AVT-373 Research Specialist's Meeting on
"Emerging Technologies for Proactive Corrosion Maintenance"

IDEaS Corrosion Detection in Ships Sandbox: Technologies Demonstrated and Next Steps

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IDEaS IDEeS
INNOVATION FOR DEFENCE EXCELLENCE AND SECURITY
INNOVATION POUR LA DÉFENSE, L'EXCELLENCE ET LA SÉCURITÉ

Outline

- IDEaS Program
- Sandbox Element
- CDIS Sandbox
- Test Scenarios
- Technologies Demonstrated
- Results and Lessons Learned

IDEaS: Generating Creative Solutions for Canada's Defence and Security Challenges

- Innovation for Defence Excellence and Security (IDEaS) is an access to innovation program for the Department of National Defence and the Canadian Armed Forces (DND/CAF)
- Designed to give Canada's innovators the opportunity to help solve some of Canada's toughest defence and security challenges
- Challenges span many domains and often require experts outside of traditional defence or security fields

COMPETITIVE PROJECTS
Phased development funding to propel technology forward

INNOVATION NETWORKS
Establish research clusters to generate knowledge in challenge domains

CONTESTS
Competition between innovators to solve complex challenges for cash prizes

SANDBOXES
We bring the experts, you bring the technology, then it's play time!

TEST DRIVE
The CAF will put the technology through its paces in real situations

IDEaS Sandboxes

- Sandboxes allow innovators to demonstrate their prototype solutions to military users and science experts for published challenges.
- The scenario and environment are provided by the Defence Team and innovators receive observational feedback to assist in their solution development.
- Cost-sharing: IDEaS program provided the environment at no cost, and covered a portion travel and shipping costs for participants

We bring the experts, you bring the technology, then it's play time!

Corrosion Detection in Ships Sandbox

The challenge…

How might we detect and assess corrosion behind surface coatings (such as paint, insulation, tiles, seamless decking, etc.) onboard Royal Canadian Navy (RCN) platforms in order to reduce corrosion's operational impact and improve the effectiveness of scheduled and unscheduled maintenance?

Photo: LS Zachariah Stopa, Canadian Forces Combat Camera, IS07-2018-0057-214

Corrosion Inspection on Test Panels

Corrosion Types

- General Corrosion
- Pitting Corrosion
- Crevice Corrosion

Coating Types

- Paint
- Seamless epoxy decking
- Quarry tiles
- Non-skid decking
- Thick insulation

Seamless Decking + Quarry Tile Panel before coating

All photos courtesy of Steven Berry, Defence Research and Development Canada, Government of Canada (unless noted)

Corrosion Inspection on Test Panels & Operational Ship

Test Panels

- Dry Hull
- Underwater Hull
- Decking (x2)
- Steel Piping
- CuNi Piping

Ship Areas

- Decks
- Exterior structures
- Showers and heads
- Laundry areas
- CuNi Seawater pipes
- Hull above the water line

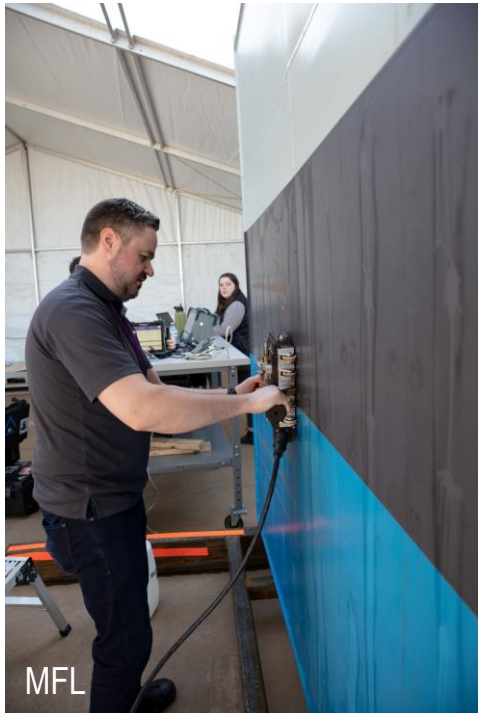
Photo credit: Corporal Jaclyn Buell, Canadian Armed Forces

