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Editorial

NEW THAI GOVERNMENT SHOWS COMMITMENT TO DEFENCE TECHNOLOGY DEVELOPMENT

Despite the surprise victory of the progressive Move Forward Party in Thailand's general election on 14 May this year, it was not able to form a government. The Pheu Thai party, who came second, was able to form a broad coalition government (without Move Forward) but including pro-military parties that it had originally said it would not include.

This means that the influence of the military on the Thai Government Defence Budget will continue to remain steady although a cut has taken place this year. The 2023 defence budget has been set at $4.3 billion (around Bt197 billion), which is down just over two percent from the 2022 defence budget. However, the Army is earmarked for nearly half of the budget (Bt96.5 billion), although with a slight decrease, and the Defence Technology Institute received a $2.4 million budget increase to $14 million (Bt504 million). In addition, a five-year Ministry of Defence Reorganisation Plan (2023-2028) was announced in June,

Writing this column just prior to the Defense & Security Show in Thailand (6-9 November 2023), it has been very noticeable over recent years how organisations such as the Thailand Government's Defence Technology Institute (DTI) has matured and pushed the development its own research themes, particularly in terms of leading product development in line with industrial capacity. Its increase in the Defence Budget likely reflects this and shows a recognition that a healthy defence sector can reflect positively on the national income.

Taking centre stage at the D&S Show 2023, the DTI focused on three particular themes that it currently holds as fundamental to the growth of the indigenous defence sector.

Firstly, it wanted to underline technologies that have been successfully developed to the point where they are ready to enter industrial production. These products might be equally applicable to defence and commercial markets.

On top of this there is a drive to expand the defence industry through physical expansion encompassed by "land/area development projects." The focus here is to create the conditions where "strategies and initiatives driving the expansion of the defence industry" can flourish.

Thirdly there is a focus on expanding academia as well as technical services, to allow the conception of new ideas, together with providing the necessary testing conditions needed to mature such projects.

While the Thai Government is looking to play its role in the wider ASEAN defence community, it is also focused on providing its own 'home grown' contributions.

Andrew Drwiega,
Editor-in-Chief

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THAILAND

Camouflage using Saab Barracuda Ultra-Lightweight Camouflage Screen (ULCLAS) Frequency Selective Surface (FSS) technology.

CAMOUFLAGE AND CONCEALMENT

The art of camouflage is turning into a science in this technology rich world.

By Andrew White

The ongoing war in Ukraine continues to provide the North Atlantic Treaty Organisation (NATO) and international partners around the world with invaluable lessons as their armed forces prepare for potential conflict with peer adversaries in the age of strategic competition.

One significant capability gap emerging from the conflict is the ability to successfully implement camouflage, concealment and deception (CCD) strategies - particularly relevant across the modern battle space which continues to witness a proliferation of multi-spectral sensors.

Today, the ability of armed forces to remain undetected on the modern battlefield is significantly more difficult with highly capable and well equipped adversaries employing mature intelligence-gathering and electronic warfare methods.

Capable of identifying even small unit teams visually or elsewhere throughout the electromagnetic spectrum (EMS), sensors provide early warning to commanders who are then able to rapidly cue precision guided munitions to destroy these targets.

Such a threat has led to an escalation in so-called 'shoot and scoot' operations which require mobile rocket, artillery or mortar units to identify targets before coming to a halt and engaging, then leaving the area as quickly as possible to avoid counter-fires from enemy forces.

Many of these lessons were highlighted in the Royal United Services Institute's (RUSI's) Preliminary Lessons in Conventional Warfighting from Russia's Invasion of Ukraine: February–July 2022 paper which highlighted "…pervasive ISTAR on the modern battlefield and the layering of multiple sensors at the tactical level [is making] concealment exceedingly difficult to sustain".

According to the paper, survivability was "…often afforded by being sufficiently dispersed to become an uneconomical target; by moving quickly enough to disrupt the enemy's kill chain and thereby evading engagement; or by entering hardened structures".

"Shell scrapes and hasty defences can increase immediate survivability but also risk the force becoming fixed by fire while precision fires and specialist munitions do not leave these positions survivable. Forces instead should prioritise concentrating effects while only concentrating mass under favourable conditions – with an ability to offer mutual support beyond line of sight – and should give precedence to mobility as a

GhostHood solutions provide "multispectral, lightweight [IR reflectance] camouflage systems.

critical component of their survivability.

"Ukrainian troops have tended to sacrifice camouflage for clear identification (using coloured bands) for their manoeuvre forces, relying on speed rather than concealment for survivability," the paper concluded.

Survivability

Today, there are multiple solutions available for armed forces seeking to optimise the survivability of units on the ground and at sea.

According to industry sources, an undisclosed number of BAE Systems CV90 infantry fighting vehicles (IFVs) are currently deployed in Ukraine following their donation from European countries including Sweden. They are equipped with Saab's Barracuda camouflage system - a modular solution designed to protect a wide range of platforms from multi-spectral threats. A Saab spokesperson was unable to comment on the deployment of Barracuda systems on board CV90 or any other vehicles.

At the DSEI Expo in London, September, the company unveiled the latest member in its Barracuda family of camouflage and concealment solutions. The Ultra-Lightweight Camouflage Screen (ULCLAS) which, according to officials allows small unit teams the capability to "…combine protection from the enemy with the possibility to communicate with friendly forces".

Essentially, this means ULCLAS allows personnel to remain undetected across the EMS while at the same time enabling them transmit and receive signals across certain radio frequency (RF) bands.

"Barracuda camouflage nets provide vital protection for a soldier, hiding the operator from, for example, radar sensors. However, the same characteristics that provide that protection, also limits the use of GPS and/or VHF communications to and from underneath the net," a Saab official explained to Asian Military Review.

Such capability is enabled by the Saab's Frequency Selective Surface (FSS) technology which, according to officials, allows "selected radio frequencies to pass easily either way through the camouflage net, while protecting against the higher frequencies of electromagnetic waves used by radar systems".

Suggesting there is "great interest" globally for the ULCAS FSS, head of Saab's Barracuda business unit, Henning Robach described how FSS allows users of specially produced ULCAS nets to make full use of radio and GPS systems while remaining fully concealed.

"Traditionally truly multispectral camouflage nets can inhibit the reception and transmission of such systems due to the frequency range within which the net is seeking to function. In such situation users face a dilemma about breaking cover to enable their use but with UCLAS FSS users can still operate these systems under the net while retaining the benefits of the wide frequency cover of the net. The nets can be customised to specific frequencies as required by the customer," he said.

"This represents a significant advancement in modern signature

management technology…we are taking camouflage to the next level with this novel feature. It changes how soldiers communicate while keeping multispectral protection, and so introduces a new era of tactical communication flexibility, offering unparalleled capabilities," he added before highlighting emerging levels in demand for camouflage and concealment solutions was growing across the Indo-Pacific, particularly concerning protection of maritime assets.

Speaking to AMR, Robach explained: "In Asia, we see a lot of interest for signature management for land and maritime use in particular. Both unit camouflage [such as} camouflage systems used to cover equipment, tents and then platform camouflage [such as] a second skin on vehicles and other platforms like combat vehicles, tanks, trucks, smaller boats."

Across the region, Saab is marketing its Barracuda Camouflage Marine solution, a combination of the company's MCS and ULCAS systems designed to provide surface vessels with the ability to avoid detection by enemy sensors.

According to Saab material, Barracuda Camouflage Marine "reduces detection by up to 90 percent" with the "ultra-lightweight design" rapidly deployed using telescopic poles for support.

"Barracuda's Camouflage Marine Solution has been designed to offer complete confidence to soldiers operating from the water, whether cutting through waves at breakneck speeds or moored to the coastline. Comprised of interlocking, fully customisable panels and an advanced multispectral camouflage net, this innovative solution delivers unrelenting protection from state-of-the-art enemy sensors in times when uncertainty could mean defeat," according to the company.

"Our maritime Barracuda Camouflage Marine solution allows for the covering of vessels docked or tied up to minimise their visual and other spectral profiles when most vulnerable," Robach added.

At the Eurosatory exhibition in Paris, France in June 2022, Saab also unveiled the Barracuda Soldier System (BSS), designed to provide dismounted personnel with the same multispectral protection as tactical ground vehicles. Coverage includes protection against near and short wave infrared; ultra-violet; and visual frequencies.

The BSS is 2x2 metres square and weighs just 21 ounces (600 grams) and can be packed into a small pouch, making it ideal for forward-deployed personnel. Worn as a poncho or used as a camouflage net to protect hides or observation positions, multiple BSS can also be connected together to protect increased areas, particularly from airborne sensors. The BSS is currently available in a variety of camouflage designs including Arctic; Desert, Urban; and Woodland patterns.

Saab has also designed the Barracuda Marine system to camouflage surface vessels when static and on the move.

Similar to Barracuda solutions mounted on board CV90s in Ukraine, Saab was unable to discuss the material make-up of BSS due to operational security concerns. BSS is currently in operation with more than 10 countries.

But a company official did describe BSS as a more cost effective solution over the company's own Special Operations Tactical Suit [SOTACS] product which is used by sniper pairs and special operations units. Saab's Robach stated that the BSS continued to be upgraded based on user trials and feedback.

"The Barracuda Soldier System has been adapted in a number of ways as part of Saab's continued focus on product evolution and customer engagement. This included an improvement in detection from thermal sensors when taking advantage of its reversible nature to use the side intended for night use, but also practical changes to the shape of the hood, tailoring for including pockets. This product is ideally for users who need to leave the protection of a UCLAS net or exit a vehicle covered with Barracuda MCS while avoiding detection by thermal or visual sensors, thereby ensuring the integrity of the work undertaken to camouflage in the first place."

Elsewhere, Fibrotex USA continues to devise next-generation camouflage and concealment solutions following its selection in 2018 to support the US Army and US Marine Corps Ultra-Lightweight Camouflage Net System Increment I (ULCANS Inc 1) programme of record.

ULCANS Inc 1 was primarily focused on protecting small unit teams at-the-pause or at-the-halt. However, Fibrotex used the Modern Day Marine exhibition in Washington, DC in June to unveil its its latest solution - the Mobile Camouflage System (MCS) which has been designed to provide protection for tactical ground vehicles and crew even when operating on-the-move.

