Weight, Cost And Space Required
- Verify Weights Of Machinery To Ensure Proper Foundation And Mount System Design – specific design rules apply to make the mounts work

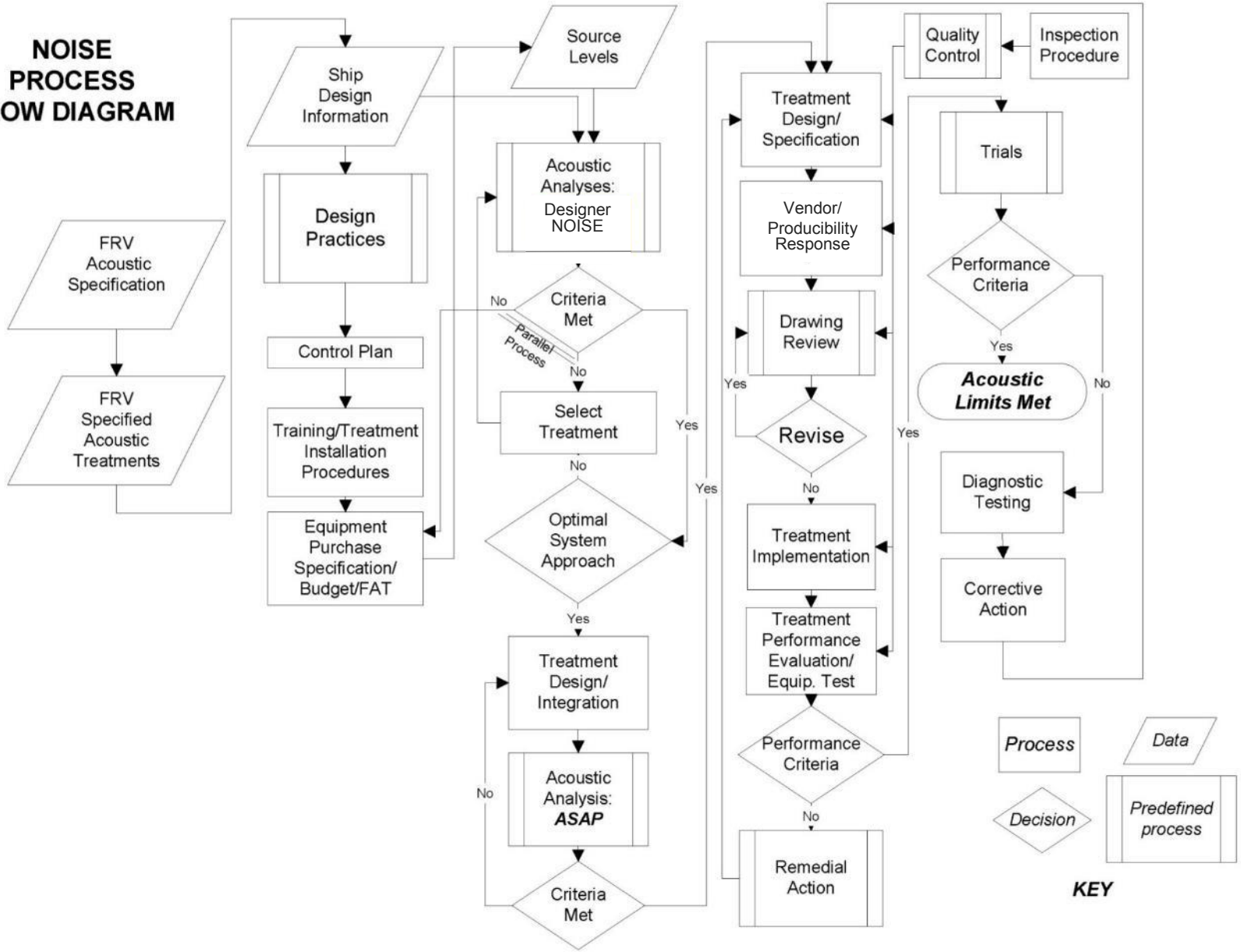
Considerations For Selecting and Meeting an Underwater Radiated Noise Level (cont'd)

- Establish Structureborne Noise Limits For Critical Machinery
- Factory Testing Of Critical Machinery Items
- Non-cavitating propeller design in operating speed range
- Noise Treatment Installation Training and Guidance
- QA – Construction Inspections For Proper Installation Of Treatments
- Make Noise Control an Integral Part of Design Team
  - Early Involvement
  - Significant Design Decisions Reviewed by Noise Consultant
- At Sea Testing To Verify Compliance
- Corrective Action if Required

Typical levels of treatment for different URN Levels

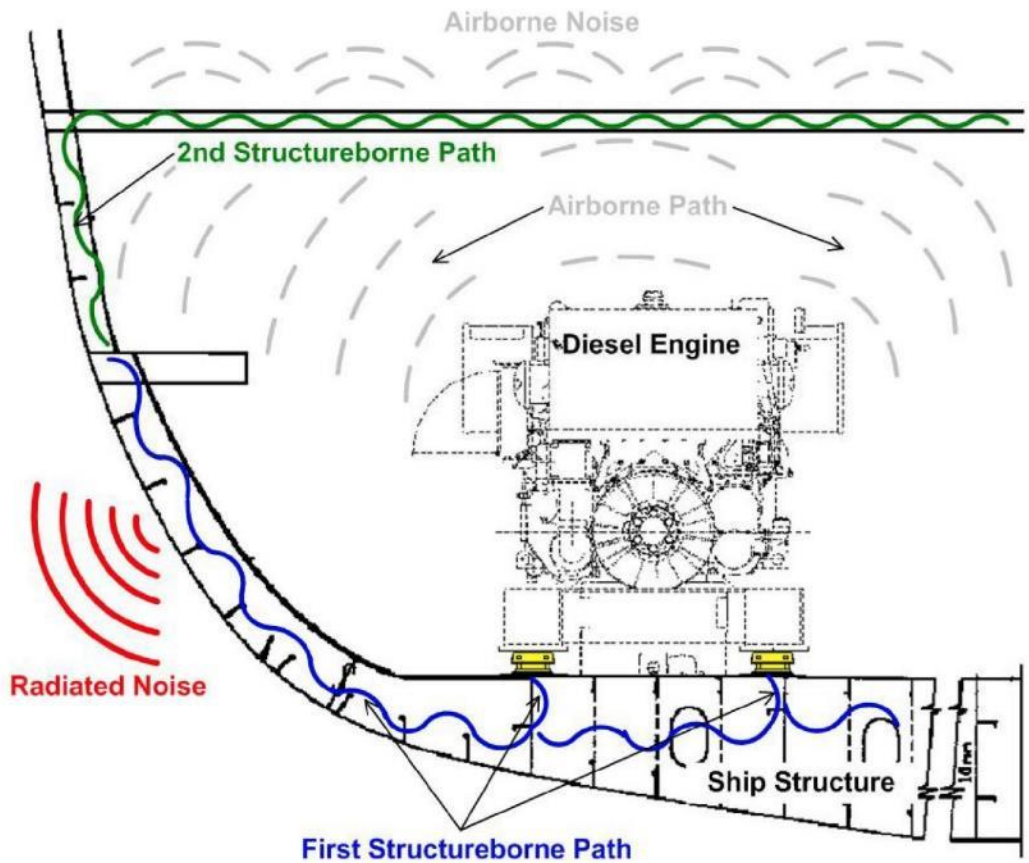
	DNV Silent R, F, ICES 209	DNV Silent A, S
Vessel Type	Fisheries Research	General Purpose Research or Survey
Resilient Mounting	Double for main machinery	Single
Structural Damping	Extensive	Little or none
Structureborne Noise Limits for Machinery	Yes	Rarely
Factory Noise Testing for Machinery	Yes	No
Special Quiet Motor Design	Yes	No
Insulation	Extensive use of HTL around machinery spaces	Occasional use
Foundation Design	Critical with high impedance	Not as critical

