Photo Courtesy Chris Hammond

Thinking Outside the AUV

By Wade Kearley, BFA, MLT

The data-collection capacity of an AUV expands significantly if you add an external 3.5 meter-long sensor-array wing while maintaining programmable flight. After two years of applied research, the REALM project within Memorial University of Newfoundland in partnership with PanGeo Subsea Inc. is closing in on the launch of an AUV prototype that could greatly reduce sub-bottom imaging costs for a broad range of marine projects.

The water ahead of the zodiac is almost calm as Ron Lewis, (M.Eng.) approaches the shore. Just ahead of him the water ripples as the Explorer, an autonomous underwater vehicle, returns from its pre-programmed mission and docks at the nearby wharf. Once lift cables are hooked on, the winch operator slowly hoists the 4.5 meter-long AUV with a difference: a 3.5 meter long wing strapped across its belly. There is no back slapping, but the team of researchers on the water and onshore at the Holyrood Marine Base, an hour`s drive from St. John's, know that, after 12 days of sea trials, they have passed an important hurdle.

Image Above

After reprogramming the "guts and glory" of the AUV two members of the REALM project team prepare to close and seal the Explorer for sea-bottom trials: (L-R) Ron Lewis, project manager and Peter King, lead engineer.

This is the culmination of a two-year partnership to deploy proven acoustic marine technology in an innovative way. The partners include PanGeo Subsea Inc. and the Responsive AUV Localization and Mapping Project (REALM) at Memorial University of Newfoundland in St. John's.

Speaking by telephone from Paris where he was attending a World Ocean Council meeting, Gary Dinn says the project had its genesis in the halls of a federal funding agency. It was 2010 when Dinn, vice president for technology development with PanGeo, struck up a conversation with a bureaucrat familiar with his company's acoustic technology. She thought he would be interested in the REALM project which had renewed research funding. "They were deploying their AUV with broadly available technology, but wanted an edge. The marriage of their AUV with our patented SBI technology presented a unique industrial application that couldn't happen anywhere else," says Dinn. The Sub Bottom Imager (SBI) uses acoustic imaging to delineate sub-seabed strata and buried geohazards up to five meters below the surface to a resolution of five centimeters. The sensor array is usually deployed with an ROV. This, according to Dinn, has been effective but costly for their customers. "A workclass ROV, including the vessel and crew, costs up to $100,000 a day. But with an AUV you take the ROV vessel and crew out of the equation, reducing costs to less than one tenth of what it now takes," explains Dinn.

He believes those savings make the technology more practical and less of a risk for applications in at least two areas. First of all are cost-sensitive applications to determine the suitability of the seabed in a pre-route survey for pipeline or cable burial with a detailed technical analysis of the seabed. Secondly there are low cost deepwater survey applications to 1,000 metres covering any distance.

According to Dinn, routine inspections of undersea pipelines and cables by an AUV equipped with their technology could become a matter of standard practice.

No Existing Models

Guiding a tour of the AUV lab on the Memorial campus, Ron Lewis can't resist resting a hand on the bright yellow Explorer which dominates the long narrow room. He says the AUV-SBI project began in earnest in 2010 with significant discussions around how to tackle a project for which there are no existing models. "There is one smaller AUV in the United States with a much smaller wing," he says, "but nothing of this scale anywhere in the world."

Engineering for the integration to succeed included modification of the SBI sonar technology for housing in the Explorer which in turn required a significant refinement of the AUV's dynamic behaviour. "For the technology to work we have to fly at 3 knots ideally about 3.5 metres above the sea floor," says Lewis. The risks were considerable, with more than $2.75 million in technology alone involved not to mention the costs of research and development. But the rewards included new AUV survey services from PanGeo Subsea and significant investment in Memorial University's design capabilities for hull design, vehicle control, stability, and performance," he says.

Ron Lewis, REALM Project Manager

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The Best Way to Mount an AUV

Conceptual design started in 2010 as they grappled with considerable road blocks. "There were some limitations to integration right off the bat," reveals Lewis. They did not want to integrate the SBI technology into the central pressure vessel where the "guts and glory" of the AUV are housed. That left the limited option of loading the sensors into the fore and aft flood chambers. "But then the team came up with the idea of mounting an external wing," says Lewis.

"We are no longer limited to the physical size of the AUV. We have introduced another dimension—it was a torpedo and now we have the starship Enterprise"

Ron Lewis

But where was the best place to mount it? After considering everything from the bio-model of a hammerhead shark to the feedback from hydrodynamics colleagues, they selected the underside near the center of gravity using a special clamp designed to hold the array in place. With the weight balanced properly the Explorer's shape had changed from a cylinder to an inverted monoplane.