"Fibrotex has developed and deployed mobile camouflage systems to a variety of customers and platforms, including Main Battle Tanks (MBTs) like Leopard 2, Merkava Mark IV; armoured personnel carriers including Stryker and CV90; as well as other ground vehicles including the Land Rover Wolf, SandCat and

Fibrotex has supported the US Army as it seeks a next-generation camouflage solution for dismounted troops but continues to upgrade solutions in line with emerging operational requirements.

Toyota Hilux," a company spokesperson informed AMR.

"These MCSs are tailor-made for each platform and are designed to reduce the platform's multispectral signature while the vehicle is fully operational in any terrain," they added.

Fire retardant, water repellant and reversible, the MCS provides protection against NIR, radar, SWIR, thermal, UV and visual signatures and is "quick and easy to assemble".

Alternative products include German company GhostHood which provides material to original equipment manufacturers of military tactical ground vehicles including Polaris Government and Defense.

Speaking to AMR, Polaris vice president, Nick Francis described how the company's inventory of MRZR light tactical all terrain vehicles were "open-concept and modular to accept a variety of camouflage and concealment packages" in line with specific end user requirements.

"The cab kit for the MRZR Alpha has been seen with an arctic camouflage wrap, but that's just the beginning. The cab can be painted and repainted for different theatres of operation. Also, the relatively small size of our vehicles provides concealment by allowing for operation in more narrow environments, be it forest, alpine or rocky terrain," he informed AMR.

GhostHood solutions provide "multispectral, lightweight [IR reflectance] camouflage systems which are compact and effective", according to the company. The focus lies on the multi-functionality of the products. "You can cover many applications during the mission with just one product," it states.

Specific solutions include what GhostHood describes as "confusion camouflage" or "conCAMO" which is currently in service with an undisclosed German special operations unit. "conCAMO patterns are based on perceptual psychology [with] 25 superimposed layers creating a chaotic illusion, tricking the viewers' sub-consciousness as our brains cannot fully resolve them. All patterns are fully tested and deceive humans and all kinds of different animals with outstanding results," company literature claimed.

"Because night vision devices become more prevalent, each piece of fabric is printed both inside and outside with high special NIR-colours (Near Infra Red Reflectance). The combination of infrared printing with the conCAMO camouflage pattern guarantees camouflage day and night."

Typically, GhostHood camouflage nets measures 6x8.5m in dimension, meaning they can be used to camouflage a sniper hide or observation position while also allowing personnel to "see-through" the breathable material to optimise levels in situation awareness.

Nets weigh approximately 13.3lbs (6kg) and are manufactured using 100 percent polyester in a variety of colour schemes.

Conclusion

Camouflage solutions from the likes of Fibrotex, Ghost-Hood and Saab will play a critical role in the operational success of armed forces moving forward, whether on land, at sea or in the air. But they will need to be integrated into a wider CCD strategy to ensure mission success and optimal levels in survivability of forward deployed personnel. A

BMT's evolved design for the RN's FSS ship, with containers positioned for'ard. When designing ships for flexibility, navies and naval architects continue to assess the differences between modularity and adaptability.

Team Resolute

RE-BALANCING DESIGN: NEW TECHNOLOGY AND THINKING IN NAVAL ARCHITECTURE

New technological threats and new operational requirements are emerging in the naval environment, raising the question of how ship and submarine designs should develop in response. For naval architects, this presents new challenges, but also new opportunities.

By Dr Lee Willett

In December 2022, the UK Royal Navy's (RN's) first-in-class anti-submarine warfare (ASW)-focused Type 26 frigate, the future HMS *Glasgow,* entered the water for the first time. The RN has often stated that Type 26, as an ASW platform, was designed from the keel up using submarine technology to deliver acoustic quieting.

On 1 October 2023, the UK government issued a contract award for the detail design of the new nuclear-powered attack submarine (SSN) that will provide the next-generation submarine capability for the RN and the Royal Australian Navy, under the Australia/UK/US (AUKUS) strategic partnership. SSN-AUKUS, as the SSN project is currently known, will be based around a UK-derived submarine design.

These two examples, amongst others, highlight the core importance of the baseline design in generating naval capability.

In the contemporary naval environment, emerging threats are driving new operational requirements. New technology is emerging too, and is both driving the threat and enabling the operational response.

In parallel, as threats intensify and as Western navies respond, new naval platforms are arriving. These platforms include not only new classes of traditional naval vessels, like aircraft carriers, destroyers, frigates, patrol vessels, auxiliaries, or submarines, but also new types of vessels, like unmanned systems.

As these new threats, requirements, and vessels emerge, technology is also presenting an opportunity to assess how such manned and unmanned platforms are developed, designed, and built.

Within discussions relating to the development of naval threats, requirements, and capability, there is the question of how the technological shift in the naval world is re-shaping the core, baseline skill of ship and submarine design – in other words, naval architecture.

According to the much-referenced naval architecture book 'Basic Ship Theory', "Naval architecture is concerned with ship safety, ship performance, and ship geometry, although these are not exclusive divisions."

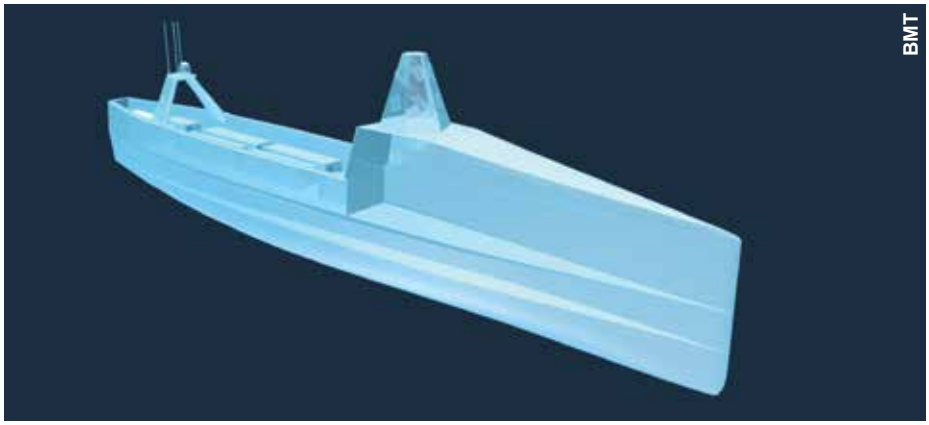
"The use of the term 'architecture' is no coincidence; like an architect, the naval architect is the person who draws together the engineering strands in the marine world – part engineer, part integrator, part manager, and part artist, bringing these strands together to consider a ship as a whole system," Andy Kimber, chief naval architect at BMT, a UK-based engineering design house and consultancy that provides naval architecture capability told *Asian Military Review (AMR)* in an interview at the Defence and Security Equipment International (DSEI) exhibition in London in September.

BMT's services include concept, design, engineering, operating, and technology expertise for the RN and other navies. As regards surface ships and submarines, the emergence of new technologies and new threats is having some impact on the process and outputs of naval architecture, including prompting new platforms, designs, and capabilities.

Change but no change

However, there are some elements of the naval architecture process that remain the same, regardless of the threat.

"If you start with naval architecture as an engineering discipline, we are ultimately governed by physics and engineering reality," said Kimber. "Naval architecture – the theory of it – doesn't change, because it is what it is. Whether it's below the sea surface or on the sea surface, the physics is there and our understanding of that physics is



Pictured is an artist's rendering of BMT's Large Uncrewed Surface Vessel (LUSV) concept design. BMT is using the LUSV concept design process to understand space requirements and use onboard platforms carrying no personnel.

reasonably constant."

"At a level that engineers are interested in, our understanding of physics is very mature," Kimber continued. "So, in that sense, the stability isn't changing, laws of resistance don't change, because the laws of physics aren't changing."

"What is changing is the tools available to us to model and understand the platform before it's built," Kimber explained.

Here, he underscored how new technology, especially information-based technology, is changing how naval architects get the best out of traditional tools such as computer simulation and modelling. "The digitisation of our industry and the tools that are becoming available are allowing us to analyse the same thing in a different way," said Kimber. The ability to use digital technology and the increased information levels available provide what he termed a 'new tool set'. This new tool set does not mean that architectural design, modelling, and testing is done faster and more easily; instead, it can be done more extensively and exhaustively, he explained. "We now want to explore more, so instead of doing five options, we want to do 100 .... We're seeing our ability to model and integrate things in more complexity grow."

"We now want to explore more, so instead of doing five options, we want to do 100..."

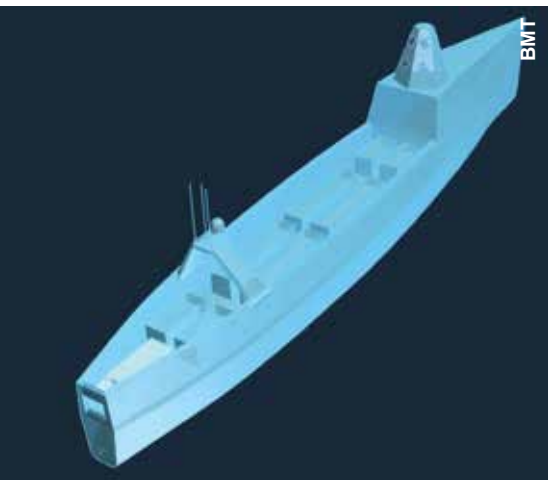
The ability to try things more extensively offers clear benefits in certain areas of the naval architecture process, Jake Rigby, BMT's head of innovation and research, told AMR during the DSEI interview. "Especially at the concept stage, because the concept stage is not necessarily about ... following a straight-line process to get to the end outcome; it's exploring the requirements, exploring what solutions could be viable," said Rigby. "Rather than just looking at a small number of hullform iterations, you can now explore a huge variation."

Architecture oversight

At DSEI, Team Resolute, a UK-based collaboration between Navantia UK, Harland & Wolff, and BMT, unveiled its latest, evolved design for the RN's Fleet Solid Support (FSS) ship programme, which will deliver three new UK Royal Fleet Auxiliary (RFA) platforms to support RN carrier strike group (CSG) and other operational requirements. Speaking at DSEI, BMT's FSS chief engineer Simon Jones explained that, while Navantia will lead on the FSS detail design, BMT's role is to ensure the continuation of the design intent. In other words, BMT will provide a form of naval architectural oversight, to ensure the detail design adheres to the original concept design.