NOISE PROCESS FLOW DIAGRAM



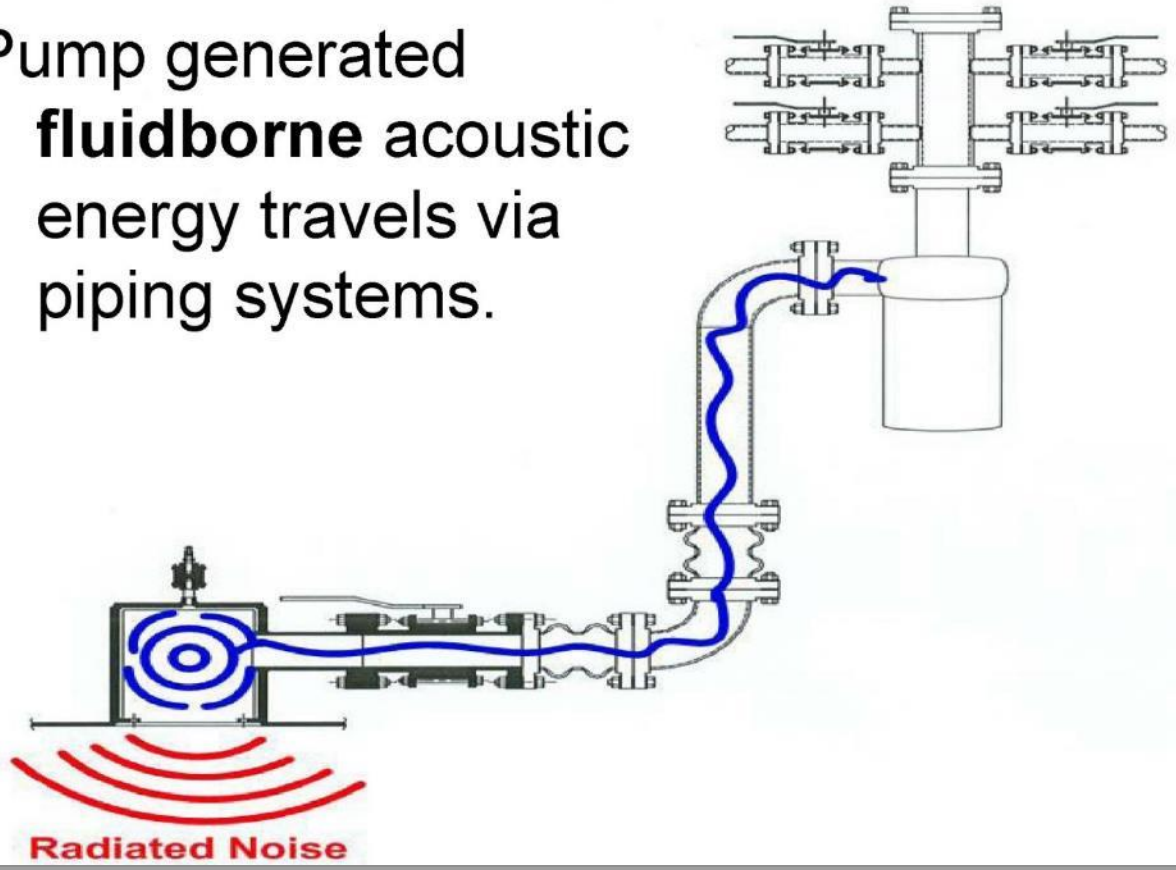
Paths for Machinery Noise

- Airborne
- First Structureborne
- Secondary Structureborne
- **U/W Radiated Noise**



Sea Connected Systems – FluidBorne Noise

Pump generated **fluidborne** acoustic energy travels via piping systems.



Noise Control Application

INVESTIGATOR Highlights

- Particulars:
  - Length Overall: 93.90 m
  - Breadth: 18.50 m
  - Draft:, Navigational 6.89 m
  - Displacement (Full Load): 5,878 T
  - Total Berths 60
  - Speed, cruising 12 knots
  - Range (at 12 knots) 10,800 nm
  - Lloyds Classification +100A1, +LMC RESEARCH VESSEL, DP (AM) UMS, ICE 1C, IWS, SPS CODE
- Delivered: 4 August 2014
- Flagship research vessel for Government of Australia
- Capable of supporting all types of oceanographic, geoscience, ecosystem, and atmospheric research
  - Entire Main Deck devoted to research – laboratories, working deck, science storage
  - One of the largest sonar survey suites covering water depths from 10 to 11,000 meters
  - Extensive suite of winches and overside handling systems
- One of the quietest vessels in the world - meets DNV Silent R, the most stringent radiated noise standard
- First AC electric powered ship to meet Silent R

Investigator Underwater Radiated Noise Signature Drivers

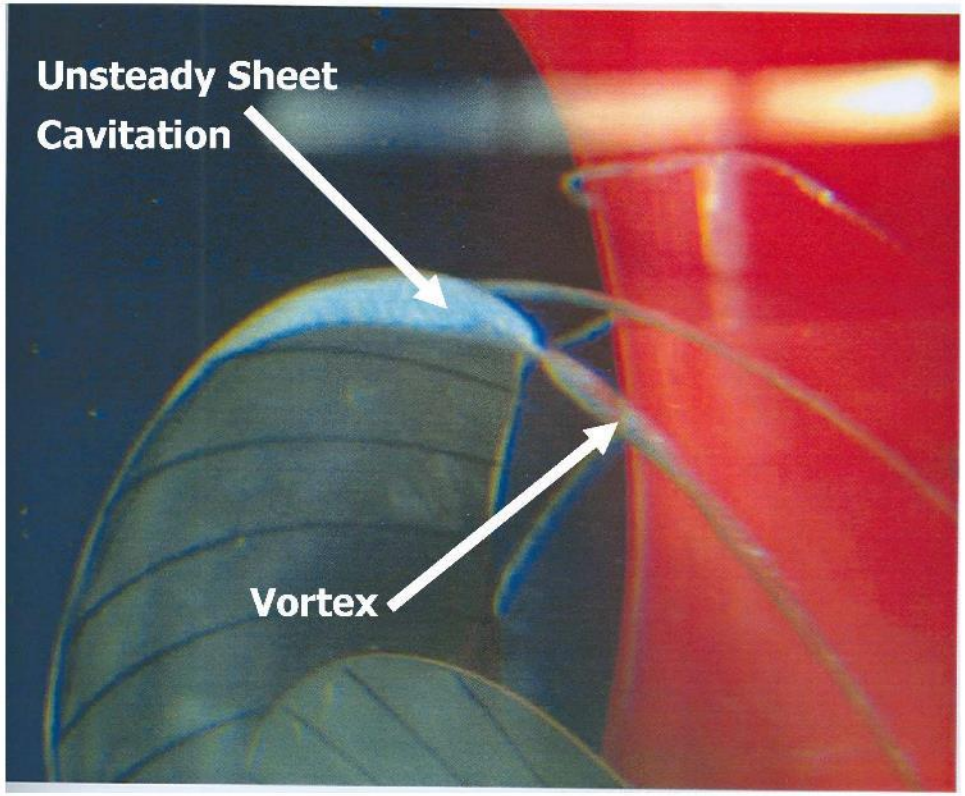
- Machinery Noise
  - Propulsion Motors
  - Diesel Generators
  - Reciprocating Machinery, Air Compressors
  - Rotating Machinery
  - Sea Connected Piping Systems
  - Hydraulic Power Units
  - Fans
  - Transformers