Next they needed answers related to performance. The SBI can only capture high resolution images at speeds of three kilometers an hour


Retrieving the Explorer after a successful 12-day trial with the external mock-up wing attached.

(Photo Courtesy Corwin Northcott)

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Gary Dinn, vice-president, technology development with PanGeo Sub Sea

but the AUV is less maneuverable at such low speeds. Would the vessel over-pitch during a dive and go too deep? Would it fail to rise to the surface after a dive as it was programmed to do?

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Crunching the Numbers with CFD

To answer these questions the partnership proceeded to computational fluid dynamics (CFD) in the virtual environment. “This was a cost effective way to look at wing drag and see if it would affect the hydrodynamics,” says Lewis, “but CFD is very easy to use incorrectly.” They brought in the technology, the software and the experts to work with graduate students and interpret results, which, says Lewis, at least in the virtual world, received thumbs up.

In December 2011, the partners moved from the virtual environment to controlled environmental testing with particle image velocimetry (PIV) at the Marine Institute’s flume tank. Equipped with recording and environmental controls they looked at different pitches and performance under different flow speeds, validating straight and level, flow around the wing as it is designed, and the wake behind the wing. After two months of data analysis they validated the CFD results, “within an acceptable margin of error,” says Lewis. With those results in place they proceeded to the next phase: twelve days in Conception Bay.

Out Of the Tank and into the Bay

For marine research in Newfoundland, April can be the cruelest month: Arctic ice, freezing temperatures, and high winds are not uncommon. But, April 2012 delivered twelve straight

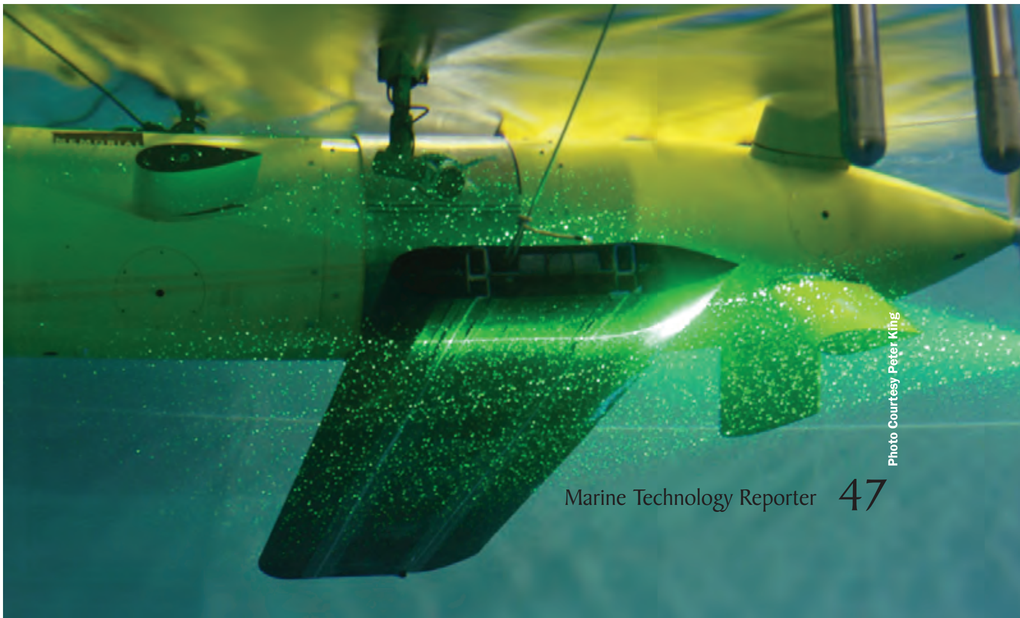

Photo Courtesy Peter King

Controlled environmental testing with particle image velocimetry, at the Marine Institute’s flume tank in St. John’s, confirmed the computational fluid dynamics results.