This underlines how the naval architect's role covers the entire capability development and delivery process, across pre-concept, concept, design, manufacture, and in-service phases.

"At the concept stage, the naval architect is probably having a greater role, because trying to incorporate many different things at that higher level is the core of what a naval architecture job is," said Rigby. "[However], as you get to



Caption: Uncrewed platform concepts like LUSV enable naval architects to consider how traditional design arrangements, covering anything from bulkhead spacing to deck arrangements to cargo access, can be done differently.

detail design, and into construction, you need the consistency [in] integration and bringing it together."

"In the early stages ... you're looking at the whole ship, you're looking at the size, you're looking at big things. At the end of the process, your hullform is fixed etc, but you're still looking at the stability because the weight's still changing, you've still got to look at the detail of the structure," Kimber explained. "The role changes ... [but] it's always there."

"Naval architecture is the glue holding all the different pieces together," Rigby added.

Modelling the threat

The improvements in modelling enabled by digitisation mean that naval architects can better understand the risk posed by threat technologies, and whether changes in the threat mandate changes in the design.

"Our ability to model those threats and what they do to the ships is much greater now. The systems we have to simulate how a ship reacts to damage from a threat are much more sophisticated," said Kimber. "That said, I think the historical lesson is 'don't design to the thing today', because tomorrow will be different.

"The threat is always evolving," he continued. "We always come back to the basics of what the threat is: the threat is explosive, it's blast, it's fragmentation, it's fire, it's a hole in the ship.

"The threat angle probably has a greater impact on mission system [designs], in terms of protecting, sensing, and defending from that threat, than it necessarily does to me as a naval architect," Kimber explained. "I view the threat as 'if it hits my ship, it's going to put a hole, it's going to create a fire, it's going to do one of a number of things that are well understood."

Where ship design does relate to the threat is reducing detection risk in the first place, Kimber continued. "That's where technology does change things, in terms of matching your signatures to the current perceptions of the threat and how you defend the ship."

"So, I don't think [the threat] changes what we're doing as naval architects, but the environment we're in and some of the solutions change, and we're putting together a slightly different balance," said Kimber. Here, Rigby explained, the balance relates to three aspects of survivability: susceptibility to detection; vulnerability relating to capacity to survive any damage and operate; and recoverability, in terms of repairing damage to the ship. "It's the balance between those three features that changes over time," Rigby continued. For example, naval architects may have focused historically on the vulnerability issue by designing ships with heavy armour; in more modern times, the emphasis has shifted to lighter-weight, stealthy vessels in tandem with emphasis on recoverability. "This balance continues to change," Rigby added.

An early rendering of the SSN-AUKUS submarine. The boat will be based around a UK-derived design, and will provide new submarine capability for the RN and Royal Australian Navy.

Designing in flexibility

Contemporary capability requirements for naval ships and submarines are increasingly focused on flexibility, designing in the capacity to adjust the capabilities onboard as and when requirements change. The Team Resolute FSS design, which is intended to give the RN flexibility to cover the evolving needs of its CSG and other operational capabilities out to beyond 2050, is designed to be adaptable.

From a naval architectural perspective, this raises the question of how best to design in such flexibility and adaptability to ensure capabilities can be adjusted as and when requirements change.

Ships like FSS, or indeed the RN's two Queen Elizabeth-class aircraft carriers, have significant capacity onboard, through using large spaces, to enable flexibility in capability. From a design perspective, the challenge is not providing such spaces themselves, however. Instead, Kimber highlighted two issues. First, is how to best design the ship's structure around that space. "You've got to get things on and off the ship, which invariably means going through the structure." Consequently, the design and positioning of equipment handling systems, rather than the spaces themselves, can create design complexity. Second, is the question of how regularly and quickly the navy concerned may

The UK Royal Navy (RN) aircraft carrier HMS Queen Elizabeth (right) conducts replenishment at sea with the auxiliary ship RFA Tidespring. The RN's future Fleet Solid Support (FSS) ship is designed with the flexibility to meet the carrier's operational requirements beyond 2050.

wish to move equipment in and out of such spaces. "The real challenge with flexibility is getting the understanding from a customer around what they really mean," said Kimber. "Do they mean 'I want to go alongside and exchange a container, and I want to do it in two hours', do they mean 'I want to change my ship over the course of a week', or do they mean 'at some point in the future I might want to fit a future system'?" "The solutions to those problems are all a little bit different," he added.

"There's a difference between modularity and adaptability," Rigby continued. "Modularity is where you can immediately switch out [equipment] within a day ....Adaptability is where you can change it alongside with some work."

"People talk about flexible ships being simpler, but from a naval architect's point of view, they're a little bit harder because there's more moving parts to think about, and some of those moving parts are usually not very well defined," Kimber added.

Designing out the human?

One new capability area that is subject to much naval architecture focus is the concept, design, and development of maritime unmanned systems (MUS). MUS as an emergent capability present both opportunities and challenges from a design perspective, including the absence of human operators onboard.

BMT has developed its Large Unmanned Surface Vessel (LUSV) concept design, which it launched at DSEI. "That's quite an interesting challenge for us, because we were going through it thinking 'if you don't have humans onboard, what spaces do you need and what spaces don't you need?' said Rigby. This can have fundamental effects from a naval architectural perspective, he explained. Having no humans onboard means no requirement to give them space and capacity to work and live.

As regards opportunities, Rigby explained, future fuel types could be incorporated if the space and weight requirements are different. The platform also can be designed with bulkheads closer together, which improves survivability. Different options can be considered for the number and arrangement of decks.

"People account for a lot of volume in a ship. A lot of the empty space is for people – not just to sleep, eat, and recreate, but in the machinery rooms for example it's for people to move around and access things. We can remove that," said Kimber. "That's a lot of volume, although interestingly it's not a lot of weight."

"So, you end up with a different balance, and that's what we're exploring with LUSV," Kimber continued. "It changes the traditional balance between how you put a ship together, because a lot of the volume you don't necessarily need, so what do you use it for?"

Answering this question can present design challenges, Kimber explained, "The conceptualised LUSV has dimensions driven by seaworthiness considerations, and the removal of volume associated with people – mostly empty space – presents an opportunity to increase the volume available for, say, propulsion systems." However, he added, "These are much heavier so the displacement becomes a limiting constraint to how much volume can be re-purposed."

Architectural intelligence

A second new technological development that is impacting naval architecture processes is artificial intelligence (AI) – especially, currently, machine learning.

As regards current impact, the important point is not whether AI could supplant human naval architects by, for example, generating ship designs more readily; it cannot yet do that. Instead, the impact is found once more in helping the naval architect tackle time-consuming processes.

"AI is such a broad term. I think what we're talking about here is machine learning as a specific sub-set," said Kimber. "We can take the processes that are repetitive, where we can gain advantage by looking at lots of evolutions and iterations, and we can teach the machine what's good and what's bad." "It's very much at that machine learning end of AI, to basically spend less time processing many options in a specific area of the design," he added.

Here, AI – and particularly machine learning – "is intelligent in the sense of repeatability and being able to use rule sets .... You still need the human intelligence to guide the artificial intelligence to look at the right thing," said Kimber. "I can use AI to look at the 1,000 options that I can't look at – but I still need to give it the parameters around the 1,000 options to look at."

BMT is already looking in detail at AI's impact on naval architecture, Rigby explained. "We have a research project continuing next year, looking at AI in ship design," he said. It will focus particularly on understanding what AI means. "The way we're breaking that down is we're not expecting to have a large language model or similar in the near future, where we can just type in 'build us a new fleet support tanker', and it will create the full design. That's not going to happen."

"What we can do is break down the design process and look at individual tasks," he continued. "There are some tasks that take considerably more time, with maybe repetitive processes, that we could automate or bring in some aspects of AI – depending on the type, whether that's reinforcement learning or otherwise – and solve that problem, giving the naval architect or the designer more time to focus on making better design decisions."

Here, Rigby highlighted the example of hullform assessment. "We're actively developing hullform automated assessments," he said. "Usually, we do parametric analysis to look at the different hullforms, assess them, and understand that solution space. With machine learning, what we do is set the solution parameters and use machine learning to explore that entire solution space." This process generates options for the naval architect to assess. "We can then say 'That's a really interesting area: we can explore that more later on'," he explained.

"The key is, this is not a different approach. That's how we've always designed hullforms," Kimber added. "The difference is the scalability. With the machine learning, we can set the machine up to assess 1,000s upon 1,000s of options, which we'd never be able to do manually .... It's just the ability to process more information."

"I'm still interested to understand whether the machine would beat a very experienced and qualified naval architect." Kimber continued. "I think there's ... still the role for the really experienced naval architect: what AI is doing is replacing people in doing all the turn-handle calculations."

"The challenge is that, in naval architecture, there's never an optimised solution. You can never say 'oh I've got a fully optimised hullform', because it's a balance, it's a compromise," Rigby added. "The human in the loop is providing that assessment of what the better compromise is, and that's not something – even with machine learning and other tools – that you can [otherwise] really make." A

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USSOCOM PURSUES NEW INSERTION TECHNIQUES

Moving onto the objective for SOF often takes methods that are 'out of the ordinary'. USSOCOM has been discussing new alternatives.

By Andrew White

At the inaugural Special Operations Forces (SOF) Week conference in Tampa, Florida in May, service leaders from across the US Special Operations Command (USSOCOM) highlighted the so-called 'tyranny of distance' across the Indo-Pacific area of operation.

As a former deputy commander of the US Indo-Pacfic Command (INDOPACOM), the incumbent USSOCOM commanding general, Bryan Fenton discussed how the rules-based international order continues to be challenged in this particular area of interest and specifically outlined how the People's Republic of China (PRC) is asserting its military power across the region while it "…coerces other nations around the world through economic and diplomatic power".

