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From the Sea and Beyond

September 2021

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The Many Challenges to Maritime Security

Photo: author

Undoubtedly, our attention has been focused on Afghanistan in recent days. The situation there makes us aware of how fragile our security is. However, beyond the obvious risks – such as Syria, Libya, Iraq, (Eastern) Ukraine, Iran, the Middle East as a whole and, of course, COVID-19 – others rarely penetrate our consciousness.

Hand on heart: how many worries do we have about exploding freight costs? The International Maritime Committee's piracy report hardly raises the heartbeat. The mega congestion on the world's oceans creates only peripheral concern. Yet experts agree: the upswing in the global economy is overburdening cargo shipping. And, according to the World Trade Organization's latest analyses, the trend in the indices for automotive products, container shipping and commodities is rising, the demand for transport continues unabated. The importance of maritime transport is clearly demonstrated by these considerations. Which brings us to maritime security. It is a truism that our economic prosperity and political stability depend on it. Beyond the pure commercial factors, maritime security is challenged by concrete risks. Take the South China Sea. Beijing's territorial claims are not only underpinned by the overnight arrival of new, inhabited artificial islands. They are put forward by its navy, but also by armadas of fishing boats. The US Navy regularly flies the flag in these waters to counter China's hegemonic efforts, an effort occasionally supplemented by other allied nations.

As a final thought, we should consider the Intergovernmental Panel on Climate Change's 6th report. Accelerating low-carbon projects to offset greenhouse gas emissions, as well as managing waste products more effectively, is becoming increasingly important; shipbuilders, shipping companies and navies will all have their part to play in building the new pillars of environmental compliance.

It is with these considerations that this issue of Maritime Security and Defence has been produced. Three Navy Chiefs put forward their views on the specific challenges their navies face, whilst we analyse the benefits and limitations of Freedom of Navigation Operations. We also access industry expertise to explore how water and waste handling technology can help navies meet their own environmental responsibilities. Against the backdrop of DSEI, we have several articles examining the importance of the Royal Navy and defence and security exports to post Brexit Britain. Along with our other articles covering force structure, technological and operational developments, we hope that they make interesting reading.

Yours aye
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Credit: Crown Copyright 2021

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EUROPE

POLAND: Progress on MIECZNIK (SWORDFISH) Frigate Programme

(cw) At the end of July 2021, an agreement was signed between the Polish Armaments Inspectorate and the PGZ-Miecznik consortium establishing the project for the construction of three new frigates under the MIECZNIK (SWORDFISH) programme. The circa PLN 8Bn (US$2Bn) programme encompasses the completion of the three ships in Poland within the broader framework of the 2021-2035 Technical Modernisation Plan for the Polish Armed Forces.

It has subsequently emerged that three companies have been selected to put forward concept designs for the new frigates. The shortlisted trio are Germany's ThyssenKrupp Marine Systems (offering the new MEKO A-300 PL variant), Spain's Navantia (F-100) and the United Kingdom's Babcock International (ARROWHEAD-140). It is intended to select a final design no later than the beginning of 2022, with an ambitious target set of having the prototype vessel in the water within the next four years.

MSD Editorial Commentary: The agreement reached with the PGZ-Miecznik consortium marks tangible progress with a wide-ranging and much-needed modernisation programme for the Polish Navy that has otherwise yielded only modest tangible gains to date. This hesitancy has been particularly marked with respect to the renewal of Poland's depleted submarine flotilla, which has repeatedly failed to gain traction. The three concepts are all credible contenders for final selection, with the appearance of Babcock's ARROWHEAD-140 on the list being noteworthy as the second recent "success" for its new design following its shortlisting for the Hellenic Navy's new frigate requirement a few week's previously (see our separate article). However, Navantia's F-100 variants have previously secured tangible export sales in the form of contracts with Spain and Norway, whilst TKMS's proposal may be regarded as the likely frontrunner given the overall track record of the MEKO series and Germany's previous links with Polish industry through completion of the MEKO A-100 corvette ŚLĄZAK.

Photo: Crown Copyright 2020

A variant of Navantia's F-100 design is one of three concepts shortlisted for Poland's MIECZNIK programme.

GERMANY: Saab to Upgrade German F123 Class Frigates

(jh) Saab has received a contract from the German Federal Office of Bundeswehr Equipment, Information Technology and In-Service Support (BAAINBw) to deliver and integrate new naval radars and fire control directors for the German Navy's BRANDENBURG (F123) class frigates. The contract includes a new Combat Management System (CMS), allowing a low risk integration of the new naval radars and fire control capabilities. The order value is approximately SEK4.6Bn (€464M) with deliveries and other services to take place between 2021 and 2030.

Saab will be the prime contractor and will contract the German shipyard Abeking & Rasmussen for the shipbuilding work while German company ESG will carry out logistical support.

The contract includes delivery and integration of:

- Saab's 9LV CMS
- SEA GIRAFFE 4A and SEA GIRAFFE 1X radars
- CEROS 200 Fire Control Director as well as third party systems, including IFF capability

It also includes a comprehensive, performance-based, logistics package supporting the frigates' operational capabilities. Saab will carry out the work in Germany, Sweden and Australia.

Photo: Saab)

A graphic of Saab's planned upgrade for Germany's F123 Class Frigates

GREECE: Schiebel Demonstrates S-100 to the Hellenic Navy

(jr) Schiebel has demonstrated the capabilities of its CAMCOPTER S-100 UAV to the Hellenic Navy. Stationed on board of the ELLI class frigate AIGAION (F-460) to the West of Crete, the S-100 showcased in its range, endurance and speed, as well as its maritime surveillance and detection capabilities, during a one-week trial. For the demonstration flights, the CAMCOPTER® S-100 was equipped with a Trakka TC-300 EO/IR sensor and a Shine Micro Automatic Identification System (AIS) receiver. The scenarios alternated day and night take-offs and landings. They included cooperation with other Hellenic Navy vessels, maritime traffic monitoring and coast observation.

Photo: Schiebel

Schiebel has been demonstrating its CAMCOPTER S-100 UAV to the Hellenic Navy.

IRELAND: Babcock Contracted to Upgrade SAMUEL BECKETT Class OPVs

(cw) Babcock International has been awarded a contract to deliver the installation of a variable speed drive system for the central cooling system on board the Irish Naval Service's P60 SAMUEL BECKETT class OPVs. Babcock was previously responsible for the construction of all four ships of the class and installed this variable speed drive technology on GEORGE BERNARD SHAW, the last of the OPVs to enter service. The success of the

Photo: Babcock International

Babcock International is upgrading the cooling systems onboard the Irish Naval Service's P60 SAMUEL BECKETT class OPVs.

system in saving power, fuel and cost has resulted in the Irish Naval Service requesting its retrofitting into the other vessels. Work will commence later in 2021 at the Irish Naval Service's base at Haulbowline, County Cork.

ITALY: Amphibious Assault Ship TRIESTE Starts Trials

(lp) Fincantieri commenced the first sea trials of the amphibious assault ship (LHD) TRIESTE on 12 August. The largest warship built and outfitted under the so-called Legge Navale fleet renewal programme by the temporary industrial consortium led by Fincantieri as prime contractor and encompassing Leonardo as combat system integrator and main sub-contractor, the new platform has been designed to conduct a wide range of missions. She represents a major breakthrough for the Italian Navy's ability to support a joint army & navy projection force from the sea. TRIESTE will be capable of transporting, launching and recovering an amphibious force of 600 personnel by rotary-wing assets, including also MBTs and other traced and wheeled fighting vehicles. She also has extensive command and control facilities and a fully equipped NATO Role 2E hospital. Equipped with a ski-jump, the ship has a back-up capability to launch and recover a limited number of the Lockheed Martin F-35Bs currently entering into service with Italy's Naval Aviation. She can also operate NH90, EH101 and NATO helicopters and has a stern well deck for operating landing craft. After completing her first sea trials based on a post-pandemic schedule, the new assault ship is expected to move from Muggiano near La Spezia (where she has been berthed since January 2020) to Fincantieri's Palermo shipyard, which has a large dry dock of suitable dimensions for the ship's overhaul. She will then return to Muggiano to conduct final outfitting, sea and acceptance trials, prior to being delivered in late 2022.

Photo: Giorgio Arra

The Amphibious Assault Ship TRIESTE seen departing La Spezia.

UKRAINE: Two ADA Class Corvettes for Ukraine

(kö) Ukraine has become the second export customer of Turkish ADA class corvettes, following on from Pakistan. On 14 December 2020, the Turkish and Ukrainian delegations led by the President of the Defence Industry Directorate (SSB), Professor Ismail Demir, signed a direct military procurement agreement in Ukraine. Originally, the number of corvettes to be built was not disclosed, but it has now become known that the order is for two vessels.

THE AMERICAS

UNITED STATES: MQ-25 STINGRAY Unmanned Refuelling Trials

(cw) Boeing and the US Navy have commenced initial refuelling trials with the company's unmanned MQ-25 STINGRAY T1 test asset. During a flight on 4 June 2021, MQ-25 T1 extended a hose and drogue from its US Navy-supplied Aerial Refuelling Store (ARS) to transfer jet fuel to a F/A-18 SUPER HORNET, thereby demonstrating the aircraft's ability to carry out its primary aerial refuelling mission. The event marked the first time that an unmanned aircraft has ever refuelled another aircraft in flight. A second trial in August 2021 saw the MQ-25 conclude a second refuelling mission, this time involving a Navy E-2D Hawkeye command and control aircraft. Testing with T1 is expected to continue over the next months, including flight envelope expansion, engine testing, and deck handling demonstrations aboard an aircraft carrier later in 2021. Meanwhile Boeing is currently manufacturing the first two of seven MQ-25 test aircraft and two ground test articles under a US Navy contract. The Boeing-owned MQ-25 T1 test asset is a predecessor to these aircraft.

Photo: Boeing

Boeing's MQ-25 T1 carried out the first unmanned refuelling of another aircraft on 4 June 2021.

MSD Editorial Commentary: As will be the case for many navies, unmanned and autonomous assets are set to play an increasingly important part in future US Navy operations below, on and above the water. The US is clearly betting heavily on these technologies as it moves to adopt its Distributed Maritime Operations (DMO) concept. The MQ-25 is likely to prove an important element of this strategy by increasing the flexibility and range of its carrier-based forces. In particular, the relatively short range of its existing primary F/A-18 SUPER HORNET strike fighters makes the navy heavily reliant on air-to-air refuelling if it is to keep its carrier strike forces beyond the range of its rivals' ever-expanding Anti-Access/Area-Denial (A2/AD) capabilities, placing a premium on expanding refuelling capacity. In particular, the use of dedicated refuelling aircraft will release strike fighters currently tasked with this role for combat operations. As unmanned aircraft operations from an aircraft carrier have already been successfully demonstrated by Northrop Grumman's X-47B, there seems to be no reason why the MQ-25 should not be a success in this role. The question, however, is whether it will be more effective than a traditional, manned alternative.

Photo: US Navy

Ukraine has become the latest export customer for Turkey's ADA class corvette design.

Considering the capabilities of the Ukrainian defence industry, the corvettes will most likely be equipped with a different propulsion system including a Ukrainian gas turbine, and will have weapon systems and sensor technologies adapted to the requirements of the Ukrainian Navy. Recently, Ukrainian officials have stated that the corvettes have been under construction since May this year and are expected to be delivered by the end of 2023 "fitted for, but not with", to be completed in Ukraine. Turkish authorities have stated that the contract has a value in excess of US$236M (€275M).

The Turkish Navy's ADA class corvette design is different from the Pakistani and Ukrainian vessels of the same class. The Turkish variants are 99.56 metres in length with a displacement of 2,400 tonnes while the Pakistani PN-MILGEM ADA class corvettes under construction have a displacement of 2,950 tonnes with a length of 110 metres and are equipped with a VLS.

It is also worth mentioning that the Turkish SSB procurement organisation is the design authority for ADA class surface combatants. As a result, the Turkish Ministry of Defence selects and decides on the Turkish companies to cooperate in the construction. In the Ukrainian programme, the state-owned company STM is involved. According to the SSB, talks are underway with five other countries for possible exports of the ADA class design.

CANADA: Arctic Offshore Patrol Ship Commences Maiden Operational Deployment

(cw) The lead Canadian Arctic Offshore Patrol Ship (AOPS), HARRY DEWOLFF, commenced her initial operational deployment in August 2021. The four month mission will commence with a transit of the Northwest Passage – reportedly the first such voyage by a Canadian warship for over 60 years –and involve a circumnavigation of North America. This will include anti-narcotics operations in the somewhat warmer waters of the Eastern Pacific and Caribbean Sea.

Photo: Canadian Defence Forces

The Royal Canadian Navy Ship HARRY DEWOLF has embarked on its maiden deployment.

The start of HARRY DEWOLF's operational service follows her delivery in July 2020 and subsequent commissioning on 26 June 2021. It marks the first fruits of Canada's much-criticised National Shipbuilding Strategy (NSS) – first launched in mid-2010 – for the Royal Canadian Navy. Moreover, the second AOPS, MARGARET BROOKE, was delivered by Halifax Shipyard on 15 July 2021. Six further vessels – including two for the coast guard – are either under construction or on order. Halifax Shipyard will then transition to building the Canadian Surface Combatant variant of the Type 26 Global Combat Ship, a project which is likely to prove a stern test of the yard's ability to deliver its part of the NSS programme.

ASIA-PACIFIC

INDIA: INS VIKRANT on Sea Trials

(jh) According to a press release from the Indian Ministry of Defence on 4 August 2021, most of the construction work for the Indigenous Aircraft Carrier (IAC) VIKRANT has been completed and the ship has entered her sea trials phase. Her propulsion and power generation elements had already been subject to harbour tests in November 2020 but the start of the sea trials was delayed due to the second wave of COVID.

VIKRANT has been designed by the Indian Navy's Directorate of Naval Design (DND) and is being built at Cochin Shipyard Limited (CSL), a public sector shipyard in the subordinate structure of the Ministry of Shipping (MoS). IAC is an ambitious example of the nation's quest for "Atma Nirbhar Bharat" with more than 76% cent indigenous content. This is the maiden attempt of the Indian Navy and Cochin Shipyard to design and build an aircraft carrier.

VIKRANT is 262 m long, 62 m at the widest part and has a height of 59 m, including the superstructure. There are 14 decks including five in the superstructure. The ship has over 2,300 compartments, designed for a crew of around 1,700 people, including specialised cabins to accommodate female sailors. The ship has been designed with a very high degree of automation for machinery operation, ship navigation and survivability.

VIKRANT has a top speed of around 28 knots and cruising speed of 18 knots with a range of about 7,500 nautical miles. The ship can accommodate an assortment of fixed wing and rotary aircraft.

Photos: Indian Navy

The first Indian indigenous aircraft carrier, INS VIKRANT, has commenced sea trials.

MSD Editorial Commentary: VIKRANT's maiden voyage has been a long time in the making, with design work on the IAC commencing late in the last Millennium and her keel being laid in February 2009. The programme has been marked by considerable delay and cost inflation, a phenomenon not unknown in the Indian shipbuilding sector (or, to be fair, naval shipbuilding in general). The commencement of sea trials must therefore be regarded with some relief by the Indian Navy, albeit there is still a long way to go beyond the ship's short, five-day maiden voyage before VIKRANT becomes fully operational. More broadly, the Indian Navy's hopes for acquiring a second, larger IAC and more potent naval aircraft than its current MiG-29K strike fighters remain subject to uncertainty in the face of opposition from elsewhere in the Indian defence establishment.

SOUTH KOREA: First KSS-III Submarine Delivered

(cw) The Republic of Korea Navy commissioned its first KSS-III submarine, DOSAN AHN CHANG-HO (SS-083), at a ceremony at the DSME shipyard at its giant Okpo shipyard on 13 August after conclusion of a lengthy series of first-of-class trials. The new boat's arrival marks further progress in the indigenisation of South Korea's submarine construction industry following previous licensed assembly of German-designed Type 209 (KSS-1 programme) and Type 214 (KSS-2 programme boats). Although now largely able to produce submarines with domestically-sourced technology, the Republic of Korea still had to access foreign suppliers for some key systems, including Babcock International (weapons handling equipment), ECA (steering and diving controls), INDRA (electronic countermeasures) and Safran (optronics masts). A further two KSS-III Batch 1 submarines are being completed by DSME and HII, with DSME also awarded construction of the first of a revised KSS-III Batch 2 design. These are likely to take the steady process of equipment indigenisation to a further level.

ISRAEL: Completion of German Phase of SA'AR 6 Programme

(cw) Germany's tkMS has completed its part of the SA'AR 6 MAGEN class corvette programme with the delivery of the third and fourth units ATZMAUT and NITZACHON at Kiel on 27 July 2021. The contract for the delivery of four SA'AR 6 corvettes was signed in May 2015 and the construction phase began with MAGEN's first steel cutting ceremony in February 2018. She was handed over in November 2020, being followed by second shop OZ in May 2021. The SA'AR 6 corvettes – with a length of 90 m and a full load displacement of circa 1,900 tonnes – will be the Israeli Navy's largest surface combatants, providing a greatly increased ability to protect energy and other economic assets in Israel's EEZ.

Photo: TKMS

The German Phase of the of SA'AR 6 Programme with the delivery of ATZMAUT and NITZACHON at Kiel.

Although all four SA'AR 6 corvettes have now been delivered to Israel, the programme is far from complete. The outfitting of the ships with largely Israel-sourced weaponry and sensors has been entrusted to Israel Shipyards, which has also constructed a new floating dock to support the class's completion and subsequent maintenance. Equipment is understood to include the ELTA Systems ELM-2248 MF-STAR active scanned array, BARAK 8 and C-DOME surface-to-air missiles and the latest variant of the GABRIEL family of surface-to-surface missiles.

AFRICA & THE MIDDLE EAST

EGYPT: Further Advances for the Egyptian Navy

(cw) Two events in July 2021 saw further progress achieved with the Egyptian Navy's remarkable programme of expansion and modernisation. On 3 July, President Abdel Fattah El-Sisi inaugurated a 1,000-metre-long deep-water pier capable of handling ships with a draught of up 14 m at Ras Gargoub, which lies between the country's main naval base at Alexandria and the Libyan border. The pier forms part of a much larger "July 3" (the day El-Sisi led the overthrow of the previous Mohamed Morsi regime) base complex which is said to extend over 10 square kilometres.

Photo: TKMS

Egypt has received its fourth Type 209/1400 submarine.

Four days later, on 7 July 2021, a ceremony was held at Kiel to mark ThyssenKrupp Marine Systems' transfer of the fourth and final Type 209/1400 submarine ordered by the Egyptian Navy. A contract for the delivery of two 209/1400 submarines was signed in 2011 and subsequently, in 2015, Egypt decided to take up an option for two additional units. The first submarine was handed over in December 2016, the second in August 2017 and the third in April 2020. The submarines have a surface displacement of 1,450 tonnes, a submerged displacement of 1,600 tonnes and are 62 metres in length.

MSD Editorial Commentary: Egypt's naval modernisation is steadily providing the means of making the country a regional maritime power, a fact reflected by the presence of Abu Dhabi Crown Prince Sheikh Mohammed bin Zayed al-Nahyan at the at Ras Gargoub inauguration. It is encouraging that Egypt is backing the acquisition of new naval hardware with supporting infrastructure, although concerns must remain about its ability to maintain the equipment it is obtaining from a wide variety of sources. This was reflected by the presence of warships and a submarine from various French, German and Italian manufacturers at the 3 July ceremony. Whilst providing Egypt with strategic independence from the actions of any one supplier, the maintenance of such a diverse fleet opens up the risk of a severe headache keeping the fleet operational in the years ahead.