Controlled vs. Real World Test Environments


Controlled environment

Real world environments

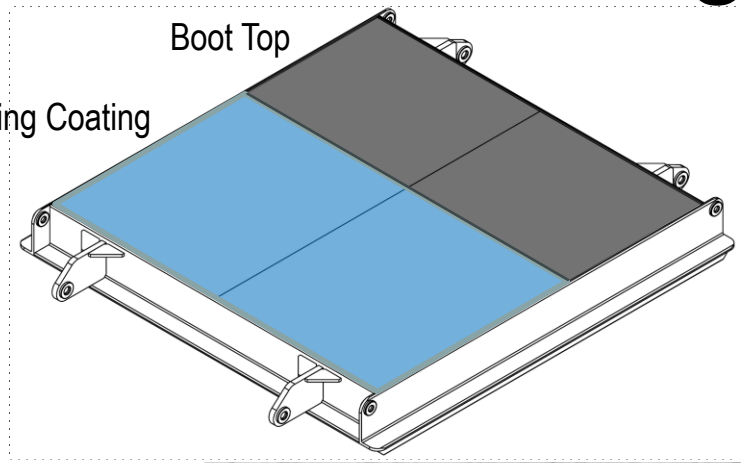
Dry Hull

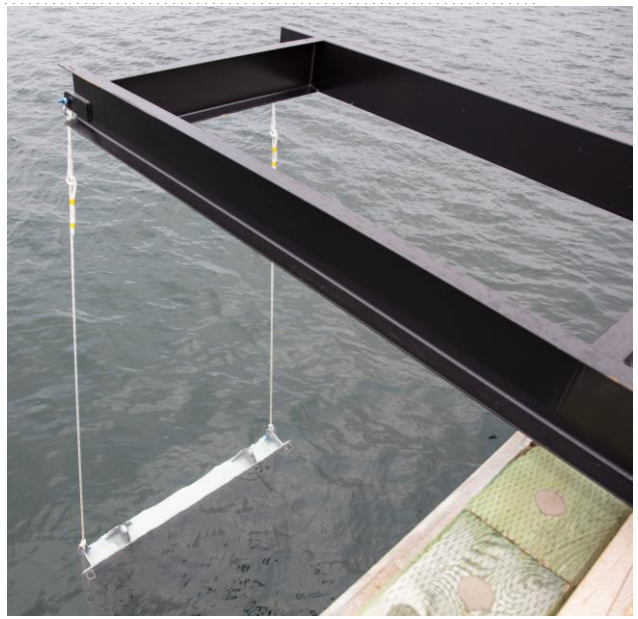

MFL


EC/PEC


Impulse Excitation

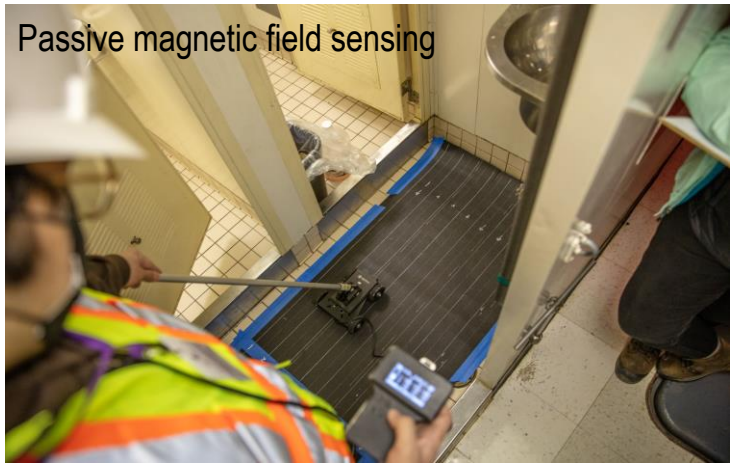
Underwater Hull





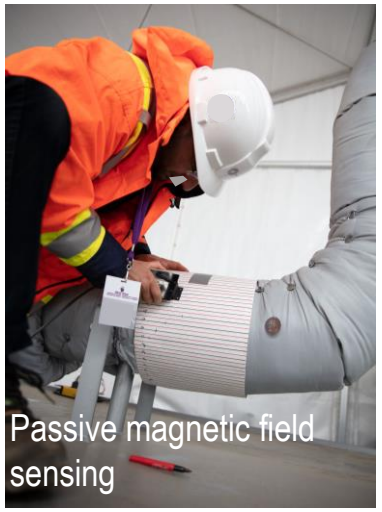
Impulse Excitation Technique
(Robotic - underwater)