Also highlighting the ongoing activities of the Democratic People's Republic of Korea (DPRK), Fenton described how the Indo-Pacific is witnessing "strategic competition in action" with conventional military action and grey-zone operations below the threshold of conflict.

To help counter these threats, Fenton called for "fluency in technology" as USSOCOM and their international partners across the Indo-Pacific seek to assert influence across a very diverse and large area of the world.

At the same event, USSOCOM's then acquisition executive, Jim Smith, also discussed requirements for US SOF to benefit from optimal levels in "manoeuvre in contested environments" which included the Indo-Pacific.

Specifically, Smith highlighted a pair of emerging concepts which are being considered by the Tampa-based command: these include the MC-130 Amphibious Capability (MAC) and High Speed Vertical Take-Off/Landing

(HSVTOL).

MAC concept

Speaking to *Asian Military Review*, Smith confirmed USSOCOM continued to have "meaningful partnership with Japan" as they consider lessons learned from their deployment of ShinMaywa's US-2 amphibious transport aircraft.

"[USSOCOM] is looking at partnering to see what we can learn from experiences from the US-2", he said although he added it would not necessarily lead to an acquisition of that particular air frame.

USSOCOM first publicly disclosed the MAC concept in 2021, comprising the modification of an MC-130 aircraft allowing it to take-off and land at sea as a "runway independent" solution.

The command had originally expected to test a technology demonstrator by the end of 2023 but defence sources described to *AMR* how the MAC very much remains in a concept phase.

"AFSOC has a really meaningful partnership with Japan. I won't say this can necessarily lead to the adoption of the US-2, but we can definitely learn what kind of capabilities it can bring to the unique [maritime] environment. We can also learn what the Japanese have learned from operating them," an AFSOC official explained.

"From an acquisition strategy, everything is still on the table as we look at different lines of efforts to make sure that we can have a runway-independent or amphibious capability. The MAC is a tough engineering challenge but we are pursuing it and AFSOC is interested in other ways of achieving it which would make all of that water in the Indo-Pacific a landing zone," it was added.

Additional mobility concepts suited to the Indo-Pacific which are being explored by USSOCOM include the HSVTOL concept.

On 30 March, the US Defense Advanced Research Projects Agency (DARPA) published a broad agency announcement (BAA) regarding the development of the Speed and Runway Independent Technologies (SPRINT) X-Plane concept which will provide the core of the HSVTOL capability.

According to the BAA, DARPA is seeking an X-Plane demonstrator capable of transporting SOF operators across extended ranges at speeds greater than 400 knots (740 kilometres per hour) and altitudes between 15,000 and 30,000 feet (4,500-9,100 metres) above ground level with an all up weight lying somewhere between 8,000-15,000 pounds (3,600-6,800 kilograms). DARPA also informed industry that it would consider manned, unmanned and optionally-piloted solutions moving forward.

At the Air Force Association 2021 Air, Space and Cyber Conference, AFSOC announced the development of the MC-130J Combat Talon II Amphibious Capability. The removable amphibious float modification allows runway independent landing.

"The SPRINT Demonstrator Project aims to design, build, certify and fly an X-Plane to demonstrate the key technologies and integrated concepts that enable a transformational combination of aircraft speed and runway independence for future air mobility platforms. The SPRINT X-Plane project will seek to validate technologies and integrated concepts that can be scaled to different size military aircraft, provide these aircraft with the ability to cruise at speeds from 400-450kts (740-830km/h) at relevant altitudes and hover in austere environments (near unprepared surfaces)," the announcement read.

Additional requirements call for the X-Plane to have capacity to "hover and perform hover manoeuvres in a stable manner"; in addition to "transition between hover, forward flight and high speed forward flight modes in both directions in a stable manner", the BAA added.

Finally, the BAA described how the X-Plane must also be capable of landing and taking off within 300ft (90m), potentially carrying payloads up to 1,000lbs (450kg) in weight. Consideration is also being paid to potential for air-to-air refuelling of the X-Plane.

"The SPRINT X-Plane is expected to have useable flight hours left after the DARPA flight demonstration and will likely transition to [USSOCOM] for further evaluation. This evaluation may include integration of a mission package. The X-Plane should have allocations for space, weight and power for the mission package; however, any integration is not part of this solicitation," the BAA concluded.

Flight tests are expected to begin in 2027 with DARPA stipulating a maximum flight test endurance of one and a half hours and a flight radius up to 200nm (340km).

Speaking to AMR, USSOCOM officials explained how the HSVTOL concept would "close those distances [associated with the Indo-Pacific] in much more operationally relevant timelines".

"We are looking at range and speed in terms of logistics challenges and support challenges for US SOF And partners. We think the technology fits very well into operating across long range distances."

HSVTOL

USSOCOM officials informed *AMR* how Bell Textron had published details regarding an HSVTOL concept which remains in an engineering phase but also stated the DARPA project would focus on a new, clean sheet design.

Nonetheless, Bell has published marketing material illustrating potential concepts of operation for HSVTOL. These include vertical take-off from landing pads at sea before the air frame transitions into a fixed wing mode of flight.

The US Defense Advanced Research Projects Agency's (DARPA) Tactical Technology Office (TTO) is requesting proposals for the SPeed and Runway INdependent Technologies (SPRINT) X-Plane project. Its aim is to study the potential for a high-speed, runway-independent VTOL aircraft for SOF operations.

Bell's concept offers "low downwash hover capability; jet-like cruise speeds over 400kts (740km/h); true runway independence and flexibility; [and is] scalable to the range of missions from unmanned personnel recovery to tactical mobility; and aircraft gross weights ranging from 4,000lbs to over 10,000lbs [1,800-4,500kg]"

On 13 September, Bell Textron announced it had delivered a HSVTOL test article to Holloman Air Force Base, New Mexico for demonstration and technology evaluation purposes.

"The team will leverage the Arnold Engineering Development Complex Holloman High Speed Test Track to test the folding rotor, integrated propulsion and flight control technologies at representative flight speeds," a company statement confirmed.

"The HSVTOL test article delivery and start of sled testing operations serves as a major milestone in our mission to develop the next generation of high-speed vertical lift aircraft. The objective of Bell's sled test operations is to validate key technologies through a full-scale, integrated demonstration in a representative operating environment. Bell plans for the test article to execute a series of HSVTOL high-speed transition manoeuvres, a first of its kind capability for vertical lift aircraft." Bell also confirmed that it had "successfully completed functional demonstrations at Bell's Flight Research Center" ahead of delivery to Holloman AFB.

Elsewhere, USSOCOM is considering new concepts to support SOF insertion over and under water with solutions including surface vessels and swimmer delivery vehicles (SDVs) capable of being deployed from larger motherships and even strategic submarines.

Options include a next-generation variant of the Combatant Craft Medium (CCM), designated by USSOCOM's Program Executive Office - Maritime as the "Mk2 replacement craft".

Service officials confirmed to *AMR* how the CCM Mk2 will comprise an "evolution not a revolution" of the original CCM with market research and requirements analysis taking place over the course of 2023.

"We need it now and we need it quickly and are building on lessons learned from the last 10 years to modernise and make it better from a lot of different sources. We are in the beginning stages of laying out an acquisition framework and considering how we move forward with this," it was explained.

Today, USSOCOM has an inventory of 31 CCM Mk1s used to facilitate the tactical insertion and extraction of SOF units across maritime environments.

Specific areas of interest regarding the Mk2 include alternative precision, navigation and timing (PNT) technologies and capability to process, exploit and disseminate data across an area of interest.

"Relevant real-time data should be able to move in and out and get it in the hands of operators, so they can make operational decisions on the move which is going to be critical. Remember though, we're limited in space, internal and external, so antenna equipment inside is very limited. So we have to think high capacity, but low space requirement," a PEO Maritime official explained before suggesting requirement for ability to operate in GPS-denied environments.

"If we get into a GPS denied area, we know our original point, but how are we going to get to waypoints 'B' to 'C' to 'D' and back? How are we going to execute the mission with an ability to navigate in those environments is going to be critical and and technology and will be a benefit to us?'

Under the waves

Similarly, USSOCOM continues preliminary design of its next-generation Dry Combat Submersible (DCS) solution which, unlike the current variant which is entering service with US Naval Special Warfare, will be capable of being deployed underwater from a Dry Deck Shelter (DDS) integrated on board US Navy Ohio- and Virginia-class submarines.

"DCS 'Next' is in really good shape and there is good competition from the industrial base," the official confirmed but explaining how the concept is now referred to as the "Submarine Launched Dry Submersible" or SLDS.

"We are pleased with its progress and partnering with the US Navy. We've been talking for years about the maritime domain, which is extremely important to what we're doing in the Indo-Pacific area of responsibility," USSOCOM's Smith said.

"We had a successful operational test with our dry combat submersible. So that's going well, and we've got good traction on what the next-generation of that dry combat submersible looks like," he added.

PEO Maritime is also looking at a next-generation DDS solution which would extend submarine-launched capabilities yet further into the future. The future variant will be approximately 30 percent larger in terms of capacity, meaning it will be able to accommodate the original DCS model as well as the SLDS upgrade when it finally enters service.

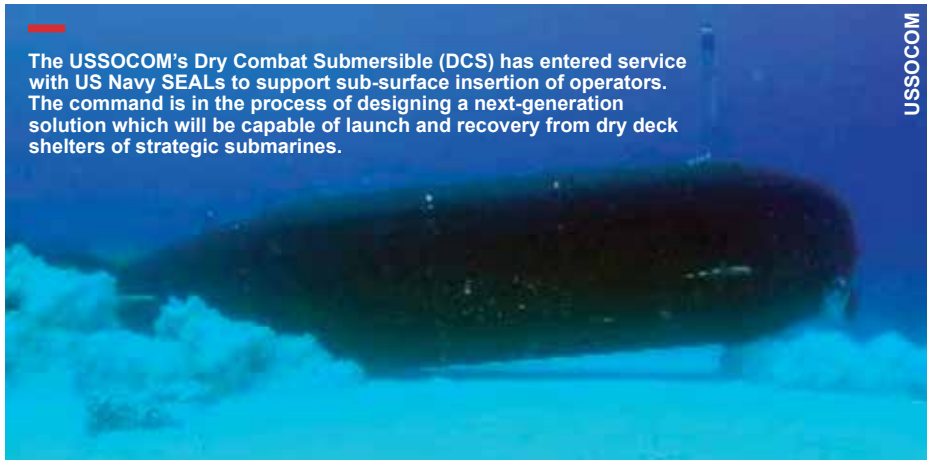
The "DDS-Next" will comprise a "21st century large ocean interface solution module, leveraging the strengths of both legacy and modified DDS to be compatible with the current and future Virginia-class submarines", according to

PEO Maritime.