The Royal Navy Post Brexit: Priorities & Challenges

Richard Beedall

The story of the Royal Navy (RN) over the last 70 years has been one of steady decline in both its size – in terms of personnel and numbers of ships – and importance, both nationally and internationally.

In 1968, the then Labour government decided that the United Kingdom could no longer afford to maintain a substantial military presence around the world. Historic naval bases such as Malta and Singapore were subsequently closed and the ships came home, often to be scrapped. By the late 1970's the RN was focused on the North Atlantic and its commitments as a member of NATO. The end of the Cold War encouraged the RN to adopt a more expeditionary focus, and this was approved by another Labour government in 1998. However, the necessary funding was diverted to pay for operations in Iraq and Afghanistan.

The mid-2010s were a low point for the RN – promised orders for new ships had not been placed, warships were laid-up for lack of sailors, other warships were operating with serious defects, and exercises were being cancelled to save money.

Brexit and Global Britain

On 23 June 2016 the United Kingdom held a referendum on the country's membership of the European Union. A narrow majority – 52% to 48% – voted in favour of Leave and, on 31 January 2020, the UK's membership of the EU ended, 47 years after it joined. After a transition period, Brexit was completed on 1 January 2021 and new treaties and agreements between the UK and EU now apply.

Boris Johnson became the UK's Prime Minister on 24 July 2019, with a vision of a post-Brexit "Global Britain" playing a far more active role on the world stage – as befitted a permanent member of the UN Security Council; a position increasingly under challenge from countries such as India. The PM considers the British armed forces, and in particular the Royal Navy, to be key components for the fulfilling of this vision. On 19 November 2020 he made a speech to parliament pledging to "restore Britain's position as the foremost naval power in Europe".

The PM has adopted a robust approach to using the RN to demonstrate the UK's strength and to defend values such as "democracy, human rights, equalities and the rule of law, and freedom of navigation". A good example is the passage on 23 June 2021 of the destroyer HMS DEFENDER through waters claimed by Russia after its annexation of the Crimea from Ukraine.

Photo: Crown Copyright 2020

The destroyer HMS DEFENDER is seen operating alongside the aircraft carrier HMS QUEEN ELIZABETH. DEFENDER's transit of Crimean waters in June 2021 is an example of the UK's use of the Royal Navy to defend international values.

The Integrated Review

A review of the UK's foreign and defence policy post-Brexit resulted in the publication on 16 March 2021 of *Global Britain in a competitive age: The Integrated Review of Security, Defence, Development and Foreign Policy* (IR2021). A week later the UK's Ministry of Defence (MoD) issued a Command Paper *Defence in a Competitive Age* which describes how the Royal Navy and other armed forces will change.

IR2021 is backed by a substantial increase in funding, with the UK's 2021/22 defence budget becoming GBP46Bn (€53Bn), an increase of circa six percent in real terms compared to 2020/21. A similar increase is planned for 2022/23. As a result, UK defence spending exceeds any EU country and is currently fifth highest in the world.

Whilst the UK defence budget is increasing, the extra money is needed to plug a funding shortfall in the Equipment Plan; and to pay for the establishment of new capabilities such as Space and Cyber Warfare. The budget for the traditional armed forces is essentially static and any increase in one area – such as underwater surveillance – requires cuts in others.

There was speculation that IR2021 would eliminate the RN's amphibious warfare capabilities, already much reduced compared to a decade earlier. However, this was avoided – perhaps because a lesson from previous UK defence reviews is that it is very easy to remove defence capabilities but very hard and and expensive to rebuild them. For example, in December 2009 it was decided to gap the RN's aircraft carrier capability, and this was implemented with-

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Photo: Crown Copyright 2019

The amphibious transport dock HMS ALBION. The RN's amphibious capabilities emerged unscathed from the Integrated Review process.

in weeks. Unfortunately, in March 2010 the UK commenced military action against Libya - which would have greatly benefited from the inclusion of a RN aircraft carrier.
In general, it takes about a decade to build a new class of warship, double that for very large and complex warships and submarines. As such, the RN is only just starting to adapt to Brexit. Also, IR2021 is surprisingly vague about how the RN will need to evolve because of Brexit; on close examination the similarities – such as force levels – with previous defence and security reviews published in 2010 and 2015 are far greater than the differences, such as forward basing. Nevertheless, several challenges have emerged that were not a high priority for the RN prior to June 2016.

The Exclusive Economic Zone & Fishing Protection

The UK's Exclusive Economic Zone (EEZ) in European waters covers 773,676 sq. km (298,718 sq. miles) and includes many rich fisheries. The Royal Navy patrols most of the UK's EEZ and enforces fishery protection laws by conducting inspections of fishing vessels. An exception is for Scottish waters, where responsibility has been devolved to Marine Scotland.

Whilst Fishery Protection is a role the RN has undertaken since the fourteenth century, it has been a low priority for many years, with just three RIVER class Batch 1 Offshore Patrol Vessels (OPVs) dedicated to patrolling UK waters since 2003. Two of these had already been decommissioned when, in November 2018, a belated decision was made to retain them "to bolster the UK's ability to protect our fishing fleet". Before Brexit, UK waters were heavily exploited by EU, particularly, Danish, Dutch and French fishing vessels, taking well over half of the overall fishing catch in tonnage terms. Post-Brexit, it has been agreed that the value of the UK's quota will increase by the assumption of a quarter of the previous EU allocations by 2026 , and that thereafter the UK will have the theoretical right to exclude EU boats. Also, the Fisheries Act, which became law on 24 November 2020 requires that the "fishing activities of UK fishing boats bring social or economic benefits to the United Kingdom". This reflected the fact that many British-registered vessels were actually foreign owned and crewed.
When a new fishing licence scheme – agreed with the EU – was introduced in April 2021, enforcement of the new rules quickly proved problematic. For example, in early May 2021, 60 French fishing vessels blockaded the St Helier Harbour in Jersey, the fishermen complaining that they had not been granted licences. Two RN OPV's were ordered to the port to protect Jersey from the potential blockade.
Whilst Brexit has resulted in the retention of three OPV's in UK waters, one is often used for training duties. Overall, the current force is under-resourced and badly stretched – with no remediation in sight.

Photo: Conrad Waters

Fishery protection across Britain's EEZ has increased in importance post Brexit. This is the offshore patrol vessel HMS MERSEY.

Forward Basing

Five new RIVER class Batch 2 OPVs were ordered in 2013 and 2016 with the expectation that they would primarily operate in UK waters, replacing the Batch 1s. However, by the time the last was commissioned in 18 June 2021, plans had completely changed because of Brexit and IR2021. Instead they now form the newly-renamed Overseas Patrol Squadron, with the ships forward deployed to Gibraltar (for service in the Mediterranean and West African waters), the Falkland Islands, the Caribbean and, soon, the Far East.

The Threat from Russia and China

The IR2021 says "China's military modernisation and growing international assertiveness within the Indo-Pacific region and beyond will pose an increasing risk to UK interests", but it also says "in our home region of the Euro-Atlantic … Russia remains the most acute threat to our security".
In an interview published by the Daily Telegraph newspaper on 23 May 2021, Secretary of State for Defence Ben Wallace described Russia as the UK's "number one adversary threat… we are regularly visited now by a number of Russian warships". He cited the appearance of a Russian submarine (KILO class) in the Irish Sea as being the first for "many, many years".
A particular concern is the danger to UK underwater infrastructure (gas and oil pipelines, power and telecommunication cables) posed by specialist Russian ship ships and deep diving midget submarines. IR2021 announced that RN will receive a Multi-Role Ocean Surveillance Ship to protect this undersea infrastructure using advanced sensors and remotely operated autonomous undersea drones. This will enter service in 2024 and a second vessel may follow.

Indo-Pacific Tilt

IR2021 proposes a UK "tilt to the Indo-Pacific" in response to China's assertiveness, which presents "the biggest state-based

threat to the UK's economic security". This had been much leaked, resulting in speculation about major new bases being built and a substantial permanent RN force in the region for the first time since 1971. The reality is that the seas around Europe will continue to be the primary focus of the RN, but its presence "East of Suez" is in the course of steadily increasing in several ways:

- The resumption of regular high-profile deployments to the region by substantial RN task groups, exercising with local navies and making "flag waving" port visits
- The forward deployment of a frigate (currently HMS MONTROSE) and the 9th Mine Countermeasures Squadron at a support facility in Bahrain
- The forward deployment of two RIVER class Batch 2 OPVs (HMS TAMAR and SPEY) to the region, probably operating from a support unit at Singapore. These will be replaced by Type 31 frigates by the end of the decade
- RFA CARDIGAN BAY, a BAY class auxiliary landing ship, will be converted to a Littoral Strike Ship. With a company-size formation of Royal Marines embarked, she will forward deploy to the region by the end of 2023
- The establishment of the UK Joint Logistics Support Base at the Indian Ocean port of Al Duqm in Oman, this can dock and maintain RN warships of any size.

The current deployment to the region of a multi-national task group (CSG21) led by the RN's new fleet flagship, HMS QUEEN ELIZABETH, is an obvious manifestation of this 'tilt'.

The increasing RN presence in the region has received a positive reception from many local countries and reputedly helped the UK's successful bid in January 2021 to become a Dialogue Partner of the Association of Southeast Asian Nations (ASEAN). It may also positively assist the UK's application to join the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTP).

The UK Carrier Strike Group

For the UK government, Brexit has fortuitously coincided with the Royal Navy's largest ever warship - the aircraft carrier QUEEN ELIZABETH - entering operational service. In January 2019 it was announced that her first deployment would be to the Far East in early 2021, and this date became politically immoveable. Despite many challenges, including the COVID-19 pandemic, Carrier Strike Group (CSG21) sailed on 22 May to begin what both politicians and media called the "largest fleet of Royal Navy warships to deploy since the 1982" – albeit with American and Dutch contributions to the nine-ship force. The PM visited the carrier just before it departed and stated that it "would be projecting not just Britain's hard power but military capabilities, but also our soft power. … One of the things we'll be doing is showing to our friends in China that we believe in the international law of the sea".

QUEEN ELIZABETH and her sister ship PRINCE OF WALES will alternate as the capital ship in the UK Carrier Strike Group. This impressive force can be matched by few navies world-wide, and only France in the EU. However, it can only be in one place at a time and represents a large proportion of the RN's mass.

Global Overstretch

A key problem for the RN is its sheer lack of warships and submarines - and deploying what it does have around the world spreads them very thinly. For example, the

Picture: Crown Copyright, Open Government Licence

A F-35B strike fighter operating from the deck of HMS QUEEN ELIZABETH during the CSG21 deployment. The Royal Navy's carrier strike group provides a capability matched by only a handful of other fleets.

Royal Navy currently has 18 escorts (six Type 45 destroyers and 12 tired Type 23 frigates). From open sources, in June 2021 around ten were operational, the highest number for many years. Of these, four were deployed with CSG21 in the Far East and one was in the Arabian Gulf – that is, half of the available escorts were committed 'East of Suez'. It is easy to envisage scenarios where the remaining escorts are inadequate in number. Further, another Type 23 frigate will be decommissioned by the end of 2022, leaving just 17 in service It's not until 2025 that the first of 13 new Type 26 and 31 frigates to replace the existing force is expected to enter service. Escort numbers will then slowly creep back up with the proposed development of a new Type 32 frigate with an optimistic target for the total escort force of 24 by the early 2030s.

The situation is even worse for nuclear attack submarines. A once 15 strong force is currently reduced to just five boats – three modern ASTUTE class and two elderly TRAFALGAR class boats – and operational availability is believed to be poor. [1] A key responsibility of the force is the protection of nuclear deterrent strategic submarines, to which has recently been added escorting the two new aircraft carriers; for example an ASTUTE class boat is accompanying CSG21. This leaves little capacity for other tasks. However, the RN does hope to be back up to seven attack submarines – all ASTUTE class – by 2026/27.

National Flagship

An unexpected priority resulting from Brexit is the construction of a "National Flagship" which will hold high-level conferences and meetings, support important sales campaigns and promote Britain.

The project is backed by Prime Minister Johnson, who stated in May 2021 that the flagship would be "the first vessel of its kind in the world" and would reflect "the UK's burgeoning status as a great, independent maritime trading nation … a clear and powerful symbol of our commitment to be an active player on the world stage". An expedited procurement process has begun, which includes a requirement that the ship is built in the UK. An order is expected to be placed by early 2022, with first steel cut before the end of the year. It is hoped that this will be attended by HM Queen Elizabeth II as part of the events marking her Platinum Jubilee, and that the Royal Family will occasionally use the ship during overseas visits.

The PM has decided that the basic construction cost of the ship will be met from within the MoD's existing budget, but other organisations will be asked to contribute towards its fitting-out. The RN will provide the ship's 60-70 crew, with trainees, naval cadets and reservists used to minimise the impact on frontline operations.

Defence Co-operation with the EU

The EU has developed a Common Security and Defence Policy, and since 2017 has been encouraging members to participate in the Permanent Structured Cooperation (PESCO). However, the UK's view – even before Brexit – was that NATO was the primary guarantor of European security, and the establishment of military command and control structures and other expensive defence initiatives by the EU was at best an unnecessary duplication and complication. Since Brexit the UK has been actively pursuing bi-lateral military and security agreements with individual EU members. France is the most important partner, despite the French President's vocal and public opposition to Brexit. The Lancaster House Treaties signed in 2010 have been revitalised, resulting in often hidden but close military co-operation. From an RN perspective this includes areas ranging from UK-French carrier strike group collaboration to the procurement of new mine countermeasure systems. The cross deployment of military assets and personnel is commonplace.

Break-up of the United Kingdom

In September 2014 Scotland narrowly voted in a referendum to remain part of the UK. However, significant powers have

The destroyers HMS DRAGON and HMS DUNCAN seen during a Mediterranean deployment. The small force of surface escorts is being increasingly stretched by the Royal Navy's international commitments.

been devolved to the Scottish Parliament, which has been dominated by the Scottish Nationalist Party (SNP) for many years. The SNP was against Brexit and is now campaigning for a second independence referendum (IndyRef2) with the slogan "An Independent Scotland within the EU". The UK government may eventually have to permit IndyyRef2 and it is conceivable that there could be a majority in favour of independence. That eventuality would present the RN with a number of major challenges.

Firstly, over the last decade there has been significant increase in warship construction in Scotland. In his November 2020 speech, Boris Johnson said "Shipbuilding … benefits the union in the white light of the arc welder's torch. If there was one policy which strengthens the UK in every possible sense, it is building more ships for the Royal Navy". In addition to BAE Systems' facilities on the River Clyde, the Rosyth Dockyard owned by Babcock Marine has developed into a major builder of RN warships, receiving an order for five Type 31 frigates in 2019. Conversely many English shipyards have closed or are a fraction of their former size.

Given that it is stated government policy to build all warships locally, an independent Scotland would require the relocation of orders back to shipyards in England or Northern Ireland, although the later may also be problematic. Scottish independence would probably trigger an Irish Border poll, which could result in Northern Ireland also leaving the UK and becoming part of the Republic of Ireland.

Photo: BAE Systems

The ASTUTE class submarine HMS ANSON being rolled out of the building hall at Barrow-in-Furness in April 2021. Delays in bringing the class into service have affected the number of operational submarines in Royal Navy service.

Secondly, the MoD is currently completing a costly upgrade of the naval base HMNB CLYDE, located at Faslane, Scotland. All RN submarines are now based there, including the VANGUARD class nuclear ballistic missile submarines, and eventually their successors, the DREADNOUGHT class. The SNP and its close allies the Scottish Greens oppose nuclear weapons and the basing of nuclear-powered warships at Faslane.

If Scotland were to become independent, it would almost certainly demand the removal or decommissioning of all nuclear facilities at Faslane. Building a new base to replace Faslane would be very expensive, even if suitable site could be identified within the remainder of the UK. The most likely solution is that HMNB DEVONPORT would be reactivated as an operational submarine base for the ASTUTE class attack submarines. The situation with respect to strategic submarines would be more difficult given their more complex support requirements, with agreement with the United States to base the strategic submarines at the US Navy's Naval Submarine Base Kings Bay being one possibility.

Photo: Crown Copyright 2012

The lead VANGUARD class strategic submarine departs Faslane. Continued pressure for Scottish independence could have a material impact on where the United Kingdom's nuclear deterrent is based.

Summary

Brexit has resulted in the RN receiving a level of political attention and support that it has lacked for decades. However current force levels are insufficient to meet competing threats, government strategy, and political objectives. It will take a decade, and a sustained level of investment, for the Royal Navy to 'bulk up' to the extent that it is stretched rather than overstretched. In the meantime, the ongoing debate over the future of the UK adds considerable uncertainty to any naval renaissance.

Note

1. A fourth ASTUTE, HMS AUDACIOUS, is in commission but still in the course of post-delivery work up.

US Navy Force Structure Divergent "Roads" Ahead

Scott C. Truver

On 20 December 2020 the three US Sea Services released the latest in a long line of maritime strategies, *Advantage at Sea: Prevailing with Integrated All-Domain Naval Power, Tri-Service Maritime Strategy, USCG, USN, USMC.* The document provides strategic guidance on how the Sea Services will prevail in day-to-day competition, crisis, and conflict during the next decade.

"Our integrated Navy, Marine Corps, and Coast Guard must maintain clear-eyed resolve to compete with, deter, and, if necessary, defeat our adversaries while we accelerate development of a modernized, integrated all-domain naval force for the future," wrote Chief of Naval Operations (CNO) Admiral Michael M. Gilday, Marine Corps Commandant General David H. Berger, and Coast Guard Commandant Admiral Karl L. Schultz. "Our actions in this decade will shape the maritime balance of power for the rest of this century."

Advantage at Sea focuses principally on China and Russia. "As Sailors, we are on the leading edge of Great Power Competition each and every day," the 2020 Strategy asserted. "Sea control, power projection and the capability to dominate the oceans must be our primary focus….. This strategy helps us do exactly that…the future fleet will combine legacy assets with new, smaller ships, lighter amphibious ships, modernized aircraft, expanded logistics, resilient space capabilities, and optionally manned and unmanned platforms."

But first the United States Navy (USN) needs to agree and stick with a plan.

Photos: US Navy

The destroyer USS BARRY (DDG-52) in company with the amphibious assault ship USS AMERICA (LHA-6). The US Navy has to decide the future role of large surface warships and amphibious vessels in its future fleet.

Navy Force Structure in Constant Flux

The Congressional Budget Office's (CBO's) Eric Labs and Congressional Research Service's (CRS's) Ronald O'Rourke have, for decades, dissected the plans, programmes, and costs for the size and mix of the US Navy's fleet, addressing the annual rate of ship procurement, the affordability of shipbuilding plans, and the capacity of the US shipbuilding industry to execute new-construction and in-service maintenance and upgrade programmes. They have been faced with an ever-evolving picture.

Author

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Current Force Structure Assessment: "In 2016, the [USN] conducted a Force Structure Assessment (FSA) that recommended a 355-ship goal," O'Rourke explained. "In an FSA, the Navy receives inputs from U.S. regional combatant commanders (CCDRs) regarding the types and amounts of Navy capabilities that CCDRs deem necessary for implementing the USN's portion of the national military strategy." He continued, "The USN then translates CCDR inputs into required numbers and types of ships, using the current forces as a baseline. The analysis takes into account capabilities for warfighting, crisis response, and day-to-day forward-deployed presence." Previous USN force-level goals are:

- 1985 Maritime Strategy: 600 ships
- 1992 Base Force: 450 ships
- 2001 Quadrennial Defense Review: 310 or 312 ships
- 2002-2004: 375 ships
- 2005: 260-325 ships
- February 2006: 313 ships in two fleet mixes
- September 2006 through 2011: 313 ships
- March 2012: 310-316 ships
- January 2013: 306 ships
- March 2015: 308 ships

The information contained in these FSAs is supplemented by the USN's annual 30-year shipbuilding reports, which are required by the US Congress. The 9 December 2020 *Report to Congress on the Annual Long-Range Plan for Construction of Naval Ves-*

sels reflected the result of a Future Naval Force Study (FNFS) that assessed competitive advantage in great power military competition through 2045.