Deck, Coatings, Tiles



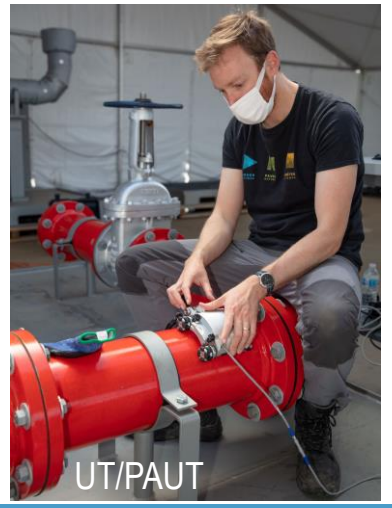
Pipes


CuNi Piping


Passive magnetic field sensing


UT/PAUT

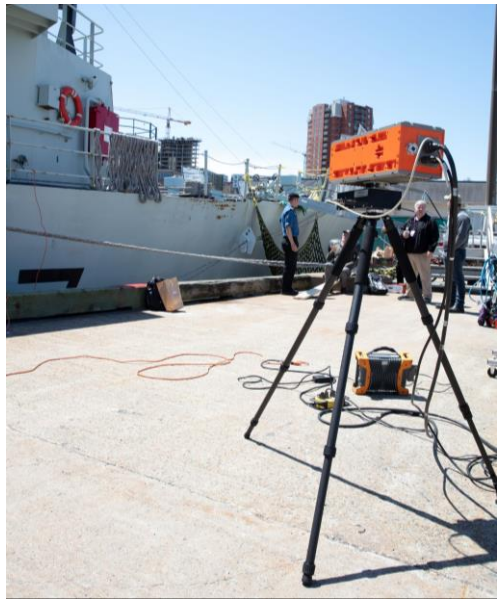

Steel Piping

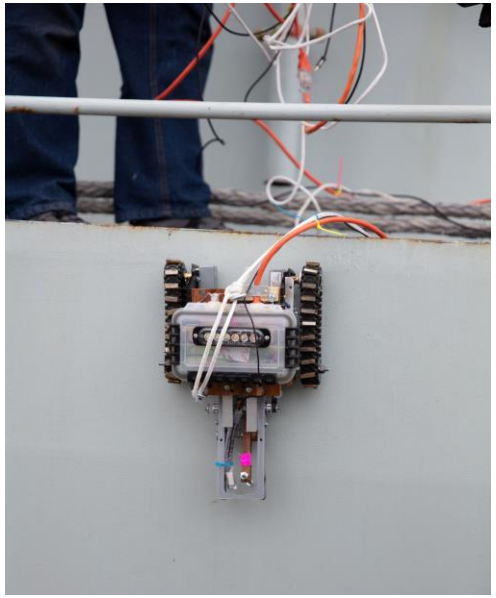

UT/PAUT

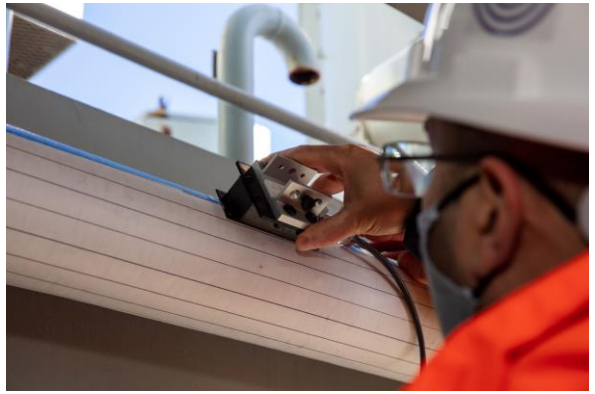
Sensor Platform Types

- Portable/Handheld
- Tripod mounted (Contactless)
- Robotic (dry)
- Robotic (wet)
- Drone (aerial)

… plus Software / AI / ML / DL







Inspection Technologies Demonstrated

Conventional Approaches

- Eddy Current, Pulsed Eddy Current
- Ultrasonic Testing, Phased Array UT
- Magnetic Flux Leakage

All solutions at TRL 9
(proven commercial solutions)