"The next generation SOF asset will be a weight optimised topside hangar, capable of launching large unmanned undersea vehicles, undersea dominance group three payloads and other technology as required," documents declared before highlighting a series of operational use cases including wet and dry, manned submersible missions; autonomous launch and recovery; surface-launched unmanned aerial vehicle missions; and "mass swimmer lock-out missions".

"We are looking forward with increased capability. We want something that's bigger that can help us get into the rest of the century and increase our capability. A big key to the DDS-Next will be remote operation. That's one of the things that we're looking for that obviously involves the host submarine architecture interface," PEO Maritime's official concluded.

At SOF Week in May, PEO Maritime also highlighted the NEREUS containerised launch and recovery system for SDVs including the DCS and potentially SLDS in the future. Comprising a total of three shipping containers, NEREUS includes a crane capable of lifting up to 30,000lbs (13,600kg) in payload.



The USSOCOM's Dry Combat Submersible (DCS) has entered service with US Navy SEALs to support sub-surface insertion of operators. The command is in the process of designing a next-generation solution which will be capable of launch and recovery from dry deck shelters of strategic submarines.

On the ground, SOF are facing a very different operating environment as governments witness a sizeable pivot away from counter-insurgency towards operations associated with strategic competition.

Speaking to *AMR*, vice president at Polaris Government and Defense, Nick Francis explained how SOF employ lightweight and highly mobile vehicles to insert via tactical air platforms into austere locations around the world.

The MRZR Alpha has an enclosed cab to shelter the occupants from the environment, while the low ground contact pressure of the track system allows it to travel over adverse terrain such as snow or mud.

"Size and weight are among the most critical design elements," Francis said. "Polaris military platforms are lightweight, which helps keep the allowable cabin load low to maximise range of the helicopter without refuelling and can allow the units to carry both vehicles and personnel in a single aircraft."

According to Francis, the company's MRZR family of vehicles are all capable of being operated as internally transportable vehicles or ITVs inside a variety of air frames including V-22; H-47; Mi-17; and CH-53. He also described how larger helicopters had capacity to carry multiple vehicles providing additional capability for SOF on the ground.

Other design considerations for internal air transportability, Francis continued, include collapsible roll-over protection systems and integrated aircraft tie-downs.

"Being able to fit into multiple aircraft is paramount for interoperability – the cornerstone of the global SOF community – as forces work together and often use local assets, including rotary wing aircraft."

Once deployed on the ground, Francis explained how expeditionary SOF units need "off-road capable and modular vehicles to maximise their load for the days to weeks they'll be in the field".

"All Polaris tactical vehicles are designed to traverse unforgiving off-road environments at full payload, whether that payload is supplies, combat medicine or communications equipment, mortar systems, drones or counter-drone systems.

"These vehicles also need to have excellent range to maximise the area of operation and available routes. Expeditionary forces also want greater exportable power from our vehicles– the more the better for power-hungry systems – so we're working on systems to address that and deliver as much as 5kW from the MRZR Alpha, stationary and on-the-move," he added before suggesting Polaris develops its fleet of vehicles for a "global theatre of operation".

"The MRZR Alpha exploits everything we've learned from previous conflicts and anticipated threats. The fully enclosed cab shelters occupants from the environment, while the low ground contact pressure of the track system allows it to travel over adverse terrain like mud or snow, even at full payload.

"Our customers – be they SOF, conventional light infantry, maritime units or other expeditionary forces – are demanding more capability from every platform and in the light mobility space, multi-mission assets are critical. Having a single vehicle that can be reconfigured for various payloads and environments helps reduce the burden on acquisition, training, concepts of operations and logistics. Common equipment and assets maximise interoperability, allowing multi-national forces to work as one," he concluded. A

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The C90 corvette design from Luerssen is considered a front runner in any potential new corvette programme emanating from Adm Hilarides' analysis of Australia's surface combatant fleet. It would supplant the existing Arafura-class OPV project.

Luerssen

CHALLENGES AHEAD FOR AUSTRALIAN AND NEW ZEALAND NAVIES

The right type? The right capabilities? What is the need for both navies to readjust their fleets to face regional threats?

By Tim Fish

The changing global strategic environment and the shift of power from the Euro-Atlantic region to the Indo-Pacific is presenting considerable difficulties for Australia and New Zealand. Both countries have been slow to recognise and adapt to the rise of China as a regional and global power. There has also been a serious lack of understanding at the political level that due to the geography of the Indo-Pacific, any future peer-on-peer conflict will be maritime in nature and that the force structures of the Australian Defence Force (ADF) and New Zealand Defence Force (NZDF) should reflect that.

But there is some progress being made. In April 2023, the Australia department of defence (DoD) published its Defence Strategic Review (DSR), which has substantially changed the country's defence posture. It has called for the creation of an Anti-Access Area Denial (A2AD) zone in Australia's northern approaches in a "strategy of denial" that can protect the continent from attack.

As a result there are major changes taking place in the ADF with a focus on the procurement of long-range surveillance and strike capabilities, however, a review of the Royal Australian Navy (RAN) surface fleet was not included in the DSR. Instead, an independent assessment of the RAN's capabilities and requirements led by ex-US Navy Admiral William H. Hilarides, the 'Independent Analysis into Navy's Surface Combatant Fleet', was completed at the end of September, but it will not be published by the Australian government until well into 2024.

Considering the need for urgency stressed in the DSR to take action and reform the ADF, it is baffling why the most important element of the review was separated out and delayed by over a year. It is likely there are going to be some difficult decisions to make about the force structure of the RAN, a realignment of its current procurement programmes and how it will introduce new capabilities to meet the strategic challenges of the future.

For the RAN, the DSR calls for new fleet with a shape, size, and scope that reflects the new level of threat. However, a majority of the speculation in the media and defence circles about what the future make-up of the RAN should be rests upon the interpretation of a key line in the DSR, which states: "Such a fleet should consist of Tier 1 and Tier 2 surface combatants in order to provide for increased strike, air defence, presence operations and anti-submarine warfare."

It goes on to say that enhancing the RAN's capability in long-range strike, air defence and anti-submarine warfare (ASW) "requires the acquisition of a contemporary optimal mix of Tier 1 and Tier 2 surface combatants, consistent with a strategy of a larger number of smaller surface vessels."

Whatever new ships are selected by the Australian Ministry of Defence, the Hunter-class frigate is likely to be curtailed as the ships are not considered as important to Australian maritime security anymore. This could be a serious misconception.

This has led to a barrage of assumptions about what Tier 1 and 2 actually mean and a sort of consensus has emerged that Tier 2 means a new class of corvettes is what the RAN needs to meet this capability requirement. But to free up the budget for a new corvette project it would mean cutting back on the DoD's SEA 5000 Hunter-class frigate project and the SEA 1180 Arafura-class Offshore Patrol Vessel (OPV) programme – a significantly costly exercise.

There are problems with this assumption. Firstly, it is not exactly clear how a bunch of corvettes will be able to deliver the kind of long-range firepower and persistent presence in the maritime domain. Corvettes are small ships with limited endurance compared to frigates and won't be able to venture into the open ocean for long periods or access operational areas further afield.

While this should make them a cheaper alternative, a larger number of hulls will be needed to allow them to sustain a consistent presence in the littorals. There are also questions, due to the size of the ships, about the number of missiles a corvette will store to provide the long-range surface attack capability desired. The RAN will also need robust communications links to provide the corvettes with all the targeting information needed to carry out an attack – the sophistication and capability of a corvettes own sensors will be limited to self-defence due to the ships' smaller size.

Secondly it is hard to see how such ships can be delivered quickly in the timeframe that Australia wants them. If the Australian DoD runs a competition for a corvette project, that will take time. One option is for a single source contract to be placed with Luerssen Australia to replace the existing Arafura-class OPV production line in Western Australia and transition to the company's C90 corvette. This would utilise existing facilities and workforce, but it is not foolproof. The design will have to adapted and new supply lines established, which increases time, cost and risk.

Shipyard investment

Another alternative is to select an overseas supplier, but it would mean the abandonment of much of the considerable investment the DoD has made in Australia's naval shipbuilding industrial base. Furthermore, whilst ships could be delivered faster any design will still have to be 'Australianised'. This latter option might be unlikely because the DSR states that it wants lethality through its surface fleet and nuclear-powered attack submarine (SSN) fleet "underpinned by a continuous naval shipbuilding programme."

Behind all this is the looming presence of the AUKUS partnership, which will see the RAN eventually operate US Navy Virginia-class SSNs and then adopt the UK Royal Navy's SSN-AUKUS submarine. The DSR stated: "An enhanced lethality surface combatant fleet, that complements a conventionally-armed, nuclear-powered submarine fleet, is now essential given our changed strategic circumstances."

But how corvettes will complement SSNs is not clear. The rational is that SSNs can do ASW therefore there is a reduced need for as many Hunter-class ships, which are specially designed for ASW. However, ASW is a team effort that requires a combination of surface, air, underwater and space assets, therefore cutting the Hunter-class seems counterintuitive. The frigates may not deliver as many anti-ship missiles as the RAN seems to think it needs, but they will provide the best defence against enemy submarines. The SSNs will be few in number and those available will likely be sent on operations farther afield, not conducting ASW in Australia's northern approaches.

In short there is no easy solution, especially considering that the defence budget is not set to increase to take account of the need for a major transition in the fleet structure. Hilarides review of the surface fleet will have given the Australian DoD its recommendations with a series of options about how the

The Arafura-class OPV project is also expected to be cut back as part of a move to a new fleet construct under Australia's DSR. Adapting the Arafura-class design to host more missiles as an alternative is an unlikely option as the OPV won't meet Tier 2 requirements

required capabilities for the RAN can be delivered. How Australia will proceed and whether the RAN will acquire corvettes or not will be the defining decision of the next 30 years.