"In December 2016," O'Rourke wrote, "the Navy released a force-structure goal that called for achieving and maintaining a fleet of 355 ships of certain types and numbers…. The Navy and the Department of Defense…have been working since 2019 to develop a successor for the 355-ship force-level goal. The new goal is expected to introduce a new, more distributed fleet architecture featuring a smaller proportion of larger ships, a larger proportion of smaller ships, and a new third tier of large unmanned vehicles (UVs)."

The US Navy's December 2016 force-level goal, still the FSA of record, outlined reaching and maintaining by 2045 a fleet of 355 battle-force ships. On 15 July 2021, the in-service fleet numbered 297 ships.

Future Plans: The annual long-range plan submitted to Congress by the lame-duck Trump administration on 9 December 2020 looked to provide a stake-in-the-ground for a revised, enlarged target for the USN's size in 2045. This "Battle Force 2045" envisioned a distributed fleet architecture of 382 to 446 manned ships and 143 to 242 large USVs.

CBO's Labs explained that the USN planned to procure "404 new ships between 2022 and 2051—300 combat ships and 104 logistics and support ships. The Navy also planned to acquire 223 unmanned undersea and surface vehicles to supplement the fleet. If the Navy adhered to the schedule for purchases and ship retirements outlined in its December 2020 plan" he continued, "the inventory of manned ships would rise from about 300 to about 400 by 2038. The force of unmanned systems would rise from just a few prototypes today to about 140 by 2045."

However, that would not have come cheap. "The December 2020 plan would require average annual shipbuilding appropriations almost 50 percent larger than the average over the past five years," Labs predicted. "CBO estimates that total shipbuilding costs, including costs for nuclear refuelling and unmanned systems, would average about US$34Bn per year (in 2021 dollars), ten percent more than the Navy estimated. Annual operation and support costs for the fleet would grow from US$74Bn today to US$113Bn by 2051." The bottom line: "The Navy's total budget would increase from about US$200Bn today to US$279Bn (in fiscal year 2021 dollars) by 2051."

These figures might have impacted subsequent developments. In June 2021, the USN

Table 1: The 355-Ship Force Level Goal 2016 and Reality 2021

	Number of Battle Force Ships	
Ship Category	**2016 FSA**	**July 2021**
Ballistic missile submarines (SSBNs)	12	14
Attack submarines (SSN/SSGNs)	66	54
Aircraft carriers (CVNs)	12	11
Large surface combatants, cruisers (CGs) and destroyers (DDGs)	104	92
Small surface combatants (frigates [FFGs], Littoral Combat Ships [LCSs], and mine countermeasures [MCM] ships)	52	32
Amphibious ships	38	31
Combat Logistics Force (CLF) at-sea resupply ships	32	29
Command and support ships	39	34
TOTAL	**355**	**297**

The autonomous USV SEA HUNTER. Large and medium-sized autonomous surface and underwater vehicles will form a steadily increasing part of the US Navy's fleet.

There is an ongoing debate as to whether the US Navy's future aircraft carrier force should be formed entirely of large, nuclear powered carriers of the USS GERALD R. FORD (CVN-78) class or whether there is space for smaller "Lightning carriers" similar to Italy's CAVOUR.

VIRGINIA class nuclear powered attack submarines – this is USS INDIANA (SSN-789) – will be an important component of US naval power under almost all plans.

submitted to Congress a FY2022 update to its 2020 long-range shipbuilding plan, stepping back from both the 355-ship fleet and "Battle Force 2045" instead articulating revised priorities for a future distributed naval force. The new plan laid out a fleet as low as 321 manned ships and as large as 372 manned ships. The high-end fleet would counter threats from China and Russia in a future fight. The lower number reflects mid-2021 fiscal constraints and industry capacity. "Based on the top-line that we have," CNO Admiral Gilday admitted, "we can afford a Navy of about 300 ships…with little hope that Navy shipbuilding budgets will increase drastically in the next few years."

Those 321 to 372 manned ships would be supplemented by a yet-to-be-determined force of between 77 and 140 unmanned surface and underwater vehicles. The update promised the USN would release a detailed long-range plan with the FY 2023 budget request in 2022.

In a 17 June 2021 congressional hearing, Secretary of Defense Lloyd Austin called 355 ships "a good goal to shoot for" but said he was working to field "the right mix of capabilities. Size matters, but capabilities also matter", he said.

Force Elements

Aircraft Carriers: As of mid-2021, the size, shape, and cost of aircraft carriers were under scrutiny, again. The carrier force then comprised ten NIMITZ (CVN-68) class nuclear-powered aircraft carriers and the first-of-class GERALD R. FORD (CVN-78). CVN-79 and CVN-80 were also under construction. CBO's Labs calculated the future carrier force under the December 2020 plan would require the acquisition of six FORD class carriers between 2022 and 2051. The number of carriers would remain at 11 through to 2040, falling to about ten through 2051. Carriers have service lives of 50 years, so to reach and sustain a force of 11 ships – the higher goal in the FNFS and one required by law – the USN would need to acquire one carrier every three and a half years between 2028 and 2051.

Although the December 2020 "Battle Force 2045" called for a study of conventional (non-nuclear powered) "light carriers" (CVLs), the plan did not commit to acquiring light or so-called "Lightning" carriers. The June 2021 update also continued support for CVNs but noted that "new capability concepts like a light aircraft carrier continue to be studied and analysed to fully illuminate their potential to execute key missions."

None of this is new. A gaggle of future carrier studies since the early 1960s have wrestled with the "big vs. little" and "nuclear vs. oil-fired" conundrum. "Big and nuclear" carriers, complemented by big-deck amphibious warships since 1975, have been the best option on which to place a bet over this period and this seems likely to continue.

Ballistic Missile Submarines/Guided Missile Submarines: In 2021, the USN's ballistic missile submarine (SSBN) force totalled 14 OHIO (SSBN-726) class boats. The Navy has ordered the first of a new class of 12 SSBNs, the COLUMBIA (SSBN-826) class, to replace retiring OHIO submarines during the next 20 years. The Navy estimates that the submarines will take seven years to build and test, so COLUMBIA would be commissioned in 2028 and go on its first patrol some three years later. These plans seem likely to continue.

"Now it's really about execution," said James Geurts, then the Navy's acquisition chief, in 2020. "The design, maturity of this program surpasses any other sub-

Large surface warships have been seen as being relatively less important in recent US Navy plans and life extension plans for ARLEIGH BURKE class destroyers – this is USS TRUXTUN (DDG-103) – have been have been scaled back in consequence.

marine we have ever done." But for COLUMBIA to be successful, it is more than just construction of each individual boat. "That's necessary, but not sufficient. We've got to make sure the enterprise is ready to execute the full scope of the program so that we can meet the requirements for the nation."

Between 2002 and 2004, the USN converted the first four OHIO class SSBNs to a conventional configuration, each capable of carrying as many as 154 Tomahawk land-attack cruise missiles (TLAMs) or fewer missiles to allow accommodation of Special Operations Forces (SOFs). In 2042, the USN could start a new-design large-payload submarine to replace the OHIO SSGNs and continue conventional missile, SOF, and other covert and clandestine missions.

The Italian FREMM design – VIRGINIO FASAN is seen here – forms the basis for the US Navy's next generation CONSTELLATION (FG-62) class guided missile frigates.

Attack Submarines: In mid-2021, the USN had three classes of attack submarines (SSNs) in service. Approximately 28 improved LOS ANGELES (SSN-688I) class submarines were in commission, each equipped with 12 Vertical Launch System (VLS) tubes for TLAMs. The fleet also has three SSN-21 SEAWOLF class submarines, exceptionally quiet, fast, well-armed, and equipped with advanced sensors. The USN continues to acquire the VIRGINIA (SSN-774) class to replace the SSN-688Is; 19 *Virginias* have been commissioned to date.

Under the December 2020 plan, the USN would have acquired 77 attack submarines during the next 30 years, 16 more than under the previous plan. Submarines remained a high priority in the FY2022 long-range shipbuilding plan and this number is unlikely to change significantly. The service lives of SSN-688Is will also be extended to sustain a minimum force of about 50 or more SSNs until new construction starts to grow numbers. In 2034, the USN intends to begin acquiring a new-design attack submarines, SSN(X). CBO's assessment of the USN's plan assumes SSN(X) submarines would be similar to the "high end" SEAWOLF class subs.

Large Surface Combatants: As of mid-2021, the USN's large surface combatant force numbered 92 warships; 22 TICONDEROGA (CG-47)-class guided missile cruisers and 70 ARLEIGH BURKE (DDG-51) class guided missile destroyers. The trend in all recent plans is to see this number reduced. CBO's Labs explained, "…the December 2020 shipbuilding plan calls for 55 new destroyers, 21 fewer than the previous plan. That change is consistent with the FNFS objective to reduce the proportion of large surface combatants in the fleet."

Earlier plans had envisaged the USN extending the service lives of all DDG-51 class destroyers to 45 years. However, "In the spring 2020," according to CBO, "the Service discarded that idea, citing the high cost of maintaining and operating older ships. The Navy now expects that DDG-51s will serve for 35 or 40 years depending on their flight, or variant. The first 28 DDG-51s – Flights I and II – would serve for 35 years; the later ships – Flights IIA and III – would serve for 40 years."

The trend in deprioritising larger combatants is reflected in delays to the new-design DDG(X) guided missile destroyer, procurement of the first of which has been shifted back from 2025 to 2028. According to the Navy, it will carry combat systems similar to those on the DDG-51 Flight III destroyers but will have a larger hull, more power, and more cooling.

Light amphibious vessels similar to the expeditionary fast transport USNS FALL RIVER (T-EPF-4) (T-EPF-4) are set to play a larger role in the US Navy's future amphibious force structure.

Small Surface Combatants: The USN's in-service small surface combatant force currently comprises Littoral Combat Ships (LCS) and eight AVENGER (MCM-1) class mine countermeasures vessels. Thirty-five FREEDOM (LCS-1) mono-hull and INDEPENDENCE (LCS-2) trimaran LCS variants have been delivered to the fleet or are in construction or under contract. The chequered history of numerous problems with the early LCS variants has convinced the USN to reduce the planned buy from an original 52 to 35 ships and essentially lay up the earlier units of each variant.

There are no plans to acquire dedicated MCM ships to replace the AVENGERS. Instead, the USN has been developing MCM mission modules to be deployed from LCSs, other ships, and even shore facilities.

Following a year-long competition the USN awarded Fincantieri's Marinette Marine a contract to design and build the first ten

The Military Sealift Command dry cargo and ammunition ship USNS CESAR CHAVEZ (T-AKE-14) undertaking vertical replenishment at sea. Future force structure plans envisage the combat replenishment force being supplemented by smaller ships to sustain distributed operations.

next-generation CONSTELLATION (FFG-62) class guided missile frigates in 2020. USN plans call for building at least 20 units, with the second tranche competed with other shipyards, as the navy seeks to expand the number of smaller combatants in its fleet.

Amphibious Warfare: The USN'S 2021 amphibious warfare force comprises 31 large ships: 9 amphibious assault ships (designated as LHAs or LHDs); 11 amphibious transport docks (LPDs); and 11 dock landing ships (LSDs). Future plans have the navy acquiring fewer large amphibious ships (LHAs and LPDs), instead standing up a major building programme for smaller Light Amphibious Warfare ships (LAWs). The June 2021 update described the LAW as "an enabler of [Marine Littoral Regiment] mobility and sustainability. The overall number of amphibious warships grows to support the more distributed expeditionary force design, with LAWs complementing a smaller number of traditional amphibious warships."

Unmanned Platforms and Systems: "In the years since the 2016 FSA," O'Rourke noted, "the Navy has developed plans to acquire large USVs and UUVs. Because of their size and projected capabilities, these large UVs are to be deployed directly from pier, rather than from manned ships, to perform missions that might otherwise be assigned to manned ships and submarines. In view of this," he continued, "some observers have raised a question as to whether these large UVs should be included in the top-level expression of the Navy's next force-level goal…and the publicly cited figure for the number of ships in the Navy. Department of Defense…officials since late 2019 have sent mixed signals on this question, but in September 2020 indicated that the Navy's next force-level goal…will include large UVs."

CBO's Labs explained, "...the new plan would incorporate large numbers of unmanned undersea and surface vehicles into the fleet". For example, as described by Labs, "The FNFS included inventory goals of 119 to 166 unmanned medium surface vehicles (MUSVs) and large surface vehicles (LUSVs) and 24 to 76 extra-large unmanned undersea vehicles (XLUUVs), for a total of 143 to 242 systems. The LUSVs would operate in conjunction with other ships, carrying offensive and defensive missiles that manned ships could employ as needed. MUSVs would serve as sensor or command and control platforms, providing information about opponents to other ships in the Navy's fleet. Although the Navy's plan is less specific with respect to XLUUVs, they could carry a variety of payloads to support naval operations. The Navy is still developing its concepts of operations for unmanned systems, which increases the risk for both cost growth and delays in their construction and operations."

"We have a really good sense of what we need," CNO Gilday asserted. "On the sea, we know that we need larger unmanned as adjunct magazines…and medium unmanned to perform a number of other functions – and some of them are classified…but they range from deception to command and control nodes. And so we know that that's a valid requirement."

Combat Logistics Force and Support Ships: Combat logistics ships operate with or directly resupply combat ships at sea. As for other force elements, future plans are driven by the need to support a larger fleet with a greater proportion of smaller ships. The current fleet has 29 large combat logistics ships – largely T-AO oilers and T-AKE dry cargo ships – but these will be increasingly supplemented by new-design smaller T-AOL oilers to support the more distributed fleet. As of mid-2021, there are just over 30 other fleet support ships in service, a number that is unlikely to change significantly under future plans.

Which Way Ahead?

"Two roads diverged in a wood," poet Robert Frost mused, "and I took the one less travelled by, and that has made all the difference." The USN confronts numerous divergent "roads" as it seeks to determine the right force structure to prevail in a new era of Great Power Competition and its thinking continues to evolve. Choosing one – even if less travelled – and staying with it through the inevitable changes in political and military leaders and strategic frameworks and guidance will make all the difference.

Note on Sources: In addition to other sources, two analysts provided valuable information. Ronald O'Rourke produces *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress* (Washington, DC: Congressional Research, RL32665, 16 June 2021); he also prepares other CRS reports on specific programmes. Eric Labs provided: "The 2021 Outlook for Navy Shipbuilding: Prospects and Challenges in Building a Larger Fleet," Presentation at the Bank of America Merrill Lynch 2021 Defense Outlook and Commercial Aerospace Forum, 6 January 2021; "Shipbuilding and Expeditionary Warfare Operations," Presentation at the 2021 Virtual Expeditionary Warfare Conference, 2 February 2021; and *An Analysis of the Navy's December 2020 Shipbuilding Plan* (Washington, DC: Congressional Budget Office, 57091, April 2021. This discussion also relies on the US Naval Systems Command Fact-Files, www.navy.mil/Resources/Fact-Files, and the Naval Vessel Register, www.nvr.navy.mil/NVRSHIPS/SHIPBATTLEFORCE.HTML. ■

A Thinking Navy, a Fighting Navy, an Australian Navy

Photo: RAN Imagery Unit

Rear Admiral Mark Hammond is Commander Australian Fleet (COMAUSFLT)

An interview with Rear Admiral Mark Hammond, Commander Australian Fleet (COMAUSFLT)

The Commander Australian Fleet (COMAUSFLT) is the primary operations advisor to the Royal Australian Navy's Chief of Navy. With his headquarters at HMAS KUTTABUL in Sydney, he has command of all of the fleet's ships, submarines, aircraft squadrons, diving teams and shore establishments. His command of shore establishments is exercised through the Commander Shore Force (COMSHORE) whilst he delegates operational command of the various units under his responsibility units to the force commanders. Operational control of fleet units will usually be delegated to the Director General Maritime Operations (DGMAROPS), with tactical command either held by DGMAROPS or delegated to Commodore Warfare (COMWAR), a subordinate tactical warfare commander, a nominated Commander Task Group (CTG) or ship's commanding officer, depending on circumstances. Since November 2020, the position of COMAUSFLT has been held by Rear Admiral Mark Hammond. MSD has been granted an interview with the Admiral.

MSD: Admiral Hammond, how would you describe your responsibilities?
Hammond: As COMAUSFLT I am accountable for delivering operationally ready maritime forces, as well as for the force generation of naval elements for subsequent operations, including task group level and joint collective training. And I also exercise operational control of our submarines and non-force assigned fleet units when at sea.

MSD: What are your current priorities?
Hammond: The area under Australia's maritime jurisdiction amounts to more than ten million km² - almost twice the size of mainland Australia – and our area of security interest encompasses more than ten percent of the Earth's surface. When we deploy our assets from their homeports – either to a domestic exercise or an operational area – this represents, by the standards of many other navies, an expeditionary task. These assets must therefore be supported by assured, long-range communications and reliable supply and repair. So my priority is simple: to do everything possible to optimise the RAN's operational readiness so that we can employ our capabilities effectively whenever and wherever they are required.

MSD: The RAN is achieving an ambitious modernisation programme. What is the status of the fleet?
Hammond: Indeed, the RAN is undergoing its largest peacetime transformation since the Second World War, both quantitatively and qualitatively. By 2030, the Navy will look very different to today with newer, more capable platforms, new systems and equipment.
The two CANBERRA class amphibious assault ships are already fully operational and are being followed by the three HOBART class air warfare destroyers and two SUPPLY class fleet replenishment oilers. Construction is also well underway on the 12-strong ARAFURA class of offshore patrol vessels (OPVs) under Project SEA 1180 and we hope that the lead ship will achieve initial operational capability later this year. In addition, we look forward to receiving a new expeditionary mine countermeasures capability with the introduction of new unmanned underwater and surface vehicles that benefit from artificial intelligence. These will be used as part of Project SEA 1905 – the Maritime Mine Counter-

Rear Admiral Mark Hammond joined the RAN as an electronics technician in 1986 and was commissioned in 1988. Following completion of his training, he volunteered for submarine service, qualifying on OBERON class submarines. Subsequent service included assignments to HMAS COLLINS, HMAS WALLER and HMAS SHEEAN. Having served as Staff Officer Future Concepts at RAN Headquarters in 2003, he graduated from the Command and Staff Course in 2004. He then deployed on operations with the Royal Navy's submarine force before assuming command of HMAS FARNCOMB in 2007. His subsequent shore postings included Assistant Naval Attaché – Washington DC, USA; Director Future Submarines – Operational Requirements; Joint Exercise Director (J75) and Chief of Staff to the Chief of the Defence Force from November 2012 to December 2013. In 2014, he was appointed as Director General Maritime Operations and then, in 2017, to the US as the Chief of Defence Force Liaison Officer to the Chairman of the US Joint Chiefs of Staff. RADM Hammond returned to Australia in March 2018 to assume duties as the Deputy Chief of Navy. On 17 November 2020 he was appointed as the Commander Australian Fleet.

