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SMaRC thinking: Sweden's cross-sector research centre builds underwater robotics capability

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Key Points

- Sweden has established a cross-sector research centre to integrate government, industry, and academic research on maritime robotics
- SMaRC is focusing on the underwater domain – an area of vital national interest for Sweden

Sweden's security situation is shaped significantly by threats in the underwater domain. The Royal Swedish Navy (RSwN) has experience and expertise in operating in the challenging underwater conditions of the Baltic Sea, with its shallow, archipelagic waters, uneven topography, varying salinity levels, and cluttered acoustic conditions.

However, others are actually exploiting that environment. In October 2014 RSwN assets were surged to seek the source of what the navy referred to at the time as "foreign underwater activity" within Swedish territorial waters off Stockholm. That same year, the government added the underwater domain to a list of vital strategic interest areas in which Sweden would seek to retain technological and operational advantage.

Within this strategic effort to build skills in the underwater domain, Swedish defence and security stakeholders also seek co-operation from commercial sectors (such as offshore energy) to draw on concepts and technologies developed there. The Swedish experience exemplifies the benefits of collaboration between defence and commercial sectors on underwater technologies, in particular relating to developing concepts and technologies for unmanned systems. These two sectors share, for example, a requirement for sustained surveillance and monitoring presence and also for accessing and securing data underwater.

There is a need to survey and monitor the environment to glean oceanographic information, for example, to improve understanding of underwater topography and sub-surface environmental conditions. There is also a need to monitor the safety and security of critical national infrastructure nodes, such as offshore energy pipes and platforms and communications infrastructure including underwater cables.

To improve government, industrial, and academic co-operation on developing technologies for underwater operations, Sweden has established the Swedish Maritime Robotics Centre (SMaRC), with a particular focus on developing unmanned capabilities to improve access to underwater data.

A Swedish Maritime Robotics Centre (SMaRC) AUV is pictured operating in the Antarctic. SMaRC looks at maritime areas ranging from coastal to polar regions to improve understanding of how robotics impact on the underwater domain (Filip Stedt)

"SMaRC is the national industrial research centre for maritime robotics," Dr Ivan Stenius, a project manager at SMaRC and an associate professor at the Centre for Naval Architecture, KTH Royal Institute of Technology, said at the 2019 Undersea Defence Technology (UDT) conference, held in May in Stockholm.

SMaRC is based at KTH in Stockholm but has partners across Sweden. It was established in 2017 with an SEK100 million (USD10.6 million) fund from the Swedish Foundation for Strategic Research (SSF). SMaRC has 20 full-time staff, with a number of others supporting the organisation's work. Staff are drawn from what Stenius referred to as "a constellation of different partners" from various research areas, such as robotics, the energy sector, vehicle engineering, and natural scientists including glaciologists and marine biologists.

Organisations contributing to and supporting SMaRC include KTH Royal Institute of Technology, Stockholm and Gothenburg universities, Swedish Defence Materiel Administration (FMV), Swedish Defence Research Agency (FOI), defence and security companies Saab Kockums and Saab Dynamics, and marine survey specialist MMT Sweden.

SMaRC is "Sweden's largest initiative for maritime robotics", said Stenius. "Before we started", he said, "there was no academic node connecting the underwater research areas" in Sweden. The SSF established several research centres to address this issue, and SMaRC in particular is focused on providing technical content, Stenius added.

Impact areas

SMaRC looks at the world's maritime areas, ranging from coastal to polar regions, to improve understanding of the underwater domain and how maritime robotics can provide impact there, Stenius explained. The programme identified three core impact areas: environmental sensing, ocean exploration, and safeguarding society. Within these areas, scenarios were developed to understand how maritime underwater vehicles could improve operational capabilities and outputs. The scenarios were used to understand what capabilities are needed, with these assessments then determining areas of research focus.

Across the core impact areas, the scenarios have demonstrated similarities in requirements. One common theme is the requirement for a sustained autonomous presence at distance.

"On the autonomy side, what kinds of capabilities do we need for these vehicles to be on their own?" said Stenius. "It's really a totally different situation sending an autonomous vehicle to Mars as sending it underwater [including] going under ice …. You cannot really call back home to a support group, say, helping you with making decisions."

If an autonomous vehicle has the capability to detect, localise, and classify objects in real time, this raises the question of the vehicle "being able to handle data, analyse data, [and] make decisions that change the operational profile based on that", said Stenius. Navigation is important here. "You have to know where you are, otherwise the data might be useful but not as useful as if you know exactly where you are when you are classifying things," he added.