New Zealand challenges

Meanwhile across the Tasman Sea, like the Australian DSR, New Zealand's new Defence Policy Review also accepts the new geopolitical realities and it has made a point of the need to double down on governmental efforts to engage in the Pacific region.

On 8 August the New Zealand Ministry of Defence (MoD) released the first two parts of its DPR: a Defence Policy Strategic Statement (DPSS) and Future Force Design Principles (FFDP) alongside a new National Security Strategy (NSS). However, the main part of the review that outlines key defence capabilities, funding and procurement programmes – the Defence Capability Plan (DCP) – won't be released until 2024.

Again, like its antipodean neighbours, the sense of urgency presented in it defence policy document to provide funding and shape the navy to better respond to crises in the Pacific is not reflected in the slow progress in completing the DPR process. Whilst it is understandable that a significant shift is being undertaken by the naval forces of both countries that will take time to plan and realise, the long-term nature of defence procurement and delivery of capabilities suggests this work needs completing more rapidly in future.

The Royal New Zealand Navy (RNZN) faces serious challenges. It is a navy in crisis with three of its nine ships tied up alongside in long-term care for lack of crews and it can only deploy its remaining ships with a core staff. The NZDF is suffering a serious recruitment and retention crisis and because the RNZN operates a fleet of nine ships across six different classes it makes training personnel and providing support and maintenance extremely time consuming and costly.

Through accident rather than design the RNZN is due to replace most of its ships by the mid-2030s, which presents it with an opportunity to completely renew its structure, how it operates and is supported and mitigate against its existing problems.

In September 2023 the NZ MoD released Industry Engagement documents for maritime domain market research to provide options for a future force structure for the RNZN that can be included in the DCP.

The Industry Engagement documents state: "Rather than taking a 'like for like' approach to replacement, there is a unique opportunity to consider alternative fleet configurations, alternative ways to operate and alternative approaches to support the fleet in the upcoming Defence Capability Plan (DCP)."

It adds: "This may be achieved through having more of the same class of ship and greater commonality of systems across the fleet. This could mean fewer classes. The ability to combine multiple capability roles into fewer common hull forms needs to be critically examined."

Common hull

A common hull would certainly offer a solution to the RNZN's problems, however it is questionable the extent to which the varying capabilities of the existing fleet can be combined onto a two or three platforms.

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The Royal New Zealand Navy's Anzac-class frigate HMNZS *Te Kaha* provides one-half of its Naval Combat Force. The frigate and its sister ship *Te Mana* will be replaced under new plans to re-capitalise the fleet in the mid-2030s.

US Navy

The RNZN's Naval Combat Force is centred on its two Anzac-class frigates, HMNZS *Te Kaha* and HMNZS *Te Mana*. A new surface combatant project to replace them by the end of the decade was postponed in the 2019 DCP to after 2030 and the ships have recently completed a Frigate Systems Upgrade (FSU) package.

The rest of the fleet includes of two Offshore Patrol Vessels (OPVS) HMNZS *Wellington* and HMNZS *Otago* – both of which, along with one of the two Lake-class Inshore Patrol Vessels (IPVs) HMNZS *Hawea,* are laid up alongside at Devonport naval base in long-term care of RNZN maintenance and support provider Babcock NZ.

The other IPV, HMNZS *Taupo,* completed Operation *Calypso* in mid-2023 helping provide maritime security and fisheries patrolling in Samoa's Exclusive Economic Zone (EEZ) covering some 967-nautical miles. The RNZN stated in its internal magazine is "the furthest north in latitude and the furthest travelled for an IPV since the commissioning of the Lake-class vessels in 2009." This journey was admirable for such a small vessel, but the fact remains that this is the task of an OPV, except neither available for the RNZN.

It is possible that the capabilities of the frigates, OPVs and IPVs could be put onto a single hull. A project for a Southern Ocean Patrol Vessel (SOPV) to be delivered to the RNZN was abandoned in March 2022, so this will have to be included in the maritime domain market research. Meanwhile of the other ships available in the fleet there is the diving and hydrographic vessel (DHV) HMNZS *Manawanui,* the tanker HMNZS *Aotearoa,* and the multirole sealift vessel HMNZS *Canterbury.*

Although *Manawanui* is new and only entered service in 2020 it was a compromise purchase. The promise of a specialist new littoral operations and support capability (LOSC) to replace the previous dive tender *Manawanui* and hydrographic survey ship *Resolution,* which retired in 2018 and 2012 respectively was expected. However, an overspend on the Frigate Systems Upgrade project led to $86 million (NZ$148 million) of LOSC funds being siphoned away. Instead the new *Manawanui* is a former Norwegian survey vessel converted into the DHV role.

Manawanui, like the new tanker *Aotearoa,* which was commissioned in 2020, are both specialist vessels with unique roles, therefore it is unlikely these capabilities could be combined on a common hull alongside those of the frigates and OPVs. This might mean a separate hull, which would be large in size but it is not clear where a replacement for *Canterbury* might fit in. The DCP 2019 called for the procurement of a new purpose-built amphibious ship like a Landing Platform Dock (LPD) in its Enhanced Sealift Capability project. This would significantly upscale the RNZN's amphibious capability, but a LPD is another expensive specialist platform. The project has since been abandoned and the requirements included in the new maritime domain market research project.

Furthermore the RNZN wants to do more than what it can currently deliver, so additional capabilities will have to be included in any new force construct and this will impact the ability to provide more common hull solutions. According to the Industry Engagement documents the RNZN roles must include naval combat operations, maritime security operations, sealift/humanitarian aid and disaster relief, ISR, Southern Ocean and Polar Patrol, replenishment, littoral operations support and include remotely operated and autonomous unmanned assets.

The challenge for the RNZN is not just the technical challenge and whether this diverse range of capabilities can fit on one or two common hull platforms, but whether it will have enough manpower to operate its ships and if the government can actually afford to replace its entire fleet in such a short space of time by the mid-2030s. This will require a significant uplift in defence spending and for the navy to be given the lion's share of the extra funds provided.

When launching the DSR, the former Minister of Defence, Andrew Little, stated that defence spending will need to rise to more like one and a half percent of GDP well beyond the normal one percent that has been common for New Zealand in recent history. However, since 14 October his Labour government has been ejected from office and a new National-led coalition has taken over. Whilst the National Party and its allies in the right-bloc have also called for defence spending closer to two percent that might make a fleet renewal programme viable it remains to be seen whether the new government will deliver on its promises. A

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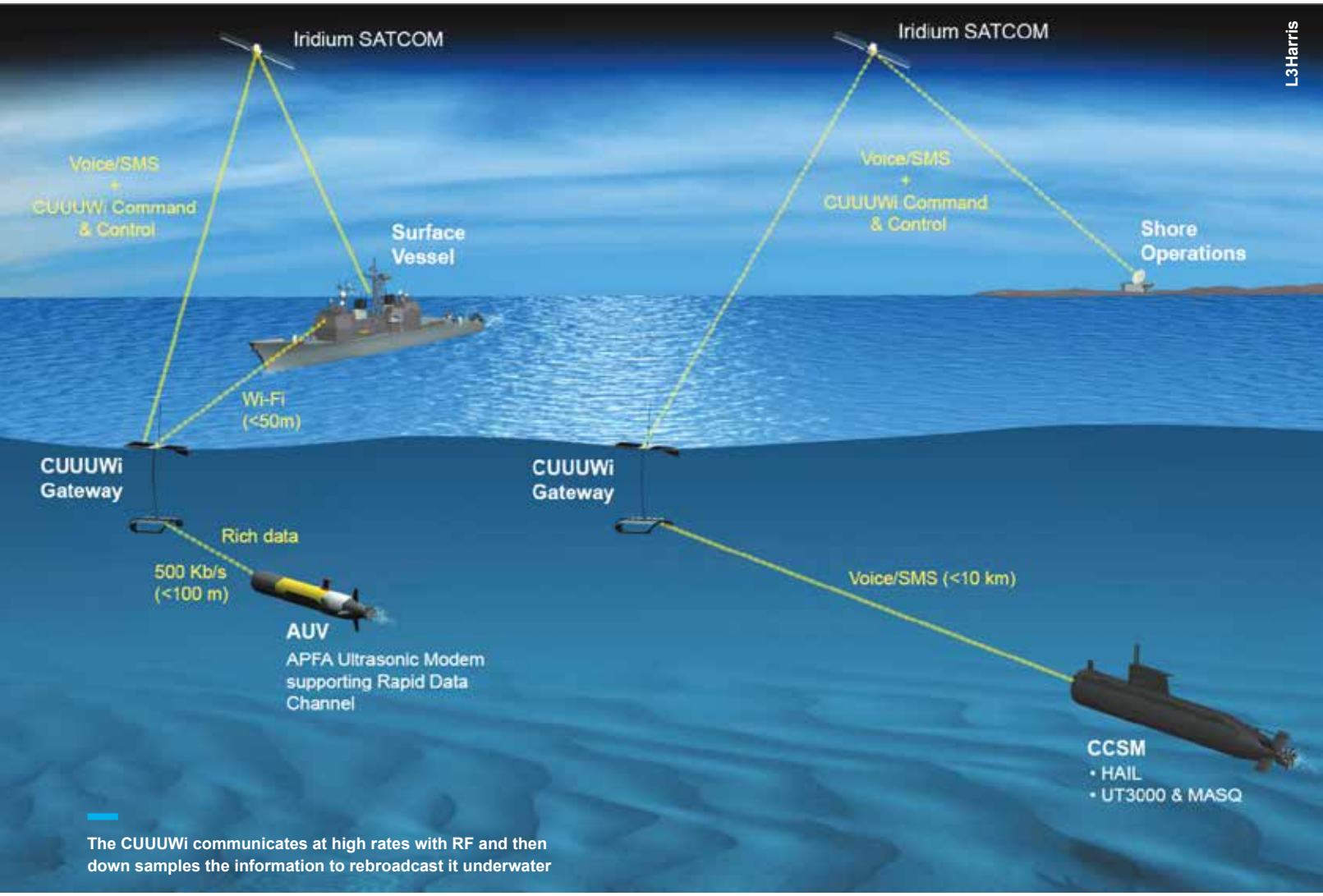


The CUUUWi communicates at high rates with RF and then down samples the information to rebroadcast it underwater

THINKING OUTSIDE THE WATER

Exploring the communication difficulties relating to seabed warfare

By Alix Valenti

Question: What do China, the Baltic and Russia have in common? Answer: seabed warfare.