Photos: Australian Department of Defence

The RAN is currently undergoing its largest peacetime transformation since the Second World War. Here, an Army TIGER helicopter conducts deck landings on the new amphibious assault ship HMAS CANBERRA.

measures and Military Survey Capability- that will replace the existing HUON class minehunters and which is intended to see on modular unmanned autonomous systems deployed from a platform based on the ARAFURA class design. A request for tenders is expected in the fourth quarter of 2021.

Other major announcements have been made around the HUNTER class frigates being acquired under Project SEA 5000 and the ATTACK class submarines (Project SEA 1000). The first of the former class should arrive around the turn of the decade, by which time all twelve of the ARAFURA class OPVs should be operational. If all goes to plan, the first of the twelve ATTACK class submarines will join the fleet in 2032, with all twelve boats in service by the early 2050s. Meanwhile, to cover any delays in ATTACK class deliveries, all six COLLINS class boats are expected to undergo a life extension programme starting in 2026 so that the flotilla can continue to operate beyond its currently planned retirement date of 2036.

MSD: Can you advise on how Plan Pelorus fits in with your objectives?

Hammond: The current Plan Pelorus 2022 is driven by Plan Mercator 2036, which is the longer-range strategic guidance for the navy's transition to the "Future Navy". This future force is built on seven pillars, viz. (i) warfighting (ii) capability programmes (iii) industry (iv) logistics (v) facilities (vi) workforce and (vii) seaworthiness. Plan Pelorus 2022, released in October 2019 and subject to review every four years, addresses the navy's shorter term objectives and capabilities to ensure our units are able to conduct sustained combat operations.

MSD: Many navies face personnel retention problems. Is this problem also affecting your navy?

Hammond: In the past 30 years it is true that we have had a lot of empty billets in both our ships and shore establishments. However, I am delighted to say that our uniformed workforce is now at its highest level since 1993, currently standing at some 15,218 personnel. So we are at our authorised strength for the first time in a long while and, moreover, we aim to grow by another 650 personnel by 2024.

MSD: You mentioned new ships such as the CANBERRA, HOBART and SUPPLY classes joining the fleet. What do these new platforms offer your navy in terms of meeting Australia's national defence and security requirements?

Hammond: As a result of their layered offensive and defensive systems to counter conventional and asymmetric threats, the three HOBART class destroyers – HMAS HOBART, HMAS BRISBANE and HMAS SYDNEY – provide considerable combat capabilities. Their AEGIS combat system and SM–2 missiles deliver advanced air defence performance with the ability to engage aircraft and missiles in excess of 150 km. Moreover, the introduction of AEGIS also brings a new level of interoperability with the US Navy.

Meanwhile, the LHD-type amphibious assault ships HMAS CANBERRA and HMAS ADELAIDE have revolutionised the Australian Defence Force's (ADF's) amphibious force projection capability. They are also a real game-changer when it comes to undertaking any sort of humanitarian aid and disaster relief response; nationally or regionally. And the new fleet replenishment oilers HMAS SUPPLY and HMAS STALWART provide a generational shift from the capacity provided by HMAS SUCCESS and HMAS SIRIUS. Although described as fleet replenishment oilers (AORs), these units can also provide dry stores, victuals and ammunition, making them a vital component of any task group. The first of class HMAS SUPPLY commissioned in April 2021 and HMAS STALWART arrived at Fleet Base West on 22 June 2021. Her commissioning is scheduled for October.

MSD: There is a strong focus on integrating with the Australian Army in conducting amphibious operations, what challenges is this presenting to your command?

Hammond: There is a lot of work going on in this area to achieve the fully integrated amphibious capability that we desire. We are working through the various issues and risks that need to be resolved to ensure we have an effective amphibious ready element available. The Australian Army's soldiers are not marines and are therefore not used to working in ships in a general sense, but that is changing rapidly. For example, the army's aviation elements are practicing with our ships with increasing frequency. To ensure a ready, relevant and world-class capability, we also regularly benchmark the Australian Amphibious Force's capabilities against that of our peers, such as the United Kingdom and the United States.

MSD: Did you have to introduce a new concept of operations (CONOPS) to make the most out of these new platforms?

Hammond: Yes. We are investing quite a lot of time and resources in developing a holistic, joint amphibious operating concept; the Amphibious Concept of Employment (CONEMP). This concept focuses on the LHD's central role in the ADF, as well as the associated training and force generation requirements. In order to keep pace with changes in our operating environment, we continually develop and refine our tactics, techniques and procedures to ensure that the new assets are capable of responding across the full spectrum of conflict.

MSD: Looking at training, can you describe the training assets and facilities you have at your disposal to ensure the desired level of operational readiness?

Hammond: Individual personnel training is the responsibility of the Head Navy Peo-

ple Training and Resources (HNPTAR). As such, many of our navy's training assets and facilities are managed by the HNPTAR. Our training assets are located Australia-wide: for example, our Flight Simulators are at HMAS ALBATROSS in Nowra, New South Wales (NSW); the Bridge Simulators at HMAS WATSON, in Watsons Bay, NSW; the Platform Training Simulators at HMAS STIRLING, in Perth; a range of facilities at HMAS CRESWELL located on south-western shore of Jervis Bay; the School of Survivability and Ship Safety at HMAS CERBERUS near Melbourne and the newly established Navy Training Systems Centre in Kingsford, NSW.

MSD: Given that there are several new platforms entering service or in the pipeline, to what extent will you have to step-up specific platform-related training?
Hammond: We plan to enhance platform-relating training with our so-called "Ship Zero" training facilities. Rather than waiting until the first vessel of a new class is in the water, these facilities will enable us to train their prospective crews so that they are fully prepared before they join their ship. Ship Zero training facilities are planned for the ARAFURA class OPVs, the HUNTER class frigates and the ATTACK class submarines.

MSD: Turning to the broader operational environment, what is the impact of the Indo-Pacific region's rise to prominence on the RAN?
Hammond: The term Indo-Pacific is a relatively new construct as it describes the coming together of the Indian and Pacific regions, in which regard Australia sits right in the middle. As one of the major regional navies, the RAN inevitably operates theatre-wide across this entire region, reflecting Australia's commitment to maintaining strong regional relationships. There is a growing emphasis on maintaining a task group presence, with various structures built around our new platforms being "operationalised". This is also reflected in the establishment of two new primary "at-sea" operational command staff structures - the Amphibious Task Group (ATG) and the Maritime Task Group (Mar TG) staff - to maximise our flexibility when deploying at sea.

MSD: How do you view the future as regards international co-operation with other navies?
Hammond: The RAN has a long history of embracing navy-to-navy engagement in order to preserve safe and free sea-lanes. Consequently we continue to invest in relationships with our allies and like-minded partners. A key focus is to build robust networks with our partners. Joint and coalition activities have become the norm. Obviously this has led to an increase in the number of engagements that we undertake with other fleets.
It is also worth noting that we are enhancing regional engagement in the Southwest Pacific in support of the Australian Government's Pacific Step-up initiative, working with partner nations to build a region that is secure, stable, and independent.

Four COLLINS class submarines pictured operating together whilst transiting Australia's Cockburn Sound. All six members of the class are receiving life extensions to maintain fleet operational capabilities pending delivery of the new ATTACK class boats.

MSD: Looking at this pattern of increased activity and engagement can you give an overview of the fleet's recent missions and operations?
Hammond: Indeed, our fleet is sustaining a high operational tempo. On a daily basis we have between five and, sometimes, up to ten units permanently at sea. To name only some of the missions on our 2021 agenda, the year began with the frigate HMAS ADELAIDE deployed to Fiji in January support of Operation Fiji Assist following Tropical Cyclone Yasa. During the following month the dock landing ship dock HMAS CHOULES deployed to Papua New Guinea whilst the ARMIDALE class patrol ships HMAS MAITLAND and HMAS LARRAKIA were working alongside the Royal Solomon Islands Police Force. In February we also organised the Ocean Shield synthetic exercise, which then rolled into Exercise Ocean Horizon in February-March and was followed by a large fleet battle staff command post exercise off Queensland. Across the Indo-Pacific, the frigates HMAS ANZAC, HMAS BALLARAT, HMAS PARRAMATTA and the supply ship HMAS SIRIUS have conducted regional presence deploy-

The HOBART class destroyer HMAS BRISBANE pictured entering Sydney Harbour. The introduction of these AEGIS-equipped ships brings a new level of interoperability with the US Navy.

A M777 155mm howitzer is prepared for air lift by a CH-47 CHINOOK helicopter from the dock landing ship HMAS CHOULES. The army's aviation elements are practising with RAN ships with increasing frequency.

ments and several bilateral and multilateral engagements with India, Japan, Malaysia, Singapore and the United States. At home, we have deployed assets to the Maritime Border Command in support of Operation Resolute and personnel to Operation COVID-19 Assist. In early July, the destroyer HMAS BRISBANE and the submarine HMAS RANKIN participated in Exercise Pacific Vanguard with units from Japan, the Republic of Korea and the United States off Australia's eastern coast. Perhaps the most significant exercise of the year is the Australian-US Exercise Talisman Sabre 2021, which commenced on 17 July. In addition to the United States, forces from Canada, Japan, New Zealand, the Republic of Korea and the United Kingdom are participants in Talisman Sabre 2021, with personnel from France, Germany India and Indonesia observing the exercise.

MSD: How has the COVID-19 pandemic impacted the RAN?
Hammond: We are committed to adhering to the Government's health guidelines to minimise the transmission of COVID-19 and to ensure the health of our personnel. Consequently this has forced us to operate in a different manner. While the pandemic continues to influence our navy-to-navy interactions and port visits, we keep on deploying our ships, submarines, aircraft and personnel on exercises and engagement activities, And our industry partners have been providing innovative solutions to correct any defects or breakdowns that arise whilst our ships are under way or in the course of port visits. Last year, HMAS CANBERRA completed a three month "contactless" regional presence deployment in the Indo-Pacific, demonstrating our ability to continue our engagements despite the global pandemic. However, the COVID-19 restrictions in force in Spain caused the shutdown of Navantia's shipyards for almost two months which, in turn, delayed the delivery and acceptance schedules of our two new fleet replenishment ships HMAS SUPPLY and HMAS STALWART.

The frigate HMAS BALLARAT passes Its Indonesian counterpart KRI KAREL SATSUITUBUN during the search for the Indonesian submarine KRI NANGGALA. Cooperation with regional navies is becoming increasingly important for the RAN.

MSD: An emerging challenge is cyber vulnerability. What are the main dangers for the RAN?
Hammond: We are engaged in maintaining the cyber security of our systems through education, governance and configuration management. We have also established the Fleet Cyber Unit (FCU) to provide deployable incident response capabilities and mission-critical cryptology to sailors. The FCU deployed for the first time in 2020, when it was embedded on board the frigate HMAS TOOWOOMBA during operations in the Middle East.

MSD: And what about Network Centric Warfare?
Hammond: Whilst network centric warfare is not a term in current fleet-usage, the integration of our current and future platforms through sharing sensor, situational awareness, decision support and command information will inevitably be key to the optimisation of our "Future Fleet".

MSD: How would you define the nature of the challenges facing the RAN in the coming years?
Hammond: The maritime domain is central to the security and prosperity of our Nation. As resources become increasingly scarce – and the competition for them greater – the future is increasingly unpredictable. The RAN has a crucial role to play in supporting our government. As such, we must adapt to emerging threats and technologies in order to be prepared for a myriad of operational possibilities. We see a significant increase in our commitment to supporting global security initiatives. Consequently, our capability programmes must be sufficiently agile to allow hardware and software to be continually upgraded. This means transitioning from a "platform-centric" approach to a "system-of-systems" methodology. Robotics, autonomous systems and artificial intelligence are proving fundamental to transforming the RAN.

The interview was conducted by Guy Toremans

Notes
1. Each destroyer has deployed to the US West Coast to conduct Combat System Ship Qualification Trials with US Navy support.

"An opportunity window is open to internationalise our defence industry."

Photo: Spanish Navy

Admiral General Antonio Martorell Lacave was appointed Chief of the Spanish Navy on 10 February 2021. The Spanish designation of his position is Almirante Jefe de Estado Mayor de la Armada (AJEMA).

Interview: Admiral General Antonio Martorell Lacave, Chief of Staff, Spanish Navy (Almirante Jefe de Estado Mayor de la Armada - AJEMA).

MSD: The Spanish Navy has to cover a tremendously large coastline and important sea lanes. What are your priorities, what does your threat environment look like?

Martorell: Indeed, Spain has a coastline of a significant dimension, approximately 8,000 kilometres, which requires prioritising maritime surveillance in our territorial waters, as well as in the maritime theatres of national interest around the world. In terms of threats, Spain and our Navy assume and contribute to the strategies and goals set forth by NATO and EU in the maritime domain. In national terms, our National Maritime Security Strategy lists a number of risks and threats that include various illicit trafficking activities, piracy, terrorism, WMD proliferation, irregular migration, overexploitation and deterioration of the marine environment, pillage of underwater heritage, cyber threats, and the consequences of marine accidents and natural disasters. True enough, this is a wide range of issues to be considered in wide sea spaces, so our activities need to be clearly directed.

The areas on which Spain concentrates its efforts are: the Strait of Gibraltar and its approaches, since it is a crucial choke point, the Canary Islands up to the borders of the Spanish Exclusive Economic Zone including the seabed, Western Africa, the Gulf of Guinea and the Horn of Africa, where the Spanish Navy deploys regularly surface units to maintain a naval presence in order to assist in preventing illegal activities related to piracy. And, finally, there are the Atlantic and the Mediterranean, where our ships participate in NATO´s operation SEA GUARDIAN.

In response to your question, I would like to highlight the negative evolution of two scenarios over the past year. On the one hand, there is the Gulf of Guinea as a crucial region for our national interests that is experiencing a sustained deterioration in maritime security. The increase in criminal acts against commercial traffic in the form of assaults, robberies and kidnappings is generating a negative impact on the freedom of navigation that could, in the long run, affect energy supply to Europe. On the other hand, we are witnessing incised tensions in the Eastern Mediterranean as a result of states' claims of sovereignty to explore and exploit new energy resources.

Besides, there is a third maritime area of permanent interest, namely the Horn of Africa. The new mandate of Operation ATALANTA resulting from the EU's most recent strategic review, will pose a challenge for the EU Spanish Operational Headquarters, which consolidated its position in command of the operation during the last year. This new mandate, which will progressively incorporate new tasks to monitor illicit activities such as arms and narcotics trafficking or illegal fishing, will represent a further step towards the completion of the EU's objective of being considered a provider of global maritime security.

MSD: You are in control of the third-largest navy in the EU. Does BREXIT and the focus change of the USN change your role?

Martorell: The Spanish Navy must be responsive and flexible. We cannot skip the fact that we operate in an international scenario of increasing complexity and uncertainty, characterised by the blurred boundaries of grey zone strategies, with marked transregional effects and a growing presence and importance of the technological component, which is also evolving at an ever-increasing speed. This uncertainty requires us and our allies and partners to be highly adaptable to the environment. An example of this need for flexibility was the transfer of the EU´s operational HQ and command function of Operation ATALANTA from Northwood to Rota, a movement directly related to the BREXIT.

Besides this, the UK is a key ally in NATO and its contribution to collective defence remains as firm as ever. As far as the US Navy is concerned, we must take into account the establishment of the new NATO Joint Forces Command in Norfolk, fully devoted to protect the sea lines of communication between the US and Europe. Also, we must remember the BMD destroyers based in Rota. They wil be reinforced by a squadron of MH60R helicopters. Moreover the Mediterranean still regularly sees the transit and exercises of carrier strike groups and marine expeditionary units. It is true that the US Navy´s activities at sea are not as intense as in previous decades, but there is no doubt that it keeps a sharp eye on NATO´s area of responsibility.

MSD: You can make valuable contributions, for example with new submarines and unique amphibious assets. What expectation and challenges are you envisaging in future?

Martorell: We will continue operating a single set of forces to cater for conventional combat operations as well as for the protection of our legitimate interests in maritime security. Hence, it is our goal to shape and maintain a balanced, full spectrum, technologically advanced, expeditionary and interoperable fleet. Flexible and capable ships operating under a robust command and control structure with consistent logistic support at their homeports and deployment areas. In the short and medium term,

besides completing the S-80 submarine and F-110 frigate programmes, we expect to acquire an underwater intervention ship, oriented to submarine rescue operations, support to all types of diving activities and cultural underwater heritage protection.
But to ensure the future fleet capabilities, our armed forces require stable and predictable budgets to ensure the timely and continuous replacement of units approaching the end of their operational life, with a focus on cutting-edge technologies. The needs are numerous, but I would highlight the replacement of the SH60B helicopters and the hydrographic flotilla as the more pressing requirements. In the long term, we will focus on key technologies that will make a difference in future operational scenarios: 5G, digital twins, artificial intelligence, etc.

Photo: Navantia

The launching of S-81 on 22 April 2021 took place in the presence of King Felipe of Spain. The boat is named ISAAC PERAL.

MSD: The Mediterranean is an area of interest for almost any European navy, for Russia and the US Navy. How does the Eastern Mediterranean and its implications concern you?
Martorell: The Mediterranean Sea was known in the ancient era as the Mare Nostrum, "Our Sea", and since then almost every power has had different interests in it. Nowadays, European navies must collaborate in creating a safe environment in this common space. Spain focuses its effort on the western and central part, but works in solidarity with our friends and allies to favour -within NATO and EU- a dual path of deterrence-dialogue, and also promotes confidence-building and control measures in the East.
NATO is making a big effort in the East, and our assets in the Standing Naval Forces, escorts and minehunters, are working hard to contribute to maintaining security in the area. Obviously, I am concerned about irregular immigration, the Libyan issue, the Syrian crisis and the increasing presence of the Russian Federation Navy in the East; but the approach of Spain is multilateralism, through the dialogue in international defence and security organisations such as the EU, NATO, OSCE and UN, to face all our common challenges, especially at sea.

MSD: Some European navies plan to dispatch ships in the Far East – do you plan to set signals to China?
Martorell: Together with our allies and friends, Spain is committed to actively contributing to preserving and building up peace and stability around the world, supported by international legality. As such, we already have ships deployed in areas were international law and shipping are threatened by piracy, maritime crime and illegal trafficking. It is true that freedom of navigation is in jeopardy in other areas of the world, but we must be mindful of the priorities established by our Government, as well as of our capabilities and limitations to operate simultaneously in distant theatres of operations. As a consequence, the Spanish Navy has no plans to deploy ships to the Far East for the time being.

Photo: EUNAVFOR

The amphibious landing ship CASTILLA on patrol as part of Operation ATALANTA.

MSD: The Spanish Armada is rather big. This looks impressive, but can you provide the capabilities and take part in all missions according to NATO requirements?
Martorell: NATO's fundamental and enduring purpose is to safeguard the freedom and security of all its members by political and military means. The greatest responsibility of the Alliance is to protect and defend our territories and populations. Being in a position to achieve this goal requires a joint effort, a shared response by all allies based on a real commitment in peace time and in crisis. Shared response responsibilities mean allies working in new and innovative ways for common defence, and cooperation with international organisations such as the United Nations, European Union, African Union, Organization for Security and Cooperation in Europe and other partners, as appropriate, in order to help safeguard Alliance freedom and security. It is important to underline, beyond any doubt, that the strongest points of NATO are unity, solidarity and cohesion.
Therefore, NATO's missions and requirements are not objects to be dealt with by individual nations independently; rather, nations must contribute to and engage with the Alliance to achieve a common goal. Spain, and particularly the Spanish Navy, will remain a reliable partner and ally within our means and capabilities. In order to implement this commitment I would like to show you some figures that reflect Spain's current commitment to NATO. With regard to our contribution to the Alliance, for the only maritime operation currently in force, Operation SEA GUARDIAN, Spain was the third country of the Alliance to contribute ressources in 2019. As for NATO's Standing Naval Forces (SNF), apart from our regular

Photo: MoD Spain

As the fifth and last unit of the ÁLVARO DE BAZAN class anti-aircraft frigates, CRISTÓBAL COLÓN was commissioned on 23 October 2012. It bears the Spanish name of the Italian explorer Christopher Columbus.

contribution with naval assets, we have commanded SNMG-2 for a whole year, since June 2020, and in June 2021 we have taken responsibility for SNMCMG-2.