"You have to build in much more intelligence and decision[-making] capabilities in these vehicles, and particularly if they have been away for a while and have started to collect data," Stenius continued. "Then that data might start to be more valuable than the asset itself. So, just how do you make sure that they [send] the data, regardless of if you can save the vehicle or not?

"Underwater communication is of course an important aspect of this, so the ability to have robust underwater networks and communications links is super important," Stenius added. SMaRC's vision is to develop a network of communications nodes, enabling different systems to communicate with each other. However, again highlighting differences compared with other environments, Stenius said, "You cannot really do it as we're used to doing with our mobile phones and networks in the air: you have to [do something] completely different." In the underwater domain, this can mean making such networks simpler, but this in turn can restrict the ability to make such networks robust. "So, you have to think about this much more," said Stenius.

SMaRC is looking at how to balance building simple but robust underwater communications networks. "We are, for example, looking at '5G' directed-communications technologies in the underwater domain to establish more robust communication links," said Stenius.

Another element is endurance. "To have these underwater autonomous vehicles do useful things, you want to have them out there for long periods at extended ranges," said Stenius. "At the moment they are good, but it can be dramatically improved." There are two aspects here, he continued. One is extending range to reach into remote, unknown areas, and assessing how to do this while maintaining required autonomy levels. The other is increasing persistence in known locations. Here, Stenius explained, "You know where you are, you know that vehicles are going to operate in that same region, but you want them to operate year round or for months at a time in that same region with as little interaction as possible." SMaRC has several projects working on different aspects of this, Stenius said.

Operating tactics

SMaRC is also looking at tactics for operating autonomous vehicles, such as swarms of heterogeneous or similar systems. "Being able to collaborate in these swarms to achieve common goals is a huge challenge," said Stenius.

SMaRC is exploring "how [to] use a number of smaller vehicles to cage [an] intruder, and how can we use assets in the water or the geographic location like islands in the surroundings as kind of the barriers", said Stenius. Using vehicles and topography to establish a perimeter means "we can kind of identify where we need to position our vehicles to make sure we know where an intruder is, or [the location of] something we want to just follow".

SMaRC is also developing its own autonomous vehicles, providing test-bed/demonstrator platforms to test its concepts and technologies. "We have decided that, for us to be able to really dig deep into how the systems work, we [need] control over code and mechanical design," said Stenius.

SMaRC is developing a 4 m vehicle that can carry large sensors and can be tested for greater range and endurance. The vehicle's size enables other systems to be fitted to or deployed from it.

SMaRC's second vehicle is a 1.4 m small AUV, weighing about 15 kg. Stenius said the aim is "looking at how we can make things small and affordable, but still useful …. Affordability gives us the opportunity to then build several of these to test swarm behaviour". Developing a smaller AUV also enables SMaRC to test docking it with the larger one.

Using its technology demonstrators enables SMaRC to "deploy things that create our own network with different types of AUVs and [to] try out our research findings in as realistic an environment as possible", said Stenius. "We cannot get real scenarios, but we can go in real waters and do things to push ourselves." The involvement of commercial partners in SMaRC also provides opportunities to work with those partners' AUVs.

The demonstrator programmes also enable SMaRC to connect its different research areas to improve understanding of what can be done with autonomous systems, with such collaborative work then fed back into the individual research programmes to help develop the next generation of technologies, said Stenius.

Defence specific

Stenius explained that SMaRC works on concepts at lower technology readiness levels (TRLs) before defence-focused partner organisations introduce defence-specific elements to potential customers.

Regarding SMaRC's development of defence-related capability, "The most important aspect is that all of our [main] research areas – [including] autonomy, endurance, and communication – need to come together to reach the defence and security capabilities targeted within SMaRC," said Stenius. "A particular interest may be swarming, where you need real-time onboard intelligence, sensor analysis, and communications," he continued. "We want to do this for extended time also, so endurance is very important too."

Sweden's armed forces are showing interest in SMaRC's research outputs. Stenius said the Swedish Defence University has established a PhD project funded by the Swedish Armed Forces to assess how to maximise the effect of the emerging new technologies for Sweden's defence community.

Comment

Research organisations from countries around the world are co-operating to build defence capability. SMaRC is already working with oceanographic research centres in Portugal and the United Kingdom.

NATO's maritime research arm, the Centre for Maritime Research and Experimentation (CMRE), is looking extensively at AUV concepts and technologies. Whether the two organisations will co-operate – with Sweden not being a NATO member – remains to be seen. However, SMaRC offers a forum to develop non-NATO-based defence research in AUVs and an opportunity to maximise the benefit of working with commercial AUV users. In the latter instance there is an established path of Swedish defence and commercial AUV developers working together where there are overlapping capability requirements.