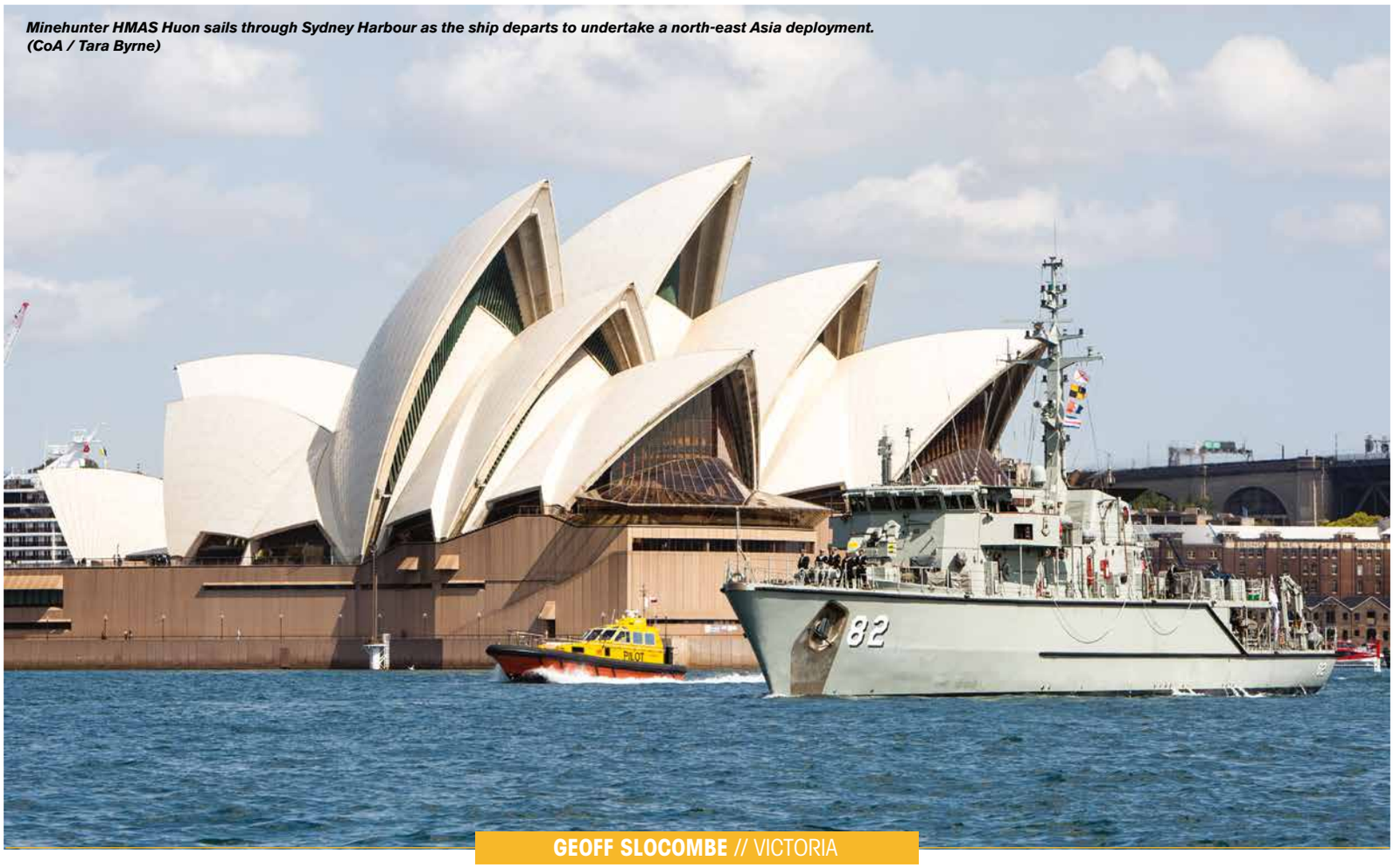

Minehunter HMAS Huon sails through Sydney Harbour as the ship departs to undertake a north-east Asia deployment. (CoA / Tara Byrne)

GEOFF SLOCOMBE // VICTORIA

DEVELOPMENTS IN SEA MINE TECHNOLOGY AND THEIR DETECTION

Evidence that the naval mine is not an outdated weapon is because in every decade since World War II both state and non-state actors have used them as a relatively cheap, simple and persistent weapon. They have frequently delivered a disproportionately higher effect against more expensive naval platforms, while denying areas of operation or deterring opposing forces, and often disrupting the flow of commercial trade, food and energy to achieve political or terrorist goals.