MSD: How do you see your future role in the Mediterranean with a special view to North Africa and the challenge of migration?

Martorell: For Spain, the Mediterranean is a primary area of interest, a region that continuously faces multiple challenges for our defence and security. In the southern vicinity of Spain, especially in the Sahel, the pandemic has triggered instability, and it seems that this situation will not be solved in the short term. As a consequence, there is an increase in irregular migration flows on the western Mediterranean and on the Atlantic routes, affecting both the Spanish mainland and the Canary Islands.

The evolution of maritime immigration routes in the short and medium term and their potential implications for maritime security are matters of concern. Thus, in order to promote regional stability, the Spanish Navy is maintaining a collaborative attitude, with the intention of providing specific support to international organisations, as well as a high level of commitment with the North African countries, strengthening multilateral and bilateral cooperation particularly with Morocco, Algeria and Tunisia, while contributing to the EU Common Security and Defence Policy through missions and operations focussed on improving security and stability in the area.

MSD: Do you expect more engagement by northern European partners?

Martorell: All European countries, not only those in the Mediterranean region, must be concerned about the problems of Africa and the Mediterranean and face the potential and real challenges and threats coming from the South. The Alliance should maintain its 360° vision around Europe so as to take into consideration the requirements of all its member countries. For that, allied countries should balance their efforts to develop specific lines of action aimed at tackling also the challenges originating from NATO's southern flank, that is to say, a real 360° Alliance.

Simultaneously, the EU is looking for a comprehensive approach in the South, so both organisations are to improve their coordination in common places, mainly in the Mediterranean, where they routinely operate. Spain, as a European country and especially because of its geographical position, must contribute to create the conditions for security in the area. But this is a common goal for Europe. Regarding the engagement of the Northern countries, I am thinking of an ever stronger Europe and with political cohesion, where all the countries share common and global interests and not only regional concerns. The security in Africa and the Mediterranean is the security of Central and Northern Europe too.

MSD: Most of the European navies favour cooperation, both in procurement and in operations. You have a long tradition in

Image: Navantia

In the scope of the F-110 programme, the Spanish Navy will receive five BONIFAZ class multi-purpose frigates equipped with the AEGIS CWCS. Service introduction is scheduled between 2023 and 2027.

partnerships. What will your future engagement be like?

Martorell: As I said earlier, in this extremely demanding scenario, the sea is and will continue to be an essential element for the security, prosperity and well-being of a maritime nation such as Spain. Consequently, to face these challenges, the Spanish Navy must adopt a comprehensive and joint approach to maintain and improve cooperation with different actors, both state and non-state, mainly under the umbrella of the international security and defence organisations that we are part of, namely EU, NATO and the UN. Those priorities have been set up at the political level. In fact, the 2020 Defence Policy Directive clearly identifies the main lines of our external action: (1) the relevance of the transatlantic dimension of our defence; (2) the improvement of the EU CSDP; (3) the promotion of confidence-building measures in the Mediterranean, African and Sahel countries through security cooperative activities; and (4) reinforce bonds with countries historically tied to Spain because of our common roots.

Other main points are cooperation in materiel procurement and research and development activities. In the past, with countries such as the Netherlands, we successfully participated in the design and building of amphibious and combat support ships, and we believe that an opportunity window is open to internationalise our defence industry, thus taking advantage of the PESCO projects and the new European Defence Fund. In fact, we lead the 4E (Essential Elements of European Escorts) project, focussed on designing the main common elements for the future European combat escorts in four areas (Combat, Information, Platform Control and Navigation Systems).

Besides, we are involved in the European Patrol Corvette project to obtain, by the end of this decade, a ship for maritime security tasks with limited combat capability, and some other projects related to the employment of all sorts of unmanned vehicles in the maritime environment.

Image: Naviris (Fincantieri / Naval Group)

With Spain's participation, the European Patrol Corvette (EPC) programme is to develop the prototype of a 3,000-ton surface combatant for various mission profiles. The figure shows an official design draft of the PESCO project.

MSD: How do you manage the challenge of the pandemic in the fleet, in your daily business and at sea?

Martorell: When the crisis began, we took some shock measures oriented to both increase the Navy's resilience and maintain a minimum level of activity that would allow us to meet operational commitments. Training activities were reduced to those necessary to enable the readiness of units assigned to operational deployments, standing national surveillance operations, OPERATION ATALANTA and NATO Standing Maritime Groups. To this end, the Navy issued plans leveraging the evolution of the pandemic to maintain operational readiness activities and deployments, education at naval schools and the Navy´s general routines. Teleworking, security distance, labelling, extreme hygienic-sanitary measures, massive use of VTCs, on-line education, etc., have become the rule. Regarding the operational units, we implemented strict protocols oriented to create safety bubbles on board, with quarantines and COVID-19 tests prior to getting underway, compulsory use of masks during the first days at sea, no leave or liberty for crews, and so forth. As soon as vaccines were available, we vaccinated the crews of the ships before deploying as well as other units with an intense contact between the personnel, such as schools. A token of the success of these measures is that all but one of the scheduled operational deployments have been successfully carried out, and that our training ship JUAN SEBASTIÁN DE ELCANO continues her trip around the world not having suffered any COVID cases.

The interview was conducted by Esteban Villarejo.

Vice Admiral Kay-Achim Schönbach:

We need to focus more on blue water operations

Photo: Michael Nitz, Naval Press Service

VAdm Kay-Achim Schönbach

In late March 2021, Vice Admiral Kay-Achim Schönbach took over the helm of the German Navy. In his inaugural speech, presented at the end of June, he caused surprise with the statement that he is reconsidering German Navy's role in blue water operations. Maritime Security and Defence / MSD took the opportunity to examine his views further.

MSD: What are your current strategic priorities for the Navy?
Schönbach: The Navy has to be seen within the overall context of the Bundeswehr's (German Armed Forces') tasks and the security policy framework. To a large extent, this has been determined in the past – and will continue to be determined in the future – by Germany's participation in collective security alliances. On the one hand, this means setting up and maintaining the navy in such a way that these tasks can be fulfilled, especially in terms of NATO. On the other hand, the task of national defence, which has been brought back into focus, is being more strongly emphasised in our command organisation. With the *Key Elements of the Bundeswehr of the Future*, a document released on 18 May 2021, our strategic goals have been articulated and it is now a matter of filling them with content.
I underline that we are optimising the existing organisation, taking the lessons learned during the past years on board in order to increase operational capability and readiness. This means that we are not just reforming. For me, the assignments from *Key Elements of the Bundeswehr of the Future* have the highest priority and I will pursue them with vigour. The first assignments are therefore already being processed. As a first step, I intend to realign the Navy's command and control organisation to separate its command-and-control functions more clearly from ministerial processes. The navy will establish a "Maritime Warfare Centre" to package responsibilities and competencies, with a focus on conceptional approaches and the further development of operational capabilities. To increase the operational readiness of our weapon systems in a sustainable manner, the possibility of integrating the Naval Arsenal, the Naval Support Command, and other pertinent elements into a "System House Sea" will be examined. Ultimately, these measures focus on strengthening our combat capability and contributing to conventional deterrence.

MSD: This seems to be a major review. Which triggers the question: Do you regret launching the F125 programme given its emphasis was placed on stabilisation missions? As it looks like the probability of being confronted with higher-intensity threats is growing, could the F 125 prove to be a wasted investment!?
Schönbach: The contract for the F125 was signed in 2007 and the programme requirement then was mainly geared towards stabilisation operations. From today's point of view, however, this is not a disadvantage, as we are and will continue to be involved in operations that require long duration deployments and a high degree of self-protection. The conflict scenarios conceivable today also require a variety of systems in which the F125 has its place and is needed to accomplish given tasks. The ship, with its up-to-date sensors and effectors, can have an impact far beyond what is required in current operational areas.
The refocusing on national and collective defence was done at a time when the F125 project was already "in full swing". Therefore, a redirection was illusory. Moreover, no investment is "wasted" for the Navy's portfolio. The F125 class will make an important contribution to the Navy's overall profile. Note, that within the German Armed Forces we have to represent the entire spectrum of capabilities, including international crisis management, today and into the future. With the possibilities offered by the F125 class, we will be able to meet a wide range of operational challenges.

MSD: Against the background of your risk assessment: Where do you see the German Navy in 2030?
Schönbach: Let me start with the general assertion that the Navy has always been oriented towards all areas of naval warfare. The military part of international crisis management is a task of equal importance to national and collective defence and influences us strongly. Mastering this balancing act is a daily challenge. For all naval missions, the ability to fight in a multi-dimensional naval war was and is the guiding principle for the Navy's capability-development. Keeping this in mind, I am consistently orienting our Navy towards national and collective defence.
In 2030, the German Navy will still have to cope with a wide range of tasks. To do

Photo: Bundeswehr / Marcel Kröhncke

VAdm Kay-Achim Schönbach: It is foreseeable that the navy will have to fulfil a variety of missions with a still limited number of units.

Photo: Bundeswehr/Marcus Mohr

German Navy's warship crew reporting for duty.

so, we need weapon systems that must be capable of naval warfare in complex environments and in all areas. This requires equally capable support. Cyber space is also an operational area for the navy that will fit into our classic "warfare areas" of surface and undersea warfare. It is foreseeable that the navy will have to fulfil a variety of missions with a still limited number of units.

In addition to the above-mentioned focal points, we have to press ahead with the maintenance and, in some cases, expansion of capabilities in the areas of air defence, anti-submarine warfare and mine countermeasures.

In terms of mindset, I am convinced that we need to focus more on "blue water" operations again. The integration into the carrier units of our allies offers the opportunity to carry out this refocusing through integration into multinational units. As you can see, we have a large catalogue of tasks with limited resources. We can only manage this with an increase in operational readiness and intelligent solutions in the allocation of forces.

MSD: Do you think that is realistic given the current budget and the ongoing debate about the size of the future defence budget?

Schönbach: I have to trust that the German Bundestag will align the goals of Germany's foreign and security policy, among which figure the politically accepted capability requirements of the Alliance and, in particular, the agreements reached with NATO partners, with the defence budget. Recently, during the National Maritime Conference 2021, all participants of the naval forum confirmed and, indeed, re-emphasised the requirement for a long-term and reliable financial allocation that meets the demands placed upon us. In her statement, Federal Minister Kramp-Karrenbauer suggested a Defence Planning Act. Personally, I think this proposal is very worthy pursuing.

MSD: Good luck, Admiral. On the downside, concerns remain related to the readiness of the German armed forces, including the availability of naval forces. Are these observations fair, and if so, what are you doing to correct them?

Photo: Bundeswehr/Sebastian Wilke

FGS MAGDEBURG patrolling waters off Beirut.

Vice Admiral Schönbach: I would like to leave it to others to judge the fairness of this criticism and stick to the facts. The availability of our ships, boats and aircraft could certainly be better in order to meet political expectations for flexible deployment, if necessary, on an ad hoc basis, adequately. The navy has been and is able to provide support for its operations including demands related to training, exercises or deployments. The relevant reports to parliament show this without embellishment. However, this is without a "net and a double bottom. In other words, without the reserves required for any additional orders that might arise from short-term political requirements or other developments.

MSD: In view of the problems that have become known, are you well served by German industry, do you feel like a 'prime client'?

Schönbach: The cooperation with industry is undoubtedly not entirely smooth, but this can be attributed to multiple reasons. I would like to emphasise once again that it is not "The Navy" that is the contractual partner. This fact tends to recede into the background in these discussions. In typical German fashion, the Bundeswehr is certainly not an easy partner for an industrial contractor. Particularly in the case of naval systems. Only "small quantities" are ordered for which, however, a considerable effort must be made in terms of logistical support in order to maintain readiness over a long operational period.

MSD: Where do you see the most promising opportunities for international cooperation in maritime armament projects?

Schönbach: Naval armament projects, and ships in particular, are characterised by the fact that the volumes procured are limited. Cooperative projects therefore offer an im-

portant opportunity to tap quantity effects and thus reduce costs.
However, international cooperation, especially in armament projects, is not an end in itself. In the future, it will also be important to maintain and, wherever possible, strengthen key national technologies. Cooperation must always include added value for the German Navy. Otherwise, the resources required cannot be justified - just think of the extensive and often time-consuming coordination processes! However, these aspects are not mutually exclusive. Bi- or multinational cooperation with regards to individual components within a larger armament project is always conceivable.
Ideally, programmes like U212 CD are the way forward as more nations join in.
From a military point of view, armament cooperation presupposes a congruent set of demands and comparable timelines. This may look different if economic policy priorities are emphasised. In principle, however, except for the intelligence complex, all areas of capability are conceivable for bi- or multinational cooperation. However, the definition of capabilities has proven to be the most difficult hurdle for joint projects. Now, I see the greatest chances of possibly adding further partners to the DEU-NOR cooperation in the area of submarines.

Photo: Bundeswehr/Björn Wilke

Naval Base Kiel

MSD: In a recent interview with MSD, your Dutch counterpart spoke positively about increased German-Dutch naval cooperation. What do you see in this? Could you imagine some kind of integration of Dutch naval capabilities into the German navy or vice versa? Mine warfare could serve as an example, building on the Belgian-Dutch MCM forces that have been jointly organised for some time.
Schönbach: The cooperation between the German and Dutch navies goes back a long way and covers many fields from training to the integration of our maritime battalion into the amphibious units of the Royal Netherlands Navy. Which is, in my eyes, extremely successful. In addition, there are also other areas of successful cooperation with the Dutch Armed Forces and other parts of the Bundeswehr. The partnership is on an equal footing, and we learn from each other every day. This opens a multitude of possibilities, which should not be limited to individual areas, but must be oriented towards fields of cooperation where we can see and realise added value for both sides. I see a lot in common with the Dutch Navy in particular, and I am happy about every form of exchange and cooperation that intensifies and expands our collaboration. Furthermore, we are in constant dialogue with all our international partners. I do not foresee any further "integration", because our goal is to establish multinational task forces. It seems important to me, however, that we continue to work closely with our Dutch partners with regards to future large-scale weapon systems.

MSD: Admiral, as we speak about cooperation. The German Navy is very involved in NATO. But not so much in the EU or in the so-called initiatives to strengthen 'Maritime Awareness', such as EMASOH or the anti-piracy initiative in the Gulf of Guinea. There we see that Denmark, not on a par with Germany as a trading nation though very weighty as a seafaring nation, is doing this differently. What are the reasons for Germany's reluctance?

Photo: hum

Frigate FGS BAYERN leaving Wilhelmshaven for Indo-Pacific Deployment, 2 Aug 2021.

Illustration: Bundeswehr

Map of FGS BAYERN deployment into Indo-Pacific

Schönbach: I do not want to speak of German restraint here. Certainly, every nation has its own maritime interests, which it pursues accordingly. Germany is currently focusing its maritime EU-led operations in the Mediterranean. The German Navy has been participating in EU-led operations for many years. It was strongly represented in Operations Atalanta and EU NAVFOR MED Sophia and is also involved in Operation Irini with maritime patrol vessels and, currently, a BERLIN class fleet auxiliary vessel. In addition, the German Navy is active with the Naval Special Forces as lead unit in the Gazelle training mission in Niger, which is expected to be transferred to the EU Training Mission (EUTM) in Mali. It is important to prioritise against the background of the totality of all commitments. Following this prioritisation, the German Navy is making its recognised contribution both in NATO and within the framework of UN- and EU-led operations.

MSD: How do you see the role of the German Navy in NATO vis-à-vis the EU's drive for greater military integration? Will these tensions lead to operational problems with NATO countries like Norway and the United Kingdom, which are not members of the Union? Friction could also arise with Denmark, a strong partner of the German Navy in the Baltic Sea.

Schönbach: I do not see a dichotomy in the role of the German Navy in NATO and the EU's pursuit of higher military integration, as the two can very well be combined. NATO looks to a wealth of experience in terms of integration and interoperability, which also benefits the EU. The supporting pillar for national and alliance defence is and remains NATO. Stability and security are thus guaranteed for all. Very good and friendly relations exist with Norway and the United Kingdom. If Germany, and thus the German Navy, is committed to strengthening the European pillar in NATO, this strengthens both sides. There are many opportunities for cooperation in the EU, without the commitment and obligations to NATO having to take a back seat. Transparency and dialogue are the key to better mutual understanding here. This dialogue has also grown through NATO membership.

MSD: Finally, Admiral, the deployment of the frigate BAYERN into the Indo-Pacific has created some controversy. What are your expectations? What led to the selection of a frigate of the F123 class when a F125 class vessel might be deemed a better fit for such an endeavour both for operational reasons and also as a marketing aid for German technology?

Schönbach: The deployment of a German frigate is a consistent and visible implementation of the Federal Government's Indo-Pacific Guidelines. Thus, this project is of the highest military policy importance. In addition to the UN sanctions regime against North Korea, the frigate BAYERN will also take part in missions mandated within the framework of the NATO Operation Sea Guardian in the Mediterranean and the EU Operation Atalanta in the Horn of Africa. This is a visible example of how the German Navy performs its allotted tasks.

The opportunities to work together with the navies of our regional partners sharing the same values during the voyage will prove the proficiency of the German Navy while simultaneously enhancing our familiarity with the region and improving our own operational capabilities through practising with others.

The frigate BAYERN with its crew is a recognised, reliable, and highly capable weapon system and is ideally suited to successfully complete the demanding operational profile required by the deployment. Initially the deployment of a F125 frigate was also considered. However, the F125 class units still have to pass significant milestones before they are fully operational. An F123 is also a flagship for German technology, as this weapon system has been continuously developed and has proven itself several times in operations.

Let me conclude with an affirmation. The expanding importance of the Indo-Pacific will result in an expectation for the Navy to maintain a regular presence there. I aim to ensure a presence at least every two years in the future. The current activities in the Indo-Pacific show me how important it is to deploy into this maritime area again. However, it is a complex security environment that requires special regional knowledge, which we must first acquire again.

The interview was conducted by
H. Uwe Mergener

The Type 26 Global Combat Ship: Global by Design

Conrad Waters

After a long gestation period, the British Type 26 Global Combat Ship programme is making tangible progress. The constituent sections of HMS GLASGOW, the first of class, were integrated in May 2021 and reports suggest that her construction is running ahead of schedule. The recent British Integrated Review confirmed plans for a total class of eight ships. Meanwhile, Australia and Canada continue to develop their own variants of the design, which will benefit from the considerable flexibility incorporated into the original concept.

Project Origins

The Type 26 programme has a long, complex history. Its origins can be traced as far back as initial concept work on replacements for the Royal Navy's Type 22 and Type 23 frigates that commenced during the mid-1990s. In 2010, BAE Systems was awarded a four year assessment contract to develop one of these concepts to meet a requirement for a "high-end" surface combatant focused on Anti-Submarine Warfare (ASW). The Global Combat Ship nomenclature was adopted at this time.