Investigator Underwater Radiated Noise Signature Drivers

- Propeller
  - Controls Signature When Cavitating
  - To Meet ICES, Must Be Cavitation Free
  - Cavitation Avoidance Through 11 Knots Is Feasible
    - Large Diameter, Slow Turning
    - Uniform Wake Inflow
    - Good Propeller Design
- Pods Or Z Drives – Unacceptable For ICES Because Machinery Is Directly Coupled To Water
- Bow Thruster – Not Operational For ICES Mode

Propeller Noise – Cavitation…

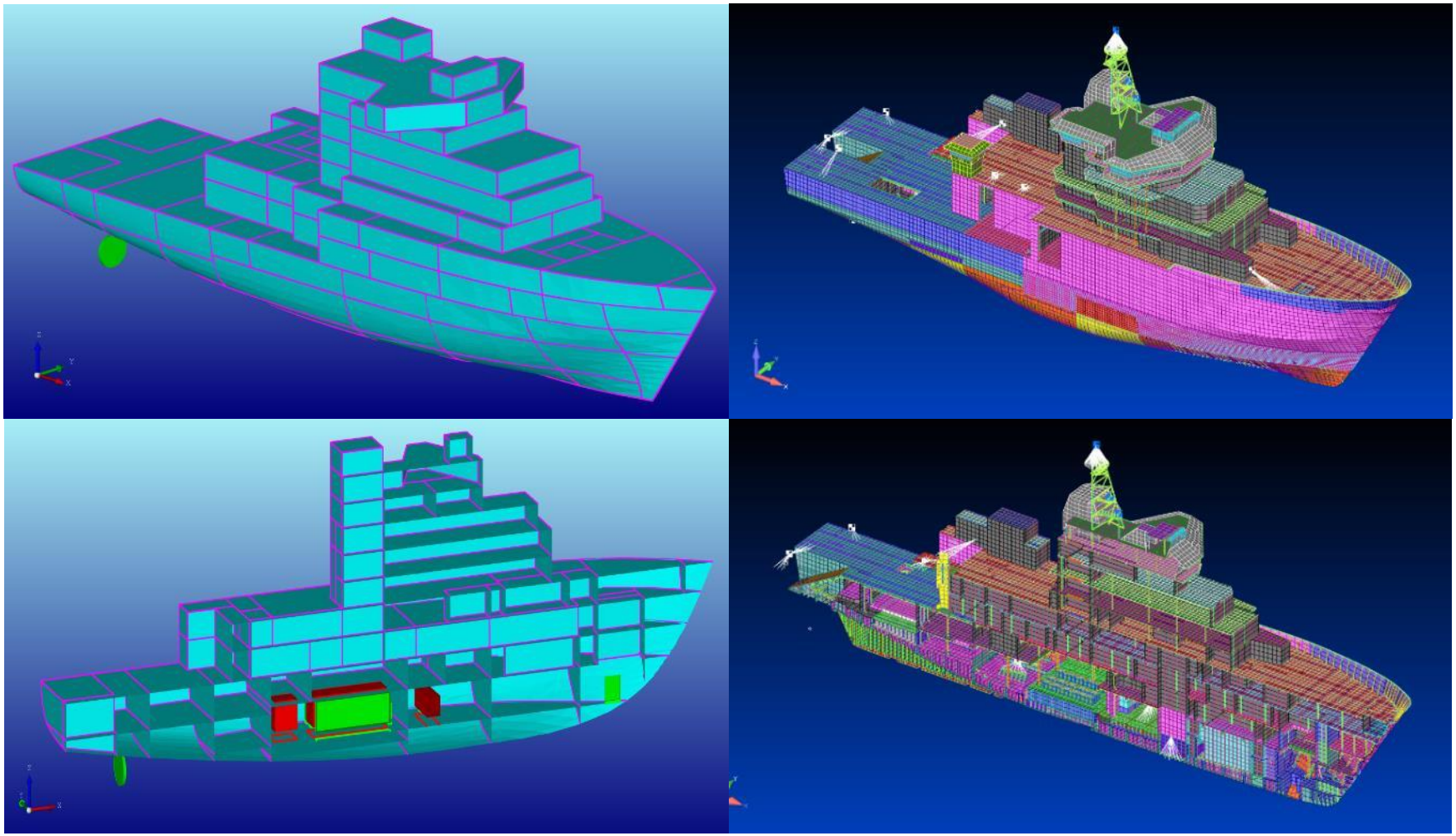
… is the vaporization of water due to a decrease of the local pressure. This generates millions of very small vapor bubbles whose collapse generates significant underwater noise.



Noise Prediction Techniques

- Use CAD Tool To Predict Hull Vibration
- Include All Machinery Sources
- Airborne & Structureborne Paths (Including 'Secondary Structureborne' Path).
- Predict Underwater Noise By Applying Hull Vibration-to-UW Noise Transfer Function

Acoustic Modeling – Whole Ship Acoustic Model



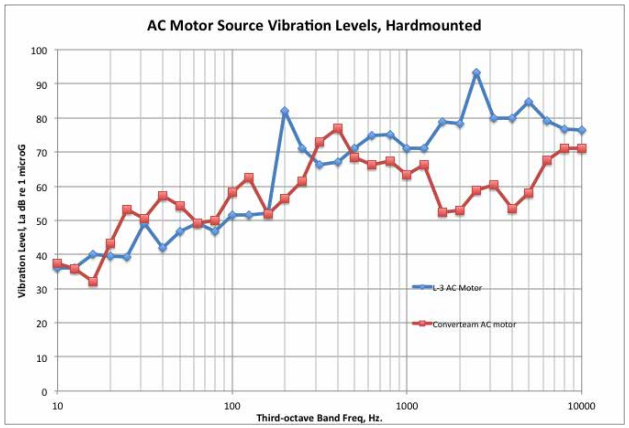
Typical Radiated Noise Treatments

- Defined Specific Structureborne Noise Limits For Major Machinery: Propulsion Motors And Diesels
  - Verified Through Factory Testing
  - Measure Onboard Vessel
- Defined Vibration Limits for Machinery Based on Industry Standards
- Compound Resilient Mounting For Diesel Generators
- Single Resilient Mounting For Other Machinery
- Careful Foundation Design
- Flexible Piping Connections, Hoses, “Dog-Legs”
- Resilient Piping Hangers
- Structural Damping Material On Foundations, Bulkheads, And Decks
- High Transmission Loss Insulation
- Design Criteria for Auxiliary Fluid Systems to Minimize Noise
- Quiet design AC propulsion motors

Noise Critical Machinery Requirements

- Noise quieting traditionally concentrates on treating the transmission path, however, big signature drivers are more efficiently treated at the source
- Identify critical machinery which drives the underwater noise signature
- Given the desired signature and expected path treatments, determine the allowable structureborne vibration limits for the critical equipment and require vendors to meet them
- For INVESTIGATOR, two of the most critical items are diesel generators and propulsion motors