Unconventional Approaches

- Passive Magnetic Field Sensing
- Thermal imaging / Thermography
- Capacitance imaging
- Hyperspectral imaging + AI / DL
- Optical Imaging + AI / ML
- Drone-mounted UT
- Impulse Excitation Technique

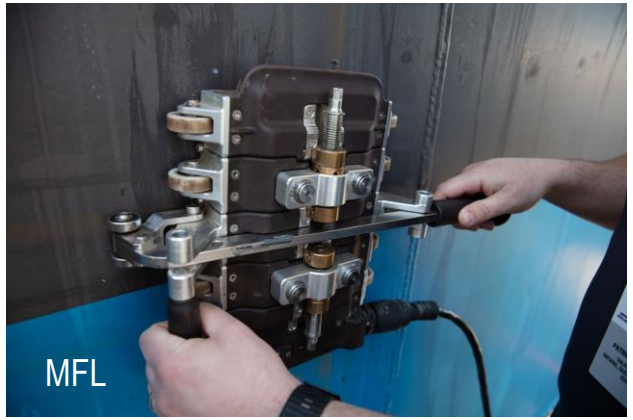
Solutions ranged from TRL 5 (early prototypes) to TRL 9

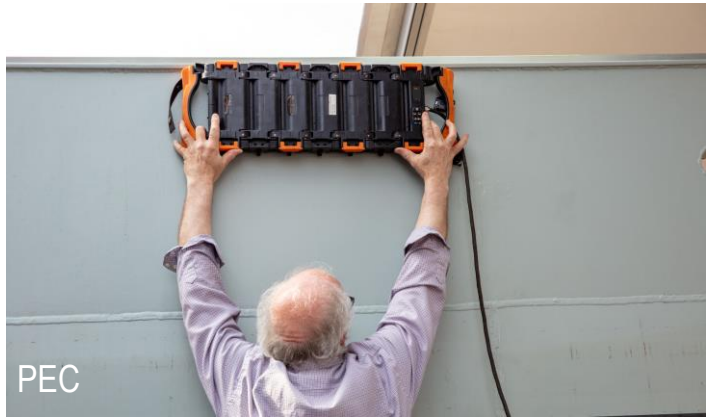
Conventional Approaches

- UT, PAUT, EC, PEC, MFL
- Mature solutions
- Different probe configurations & sizes available
- Thick or uneven coatings may still present challenges


MFL

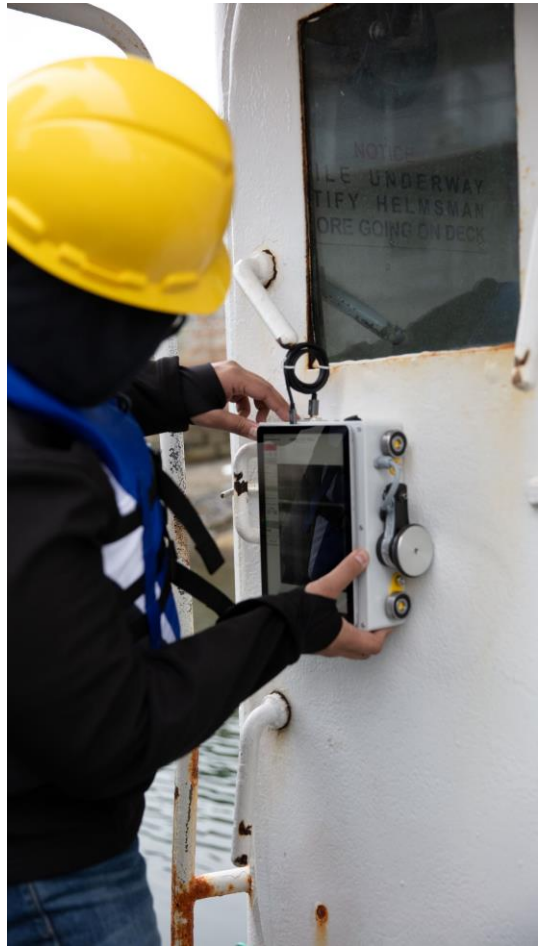

UT/PAUT


MFL


PEC

Capacitance Imaging

- Applies AC voltage to establish an electric field between two capacitor plates
- Discontinuities or defects affect the electric field pattern
- Detects corrosion and defects under thin coatings (paint, seamless decking, etc.)
- Small unit with low power requirements