Britain's subsequent 2010 Strategic Defence and Security Review (SDSR) essentially confirmed the programme. However, it looked to recast the design to allow a common hull to be used to meet the ASW requirement and also a need for a less capable, general-purpose frigate. Exportability was to be a key design priority. Ultimately it proved impossible to combine the needs of sophisticated ASW frigate with the more basic general-purpose ship whilst keeping overall costs within a constrained budget. The 2015 SDSR therefore split the planned acquisition, with the general purpose frigate ultimately becoming the Type 31. One beneficial legacy of the shared design work was the large amount of flexibility built into the Type 26 hull; a factor which undoubtedly assisted its adaptability to meet export requirements.

Although SDSR 2015 set the stage for Type 26 construction to progress, ongoing financial haggling between the British Ministry of Defence and BAE Systems meant that it was not until July 2017 that a construction contract was finally awarded. The GBP3.7Bn (US$5.1Bn) deal – including material sums allocated to project infrastructure – covered an initial batch of three ships. The overall requirement is for a total of eight Type 26 frigates, a number confirmed in the recent British 2021 Integrated Review. The order for the remaining batch of five ships is to be placed during the "early 2020s".

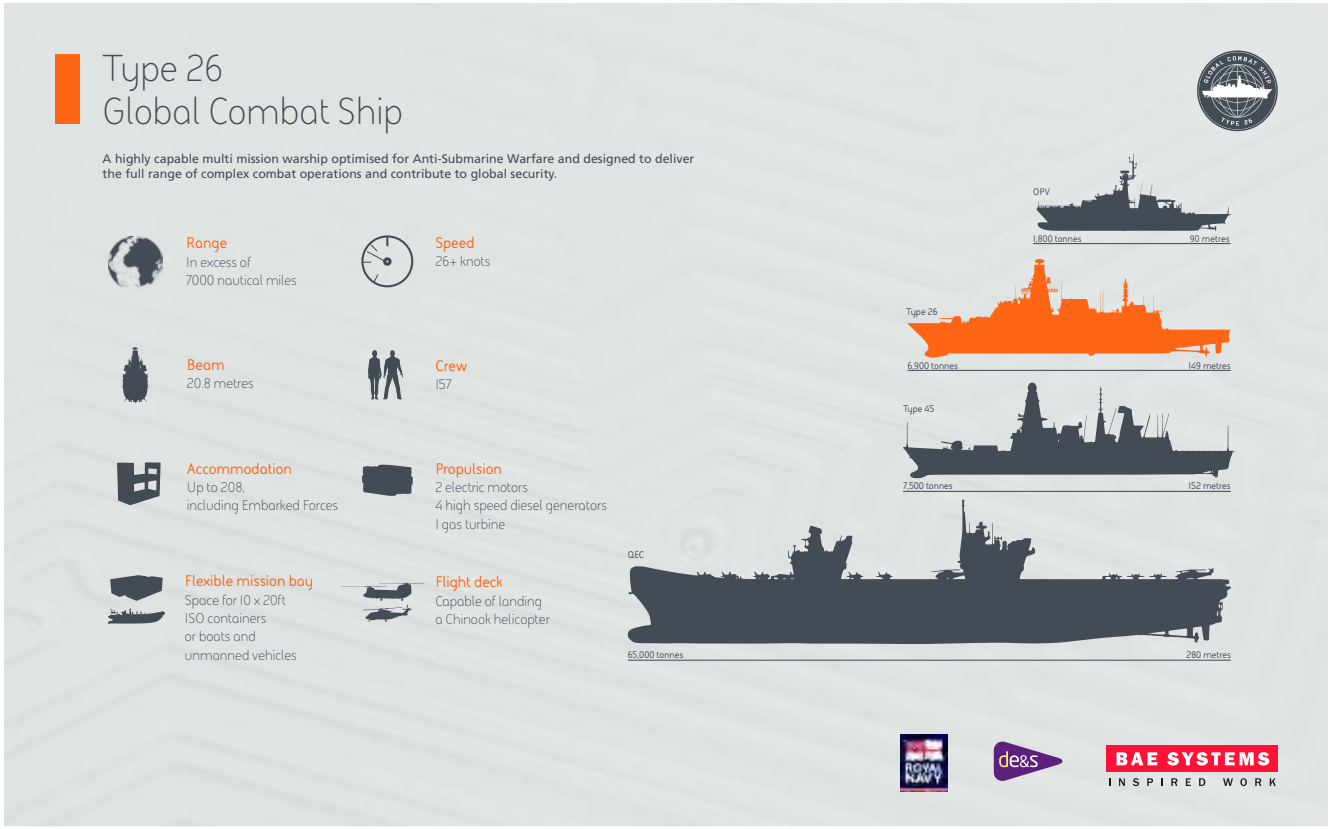
Photos / Images: BAE Systems

A computer generated graphic of the British Royal Navy variant of the Type 26 Global Combat Ship.

Design

The Type 26 Global Combat Ship is a conventional all-steel mono hull with an overall length of 149.9 metres and a breadth of 20.8 metres. Displacement was initially set in the region of 7,000 tonnes. Although designed to be a multi-mission surface combatant, the Royal Navy's intended primary ASW role for the class is reflected in an emphasis on acoustic stealth. This is most notably evidenced by the combined diesel-electric or gas propulsion system that pairs a single Rolls-Royce MT-30 gas turbine with twin GE propulsion motors supplied with power from the ship's four MTU 20V 4000 M53B generators. The gas turbine permits a swift sprint at speeds in excess of 26 knots to the location of a potential target, with the electric motors then being used for a sustained period of silent, low speed target prosecution. Less immediately evident is the specification of a low-noise hull design and the effort expended on silencing auxiliary equipment.

The Type 26's combat and platform management systems are hosted on BAE Systems' shared infrastructure. This common computing architecture infrastructure replaces the separate hardware and associated networks used to support specific



This infographic of the Type 26 compared with other British Royal Navy warships gives some idea of the design's relatively large size.

functions in previous generation ships, easing the ability to integrate a wide range of systems into the network and easing subsequent upgrades. The British ships will be equipped with the latest variant of the BAE Systems' CMS combat management system already in widespread Royal Navy use. The Royal Navy Type 26 variant utilises a wide range of tried and tested equipment used in existing British ships. This includes Thales' Sonar 2087 (internationally marketed as CAPTAS-4) variable-depth towed and Ultra Electronics' Sonar 2150 bow-mounted arrays that have been retrofitted to a number of the existing Type 23 DUKE class frigates. The Type 997 ARTISAN surveillance and tracking radar and MBDA SEA CEPTOR (CAMM) surface-to-air missiles are also carry-overs from this previous frigate class. Technology that is new to the Royal Navy but is already in common service across the world include a 24-cell Mk 41 Vertical Launch System (VLS) and 127mm/62 Mk 45 Mod 4 gun, both of US Navy origin. The VLS will be equipped with the Anglo-French Future Cruise/Anti-Ship Weapon (FCASW) being developed by MBDA and which should enter service by 2028.

An innovative feature incorporated in the Type 26 design is an adaptable mission bay immediately forward of and linked with a single helicopter hangar. Similar in concept to facilities incorporated in, for example, the US Navy's littoral combat ships, it can be used to ship a wide variety of equipment dependent on particular mission requirements. The space is large enough to house up to ten TEU containers. Alternative payloads could include various types of unmanned vehicle or a second, MERLIN-sized helicopter.

Progress to Date

First steel-cutting of the lead British Type 26 frigate took place at BAE Systems' Govan facility on the River Clyde on 20 July 2017. She is to be named GLASGOW and the class known as the CITY class in British service. Assembly of the ship's constituent blocks has proceeded largely according to plan in spite of the pandemic, with the ship's forward and aft structures moved out of the building hall and joined together at the start of May 2021. Once "launched" – by means of a submersible barge – she will be docked at the downstream Scotstoun yard, where final outfitting and systems commissioning will be undertaken. A report from Britain's National Audit Office in mid-2021 stated that the construction programme was actually running around 12 months ahead of schedule. This suggests the new ship may enter service in the course of 2025 after completion of an extensive trials and acceptance process. [1]

Work is also now underway on the other two members of the class that form the first batch. These have followed behind GLASGOW at roughly biennial intervals. CARDIFF, the second ship, commenced fabrication on 14 August 2019. The first steel for the third and final member of the batch, BELFAST, was cut on 29 June 2021.

Australia

The selection of the Global Combat Ship for the Royal Australian Navy has arisen as a result of the need to find replacements for the existing ANZAC class, which first entered service in the mid-1990s. The replacement programme was first heralded in Australia's 2009 Defence White Paper, which stated that the new ships would be focused on ASW operations. The resultant Project SEA 5000 Phase 1 was formally launched in 2015. Three companies – BAE Systems (offering a design based on the Global Combat Ship), Fincantieri (FREMM) and Navantia (evolved F100 frigate) – were shortlisted to refine their design proposals the following year. After completion of a rigorous and comprehensive competitive evaluation process, it was announced in June 2018 that the BAE Systems' proposal had been successful. A head contract for what will be known as the HUNTER class was signed with BAE Systems Maritime

Multi-Mission Surveillance Radar for Maritime Security

The SeaGiraffe 1X radar is optimised for maritime security and force protection, but its capabilities extend far beyond that to serve the many dimensions of conflict at sea.

The versatile, lightweight 3D AESA SeaGiraffe 1X radar gives you the multi-role advantage providing quick and reliable simultaneous detection of surface and air targets including sea-skimming missiles with very small radar cross-sections. Thanks to Saab's world-leading naval radar technology, this capability is also maintained in the extreme clutter conditions of littorals.

Detection superiority

The SeaGiraffe 1X has a range of 100 kilometres, covers the entire search volume every second and provides accurate 3D data for all aerial targets in the search volume. The automatic detection and tracking functionality provides fast and reliable feedback to the operator. The radar is able to distinguish between a wide range of targets such as fixed-wing, rotary-wing and surface targets. It is one of the few systems designed to handle more than 600 tracks. The SeaGiraffe 1X can be used for C-UAS (Counter Unmanned Aerial Systems) through Enhanced Low, Slow and Small (ELSS) classification. In addition, SeaGiraffe 1X offers comprehensive electronic countermeasures (ECCM) capabilities and is designed with easily adapted interfaces so that this radar solution supports any combat system interface architecture.

Small size, great performance

With a size of 120 x 70 cm, the low weight of less than 150 kilograms and very low power consumption of no more than 2.3 kW (i.e. the power of a household socket) make SeaGiraffe 1X suitable not only for use on smaller vessels and highly manoeuvrable forces, but also as a radar complement on larger vessels. The system operates in X-band and has its own HMI (Human Machine Interface).
SeaGiraffe 1X is based on over 60 years of radar development by Saab and is the perfect choice for navies, amphibious forces and coastguards looking for a system with higher performance and an extremely small logistical footprint. For example, the system has recently been adapted to the CB90 NG (Next Generation) patrol boats. CB90 NG includes a new combat management system and sensors for surveillance, ballistic protection, as well as further improved stealth, manoeuvrability and speed. These patrol boats are designed to swiftly transport marines and other forces.

F123 in Germany

In July, Saab signed a contract with the German Federal Office of Bundeswehr Equipment, Information Technology and In-Service Support (BAAINBw) and received an order for the delivery and integration of new ship radars and fire control systems for the German Navy's Brandenburg-Class frigates (F123). Among other things, the contract also includes the delivery and integration of the SeaGiraffe 4A and SeaGiraffe 1X radars. In addition, there is Saab's 9LV Combat Management System, the Ceros 200 fire control director and other third-party systems, including IFF (Identification Friend or Foe) capability.

Multi Sensor Solution for Finland

As part of the combat system delivery and integration for the Finnish Navy's new Pohjanmaa-class corvettes in context to the Squadron 2020 order, Saab is supplying the SeaGiraffe Multi Sensor Solution, which includes SeaGiraffe 1X and the sophisticated SeaGiraffe 4A Fixed Face radar. The Multi Sensor Solution provides optimal overlapping performance and redundancy for air and surface surveillance. In addition, the contract includes the Saab Combat Management System (9LV), the TactiCall communication system and the Trackfire long-range weapon station. The new corvettes will be fully operational by 2028.
The SeaGiraffe 1X radar solution makes maritime platforms more capable and better prepared to execute missions in the world's littorals, ruling your domain.

Read more: **saab.com**

This is Enforcer 3 (Combat Boat 90) with Giraffe 1X.

Photo: Glenn Pettersson, Kockums, Saab AB

Saab receives order to modernise German Navy's F123 frigates.

Photo: Saab

Type 26 production has been allocated to BAE Systems' shipyards on the River Clyde, where this image of the forward block of lead ship HMS GLASGOW was taken.

Australia in December that year. The programme envisages the construction of nine frigates over a period extending for more than two decades.

Although utilising the Type 26 Global Combat Ship hull and propulsion train, the HUNTER class frigates will encompass significant design changes from their British "cousins". The more significant design alterations include:

- Incorporation of the AEGIS combat management system combined with a Saab Australian tactical interface
- Specification of the CEA Technologies' CEAFAR2 phased array as the main multi-function radar
- Integration of Australian-specific weapons systems
- Utilisation of Australian communications systems
- Integration of the MH-60R SEAHAWK helicopter

It seems that the incorporation of these alterations and additions have added to the overall displacement of the HUNTER class design. The original estimated full load displacement was in the order of 8,800 tonnes but recent Australian press reports suggest that this figure has increased to around 10,000 tonnes.

An important aspect of the HUNTER class programme is its utilisation to support the Australian government's intent to revitalise the domestic shipbuilding sector. Contractual arrangements have seen BAE Systems acquire the government-owned ASC Shipbuilding (now BAE Systems Maritime Australia) for the duration of the HUNTER class project, with its Osborne South Naval Shipyard in South Australia being modernised to form the centrepiece of future surface combatant construction. The intention is to maintain a regular "drumbeat" of production throughout the life of the project and beyond to prevent the boom and bust cycle that has typified Australian shipbuilding in the past. A downside of this approach – which has extended the overall production cycle – has been the increase to overall programme cost, which is now estimated to amount to circa AU$46Bn (US$35Bn).

BAE Systems commenced prototype block fabrication at Osborne on schedule in December 2020. The aim is to assemble five representative ship blocks to test production processes and hone workforce skills prior to the start of production of the first actual ship. This was scheduled to commence build at the end of 2022 but recent Australian press reports suggest a delay in the region of 18 months might occur due to delays in maturing the final HUNTER class design against the backdrop of the weight increases referenced above.

There has been some criticism in the local media that Australia made a mistake in selecting the Type 26 design over its more mature FREMM and F100 competitors. These critics argue that the construction process would have been easier and swifter if a tried and tested ship, already in the water, had been selected. This seems a little unfair. Australia's desire to adapt their new ships to carry Australian-specific equipment, including locally produced technology, would have always required significant adaptation. Moreover, the fact that the Type 26 is a larger ship than these two frigate designs should make it easier for Australia to incorporate the capabilities it requires without the inevitable compromises that would arise from using comparatively smaller hulls. Nevertheless, the size, complexity, risk profile and negative media interest associated with the programme has resulted in it being added to the Australian Department of Defence's 'projects of interest' watch list.

Canada

The process which has resulted in the Royal Canadian Navy becoming the third country to select the Global Combat ship design dates back to a Single Ship Transition Project to replace both the IROQUOIS and HALIFAX classes with just one future class of surface warship. The project subsequently became known as

The constituent blocks of HMS GLASGOW were joined together at the start of May 2021.

the Single Class Surface Combatant and, finally, as the Canadian Surface Combatant (CSC). Canada's 2010 National Shipbuilding Procurement Strategy (now the National Shipbuilding Strategy or NSS) laid out plans to ensure these ships would be built domestically as part of a policy to bolster indigenous shipbuilding capabilities. Irving Shipbuilding's Halifax yard was selected to build the new class the following year. However, it was only in 2016 that it was decided to modify an existing ship to form the basis for new ships rather than to create a new design from scratch. Reports at the time suggested 12 countries had been asked to submit design proposals but it seems that only proposals based on the Dutch LCF DE ZEVEN PROVINCIËN, the Spanish F100 and the Global Combat Ship were ultimately submitted. [2] In October 2018, it was announced that a Lockheed Martin Canada bid based on the BAE Systems Type 26 Global Combat Ship had been selected as the preferred bidder. Just as was the case for the United Kingdom and Australia, the ship's strong ASW emphasis seems to have been a key element in Canada's decision.

A design contract for the CSC was subsequently awarded to Lockheed Martin Canada in February 2019, with the Canadian ships' main parameters now largely established. As is the case for Australia's HUNTER class, the CSC retains the hull and propulsion train of the Type 26 but incorporates much Canadian-specific equipment. Notably, LMC's CMS 330 combat management system – used, inter alia, in the existing HALIFAX class frigates' modernisation – will interface with an AEGIS module and the new AN/SPY-7 active phased array to control three layers of protective missile systems. These will encompass missiles from the STANDARD series for area defence, EVOLVED SEA SPARROW missiles for point defence and SEA CEPTOR missiles for last ditch, close-in protection. Other equipment, such as the Ultra-supplied hull-mounted sonar, will have much in common with similar systems found in the British ships but will be customised to meet Canadian requirements. Just as for the HUNTER class, this has all added to ship displacement, which is now estimated to be around 9,400 tonnes in full load condition. Although within the Global Combat Ship's design margin, this may impact the scope for further change in the course of the class's operational service.

A construction contract for what is expected to be an initial batch of three CSCs is currently anticipated in 2023, with fabrication commencing the following year. Canada has also extended the amount of time it expects Irving to take building the ships on the basis of information gained from the more advanced British and Australian projects, suggesting the first ship will not be delivered until circa 2030/31. This, combined with a programme cost currently estimated to amount to CAD$56-60bn (US$45-48Bn), has fuelled criticism of the high costs associated with the NSS. However, the programme is doing much to revitalise both Canadian naval shipbuilding and the wider indigenous maritime supply chain, which formed the strategy's key underlying objectives.

An early computer generated graphic of the Australian HUNTER class variant of the Global Combat Ship.

A Promising Design

In spite of its protracted development process, the Type 26 Global Combat Ship has found an important niche, offering the prospect of providing high end ASW capabilities to navies emphasising this requirement. Moreover, it is apparent that the basic design has been sufficiently flexible to be adapted from the Royal Navy's initial specification to meet the varying demands of partner navies overseas. Interestingly, it is also playing an important role in revitalising the shipbuilding industries of all three countries involved in the programme, delivering important economic – as well as security – benefits. Although a sophisticated design with an expensive price tag, the Global Combat Ship looks set to prove its worth in the years ahead. ■

Notes

1. As the first of the preceding Type 45 destroyers took only a little over six years from first steel-cutting to commissioning, this circa eight year timescale does not appear to be overly challenging.
2. In addition, France's Naval Group and Italy's Fincantieri put forward a proposal outside of the formal selection process that the Canadian government rejected.

Like the HUNTER class, the Canadian Surface Combatant variant of the Global Combat Ship shows considerable variation from the original British design. Some equipment has been changed since this early graphic was produced.

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Medium Calibre Naval Gun Systems and Smart Ammunition

Luca Peruzzi

The growing range of sophisticated threats and multi-domain operations in both littoral and blue waters are causing navies worldwide to implement multi-purpose weapon systems that effectively contribute to the defensive and offensive capabilities of naval platforms. European, US and Russian industries are striving to expand the capabilities of medium-calibre artillery systems. With the introduction of smart munitions and enhanced fire control systems, inherently affordable artillery will be able to counter contemporary and future sophisticated threats such as missiles, swarms of attacking boats and unmanned systems. They also attain greater ranges and allow the engagement of land-based or coastal threats in a contested environment. In parallel, weight savings make it possible to use such weapon systems on smaller platforms.