In April this year Prime Minister Scott Morrison made some naval shipbuilding announcements relating to the Royal Australian Navy's mine-clearing and hydrographic capabilities. He was on the campaign trail before the May 18 Federal election and while at the Henderson WA shipyard he announced that on re-election the Government will build three naval ships – two mine warfare support vessels and a hydrographic vessel - in Western Australia at Henderson.

Mr Morrison pledged to bolster the Australian navy's mine hunting capabilities by bringing forward the replacement of the Huon-class mine hunters coastal. Defence had gained approval in 2017 to extend their service into the mid-2030s. "We will bring forward the replacement of the Huon-class mine hunters from the 2030s to the mid-2020s, as part of our new Maritime Mine Countermeasures Programme (to be known as SEA 1905)," Mr Morrison said.

A Defence spokesperson told APDR that the SEA 1905 Maritime Mine Countermeasures Programme is still in the early requirements definition stage and no decision has been made by Government. The programme includes building two mine warfare support vessels and investment in Mine Warfare Mission packages comprising remote and autonomous Mine Counter Measures systems.

APDR questioned "Is there any relationship between SEA 1905 and part of the Hydrographic Data Collection Capability project (SEA 2400), the vessel that would undertake strategic collection of maritime environmental data as part of the military survey function?" The Defence spokesperson replied "As both projects are set to acquire and utilise various autonomous technologies

capable of operation in a maritime environment, opportunities are being explored as to any potential commonalities that may be leveraged in the delivery of the projects.

"The SEA 1905 Programme is still in its initial planning stages therefore no decisions have been made in regards to specific commercial arrangements at this time," he said.

First pass approval of this hydrographic military survey vessel (SEA 2400) is expected in fourth quarter 2019, with the build commencing in the early 2020s, at Henderson.

APDR asked Commodore Chris Smith RAN, Director General Littoral, for his views on the possibility of autonomous systems being used in mine counter measures. He commented that "The nature of the mine threat continues to evolve, in addition to the significant advance in reliability and performance of autonomous Mine Counter Measures systems – much faster than that predicted at the inception of SEA 1179 Phase 1. The success of exercise Autonomous Warrior 2018 conducted in November 2018 further demonstrated the rapid advancement and application of Robotics, Autonomous Systems and Artificial Intelligence (RAS and AI) technologies. Similar alternative approaches to dealing with the mine threat are being adopted by other western nations,"

Less publicity has been given to planned use of drones – autonomous underwater, surface or aerial unmanned vehicles to help with dangerous missions to safely search, classify, identify and neutralise mines. Defence are making concerted efforts to qualify various unmanned systems which can help with these tasks.

However, at UK's 14-17 September 2019 DSEI Conference Stephen Olson, deputy head of the Office of the Chief of Naval Operations' mine warfare office, said that "the US Navy has successfully demonstrated what's known as single-sortie mine hunting, which sends out an autonomous boat to sweep for mines with a sonar system, detect a mine-like object, classify it and then deploy another system that destroys the mine

"It's a significant achievement in the years-long effort to "get the man out of the minefield" by deploying robots to perform a job traditionally performed by manned minesweepers and highly trained divers. Beyond the safety benefits, it also quickens the process. The successful test opens up the possibility of having a small cadre of human operators who can oversee whole packs of robots as they sweep minefields on their own."

For security reasons APDR has chosen not to list the sea mines in service with the ADF.

SEA MINE TECHNOLOGY AND DEPLOYMENT

Sea mines placed in patterned fields are used offensively to force an adversary's warships into sea lines of communication where friendly submarines may be waiting to attack them on their arrival, or to lock vessels into an anchorage or harbour. Defensively, because minefield maps can be promulgated securely to friendly vessels, they deny an adversary rapid access to a friendly force location such as an amphibious landing site, anchorage or port.

Naval mines may be classified into four major groups: contact, remote control, influence and dummy mines.

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Looking in more detail, contact mines, which may be tethered or drifting, are the lowest cost to produce and have been widely used during both the 19th and 20th centuries. They have to be hit by a target ship, usually causing liquids inside the fuse to run into another agent generating heat or battery electricity, thus causing the mine to explode.

Tethered contact mines were usually set below the surface so that small craft, as low value targets, could pass over them, while larger craft like aircraft carriers, cruisers, destroyers, frigates and heavy merchant ships would detonate them.

Drifting contact mines are no longer used because of their indiscriminate action to foe and friend alike. But the threat of their use has stopped pursuing vessels from getting closer to their fleeing warship targets.

