25 Years of ISE Under Ice

Presented by Jean-Marc Laframboise, co-author Alex Johnson and Chris Kaminski
Exploring the Sørsdal Glacier in Antarctica. University of Tasmania and the Australia Government Antarctica Gateway Partnership and their ISE Explorer AUV named “nupiri muka”, at Davis Station in February 2019.
Why are under ice missions challenging?

- **The risk of loss is high.**
  - A single point failure can result in loss.
  - A drop weight deployment will result in becoming permanently lodged under the ice.

- Poor to no communication with the AUV while it is under the ice.
  - The pilot cannot intervene to save the AUV if there is a fault or failure.

- Poor or no tracking
  - Missions are out of range of USBLs, LBLs, etc.

- Unknown terrain
  - The OAS, Mission Plan, and Autonomy must be robust.

- Human error
  - An “Oops” can result in loss.
The latest ISE technologies developed for under ice exploration is how we ensure great data and mitigate the extreme risks.

- New payload mounting arrangement that allows Side Scan Sonar and Bathymetry to face up, down, port or starboard side.
- Upward DVL for under ice navigation.
- Variable ballast system to park on the sea bed or under ice.
- Adaptable AUV Fault Management for under ice condition mitigates human error.
- Specific mission planner task verbs for under ice exploration.
- Improved Obstacle Avoidance Sonar for under ice exploration.
- Back seat driver for customer developed algorithms, and payload management.
- Extreme reliability testing and redundancy.
ISE Explorer “nupiri muka” getting ready for deployment from mobile trailer system at Davis Station.

Payloads: EdgeTech 2205 SSS, SBP, Bathymetry, SeaBird CTD, ISE variable ballast, Up and Down DVL.
For the first time in history, an ISE Explorer AUV sits ready to dive and explore underneath the Sørsdal Glacier ice shelf.
Surface support boat escorting the ISE Explorer AUV around icebergs and broken ice.
After a successful mission underneath the Sørsdal ice shelf, the ISE Explorer is coming home safely.
Where did the technology that makes the ISE Explorer the most successful and reliable AUV under ice come from?

- **Experience**
  - Lessons learned from over 25 years of under ice experience.
  - The ISE personnel and engineers’ firsthand knowledge of arctic operations.

- **R&D**
  - Specific technologies developed for each unique polar mission.
  - Technologies developed to prevent loss of the AUV.

- ISE’s history of continuous technological development.

- Visionary thinking
Project Cornerstone
2009 to 2015

2 ISE Explorer AUV’s were deployed through ice off Borden Island in the Canadian high arctic and from the Canadian Coast Guard ships. The mission was to survey the continental shelf for Canada’s UNCLOS submission to expand Canadian sovereign territory in the high arctic.
Two ISE Explorers built for NRCan beside Theseus and ARCS at ISE
ISE, DRDC, and MUN at Alert on Ellesmere Island, developing and testing an underwater handling system for the ISE Explorers in 2009.
The ISE Explorer owned by MUN getting ready for testing the through ice deployment system.
Setting up the catchy system to secure the ISE Explorer under ice. The catchy system has two roles, first to secure the AUV at the end of a long pole so it can be rotated for INS alignment, second to permit underwater battery charging and data transfer.
Borden Island main home base in 2010, for the deployment of the two ISE Explorer AUVs owned by NRCan. The modularity of the ISE Explorer AUVs allowed easy shipping by small planes and fast reassembly at the floating ice camp.
ISE Explorer in the home base assembly tent. Checking all sub systems and planning missions.
ISE Explorer getting ready for deployment.
ISE Explorer secured at the end of the catchy system, ready for batteries charging, data transfer, and INS alignment under ice.

Built in to these ISE Explorer AUVs was a special long range acoustic homing system to allow it to find the remote camp as it drifted 5-10 km/day on sea ice.

This ISE Explorer AUV spent 11 days under water, and traveled a distance of over 1000 km.
In 2013 and 2015 two ISE Explorer AUVs, on board the Canadian Coast Guard ship the Louis St-Laurent, for more sea bed mapping for Canada’s UNCLOS submission in the Canadian high arctic.
ISE Explorer AUV deployment from a customized 40 ft container on board the Louis St-Laurent.
ISE Explorer at the surface after a long under ice mission, getting ready for ship recovery.
The Canadian Government and the US Government had a requirement to deploy a remote sensor on the sea bed, at the edge of Canadian Continental Shelves. This sensor would communicate via a fiber optic cable to CFS Alert. Using a custom built ISE AUV called THESEUS, a 200 km fiber optic cable was deployed on the sea bed between Ellesmere Island and US remote sensor.
Theseus deployment tent, at the main camp in Jolliffe Bay, near Alert on Ellesmere Island. Theseus was designed to be modular so it can be shipped by air, in medium size shipping crates, and reassemble on site.
Theseus special design consideration for long endurance under ice missions.

- High capacities Silver Zinc batteries for long range.
- Internal fault management system, and redundancies.
- Forward and Aft variable ballast systems for parking under ice or on the sea bed.
- A fixed one time flood ballast system, for each fiber optic spools when cable is deployed.
- Inverted USBL for homing on the destination target.
Theseus under Arctic ice starting its fibre optic cable deployment in 1995 and in 1996.
Back in the early 1980’s, the ocean exploration was done with manned submersibles and remotely operated vehicles. Because of the limitation of the ROV umbilical, and risk of sending people in a submersible under ice, new technologies had to be developed.

ISE’s first AUV was called ARCS, Autonomous Remote Controlled Submersible.

ARCS was the beginning of ISE AUV engineering expertise and experience.

Many AUV subsystems draw heritage from the lessons learned with ARCS.

Success today, and in the 2019 Antarctic Sørsdal Glacier mission, is thanks to ISE’s history of polar AUV experience.

In the years since ARCS, ISE has developed many different types of AUVs for unique and complex missions.
ISE visualized the concept for arctic operations in the early 1980’s, using an Autonomous Underwater Vehicle in the Canadian high arctic.

A medium size AUV was conceived to be deployable through a hole in the ice to explore the new world below.
Thank you