INVESTIGATOR AC motor vibration data



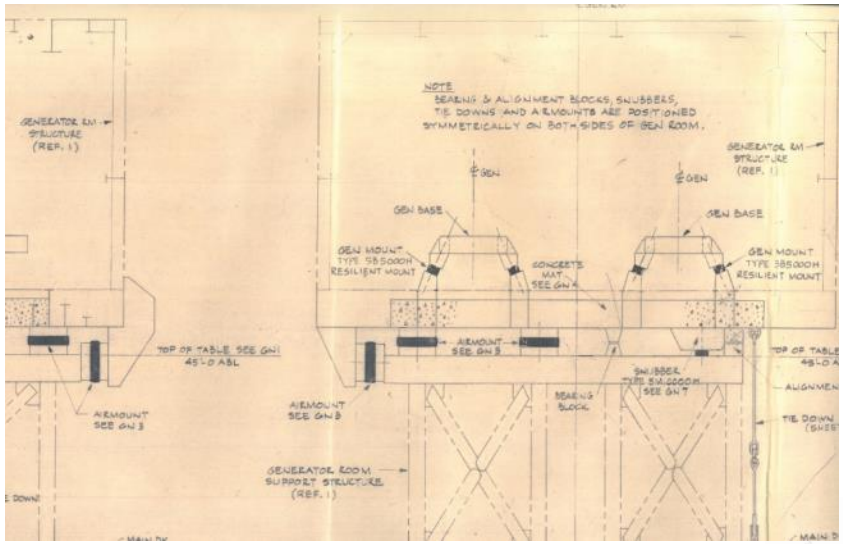
INVESTIGATOR DG Vibration Criteria

	REVISED NCE Criteria
OB Freq	dB re 1 microG
31.5	70
63	67
125	69
250	77
500	84
1000	85
2000	82
4000	82
8000	80

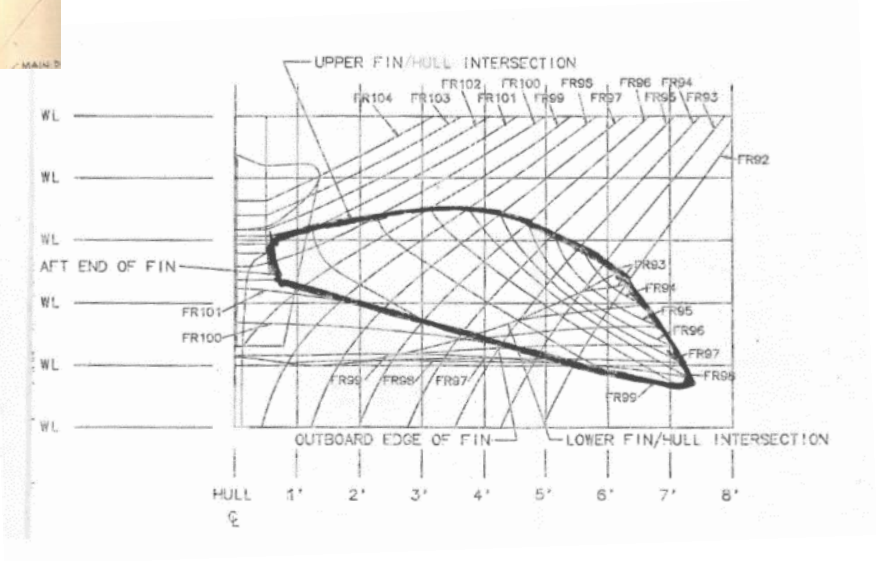
Potential Machinery Acoustic Treatments

NOISE CRITICAL SYSTEMS AND ASSOCIATED NOISE CONTROL		Resilient Mounts	Special Sub-base	High Impedance Foundation	Foundation Damping	Flexible Connections	Resilient Pipe Hangers	Low Noise Motors
PROPULSION	PROPULSION MOTOR		YES		YES			YES
	MOTOR COOLING PUMP			YES		YES		
	MOTOR COOLING FAN	YES						
	MOTOR LUBE OIL PUMP	YES		YES	YES			
	PROPULSION CONVERTERS	YES						
ELECTRICAL	DIESEL GENERATORS	Compound	YES	YES	YES	YES	YES	
	DIESEL EXHAUST PIPING	YES				YES	YES	
	DIESEL EXHAUST MUFFLERS	YES				YES		
	TRANSFORMERS	YES				YES		
	UNINTERRUPTIBLE POWER SUPPLIES	YES				YES		
	POWER SUPPLY COOLING					YES		
AUXILIARY	FUEL OIL PURIFIER	YES				YES		
	SEA WATER COOLING PUMPS	YES				YES	YES	
HVAC	A/C SUPPLY FANS	YES				YES	YES	
	A/C REFRIGERATION PLANTS	YES		YES	YES	YES	YES	
	A/C CHILL WATER PUMPS	YES				YES	YES	
	VENTILATION FANS	YES				YES		
	FAN COIL ASSEMBLIES	YES				YES		
DOMESTIC FRESH WATER	FRESH WATER PUMPS	YES				YES		
	HOT WATER CIRC PUMPS	YES				YES		
SANITARY	SEWAGE TREATMENT PLANT	YES				YES	YES	
	VCHT SYSTEM PUMPS	YES				YES	YES	
REFRIGERATION	SHIP SERVICE REEFER PLANTS	YES		YES	YES	YES	YES	
COMPRESSED AIR	AIR COMPRESSORS	YES		YES	YES	YES		
STEERING GEAR	HYDRAULIC PLANT	YES		YES	YES	YES	YES	