Sea mines can be remotely controlled to block important sea lines of communication if necessary. This has the advantage that friendly vessels can travel through the minefield, but should an adversary attempt a transit the mines can be activated remotely then become subject to their normal means of detonation.

Influence mines respond to the presence of a ship or submarine rather than direct contact. Historically this influence would be detected magnetically, acoustically or by water pressure. These days technology developments such as total field magnetometers, narrow band acoustic sensors, and the incorporation of computers provide much more sensitive detection. These mines can be programmed to respond to combination of historic sensors plus being able to filter these inputs for specific ship passage sounds such the type of propeller, vessel propulsion and power generation plant, plus hull and propeller cavitation patterns.

Large influence lines can be laid on the sea bed to destroy submarines or, if the water is shallower, sink surface vessels. They are also incredibly difficult to clear because of their size, weight of explosives, and potential booby-traps for divers or mechanical tools on unmanned underwater vessels.

BAE Systems have developed and supplied their Stonefish computerised influence mine. Describing Stonefish mines, a public domain source states 'They incorporate acoustic, magnetic and pressure sensors, coupled with computerised electronics to provide target assessment i.e. whether the target is genuine, whether it is regarded as a legitimate enemy target, and whether it lies within the destructive blast radius of the warhead. Detonation will only be triggered when all three criteria have been met.

'Stonefish incorporates arming delays, ship counting and self-sterilisation features which can be configured by the user.'

Ship counter features of influence mines have been around since World War II. Quite simply the mine's control mechanism counts the number of ships passing over it, then at some pre-determined number activates the mine. This way the mine has the real chance of damaging a major warship like an aircraft carrier or a merchant container ship.

As well as operational large sea mines being laid on the sea floor, a further challenge can be dummy mines laid there as well. They typically are made from plastic or metal oil drums filled with sand or concrete. Dummy mines require the same caution in mine neutralisation procedures as live mines, extending the time taken to clear a minefield.

MINE CLEARANCE AND AUTONOMOUS VEHICLES

Darren Burrowes, chief technology officer of Australia's BZG told APDR, "If you change your tools you change your world – new tools like Unmanned Underwater Vehicles are changing the undersea battle space and the navy that finds the best way to operate, support and innovate using these tools will be the one with the sustainable technology advantage."

A common dictum amongst mine clearance officers is "Hunt if you can, sweep if you must."

The two main technologies used are mine hunting using specialised sonars, then unmanned underwater vehicles (UUVs) or divers to neutralise the mines,

or secondly mine sweeping using a wire sweep to either cut a mine loose from its tether for subsequent destruction by gunfire when it surfaces, or an influence sweep which mimics the presence of a "ship" strongly enough to detonate the mine.

Just before the turn of the 20th century, Navy started their SEA 1778 Phase 1 Deployable Mine Countermeasures project by considering deploying unmanned mine countermeasures (MCM) equipment on combat vessels which could travel at speed to the suspected mine field which needed to be neutralised. They probably now give more weight to the risks of having high value combat vessels, deployed on MCM, where the extent of the suspected or actual minefield is not known.

In mine clearance work, AUVs offer increased safety (through direct intervention or avoidance); improved efficiency; reduction in dull, dirty, dangerous tasks for personnel; increased operational effectiveness through persistence; reduced/hostile communications environment; and reduced cost.

There are four phases where AUVs can be used:

- Detection. AUV search using side-scan sonar
- Classification. Diver or AUV with Synthetic Aperture Sonar (SAS)
- Identification. Diver or Remotely Operated Vehicle
- Disposal/Neutralisation. Diver or Remotely Operated Vehicle

A DST Group spokesperson told APDR that "Australia's capability edge will depend on having superior autonomous systems and sensors effectively integrated into ADF capability."

Defence's CRC for Trusted Autonomous Systems became operational mid-2019 in its Brisbane headquarters. Headed by Professor Jason Scholz, the CRC is enabling Defence to partner with industry and universities to investigate innovative approaches regarding the use of autonomous vessels and systems in the maritime domain.

APDR approached Robert Dane, CEO of Ocius Technology, to enquire about work they are currently doing with autonomous systems that are relevant to mine clearance.

He stated "We are working with a post-graduate intern from DSTG Eveleigh NSW over the summer to build on the work done at Autonomous Warrior 2018 (AW18) continuing to integrate our Unmanned Surface Vessels (BlueBottle) with DSTG's Autonomous Underwater Vehicles (Remus 100 and 600) using underwater acoustic communication systems.