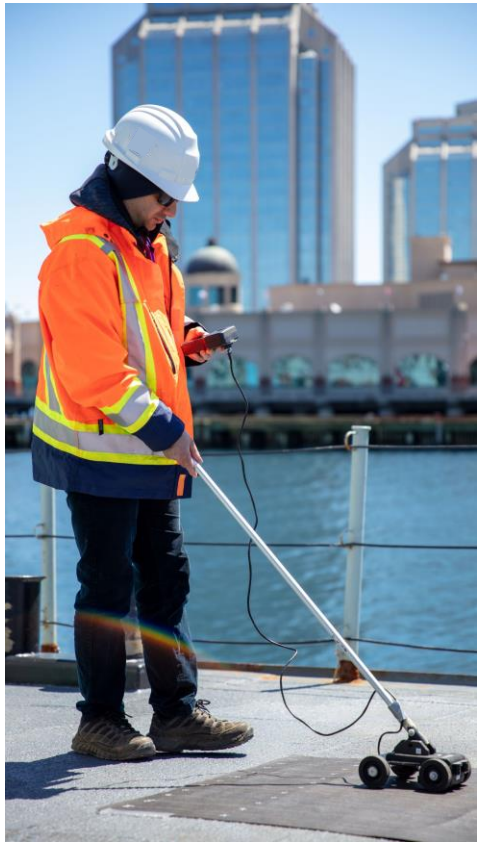


Impulse Excitation Technique

- The light tapping impact machine generates an acoustic signal which can be analyzed
- Changes in sound / waveform can indicate changes in materials (patches, welds), or fully bonded vs. delaminated material (non-skid, seamless, and tiles)
- Rapid inspection, low power requirements