Photo: Leonardo

The Leonardo SUPER RAPIDO gun system in the STRALES configuration successfully engaged a subsonic target simulating a sea-skimmer threat.

76/62 SUPER RAPIDO, STRALES and VULCANO

Last June, the Italian Navy's FREMM frigate MARCEGLIA, equipped with the Leonardo OTO 76/62 mm SUPER RAPIDO gun mount in the STRALES configuration, successfully engaged a subsonic target with DART (Driven Ammunition with Reduced Time of Flight) during the NATO AT SEA DEMO/FORMIDABLE SHIELD 2021 IAMD (Integrated Air and Missile Defence) live-firing exercise. The live fire demonstrated the operational capabilities of the system. Thanks to the high-velocity projectile (1,100 metres/second initial velocity), supersonic threats can be engaged. Even though, according to LEONARDO, no live trials have been conducted so far.

The lighter version of the 76 SUPER RAPIDO with a smaller footprint, the 76 Single Deck, requires no deck penetration and weighs almost 40 percent less - with the same performance characteristics. The rate of fire is 120 rounds per minute. With a mass of 7,900 kg without ammunition, or 9,200 kg with the STRALES superstructure, the weapon system can be used even under constrained space and weight conditions. In the STRALES/DART configuration together with the VULCANO family of guided and unguided ammunition, it represents the latest development in the Leonardo OTO 76/62-gun family.

SUPER RAPIDO has a multiple-feed ammunition magazine (hence the designation 76/62 mm SR MF). It is based on a dual ammunition feed, each capable of holding up to 38 rounds, allowing the use of specific ammunition for different types of threats. A new AC3v2 digital remote-control console and a digital link to the Fire Control System in combination with a universal ammunition programmer for setting both 4AP and VULCANO fuses provides flexibility in engaging air and sea targets. SUPER RAPIDO is in service or under contract with more than 40 customers worldwide. More than 240 guns have been delivered since the late 1990s. DART operates in conjunction with a gun-mounted guide antenna in the HF-Ka band as in the STRALES configuration. Alternatively, a compatible ship-based Fire Control System (FCS) can be used, such as the Leonardo dual-band radar EO/IR NA-30S Mk2 or PHAROS from Thales Nederland. DART is already in use in the Italian and Colombian navies. Egypt has recently received the two Fincantieri-built FREMMs equipped with the SUPER RAPIDO/STRALES. The Dutch Ministry of Defence announced in January that it had selected the SUPER RAPIDO with PHAROS/DART guided munitions and Raytheon's RAM surface-to-air missile system to replace the in-service GOALKEEPER short-range weapon systems. This will be used to equip the future multi-purpose frigates that will be jointly procured by Belgium and the Netherlands.

In August 2020, the Indian Ministry of Defence approved the procurement of an upgraded version of the SUPER RAPIDO by BHEL, India's gun manufacturing licensee. MSD understands that this will be both the STRALES/DART and VULCANO 76 mm.

Leonardo has also developed 76mm sub-calibre non-self-propelled guided and unguided ammunition (Ballistic Extended Range, BER) versions equipped with a programmable 4AP fuse. While

the BER ammunition will have a range of 27 km (compared to 16 km with conventional ammunition and up to 20 km with Leonardo's SAPOMER ammunition), the 76 VULCANO GLR (Guided, Long Range) (equipped with IMU and GPS for autonomous guidance) will have a range of up to 40 km. The Italian group is working on testing and qualification for the start of production in 2023-24, and the first customer for the 76 VULCANO GLR is the Italian Navy. In addition, other nations are showing interest, Leonardo said.

BOFORS 57 Mk 3, ALaMO and MAD-FIRES

In October 2020, Babcock International awarded BAE Systems a contract for the delivery of five BOFORS 57 Mk 3 and ten BOFORS 40 Mk 4 (see subsequent paragraph) to equip the new class of five Type 31 light frigates. The UK is the latest addition to the worldwide club of BOFORS 57 Mk 3 (and US Mk 110 variant) customers, including the navies of Brunei, Finland, Indonesia, Mexico, Malaysia, Norway, Saudi Arabia (to equip Lockheed Martin's Multi-Mission Surface Combatant platforms which are under construction), Sweden (in the stealthier configuration to equip the VISBY-class corvettes), US (Navy and Coast Guard) and UAE (Critical Infrastructure & Coastal Protection Authority).

From the beginning the Swedish company developed the 57 Mk 3 to capitalise on the multi-target functionality commonly designated as 'smart' 3P (Prefragmented, Programmable, Proximity-fused). The medium calibre gun is the third generation of a family's lineage of high rate-of-fire multipurpose weapon systems with a compact lightweight mounting. This makes installation possible on board smaller surface combatants (down to 150 tons). The gun is equipped with with a fully automatic, computerised ammunition handling system capable of accommodating 120 ready-to-fire rounds in the gun mount with a loading system from the magazine centred on two parallel hoists enabling instant switching between ammo types. The BOFORS 57 Mk 3 has a maximum rate of fire of 220 rounds per minute and 17 km maximum range. This offers offensive as well as defensive options in Anti-Air-, Anti-Surface-Warfare and in shore bombardment.

An integrated muzzle-velocity radar delivers data to the fire-control computer for calculating ballistics and the target intercept point, enabling the BOFORS 57 Mk 3 to achieve maximum accuracy. The gun is controlled by a single remote operator console. As a backup and due to a gun-mounted TV-camera, it can also be controlled from a PC-based gun panel located anywhere onboard. Total system weight including 1,000 rounds is around 14,000 kg.

Designated as Mk 110 Mod 0 by the US Department of Defence, this variant is the standard medium calibre for the US Navy and Coast Guard, equipping both in service and new generation ships to include the FFG 62 CONSTELLATION class frigates. In addition to the 3P ammunition (designated Mk 295 Mod 0), the US Navy awarded L3 Mustang Technologies the contract to develop and provide the Mk 332 High Explosive-4 Bolt Guided (HE-4G) cartridge under the ALaMO (Advanced Low-cost Munitions Ordnance) programme. It will allow the gun to hit fast moving sea-surface targets at significantly longer ranges and with greater accuracy compared to current 57 mm munitions. According to US DoD Fiscal Year (FY) 2022 budget documentation, the ALaMo programme is expected to complete qualification activities in the last quarter of FY 2021, without providing information on production. In September 2020, the Defense Advanced Research Projects Agency (DARPA) awarded to Raytheon the 'Phase 3' activities to the previously awarded procurement contract for the Multi-Azimuth Defense Fast Intercept Round Engagement System (MAD-FIRES) programme. According to US DoD FY 22 budget documentation,

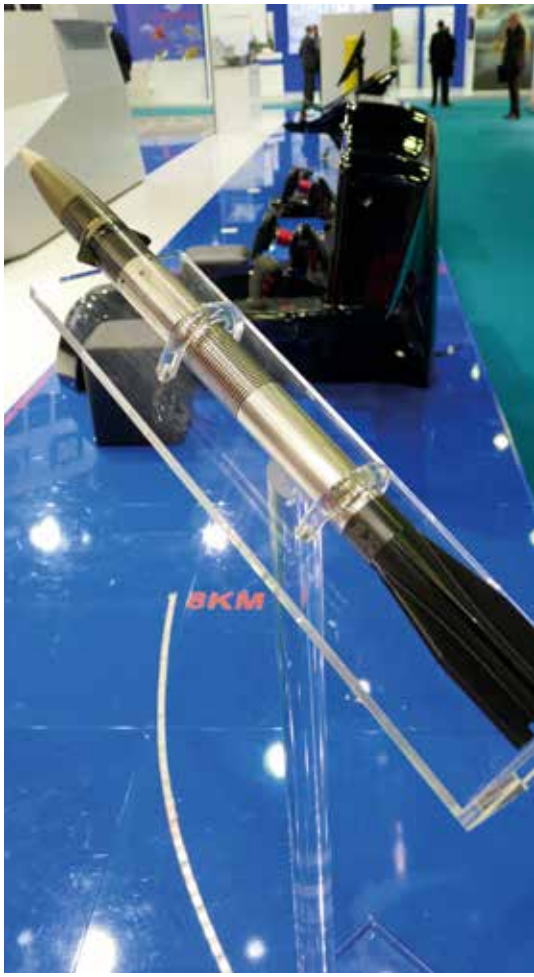


Photo: Luca Peruzzi

DART–ammunition was developed by Leonard against manoeuvering missiles and small manoeuvering targets at sea.

Photo: Leonardo

The Leonardo 76/62 VULCANO ammunition with IMU/GPS for autonomous guidance will be capable of ranges up to 40 km. Being developed for Italian Navy, it will be available in 2023-24.

Photo: Luca Peruzzi

Leonardo has developed a lightweight and non--deck penetrating version of the 76 SR. The 76 Single Deck is installed on the Italian Navy's PPA.

Photo: BAE Systems

The latest BOFORS 40 Mk 4 version offers full compatibility with the latest 'smart' 3P (Prefragmented, Programmable, Proximity-fused) ammunition.

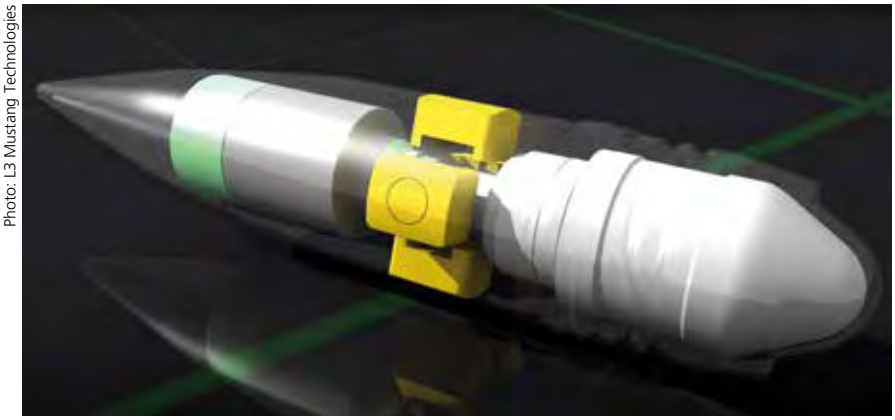
the latter seeks to develop a close-in defence system against today's most stressing threats. The objective is to develop a highly manoeuvrable, medium calibre, guided projectile, fire sequencing and control system capable of neutralising raids of high speed, highly manoeuverable and numerous targets. On the basis of information and videos provided by US DoD and Raytheon, the Mk 110 57 mm gun's new guided projectile and guiding system seeks to achieve lethal superiority through accuracy rather than size. This may expand the role of smaller combatants into missions where they have been traditionally outgunned. According to US DoD documentation, demonstrations against subsonic aerial targets are planned for FY 2022, preceded by a series of preparation activities. These include the verification of the fire control system's ability to guide rounds against simulated targets and projectile compatibility with the gun feed system. The ultimate programme goal is for the testing and demonstration against supersonic targets to be carried out in FY 2022.

BOFORS 40 Mk 4

In the last twelve months, BAE Systems has been selected to provide its BOFORS 40 Mk 4 gun system to additional customers. As previously mentioned, it will be fitted onto the Royal Navy's Type 31 light frigate. In February this year, French shipbuilder Kership selected the system to equip the fleet of twelve mine countermeasures mother mother vessels being acquired under the joint procurement programme between The Netherlands and Belgium.

The reengineered gun mounting presents a more compact and stealthier cupola re-

Photo: L3 Mustang Technologies



L3 Mustang Technologies is under contract to develop and provide the Mk 332 High Explosive-4 Bolt Guided (HE-4G) cartridge with enhanced anti-surface capabilities.

Photo: Thales

The naval RAPIDFIRE 40 mm gun mount with A3B ammunition will be able to engage aerial threats like drones.

Giorgio Arra

Developed by the JSC Central Research Institute Burevestnik, the 100 mm A-190 gun mount equips mainly frigates and corvettes, like the SOOBRAZITELNY STEREGUSHCHY class Project 20380 corvette.

sulting in a weight of 2,300 kg (without ammunition) compared to the 3,700 kg of its predecessor. Up-to-date electric drives replacing the known electro-hydraulics and a fully digitised modular architecture enable the Mk 4 version to achieve variable firing rates between 30 and 300 rounds-per-minute. The maximum range is 12.5 km. While any 40 mm L/70 round can be employed, the Bofors 40 MK 4 offers full compatibility with latest 'smart' 3P (Prefragmented, Programmable, Proximity-fused) programmable ammunition, providing 6-mode all-target ammunition. The system offers the possibility to switch between two different types of ammunition. Storage is 30 ready-to-fire rounds in the primary magazine, plus 70 rounds in an intermediate magazine.

RAPIDFIRE and A3B Ammunition

RAPIDFire is the result of Thales' and Nexter's combined expertise to enhance the close-in defence capability of naval units against modern air and surface threats. Its specifications include the protection against surface and air unmanned vehicles (USVs and UAVs) individually employed or in swarms. As a self-contained gyro-stabilised gun mounting with an optronic fire control system integrated on the turret, RAPIDFire incorporates a 40 mm Cased Telescoped Ammunition (CTA) gun. CTA was developed by CTAI, the international subsidiary of Nexter Systems and BAE Systems to equip the latest generation armoured vehicles for the Belgian, British and French land forces. The automatic ammunition management system draws upon a magazine of 140 ready-to-fire rounds. RAPIDFire's co-located but independently gyro-stabilised electro-optical system includes infrared, daylight and a laser range finder. Firing range is indicated with 200 rounds-per-minute with an effective range of up to 2,500 meters against surface targets and up to 4,000 meters against air targets with the under development A3B (Anti-Aerial Air Burst) ammunition which features a payload of 200 tungsten pellets.
The French DGA chose RAPIDfire for the 31,000 tons Bâtiments Ravitailleurs de Forces (BRF)(fleet replenishment vessels) which are currently under construction under the FLOTLOG (FLOTte LOGistique) programme as well as for the future Patrouilleurs Océaniques (PO) (OPV).

Russian medium calibre guns

With the construction of a new generation of naval platforms for the Russian

Federation Navy, Russian national industry developed new combat and weapon systems. The JSC Central Research Institute Burevestnik, belonging to the JSC UralVagonZavod research and production corporation, today part of the Rostec State Corporation, developed three main gun systems: the 100 mm A-190, the 76 mm AK-176MA and the 57 mm A-220M.

Starting with the Project 20380 STEREGUSHCHY class, the A190E-5P-10E with its weight of 15,000 kg has been installed on platforms of 500 t and more, mainly on frigates and corvettes. The system includes the 100 mm A-190E multi-purpose gun mount with a single-barrel 100/59 mm and the 5P-10E fire control system. The two independently operating sides of the ammunition loading system handle 80 rounds of two different types of ammunition simultaneously ready-to-fire. Maximum gun range is indicated as being over 20 km, maximum rate of fire is 80 rounds-per-minute. Both surface-to-surface HE (impact fuse) and anti-air (time fuse) ammunitions with a weight of about 15.6 kg can be fired. The JSC Ratep 5P-10E Puma multipurpose Fire Control Radar provides autonomous search for air and surface targets, automatic lock-on and tracking of up to four threats. In addition, it is said to have the capability to also control different calibre gun mounts engaging simultaneously up to two targets.

Developed to be installed on board smaller combatants, the latest addition to the AK-176 family of 76 mm gun mounts, the AK-176 MA-01 is characterised by a 9,500 kg full mass gun mount with reduced radar cross-section shaped shield and reduced footprint. Enabled to fire both anti-air HE and surface-to-surface HE fragmentation shells, the AK-176 MA-01 achieves 120-131 rounds per minute while the maximum range is 15.7 km. Ammunition load is 152 rounds.

Interestingly, China has developed an enhanced version of the former Russian AK-176M which figures under the designation H/PJ-26.

Derived from land-based applications, the naval version of the AU-220M (M stands for Upgraded) is the latest product of naval medium calibre artillery in the category of 57 mm. With a weight of 8,500 kg, the AU-220M is designed to be installed on small surface combatant vessels of not more than 150 t. The Remotely Operated Weapon Station (ROWS) is proposed in a configuration where the gun turret is mounted on top of a hexagonal-shaped superstructure installed in the ship bow-area. The baseline navalised AU-220M includes beyond its 57 mm automatic gun a coaxial electro-optical/infrared (EO/IR) fire control suite on top of the turret and a magazine for 148 rounds. While the maximum firing range is 14.5 km, 100-120 rounds can be shot per minute. During cruises, the module and the gun turret can be covered by a triangular-shaped protection thus reducing its radar cross section.

Unveiled by the JSC Central Research Institute Burevestnik for the first time during the Indian Defexpo 2020, AU-220M has already found export opportunities. According to local sources and confirmed by latest images, at least some of the Indonesian Navy's KCR-60M class missile boats are equipped with the ROWS.

Stopping the Anti-Ship Missile

Doug Richardson

The sinking of the Israeli destroyer EILAT in 1967 by SS-N-2 STYX anti-ship missiles launched by Egyptian KOMAR-class missile boats was a wakeup call to the navies of the West, demonstrating the need for ship-mounted defensive systems able to counter the threat posed by these weapons. Various companies around the world soon concluded (as had their equivalents in what was then the Soviet Union) that the most practical solution would be a Close-In Weapon System (CIWS) based on a radar-directed gun with a high rate of fire.

Most CIWS are typically armed with 20-40mm cannons that can use several potential kill mechanisms. Until the 1960s, the smallest size of round able to carry a proximity fuze plus a useful explosive payload was 40mm, but this limit has now been extended down to 35mm. CIWS based on the smaller calibres rely on achieving direct hits on their target, and either use the kinetic effects from strikes by solid metal projectiles, or use a contact fuze to initiate an explosive payload. Solid projectiles can be of the Armour Piercing (AP), Sabotted Light Armour Piercing (SLAP), Armour Piercing Discarding Sabot (APDS) or Fin-stabilised Armour Piercing Discarding Sabot (FAPDS) type, while explosive-filled projectiles are typically of the Armour Piercing Incendiary (API) High Explosive Incendiary (HEI) and Semi-Armour Piercing High Explosive Incendiary (SAPHEI) ammunition.
The shorter the range at which a kill is achieved against an incoming missile, the greater the risk that its debris, or even a fairly intact but non-functioning mass, will strike the ship, causing some degree of damage. But given that the debris is no longer powered and is not of good aerodynamic configuration, it will lose velocity. Weapons such as the Raytheon PHALANX and Thales GOALKEEPER are intended to strike the warhead of the incoming missile with solid shots the remaining kinetic energy of which is high enough to detonate the explosive content, inflicting massive damage on the target that will reduce the risk of debris striking the ship.
Choice of calibre is inevitably a compromise. The smaller calibres will probably be a higher velocity, while the smaller size of the complete round will result in greater magazine capacity for a given storage volume. A larger and heavier projectile could be harder-hitting provided that there is no significant penalty in muzzle velocity, but magazine capacity for a given volume will be reduced.
If a CIWS is incorporated into the ship when the latter is being designed, it can be configured in a deck-penetrating form able to receive power, cooling, and a good supply of ammunition from within the hull of the vessel it is protecting. But in practice, a CIWS is often an add-on feature for an existing ship or ship class, in which case a system that is not deck-penetrating and does not require external power, cooling, or ammunition feeds will be more practical. As a result, the mount can only house a limited amount of ammunition, so may need to be manually reloaded while the ship is in action and further threat missiles may be incoming.

Author

Following an earlier career in engineering, **Doug Richardson** is a defence journalist specialising in topics such as aircraft, missiles, and military electronics.