Other Noise Reduction Techniques

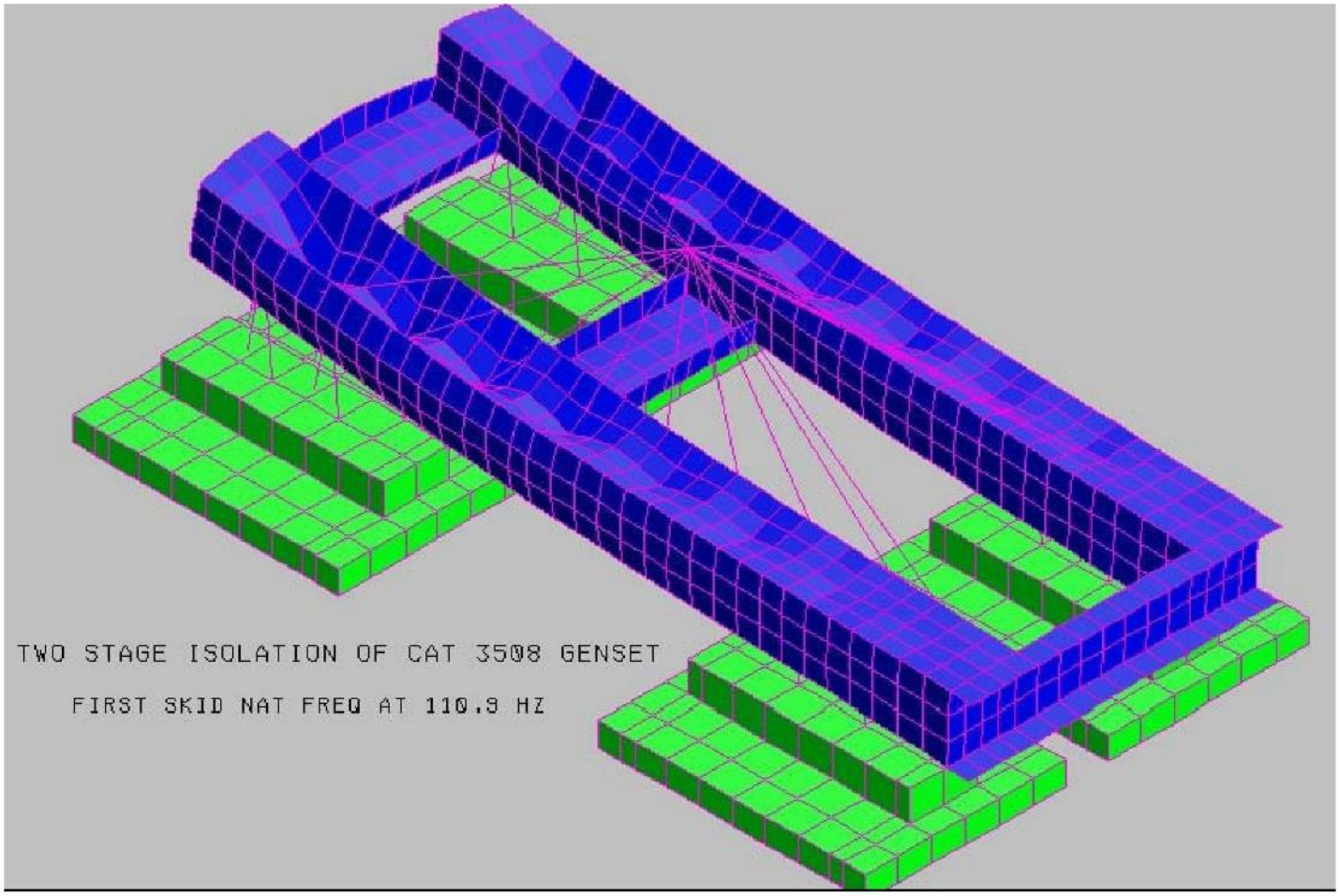


Inflatable Air Mounts

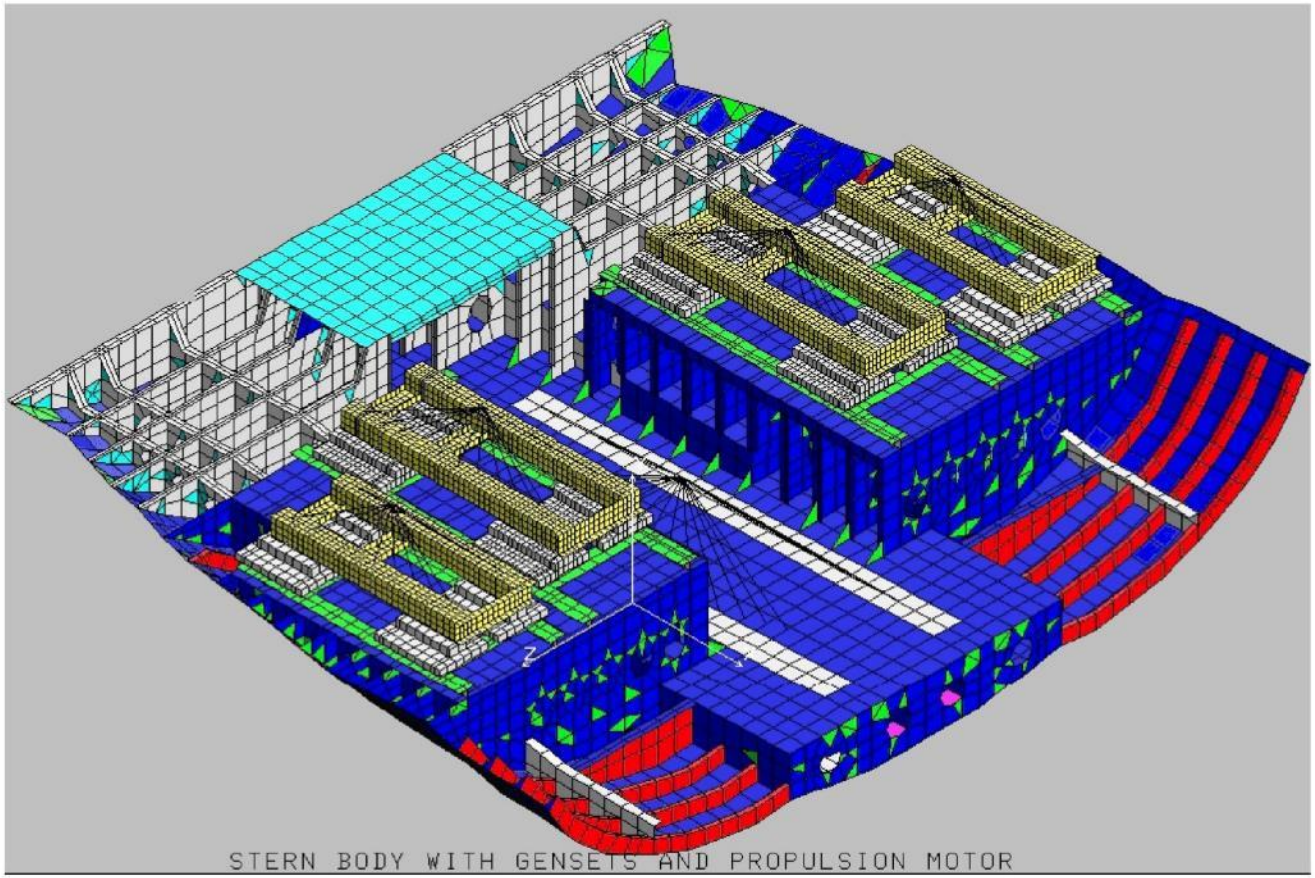


Wake Modifying Fin

FEA of Diesel Generator Foundation on FSV



FEA of Engine Room for NOAA FSV



INVESTIGATOR Soundpaint Damping Coating

Soundpaint® SP150 is a fast drying, water based viscoelastic vibration damping compound. The unique formulation outperforms other similar compounds. The exceptional vibration damping properties are complemented by ease of use, environmental friendliness and low combustibility (dry film).

Auxiliary Machinery Room: tank top, longitudinal bulkheads, forward and aft bulkhead

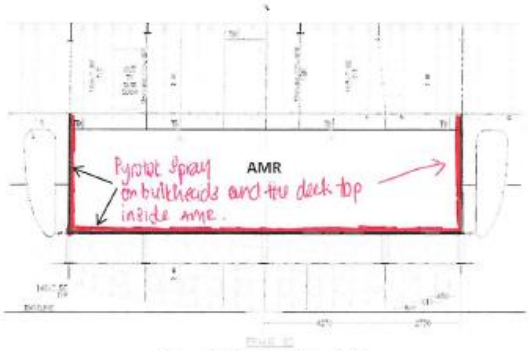


Figure 1: Damping tile in AMR

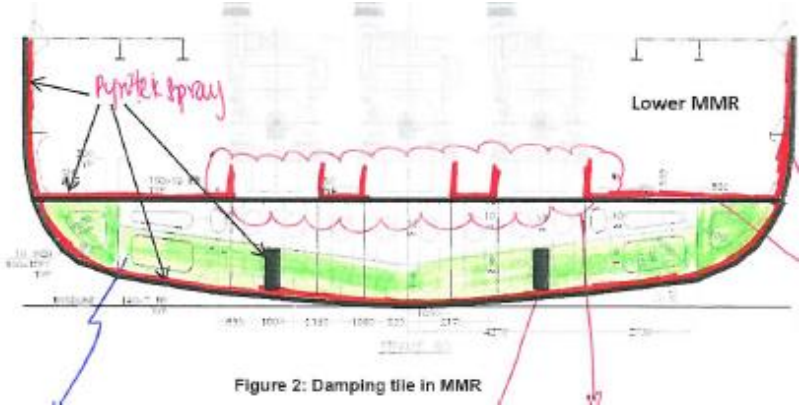
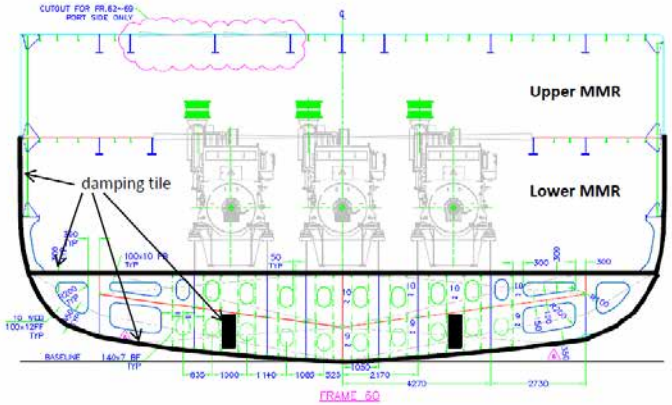