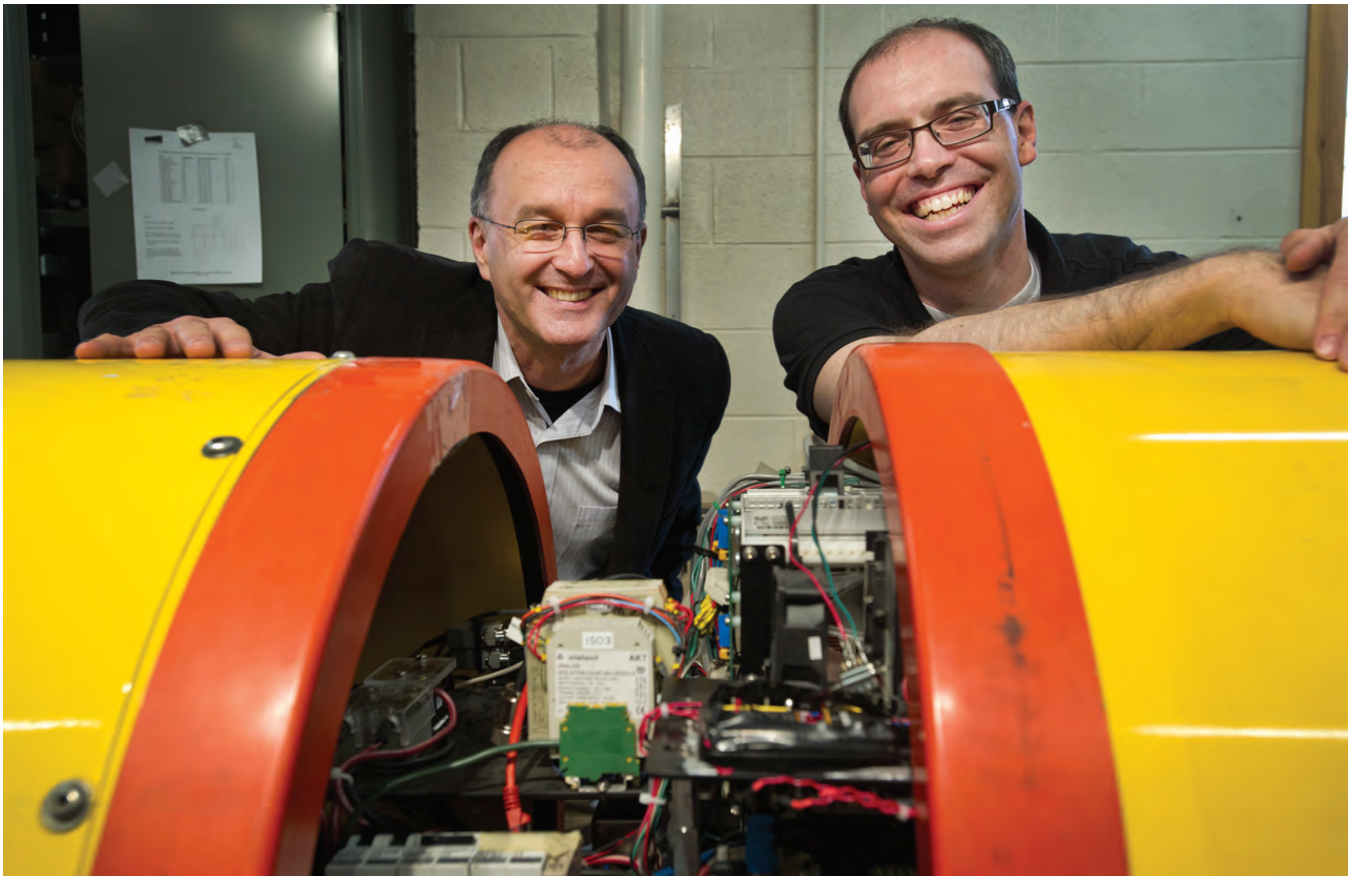

Photo Courtesy Chris Hammond

With the preliminary work behind them, the team is now into the full integration phase in preparation for prototype tests in the autumn of 2012: Gary Dinn, vice-president, technology development with PanGeo Sub Sea (left) and Ron Lewis, project lead for the REALM project.

days of calm. Standing on the wharf in Holyrood, an hour's drive outside St. John's, Lewis is cautiously enthusiastic about the sea trials. "Technically everything went well," he says. Explorer, outfitted with the mock-up wing, operated within the speed envelope at the required distance from the seabed.

"We know now that the technology can go out and cover an area and bring back the data," says Lewis. "We did repeatable runs. We made sure we could operate safely at the right speed, depth, and range. The rest is just engineering."

There were, however, a couple of issues. "It's not as easy to pull out of a dive or an ascent as we would like," reveals Lewis. In practical terms that means, if they were to run a mission at the present state of development, indepth mission planning would be vital.

Critical Analysis

When drilling and excavating on the Grand Banks the majors know they need to be on their game and not just because of the massive icebergs, but also because of the challenges buried in the seabed, such as large boulders or other unexpected formations which can cause delays and cost overruns. So if there is a way to get a preview of potential hazards on the proposed drill center, even to the depth of five meters, the risks could justify the cost of a sonar survey.