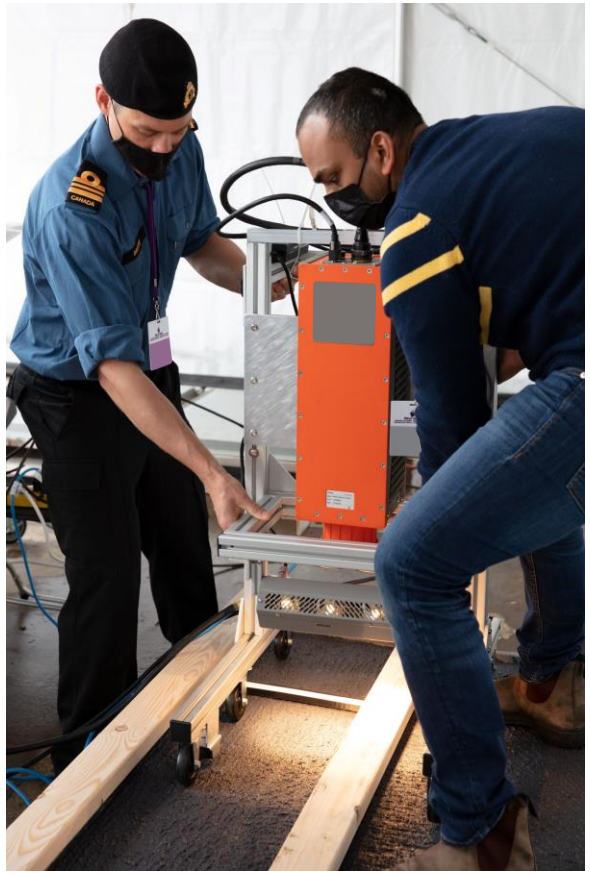
Passive Magnetic Field Sensing

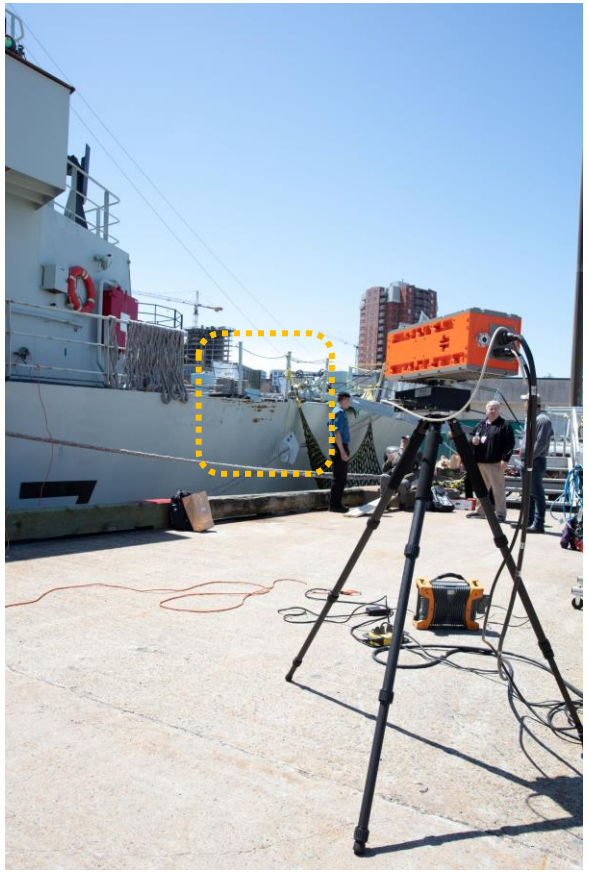
- Detects changes in the magnetic properties of ferromagnetic objects caused by discontinuities such as corrosion and cracking
- Detects corrosion and defects under non-ferromagnetic coatings (paint, insulation, etc.)
- Small profile, fast scanning, low power requirements



Hyperspectral Imaging + AI / DL

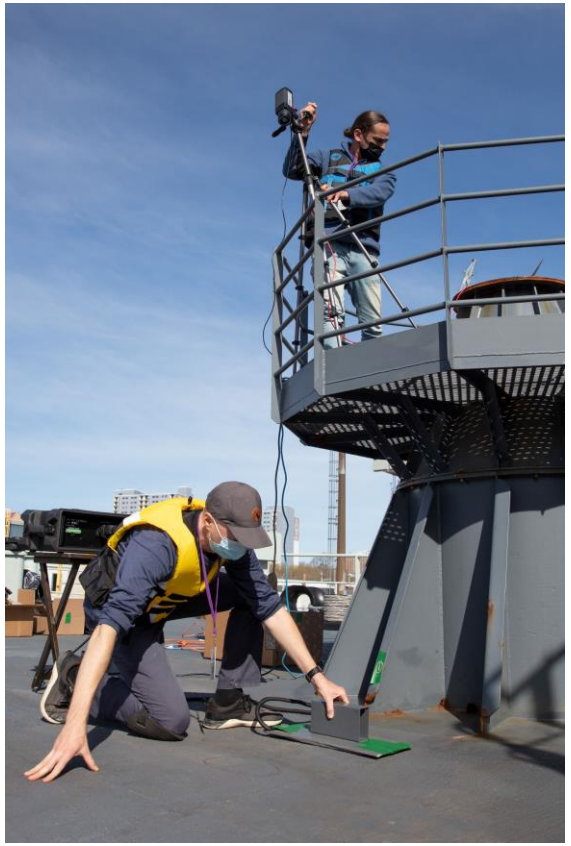
- Hyperspectral imaging collects a wide spectrum of electromagnetic energy bands that are emitted from objects within its field of view.
- AI/DL used to identify the reflectance patterns for specific chemical fingerprints within the images
- Rapid scanning of large area