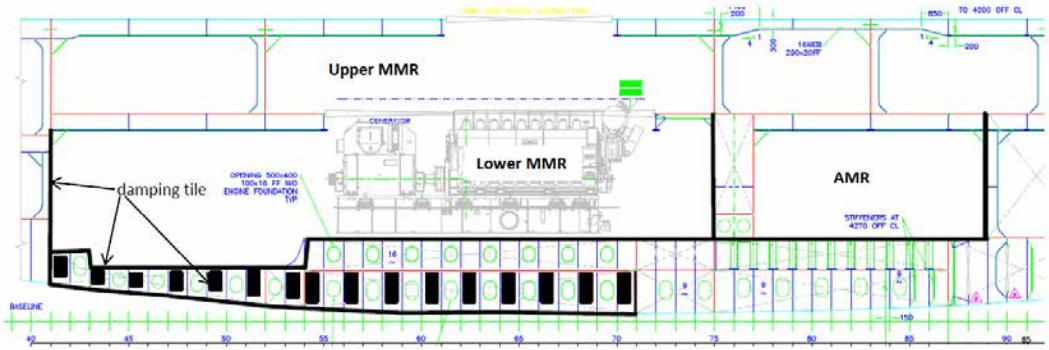
Figure 2: Damping tile in MMR

INVESTIGATOR Damping Tile Locations

Main Machinery Room: tank top, side hull, bottom hull, forward and aft bulkhead, and **ALSO** transverse and longitudinal floors in the void that can accommodate a damping tile

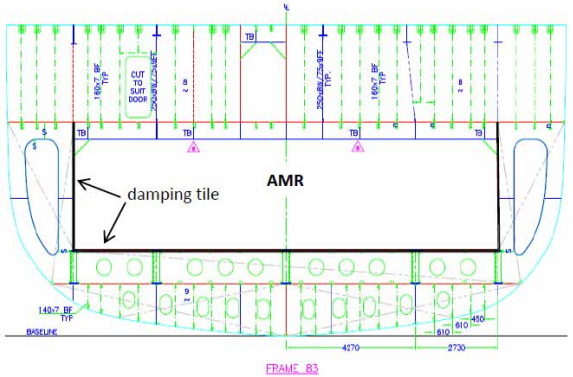


Longitudinal view of damping tiles



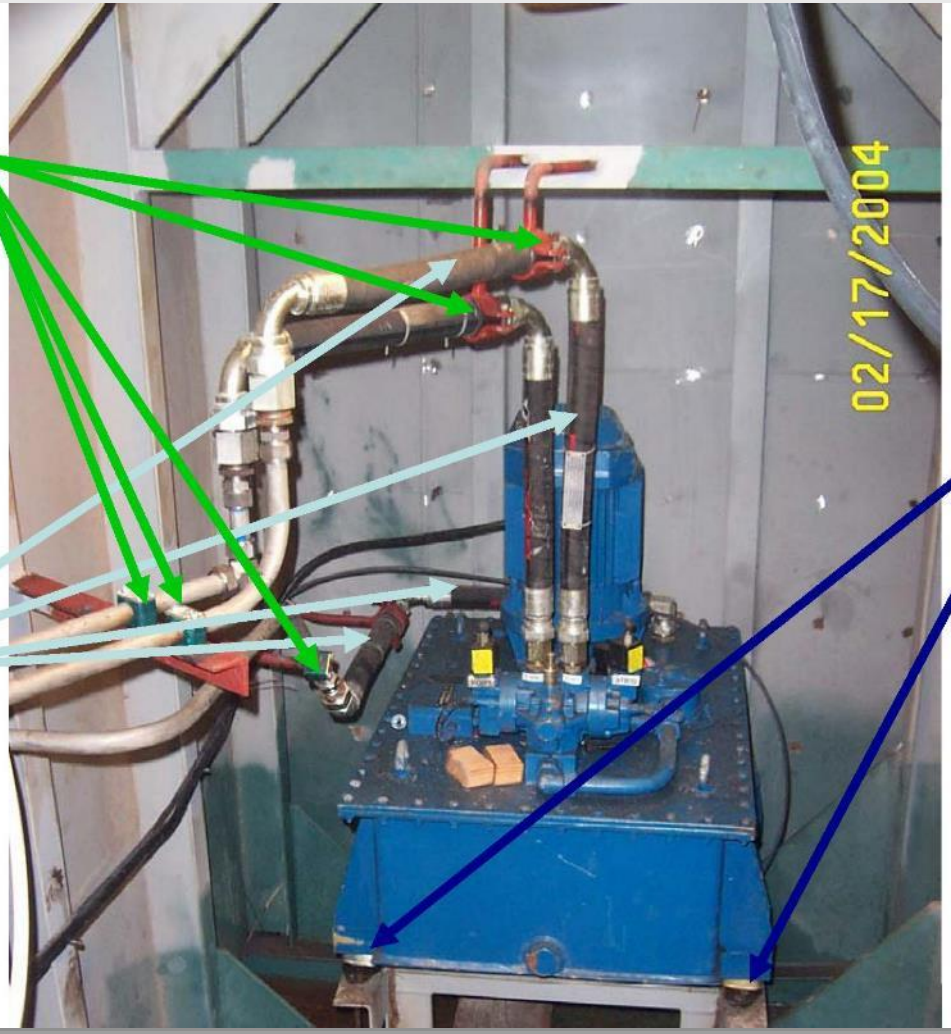
R/V Investigator Damping Tile Locations, March 29, 2012

Auxiliary Machinery Room: tank top, longitudinal bulkheads, forward and aft bulkhead