Many of the majors working on the east coast of Canada require a WROV vessel which, despite a daily cost in the vicinity of $100,000, appears to be in constant demand. It seems likely that if they had access to a proven technology to conduct a percentage of the sub-mud line surveys, it would be an advantage because it frees the costly WROV vessel for heavier work.

Industry sources say there is a precedent in the oil and gas industry for the kind of opportunities to which the AUV-SBI technology might lend itself. Specifically, as offshore fields mature there are often smaller pockets of oil which attract smaller players to develop them on a cost effective model. This is already happening in the North Sea and these sources say it could be in the interest of smaller players on the Grand Banks to adopt this technology, allowing them to leverage the least expensive solution and get the sub-mud line information they need.

Gary Dinn appreciates this perspective. "There are advantages to an ROV. You get real-time feedback, instead of the post mission data you get with the AUV. And the ROV gives you more precise control when you want a closer look. But this new technology is meant to complement that, not replace it," he says. And Dinn believes the market is much broader than oil and gas. "There are applications for power projects running seabed power cables for domestic use and for export."

The crown corporation Nalcor Energy has explored routes for an HVDC transmission line from the Lower Churchill Hydroelectric Project across the frigid Strait of Belle Isle to the island of Newfoundland. For that work in the relatively shallow waters, they selected conventional tow fish technology. For new technology to break into such a market the AUV-SBI team will need to demonstrate that they can cost-effectively fly accurately and bring back good, robust data to generate results in which the clients can be confident.

The Last Ten Percent

Back in the lab after the sea trials, Lewis is pleased but reserved. "We have completed ninety per cent of the process towards integration," he says. When Gary Dinn first broached the idea they wanted to see if they could engineer the solution in such a way that they could understand the dynamics and teach it to others. Now he knows.

"What gets me excited is that we have a lot more vehicle," says Lewis. We are no longer limited to the physical size of the AUV. We have introduced another dimension—it was a torpedo and now we have the starship Enterprise," he says with a broad smile, adding that it is up to the PanGeo's of the world to create the commercial opportunities.

At the time of writing Dinn and Lewis were scheduling meetings for late May 2012, to map out the final integration and trials of the "live" unit in early autumn, 2012. "As part of that, we will confirm the test results, complete the physical integration and get ready to fly," says Dinn.

Dinn says the ideal outcome would be to see the SBI integrated into the unit and an oil company contract them to survey a potential pipeline route. "But applications for this type of mobile, inexpensive surveying is pretty broad, and can even include mineral prospecting, and archaeological work," explains Dinn. "The AUV changes the equation."

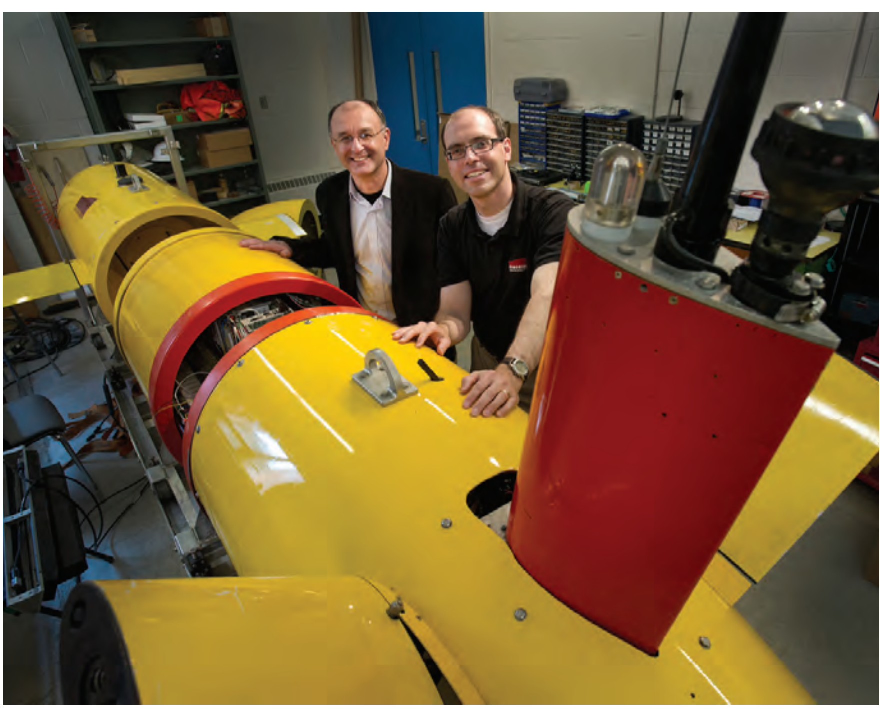

Photo Courtesy Chris Hammond