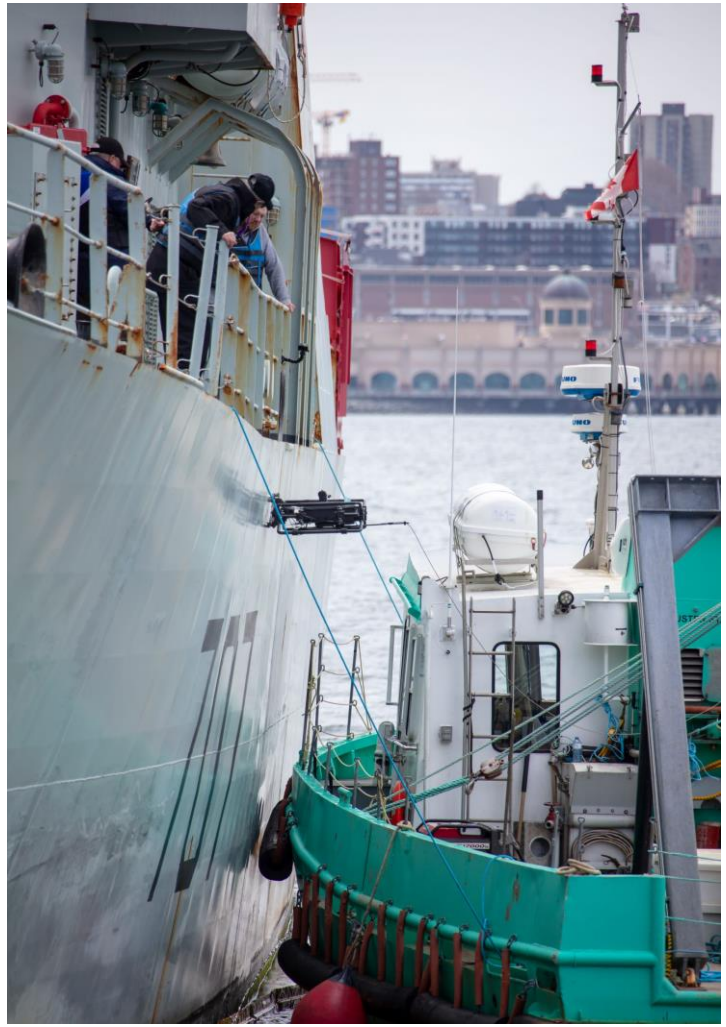
IR Thermography + Induction Heating

- Imaging with an IR camera
- Induction heating used to excite the material
- Corrosion, holes, lack of material, delamination, inclusions, etc. cool at different rates from surrounding material
- Fast to detect general corrosion



Drones: UT + Optical

- UT & Optical camera mounted on tethered drone
- Spot UT measurements
- Can reach difficult to access areas without need for scaffolding



Drones: Optical + AI / ML

- Drone flies around taking images
- Images are stitched together to form a 3D model which can be used as a reference to observe an asset.
- AI / ML image analysis to determine the size, shape and location of corrosion
- Sensor agnostic
- Fast: RCN ship (length 55m) scanned in ~ 2 hours

Sandbox Lessons Learned

- Test panels biased towards thickness measurements vs. detection of corrosion
  - Having an operational vessel to demonstrate on helped, but results couldn't be quickly confirmed
- A well-designed test environment is crucial to a sandbox
  - There are always surprises in the technologies that apply (we did not expect to see drones).
  - Flexibility and creativity required to facilitate the demonstrations (e.g., operational vessels)
- Post-sandbox investment mechanism:
  - To encourage further development of promising but immature technologies
  - Provide additional incentive to apply (especially for the smaller companies)

Sandbox Lessons Learned

- No “one-size fits all” solution for inspection of RCN vessels; each had its own niche, and a suite of solutions is required for full inspection
- Large gaps in abilities to detect corrosion types and inspection conditions:

	Paint	Insulation	Underwater
General Corrosion	Easily Detected	With Difficulty	Not Detected
Pitting Corrosion	Limited Success	With Difficulty	Not Detected
Crevice Corrosion	Not Detected	Not Detected	Not Detected

- Solutions that can address these gaps will be of interest not only to the RCN, but to the greater corrosion inspection and maintenance community

Innovation Opportunities

- Solutions that address our capability gaps:
  - Crevice Corrosion
  - Inspection through insulation or thick coatings
  - Underwater Corrosion inspection
- Robotic or semi-autonomous platforms
- Positional encoding / mapping functions (especially underwater)
- Real-time feedback to operators
- Ease of use / no specialized training requirements
- Self-contained units for quick inspections while vessel is operational
- Solutions to do rapid inspections of large areas

Sandbox Benefits

- The Corrosion Detection in Ships Sandbox was an opportunity for **DND/CAF** to:
  - Evaluate new and emerging technologies to solve current and future operational challenges
  - See the solutions in both controlled and real situations
  - Identify capability gaps, which represent opportunities for further development

- And for the **Innovators** to:
  - Gain an understanding of the requirements of DND/CAF
  - See how their solutions perform in specific or unusual situations and in the field
  - Seek feedback from the potential DND/CAF end users for new applications of technologies

Questions?

Visit our website for information about the program and current and past challenges:

www.Canada.ca/defence-ideas

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