Typical Isolation Mounting of Auxiliary Equipment

Typical Isolation Mounting of Auxiliary Equipment



Pipe Clamps

"Dog-Leg" Flexible Pipe Hoses

Vibration Isolators

Typical Resilient Piping Supports

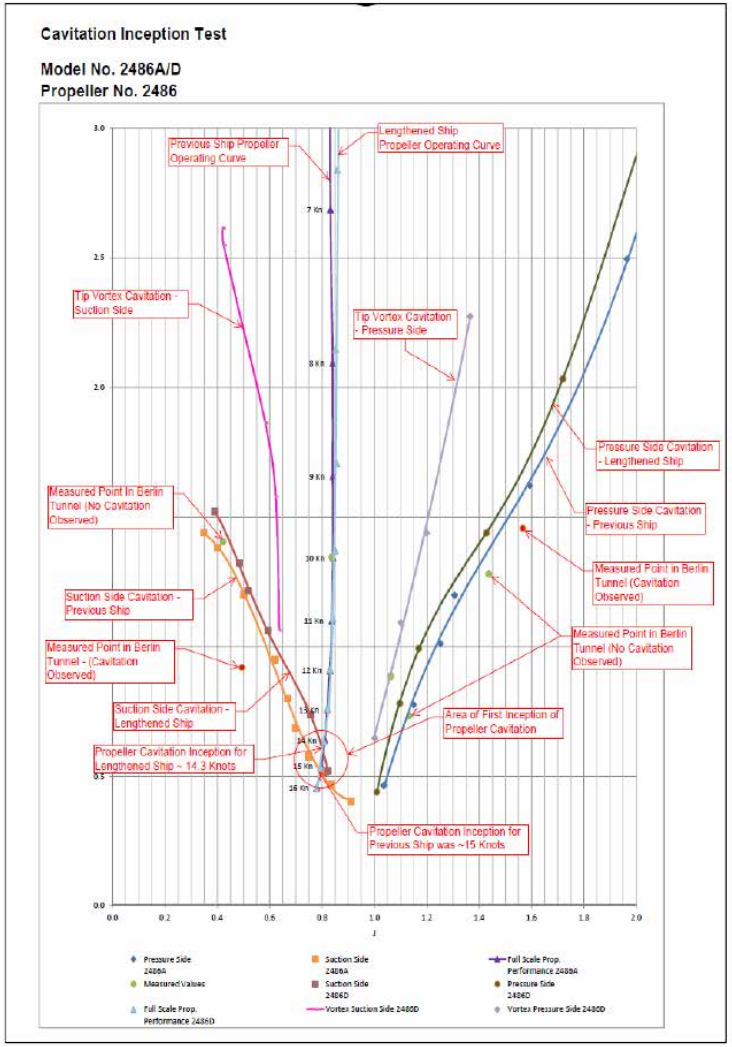
Quiet Design Propulsion Motor

Motor Quieting Features

- AC Drive
- Active Front End power conversion (avoids AC power distortion, filters not needed)
- Skewed slots
- Low flux density
- Increased air gaps
- Resiliently mounted stator

Low Noise Propeller Design

Cavitation Free Through 14 Knots



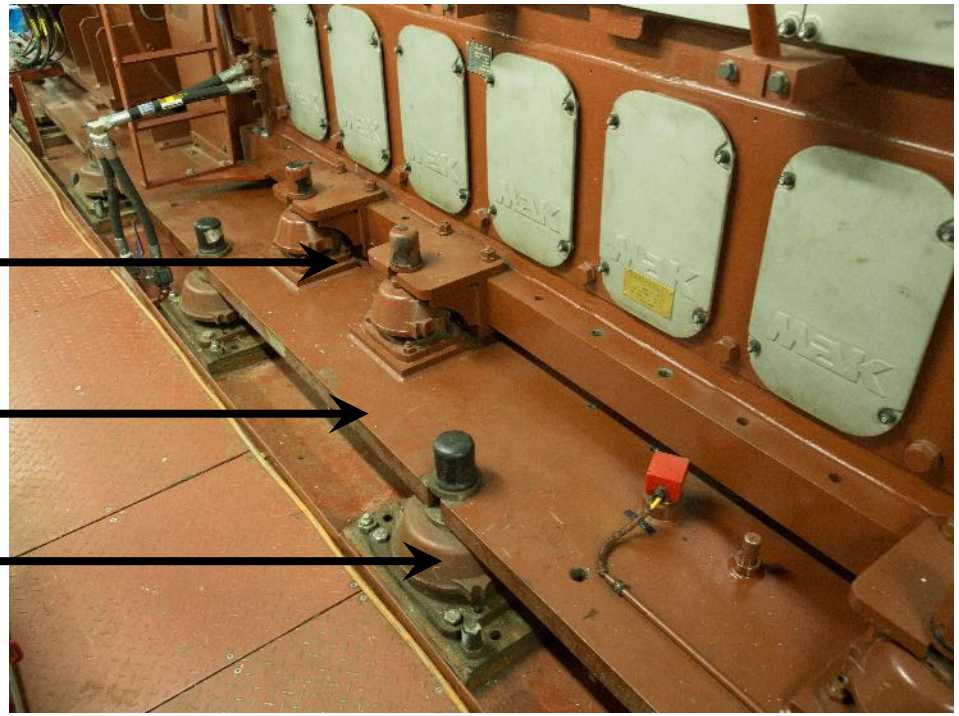
Main Engine High Impedance Foundation with Double Resilient Mounting

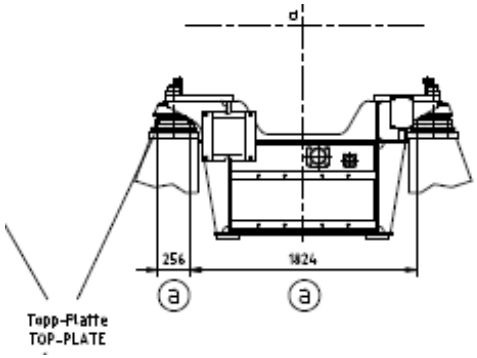
High Impedance Foundation

Second Stage Mounts

Intermediate Mass

First Stage Mounts





INVESTIGATOR Noise Characteristics

Predicted Signature

Figure 4: Underwater radiated noise prediction, Gensets 1&3

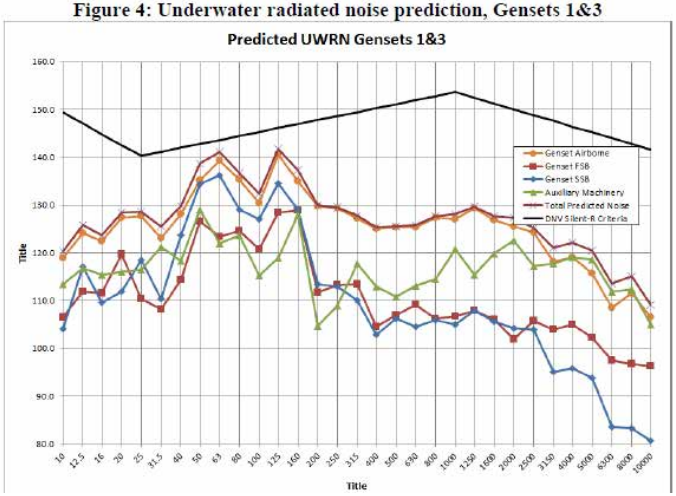
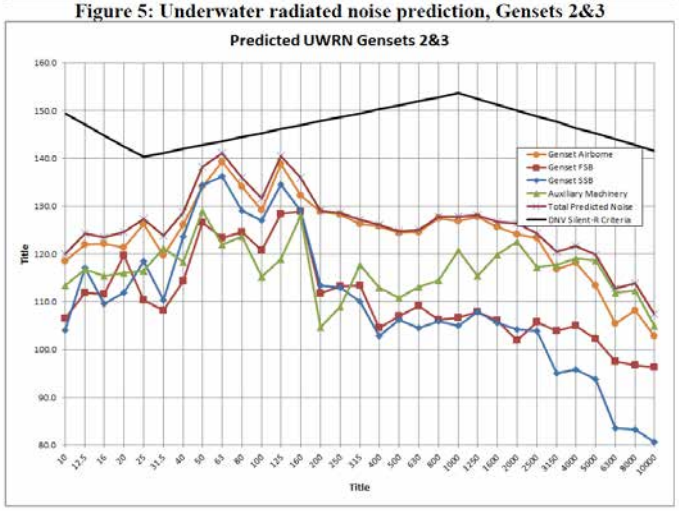
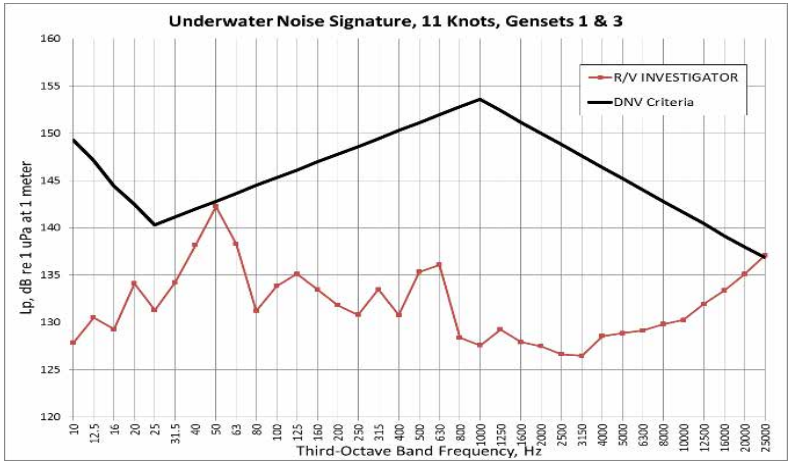
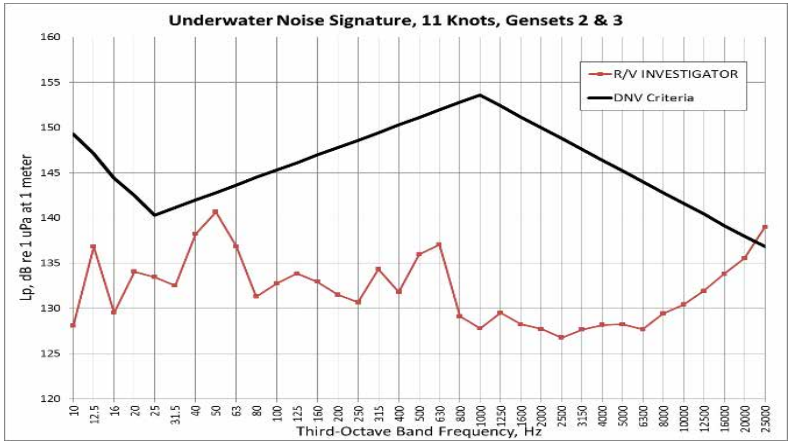