There may not be any agreed definition – yet – of 'seabed warfare', but examples of what it might entail are increasingly making the headlines. From Baltic gas pipeline explosions and cutting of undersea communications cables to the revival of Cold War spy submarine programmes in the US and the development of Chinese underwater gliders - all evidence that the underwater space has become the new frontier.

But operating in this space remains a significant challenge as salinity, temperature, bathymetry and nature of the seabed all affect acoustic communications. Yet it is precisely communications that enable underwater operations, be it for cooperation or navigation purposes. In such context and contested space, industry and navies alike are working on the development of technologies and Concepts of Operations (CONOPS) that require thinking outside the box – or rather, the water.

Putting 'warfare' in 'seabed'

The technological advances of the past decades have, unquestionably, transformed the seabed into one of the most strategic spaces of our planet. Beyond undersea communications cables, known to carry 99 percent of international data and internet traffic, and gas pipelines, which provide several countries with critical energy resources, the seabed is now also at the heart of the world's energy transition. The offshore wind market, which continues to grow year on year, depends on the seabed not only for the cables connecting offshore

wind farms to shore, but also for the rare earth materials indispensable for wind turbines' construction.

In such context, the past decade has seen the transformation of the seabed into one of the most contested areas at sea.

In some locations, like the Baltic Sea, the main issue is the protection, or lack thereof, of critical undersea maritime infrastructure. On 26 September 2022, the Nord Stream gas pipelines, located in the Baltic Sea and supplying gas to Germany, exploded. On 8 October 2023, a leak in the Baltic Connector gas pipeline, which connects Sweden and Finland, was revealed and the pipeline was shut down. Recent reports indicate that telecommunications cables may also have been severed in the same incident.

While no definitive answer has been given as to the perpetrators of both of these attacks (the former has been successively attributed to Russia and then Ukraine, while the latter reportedly involved Russian and Chinese ships working in concert), they have nevertheless prompted NATO to significantly increase patrols in the area to prevent further incidents. On 12 October 2023 NATO and Allied forces also launched the Digital Ocean Initiative, which will enhance maritime surveillance from space to seabed.

In other areas, such as the Indo-Pacific, two different types of activities around the seabed have been the root cause of regional tensions. First, China has been significantly proactive in mapping out regional ocean floors, deploying underwater gliders in the South China Sea and hydrographic vessels in the Indian Ocean. Second, China's interpretation of and/or respect for the United Nations Convention of the Law of the Sea (UNCLOS) has been at the centre of multiple regional diplomatic incidents.

UNCLOS stipulates that, within their territorial sea (up to 12 nautical miles from the coast), coastal states regulate any activity undertaken on the seafloor and have the power to refuse innocent passage if some activities are deemed to prejudice the coastal state's defence or security – including research or hydrographic surveys. As such, over the past decade, China has been busy building artificial islands that aim to significantly extend its territorial sea and Exclusive Economic Zone (EEZ), where UNCLOS also grants multiple rights. The Asia Maritime Transparency Initiative counts 20 Chinese outposts alone in the contested areas of the Spratly Islands, the Paracel Islands and the Scarborough Shoal. Over the last months, there have also been multiple reports of altercations between Chinese ships and Filipino coast guard and navy vessels.

Thinking outside the water

For centuries the underwater domain was the prerogative of submarines. "These systems were solitary hunters that received an initial order and then went off on their mission," Thierry Petit, operational expert at Naval Group, told Armada International. Communication with the world above the surface, if any, was minimal. Today, submarines have company. In addition to divers mostly employed for mine warfare and covert missions, Unmanned Underwater Vehicles (UUV) are becoming an important feature of the underwater space.

As seabed warfare becomes a critical focus for several navies across the world, this trend is set to continue. In fact, taking example from the Oil & Gas (O&G) industry, these navies are looking at UUVs and Remotely Operated Vehicles (ROV) to extend their Maritime Domain Awareness (MDA) capabilities.

"This has transformed the underwater battlespace from one where platforms did not want to communicate and be found to one where communication has become critical to MDA," Ioseba Tena, commercial director at Forcys, told AI. A sentiment echoed by Petit, who added: "In the underwater domain we continue to talk extensively about platforms, such as submarines, UUVs, buoys, but these only have an added value if they can communicate while retaining stealth."

Yet communicating in the underwater domain remains challenging. Acoustics continue to represent the primary means for underwater communications, but salinity, water temperature, pressure, bathymetry and seabed composition all contribute to affecting range and bandwidth. This translates into a constant operational compromise: low frequencies allow longer ranges, typically up to 27 nautical miles (50km) but severely limit the quantity of information that can be transmitted; higher frequencies enable higher bitrates but at much shorter ranges (generally over 5nm/10km).

"Depending on whether platforms will operate in coastal or blue waters, these problems will be exacerbated," said John Camin, senior manager at L3Harris. In blue waters there are areas where the sound bends downward, impeding the propagation of sound between two points, whereas in shallow coastal waters, acoustic waves bounce around different surfaces resulting in weaker signals.

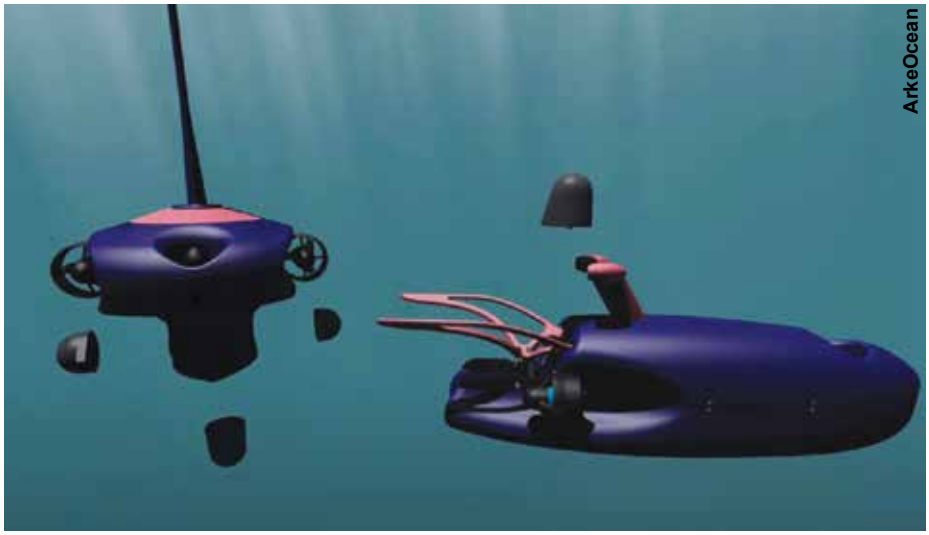
The MPT30WGX is ideal, given the constraints of a submarine, because its circumference is only 30cm and it is a proven, ruggedised technology

Similarly, navigation is challenging because there is no such thing as a GPS underwater. Underwater systems rely on acoustic waves to measure attitude and position. "The problem, however, is the doppler shift resulting from issues with the speed of sound underwater," Camin explained. As sound travels, frequencies change thus affecting the accuracy of positioning. "The same issue also affects the ability of UUVs to communicate with each other as they navigate."

"In such complex environment, developing adequate underwater communication [and navigation] systems is only possible if operational needs and profiles are well defined," Petit concluded. This includes defining range, bandwidth, stealth and reliability for each platform and system. "It also means defining how much data should be or needs to be communicated, as well as when and how," Tena added.

Multi-domain submarines

"Today submarines are fully integrated into the naval force, which means that communication between submarines and other platforms, such as frigates and potentially Maritime Patrol Aircraft [MPA], is not only more frequent but also both downlink and uplink," Petit explained.



French SME ArkeOcean, for example, has developed a solution to enables UUV swarms by building on three interconnected systems

But if a submarine's main advantage is its stealth, how can these systems safely communicate with other platforms in the naval force? Strange as it might sound, one way submarines can communicate critical information about underwater domain awareness is through SATCOMs: the submarine moves up to periscope depth, hoists the SATCOM antenna and transmits critical information to ships, MPAs and/or shore. "Currently, a submarine's main SATCOM link works in L-band, a legacy band that is not only narrow but is also no longer a match for the satellites that now function with Ku and Ka bands," Asaf Punis, VP global marketing and Business Development at Orbit Communications Systems, told AI. Additionally, issues of real estate space in a submarine mast have to be taken into consideration as the number of critical systems continues to increase.

To address these challenges, Orbit has been working to transform its airborne SATCOM antennas into systems that can be integrated into Unmanned Surface Vehicles (USVs) and, in the future, submarines. "The MPT30WGX is ideal, given the constraints of a submarine, because its circumference is only 11.8 inch (30cm) and it is a proven, ruggedised technology," Punis commented. Additionally, the MPT30WGX features low power consumption, another important characteristic for a submarine. Orbit is currently looking for partners for the integration of the MPT30WGX in the mast.

Over the past few years, industry has also been working on using submarine-launched UAVs and buoys to increase the amount of data shared between submarines and other platforms, both uplink and downlink.

At DSEI 2023, for instance, Spear UAV showcased a new capsule designed to enable of the launch of the company's Viper 750 UAV from the 4inch (10cm) signal ejector featured on most submarines and underwater platforms around the world. The capsule is programmed to either automatically release the UAV upon reaching the surface or release it at a pre-programmed/pre-agreed time. "The latter would give the submarine enough time to leave the area of operations and avoid detection, since the capsule has been designed to sink once the UAV is released," explained Itamar Ben-Tovim, chief business development officer at SpearUAV. The UAV then enters into contact with other platforms to deliver the information.

Similarly, Naval Group has been working with Alseamar to develop submarine launched buoys that can release the information at a pre-established Radio Frequency (RF) once they reach the surface. "The same can work the other way around," Petit told AI: at a pre-established time and place, a submarine can launch a buoy that then deploys its acoustic sensor to enable communications with a submarine or UUV.