"The general goals are:

- Prototype development and requirements identification for an Autonomous USV gateway for persistent UUV- based MCM operations using underwater acoustic communications.
- Determine future pathways for collaboration with DST/NAVY/Ocius in autonomous maritime systems.

"Where possible we also seek to work with NAVY, particularly building on our recent successful engagement with HMAS Waterhen during AW18.

"Our first task will be to put together a high-fidelity Hardware in the Loop simulation of the autonomous MCM scenario that we attempted at AW18, including USVs, UUVs and DST's MCM automatic target recognition software."

Hydroid REMUS AUVs are proven and in-service with 21 navies. REMUS includes the Sea Launcher providing proven "bolt-on" capability for AUV deployment and capture/recovery.

While operating, especially when some distance from their mother vessel, AUVs need to be protected from enemy action. Threats can come from a variety of sources including submarines, helicopters, other aircraft, fast inshore attack craft and other asymmetric threats. Not surprisingly AUVs can also be held up by something as simple as fishing nets or sent off on wild goose chases because the mines detected are dummies.

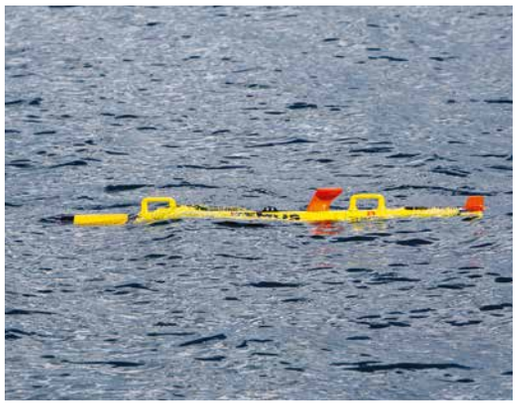
Thales have a memorandum of understanding for strategic cooperation with Aquabotix for autonomous system mission systems involving micro-sized swarms of autonomous underwater vehicles. APDR is interested in this concept and asked a Defence spokesperson who said "Defence is unable to comment on this matter as it is commercial-in-confidence."

More positively he said "The Atlas Elektronik SeaFox® mine disposal system is being introduced into service in Defence through Project SEA 1778 – Deployable MCM."

CONCLUSIONS

Mines are the ultimate asymmetric warfare weapon in naval operations. Whether buried, tethered, concealed, drifting or even a dummy, they have the ability to deny access to a choke point, harbour, amphibious landing site, or even to deep water passages. They are very effective anti-access/area-denial (A2/AD) weapons.

Maritime autonomous technology for unmanned vehicles can offer a credible capability on how MCM operations are undertaken. This will lead to Defence involving the DSTG and Australia's defence industry in changing the way in which they consider and conduct Mine Warfare. Innovative and proven autonomous development, provide the opportunity for risk reduction and in doing so requires a change in the concepts of operations for both MCM vessels and associated MCM equipment.



REMUS 100 returns to the surface after completing sonar and oceanographic surveys of the sea floor during Autonomous Warrior 2018. (CoA / Justin Brown)

A research paper read by APDR noted that 'The development of mine technology has produced smart mines built from composite materials, with multiple actuation methods and the ability to recognise and ignore influence sweep counter-measure activity, compound the detection, identification and classification challenges of mine clearance. These smart mines, alongside other examples such as autonomous re-positioning mines and seabed-moored torpedo mines, present a developing threat to naval forces; one that future mine counter-measures will need to meet to remain relevant.'

Darren Burrowes noted in a communication with APDR that 'The next challenge for Navy may be to understand how they will deploy/recover, operate and support AUV & USV teams in the field. With a dedicated ship (e.g. Huon Class Minehunter Coastal) the ship could be dispatched to an area to complete all aspects of MCM: Search, Identification, Classification and Disposal. The ship is entirely self-supporting with supplies, communications, command structure etc. and can complete all tasks with minimal support.

'Navy now needs to develop a CONOPS of how teams (e.g. Mine Warfare Team 16) can be deployed to an operational area and effectively conduct all aspects of MCM over a period of time. The technology may not be the main issue but the CONOPS for unmanned operations may be the next challenge. Operators for unmanned systems will require different skills and training compared with existing operational roles. The possibility of synergies between Mine warfare teams operating AUVs and Deployable Geospatial Survey Teams operating AUVs for very similar applications could be considered.

'The future of successful unmanned MCM operations will be heavily reliant on robust communications, reliable GPS and the ability to withstand drone attacks.'