Figure 5: Underwater radiated noise prediction, Gensets 2&3



Measured Signature





Summary

- Achieving a selected underwater radiated noise level is possible
- Select a noise level based on the vessel's planned use
  - Avoid stating "as quiet as possible"
- Develop a noise control plan and follow it
- Understand what drives the signature, e.g. diesel engines, motors, airborne/structureborne paths
  - Work with major suppliers to ensure any machinery limits are met
- Perform analysis and select/implement treatments correctly
- Train the shipyard if little/no experience in applying acoustic treatments
- Perform factory, shipboard and at sea testing
- Implement corrective actions, where necessary

Questions

HYDROCOMP® Inc.

Industry Collaboration Opportunities with HydroComp's "Design for Sustainability Tool" Initiative

Donald MacPherson, HydroComp, Inc., Durham NH USA

CISMaRT 2018, Halifax, NS

ABOUT HYDROCOMP: **WHO WE ARE**

- Small team of naval architects and developers of commercial engineering software
- Specific technical expertise in propeller design, performance, and computational modeling
- Existing "technology-to-market" customer base (with over 1000 professional maritime software customers)

HYDROCOMP Inc.

HYDROCOMP® Inc.

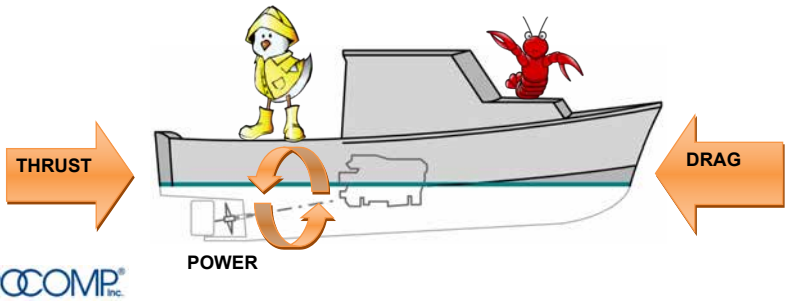
DESIGN FOR SUSTAINABILITY: **INDUSTRY NEED**

- "**Design for Sustainability**" must consider disruptive as well as incremental technologies
- Naval architects need capabilities and tools to:
  - Investigate how innovative or emerging technologies can address client/project sustainability objectives
  - Do so in the context of "**cost of ownership**"
  - Support special interests (URN, sulphur)
- **Industry collaboration for URN**

HYDROCOMP Inc.

DESIGN FOR SUSTAINABILITY: **A SYSTEM PROBLEM**

- This is principally a system problem
  - **Vessel-Propeller-Drive** is a system of components
  - Disruptive solutions for sustainability are system-driven; incremental solutions are component-driven



HYDROCOMP Inc.

DESIGN FOR SUSTAINABILITY: **THE SYSTEM MODEL**

- Our system simulation software (NavCad®) is outstanding for "conventional" systems
  - Example: Symmetric engine-gearbox-propulsor
  - Recent work: Emissions (CO2), fuel (LNG, dual-fuel)
- It does not properly handle disruptive solutions!
  - Work required to investigate future/unknown options!
  - Development plan in place for a multi-year effort

HYDROCOMP Inc.

NavCad

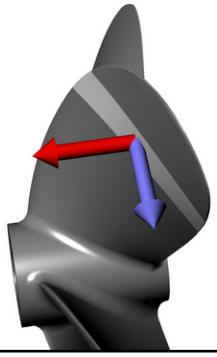
DESIGN FOR SUSTAINABILITY: **OUR INITIATIVE**

- Substantially modify tool architecture to allow for innovative and emerging technologies – with assessment of "cost of operation/ownership" and evaluation of environmental metrics
  - Sail assist, hybrid drives, shaft motor/generator, wake equalizing devices, asymmetrical "trail-shaft" operation, compound drive systems, ...
  - Fuel rate, costs, scheduling/planning (cleaning)
  - Emissions (CO2, SOX), **underwater radiated noise**

HYDROCOMP Inc.

DESIGN FOR SUSTAINABILITY: **UNDERWATER NOISE**

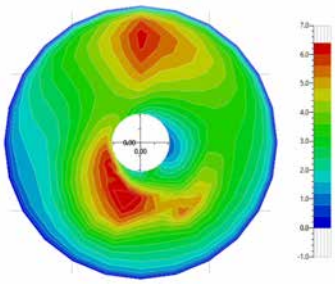
- Part of initiative is to update our existing design tools with **new URN capabilities** (near term)
- Leverage our expertise in propeller performance and computational model building
- Working with a UK university effort that offers substantial data
- Particularly relevant to Canadian interest in our initiative



HYDROCOMP Inc.

DESIGN FOR SUSTAINABILITY: **OUR MODEL FOR URN**

- Many models are for "traffic"; we look at "ships"
- "Calculate what you need. No more. No less!"
  - Balance functionality with complexity; deliver enough clarity to make engineering decisions for specific ship
- Models: Parametric (1D) and Distributed (2D)
  - Predictions of "body forces" and cavitation fluctuation



HYDROCOMP Inc.

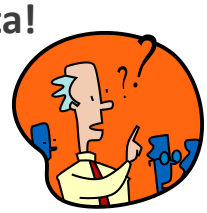
DESIGN FOR SUSTAINABILITY: **INDUSTRY OUTREACH**

- **Data!** Enhance full-scale noise measurement projects for data refinement
- Document for new tests or "back fit" for existing:
  - Corresponding vessel speed and RPM
  - Shallow water or channel characteristics
  - Relevant ship **Vessel-Propeller-Drive** characteristics
  - Vessel loading measurements (i.e. draft marks)
- Publish "design data sheets" (e.g. SNAME sheets)

HYDROCOMP Inc.

DESIGN FOR SUSTAINABILITY: **WITHIN REACH**

- Our "Design for Sustainability" tool development initiative looks to provide the means to:
  - Evaluate the benefits of disruptive technologies
  - Simultaneously consider the "cost of ownership"
  - Provide functional URN modeling in the near-term
- **Industry can help: data!**
- **Thanks! Questions?**



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