The key, in this CONOPS, is to be able to transform acoustic waves into RF, and vice versa. It is in this context that L3Harris offers its CUUUWi (Communicating Using Underwater Ultrasonic Wireless) communication gateway. "The CUUUWi communicates at high rates with RF and then down samples the information to rebroadcast it underwater," Camin explained.

Finally, in order to overcome the challenge that environmental issues pose to underwater communications, DSIT has developed a computer controlled acoustic communication solution. "The way we are controlling the acoustic signal is changing," Capt. Ziv Rom, marketing/BD and Naval Warfare Systems director at RAFAEL stated: "we are now testing the underwater environment in real time to adjust the way in which we are transmitting data into the water." To achieve this, DSIT uses a pre-determined algorithm based on a table providing information on optimal data transmission according to temperature, depth and salinity. "Using the algorithm, the computer automatically adjusts transmissions in real-time to enable longer range transmission," Rom added. Thus far the system has been developed and integrated to enable transmission of text between submarines and surface ships as well as divers up to 5.3nm (10km).

Integrating UUVs

"In the present geopolitical climate, navies are already stretched, busy with multiple missions around their territorial waters, regions and/or the world and limited by budget constraints, so UUVs and ROVs are the ideal solution to try to ensure a near-constant monitoring of the seabed," said Rear Admiral Cédric Chetaille, deputy commander in charge of seabed warfare for the French Navy, during the second edition of the Euronaval Talks on 28 September 2023.

UUVs, ROVs and USVs (surface) have already become the focus of much research & development (R&D) in the Mine Countermeasure (MCM) domain and the O&G sector over the past decade. Yet while these advances clearly represent a strong basis to build on, the CONOPS within which they have been used are quite different and, therefore, less constrained by the challenges of underwater communications and navigation.

Communications, for instance, are less problematic for MCM and O&G infrastructure protection because the systems are either tethered, in constant contact with fixed beacons or simply

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Industry leaders are working on the ability of UUVs to work in swarms and communicate with one another - pictured here, ArkeOcean's Proteus (ArkeOcean)

relay the information once the mission is over. "The difference with navies is that they need to think about how to use these systems to rapidly survey vast areas and quickly (preferably covertly) alert of any anomalous activity," Tena explained. As such, the key question for navies is: how much do they wish to communicate, to whom and how?

Increasingly, industry leaders are working on the ability of UUVs to work in swarms and communicate with one another. This presents two challenges. First, as Dr Bruce Russell, head of mission systems at BMT, wrote to AI: "Increasing use of UUVs will make the underwater communication frequencies potentially more congested." To address this issue, L3Harris has developed the MASQ, a third-generation multi-channel spread spectrum technology. Emulating the technology allowing cell phone towers to process multiple cell phone individual codes at the same time, MASQ assigns each UUV a unique individual code that allows communication between multiple UUVs or between UUVs and a bay station.

Second, UUVs communication is also closely linked to their ability to position themselves within the underwater space, which is impaired by the doppler shift they experience as they navigate. One key technology on which the commercial sector depends to mitigate this issue is Ultra Short Base Line (USBL) systems. "While such technology is ubiquitous to the commercial domain, it has yet to gain more traction in the defence industry," Tena said.

Nevertheless, some emerging concepts and solutions are also integrating USBL. French SME ArkeOcean, for example, has developed Proteus, a solution to enables UUV swarms by building on three interconnected systems. INCA UUVs drift in the ocean in swarms and share the information they gather with their large synthetic receiving antennas through the MAYA UUVs, which act as data relay with surface assets. The presence of a USBL on the MAYA is what allows INCAs to continue evolving as a swarm – possible only with constant precise positioning – by recalibrating every time the MAYA surfaces. The SEAKER is the acoustic system that enables the MAYA to dock onto the INCA.

Finally, as noted by Dr Russell, "cyber security/encryption of signals will also need to be designed into network solutions." To this end, Sonardyne has been leading a technical programme to develop Phorcys, a high-integrity secure waveform for acoustic communications. The critical element of the programme is that the standard – Phorcys – is not classified, enabling access by multiple users; what is classified is the key necessary to decode the cryptographic keys that ensure the protocol is secure-by-design. In parallel, L3Harris is working on the SDAC (software defined acoustic communications), a next generation modem that will allow customers to use multiple protocols, including JANUS and Phorcys.

Swimming ahead

Because of the environment's inherent complexity, underwater communications are first and foremost about tactics. Technologies, to date, are developed to facilitate those tactics as the physics of the underwater domain continue to largely constrain decision-makers to a constant compromise: range versus bandwidth.

While for now acoustics remain the communication technology of choice, often supplemented by RF through the use of surface relays, industry leaders are also exploring other options. Naval Group, for instance, is currently looking into different uses of fibre optic cables. "One option would be to have a fibre optic cable connecting the UUV to its 'mothership' in order to relay large quantities of data very fast at relatively long distances," Petit said. Fibre optic cables as long as 50km are already being used for modern torpedoes. "Another option would be to exploit seabed fibre optic cables," Petit continued. This would be a sort of undersea 'WiFi' that would facilitate information sharing between UUVs and cables at very close range.

As is the case in multiple military domains, the use of quantum technologies is also being explored. "Quantum technologies could be used, for instance, to better model communications paths via different means, such as acoustic/RF/optical," Dr Russell added. Thales, on the other hand, is looking at quantum technologies to enable the development of smaller antennas with larger bands to provide ultra-low frequency communications with a longer range. "This would be key for UUVs where optimal SWAP is critical," Marc Delorme, Director of unmanned underwater warfare and seabed warfare projects teams at Thales, told AI.

"Currently industry and navies alike are looking at communications as a niche and are developing solutions for niche applications, but underwater communication is much bigger than that," Tena concluded. "It requires a strategy about how UUVs will communicate underwater, their interoperability, and how much information should be shared,". In other words, seabed warfare is putting the strategy into underwater communications. A

TAIWAN BRAVELY REINVIGORATES ITS SUBMARINE FLEET

By Gordon Arthur

CSBC Corporation unveiled the Indigenous Defense Submarine in Kaohsiung.

Taiwan MND

The Republic of China's (Taiwan) latest naval shipbuilding achievement is remarkable. While countries like Australia waste years dilly-dallying with indecision, Taipei has gone ahead and built the first of eight submarines in just a few short years.

Of 38 vessel classes in the Republic of China Navy (ROCN), 23 are indigenous designs. However, these are not major surface combatants like frigates or destroyers, and the country certainly had not attempted submarines before.

President Tsai Ing-wen, who initiated the submarine programme in 2016, noted: "In the past, a domestically developed submarine was considered an impossible task ... Even if there are risks, and no matter how many challenges there are, Taiwan must take this step and allow a self-reliant national defence policy to grow and flourish on our land."

CSBC Corporation unveiled the first-of-class Indigenous Defense Submarine (IDS) in Kaohsiung on 28 September. Christened Hai Kun, it was launched just 34 months after construction commenced. It is expected to perform sea trials next April, and to enter ROCN service later in 2024.

The boat, an evolution of the 1980s-era Hai Lung (Dutch Zwaardis) class, measures approximately 230 feet (70 metres) long with a 2,700-tonne displacement. It has been updated with newer technologies – primarily American ones – and X-shaped rudders which offer greater manoeuvrability.

Perhaps wisely, the ROCN has opted for traditional lead-acid batteries rather than air-independent propulsion. This reduces technical risk, especially considering that Taiwan had never built submarines before. The first IDS does not have a towed array, but this might be fitted on follow-on boats.

One concern is the price, though. Each submarine is estimated to cost $1.54 billion, so are they worth the money, or could Taiwan have invested that money more effectively on alternative asymmetric weapons like missiles and unmanned systems?

Let's remember that Taiwan is an island, and securing sea lanes, or interdicting an enemy's, is vital. There is no doubting the utility of stealthy submarines to deter enemy navies and to counter a People's Liberation Army (PLA) amphibious invasion or naval blockade. Submarines are inherently asymmetric. Furthermore, with the PLA's anti-submarine warfare capability not its greatest strength, this reinforces how it is a good asymmetric ploy.

China scoffed at Taiwan's efforts. Senior Colonel Wu Qian, the Ministry of National Defense spokesman, described the IDS as 'a broom attempting to hold back the tide'.

We do not yet know how the IDS will perform or whether it will possess design or construction defects. Nonetheless, submarines will force the PLA to dedicate considerable resources to countering them, since they can conduct reconnaissance, torpedo warships, launch cruise missiles against coastal military facilities, lay mines near enemy ports, disrupt shipping and insert/extract special forces.

Taiwan must consider its long-term defence posture, and a sizeable fleet of submarines will worry the PLA for years to come. Of course, the best zone of operations for submarine warfare is east of Taiwan, rather than the shallow waters of the Taiwan Strait.

The Hai Kun's well-balanced design is suitable for ocean-going patrols, with good weapon capacity, crew accommodation and space for three diesel generators to recharge the batteries. Armament will be SAIC-designed Mk-48 Mod 6 torpedoes, while Harpoon missiles are virtually guaranteed in the future too.

Companies from nations such as the UK and USA contributed to the IDS programme. In fact, 60 percent of an IDS boat's content comes from overseas. For instance, Lockheed Martin is supplying the combat management system, Raytheon the bow sonar and flank arrays, and L3Harris the mast-raising system. It is expected to receive electro-optical masts.

The second Hai Kun submarine is already under construction, and is due for completion in 2027. Fleet numbers are important, as Taiwan needs to have multiple hulls at sea simultaneously. It certainly does not want submarines caught by surprise in port. After losing a Kilo in Sevastopol recently, Russia knows all too well their vulnerability when not at sea!

Naturally, a single submarine, and not even eight submarines, will seriously tilt the military balance in Taiwan's favour. The PLA grossly eclipses Taiwan's military in every capability, but modern submarines do make a PLA invasion more complex and riskier.

Submarines are a deterrent, but perhaps it is more pertinent to ask whether Taiwan has the determination to build all eight boats as originally planned, and whether it can find enough personnel to crew them. A

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