Photo: US Navy

This test firing of a 20mm PHALANX shows how the entire gun, radar, and sensor assembly must be tilted to direct the barrels to the required elevation.

USA and Europe

Originally developed by General Dynamics Corporation, Pomona Division (now Raytheon), the PHALANX is one of the classic CIWS. Its unique form – a 20mm VULCAN rotary cannon, ammunition magazine and radar packaged into a tilting housing that has been likened to the R2D2 'droid' from the movie Star Wars – made it immediately recognisable. It entered service aboard the aircraft carrier AMERICA (CV-66) in 1980, is now installed on most US Navy ships, and has been adopted by 22 export customers.
The AN/UPS-2 J-band pulse-Doppler radar using a search antenna is located under the tall radome at the top of the tilting housing, and provides bearing, range, velocity, heading, and altitude information of potential targets to the CIWS computer. If a valid target has been detected, the mount turns to face the perceived threat, and the radar uses a tracking antenna mounted behind

the front of the radome to follow the target until the conditions for an engagement are satisfactory. Once this has been achieved, the system fires automatically unless a 'hold fire' command has been given.

To meet the threat posed by high-diving targets, the Block 1 Baseline 0 version was fielded in 1988, but was soon followed by the Block 1 Baseline 1 in which the hydraulic gun drive was replaced by a pneumatic drive system that increased the rate of fire to 4,500 rnds/min. Subsequent variants have continued to improve the system, improving the radar and computing subsystems, adding a stabilised electro-optical tracker, and giving PHALANX the ability to engage small high-speed surface craft, helicopters, and low-performance fixed-wing aircraft.

The Thales (formerly Signaal) GOALKEEPER is based on a 30mm, 7-barrel GAU-3/A rotary cannon that fires Missile-Piercing Discarding-Sabot (MPDS) ammunition. An I-band search radar is teamed with a dual-frequency I/K-band tracking radar whose higher frequency subsystem results in a narrow pencil beam intended to avoid problems caused by reflections from the sea surface, but the system automatically compares the signal-to-noise ratios of the data from the two frequencies. The mount of the tracking radar also incorporates a TV camera. Since the system is deck-penetrating, ammunition can be stored within the ship's hull in a drum magazine with a capacity of 1,190 rounds

A modernisation programme announced in 2012 involves radar upgrades, a new electro-optical tracking system with colour and infrared cameras, new frangible ammunition, and various mechanical improvements, while the existing surface mode was modified to improve its capability against high speed boats and fast attack craft - a capability that has been demonstrated by the destruction of pirate craft during operations off the coast of Somalia. To date, a total of 63 GOALKEEPER systems have been delivered to the Royal Netherlands Navy and seven export customers.

The Dutch Navy's GOALKEEPER modernisation programme also includes improved software algorithms, and a new operator console. Known as the Instandhouding GOALKEEPER programme, this should keep the system effective until 2025. In the longer term, the upgraded GOALKEEPER will be replaced by a combined missile/gun solution based on the Raytheon/RAM-System RIM-116 Rolling Airframe Missile (RAM) and the Leonardo DART (Driven Ammunition Reduced Time of flight) 76mm guided ammunition. This will be integrated with Thales Nederland's PHAROS fire-control radar.

Developed by Navantia in the late 1970s and early 1980s and used only by the Spanish Navy the 20mm MEROKA obtains the rate of fire needed for the CWIS role by using an array of twelve barrels. These are arranged in two superimposed rows, but share a common breech-block. This array of barrels is trained and elevated just like a conventional weapon, but their mutual position can be adjusted to cone or spread their fire for greater effect. The twelve barrels do not fire simultaneously, but in four bursts of three, a measure intended to reduce the recoil forces and avoid degrading the accuracy. Once the fourth burst has been fired, the common breech block opens, the spent cases are ejected, and 12 new rounds are chambered as the breech block closes. The mount contains the gun system, a drum holding 720 rounds, an AN/PVS-2 I-band pulse-Doppler target tracking radar, and a low-light TV camera.

Developed by Oerlikon Contraves (now Rheinmetall Air Defence), the GDM-008 MILLENNIUM is based on a 35mm revolver cannon. It uses the AHEAD (Advanced Hit Efficiency And Destruction) ammunition invented by Oerlikon Contraves. As each projectile reaches the muzzle end of the gun barrel, its velocity is measured by the first two coils of a muzzle-mounted unit through it must pass. These coils measure the round's velocity, which is combined with target data from the fire-control computer to calculate the exact time at which the projectile must be detonated so that it bursts some 8 - 10m ahead of the target. This firing time is programmed into the projectile's fuze by the third and final muzzle-mounted coil. When the projectile detonates, it releases a cone-shaped pattern of 152 3.3g spin-stabilised tungsten projectiles. The system is battery powered and requires no through deck penetration or supply of coolant. A total of 252 rounds of AHEAD ammunition is stored in an on-mount magazine.

Thales and Nexter have teamed to create RAPIDFire, the weapon chosen by the French defence procurement agency (DGA) to arm future French Navy ships. The new turret will house an optronic fire control system and a 40mm gun developed by CTAI and able to fire the recently-developed ANTI AERIAL AIRBURST (A3B) rounds.

Turkey was the only customer for Oerlikon Contraves' SEA ZENITH CIWS. Deployed on that country's MEKO 200 and Modified MEKO 200 frigates, it has an enclosed auto-

Photo: US Navy

PHALANX is been built in larger numbers than any other Western CIWS. Since production began in the late 1970s more than 900 have been manufactured.

Photo: Thales

Thales' GOALKEEPER uses a more conventional layout that PHALANX. It is currently in service with service navies.

Photo: US Navy

In the SeaRAM system, an 11-cell launcher for the RIM-116A Rolling Airframe Missile (RAM) replaces the 20 mm gun of the PHALANX.

matic turret armed with four 25mm calibre Oerlikon KBB cannon that fire discarding-sabot ammunition at a combined rate of 3,400 rnds/min. Maximum range is 2km. One novel feature of the system is that the mount is inclined at an angle of 35 degrees to the horizontal in order to be able to engage vertically-diving missiles.

Turkey and South Korea

Aselsan based its GOKDENIZ CIWS on a 35mm twin gun system and Airburst Ammunition (ATOM), a combinationintended to offer effective defence at greater ranges than are possible with smaller-calibre weapons. The system can be loaded with both ATOM and high-explosive incendiary ammunition (HEI) at the same time and can switch between ammunition types as needed. The system is in service with the Turkish Navy – for example, it will be installed on the new ISTANBUL-class frigate – while the first export customer was an unidentified Asian country. South Korean warships currently use a number of CIWS systems. For example the KDX-I, KDX-II, KDX-III class destroyers are fitted with GOALKEEPER, while the latter two classes also have RAM. A new CIWS-II system is now planned, and both Hanwha Systems and LIG Nex1 have indicated interest in the programme. The chosen system is expected to combine a Ku-band active electronically scanned array (AESA) radar with the GAU-8/A AVENGER seven-barrelled cannon already used by GOALKEEPER, but a 40mm gun firing case-telescoped ammunition is also a possibility. The resulting system is expected to serve aboard KDDX-class destroyers and FFX-III-class frigates.

Photo: Rosoboronexport

This AK-630M is an improved version of the original AK-630 that was rushed into Soviet Navy service in the early 1970s even before being trials had been completed.

Chinese-Russian Cooperation

Russia's AK-630 is based on the six-barrelled AO-18 30 mm rotary cannon with water cooling. Housed in an enclosed automatic turret, this is directed by an MR-123-02 'Base Tilt' fire-control radar and an SP-521 electrical-optical tracker. From the 1970s onwards, the AK-630 was installed on all major combat vessels of what was the Soviet Union, while the improved AK-630M-MR-123 was fitted to smaller combatants such as frigates, minehunters, and patrol boats. While primarily intended for use against anti-ship missiles and other guided munitions, the AK-630 can also be used against fixed or rotary wing aircraft, and small ships including fast-attack craft. It can fire HE-I or HE-T ammunition, with 2,000 rounds being stored in the below-deck magazine.

The basic AK-630M has a rate of fire of 4,000–5,000 rnds/min. Muzzle velocity is 900m/sec, slightly below the 1,100m/sec of the PHALANX and GOALKEEPER. By the late 1980s, Russia had begun development of a version in which two AO-18 cannon were mounted one above the other. The resulting AK-630M-2 DUET has a fire rate of 10,000 rounds/min. China is reported to have become a partner in the Russian project that developed the AK-630M1-2, and this double-gun mount is now being manufactured in China as the Type 630.

The Type 730 (also known as the H/PJ12) is a Chinese CIWS based on a seven-barrelled 30 mm rotary cannon with a firing rate of 4,500-4,800 rounds/min. Similar in concept to GOALKEEPER, it uses an I-band EFR-1 tracking radar and an OFC-3 director that combines a TV camera, thermal imager, and laser rangefinder. It is intended to engage incoming missiles at ranges from 1,400m down to 150m. Two 500-round ammunition boxes contain either armour piercing or high-explosive (HE) rounds.

A Type 1130 (H/PJ11) CIWS based on an 11-barrel rotary cannon first appeared on the aircraft carrier LIAONING in 2012, but has since been installed on some destroyers. It has a reported firing rate of 9,000-10,000 rounds/min, but it is not clear whether an on-mount or below-deck ammunition supply is used.

China's H/PJ-13 is based on the Russian AK-630M, but is aimed by a ZFJ-1A fire-control system that uses target data from a modified version of Type 347 radar and a ZGJ-1B EO system. It can fire a Chinese-developed APDS round.

Earlier this year, imagery circulating on the Internet showed what appears to be Chinese rotary cannon with 20 barrels. In a conventional rotary gun or cannon, as the

barrel assembly rotates, each barrel goes through a cycle in which a round is fired, the empty case is extracted, a fresh round is chambered, and is then fired. So only one position in the 360-degree revolution is used for firing. Imagery of the Chinese 20-barrel weapon shows that two barrels are fired simultaneously at locations 180 degrees apart, so the load-fire-eject sequence is conducted over half a revolution. The barrels of the new cannon seem shorter than those of other Chinese CIWS guns, and the mount does not incorporate a tracking a radar or EO sensor. So it is possible that this hardware is a technology demonstrator rather than a prototype of a planned CIWS system.

In 2015, Rear Admiral Habibollah Sayyari, at that time Commander of the Iranian Navy, announced plans for the development of an indigenous system similar to PHALANX. Following a programme that involved tests at a coastal site and at sea, deployment of the resulting weapon aboard a destroyer was announced in August 2018. Designated KAMAND, it has a firing rate of 4,000-7,000 rnds/min, and a maximum range of 2km.

Since cannon-launched projectiles have a significant time-of-flight, the fire-control system of a CIWS will aim these at the location where the incoming threat is expected to be when the round arrives. That was not a major problem in the case of early-generation missiles which flew a direct path towards their target, but a modern antiship missile is unlikely to keep this planned appointment with the defensive projectiles that would result in their mutual destruction. Instead, it will fly an evasive terminal manoeuvre intended to stress if not confound the ability of a CIWS to track these movements and predict their future. Precise details of such evasive manoeuvres are inevitably classified, but the unclassified literature suggests that some form of barrel roll is likely.

By the 1980s, it was becoming clear that a gun solution might prove of limited use against modern anti-ship missiles. This resulted in the development of combined gun/missile systems that would allow incoming threats to be engaged at greater range, leaving the gun free to fire against 'leakers' that had survived a missile engagement.

SeaRAM

In the late 1990s Raytheon teamed with RAMSys 1998 to developing a hybrid RAM and PHALANX Integrated Defense System (RAPIDS) that would replace the 20 mm gun of the PHALANX CIWS with an 11-cell launcher for the RIM-116A Rolling Airframe Missile (RAM). An Operational Suitability Model (OSM) version of what by then was known as SeaRAM was tested at sea on the UK Royal Navy (RN) Type 42 Batch 3 destroyer YORK in 2011, then used for land-based tests at the Naval Air Weapons Station at China Lake in 2012. A full prototype was delivered in 2003, and in 2006 the system was selected for installation on the US Navy's Littoral Combat Ships. A contract modification in 2011 covered the supply of what by then was designated Mk15 Mod31 for use on selected US and Japanese vessels. Four years later the system was earmarked for installation on four DDG 51 ARLEIGH BURKE-class destroyers scheduled for forward deployment to Rota in Spain.

Photo: Rosoboronexport

KASHTAN-M is the latest version of this Russian gun/missile system. Improvements include a longer missile and gun ranges, a higher engagement altitude, and a shorter reaction time.

Russian Systems

KORTIK (SA-N-11 'Grison') is the CIWS installed on Russia's aircraft carrier ADMIRAL KUZNETSOV, KIROV class battlecruisers, and NEUSTRASHIMY class frigates, while the KASHTAN export variant is fitted to the SOVREMENNY class destroyers sold to China. Essentially a shipboard version of the 2S6M TUNGUSKA (SA-19 'Grison') land-based air-defence system, the 3M87 KORTIK consists of a 3R86 command module mounted below deck and several 3R87 combat modules. The command module uses a 3-D radar and IFF system to detect and track threats, then passes targeting data to the individual combat modules. These combat modules are fitted out with radar and EO tracking systems and armed with two six-barrel 30 mm rotary cannons, and two missile launchers each with four ready-to-fire 9M311 missiles. Two types of 30mm gun can be fitted to the combat module – the AO-18 rotary cannon, which has a 4,000-5,000 rounds/min rate of fire, and a muzzle velocity of 900m/sec, or the GSh-630K double-barrelled cannon from

Photo: Nudelman

PALMA is the export version of the PALASH (CADS-N-2). The only known customer is Vietnam.

the 2S6M TUNGUSKA with a 1,950-2,500 rnds/min rate of fire, and a muzzle velocity of 960m/sec.

PALASH (CADS-N-2) is similar to KORTIK/KASHTAN but was developed with the intention of making a system better suited to the export market, where it is designated PALMA. It uses a 3T99 POSITIV ME 1 radar plus an 3V89 EO system for target detection and tracking, and is armed with semi-automatic command to line to-line-of-sight (SACLOS) SOSNA-R (9M337) missiles and twin AO-18KD revolver cannons. Russia uses PALASH on its Project 11661 GEPARD-class and Project 22350 ADMIRAL GORSHKOV-class frigates. The only known export customer for the PALMA version is Vietnam, which uses the system on its GEPARD-class frigates. A more advanced variant designated PALITSA teams a three-dimensional radar with AO-18KD revolver cannons and the two-stage 57E6 missile.

In 2015 Russia revealed that it was developing a shipboard version of the PANTSIR (SA-22 'Greyhound') vehicle-mounted anti-aircraft system as a replacement for the KORTIK/KASHTAN. Several shipboard versions are planned – PANTSIR-M, a PANTSIR-ME export model, and the follow-on PANTSIR-SM. On the -M and -ME, a cannon and four missile tubes are mounted on either side of a tracking system that combines radar with TV and thermal-imaging sensors and a laser rangefinder. The gun is the same GSh-630K or AO-18KD used in KORTIK and KASHTAN, while the missiles are the IR-guided 57E6 (or the 57E6E for export systems). Missiles will be used against targets at ranges of 20km down to 1.5km, while the guns will cover from 4km down to 300m. According to the Russian press, the first ships to receive the PANTSIR-M will be the Project 22800 KARAKURT class corvettes, but the system is due to be fitted to the aircraft carrier ADMIRAL KUZNETSOV as part of that vessel's current modernisation.

In the PANTSIR-SM version, the 57E6 missiles will be replaced by the HERMES-K missile. This is expected to increase the system's maximum range to 40km, and improve its performance against cruise missiles an UAVs.

Image: Saab

Saab's TRACKFIRE Remote Weapon Station is portrayed here on a CB-90 combat boat form Docksta-varvet, displaying its ability to remain accurate and independent of boat's movements during High-Speed Boat Operations by using Saab's Fibre Optic Gyros – a vital component in many different platforms.

Light CIWS

While the antiship missile remains a major threat to warships of all sizes, today's naval environment can see ships attacked by swarms of UAVs, small craft or even by pirates. The attacks on the tanker MERCER STREET on 29-30 July by what appear to have been Iranian UAVs shows the need for weapons such as remote weapon systems (RWS) able to deal with such "low tech" threats. A quick survey of the available products shows more than a dozen intended for shipboard use, but the following three will serve as examples.

Saab designed its TRACKFIRE family of RWS for use on all ships, land vehicles, and static emplacements. Able to mount weapons ranging from small and heavy-calibre machine guns to 40mm cannon, smoke grenade launchers, and laser dazzlers, it incorporates a cooled IR sensor operating in the 3-5 micron band, a day camera with an optical zoom lens, and an eye-safe laser rangefinder. The target can be continuously lased during an engagement sequence, allowing an accurate ballistic calculation. including 3D target prediction. TRACKFIRE systems have been delivered to Finland and Sweden. Known applications are Sweden's COMBAT BOAT 90 (Strb90 HSM), and Finland's WATERCAT M18 AMC amphibious assault craft.

Kongsberg's SEA PROTECTOR is another system intended for mobile or static use. It is a member of the company's Protector series of RWS, which has been in production since and has been sold to 14 nations. A colour day camera, IR camera, and laser rangefinder (LRF) are integrated with a automatic target tracking system and comprehensive fire-control solutions. Weapons can range from 5.56mm, 7.62mm, and 12.7mm machine guns to 40mm grenade launchers, 2.75 inch unguided rockets, or the US JAVELIN missile system. SEA PROTECTOR can be fitted to any class of naval ships and patrol craft, and several mounts can be networked on a single vessel.

BAE Systems offers the Bofors LEMUR family of gyro-stabilised RWS for land and naval applications. The basic design is modular, allowing it to be tailored or upgraded to meet current or future requirements. Electro-optic subsystems can be used target identification and tracking, or even as a navigation aid, while machine guns and cannon of up to 30mm calibre can be installed, or optional launchers for countermeasures.

Inevitably, the designers of anti-ship missiles are responding to recent developments in CIWS technology. More sophisticated terminal manoeuvres will stress the tracking ability of the CIWS, while the growing use of supersonic speeds is reducing the time available between detection of an incoming missile and its final impact. Since aircraft have long needed electronic warfare systems to ensure their survival in the face of hostile air-defence systems, the installation of small EW systems in future anti-ship missiles seems a predictable development. The struggle between missile and CIWS seems set to continue. ■

Photo: Jakob Ostheim, Norwegian Armed Forces

Kongsberg Defence Systems' SEA PROTECTOR Remote Weapon Station for close-in protection at sea is shown here mounted on a Norwegian patrol craft.

Water & Waste Handling on Navy Vessels: A Matter of Honour?

Konstantin Tchetchine

The Current Status of Our Oceans

Oceans cover over 70% of the earth's surface and contain 97% of the world's water. The oceans control our climate, provide us with food and produce most of the oxygen on our planet. Our oceans facilitate many human activities including shipping, tourism and commercial fishing. At the same time oceans play a key part in the maintenance of international peace and security, providing a crucial role for both navies and coast guards.

Our world's total fleet consists of more than 100,000 vessels. These include merchant vessels, cruise ships, offshore vessels, as well as navy and coast guard ships. In a normal day, about 60,000 merchant vessels carry 90% of globally traded goods, 400 cruise ships take 600,000 tourists to exotic places and over 10,000 navy and coast guard ships defend the maritime borders of their countries. Each day over 3.2 million people sail the oceans.

With this large number of ships and people afloat, a tremendous amount of waste is generated each day, viz.:

- **Wastewater & other Wet Waste:** 735,000 tons
- Dry Waste: 4,800 tons or 55,000 m³

Of these total figures, the waste generated by naval ships is more than 16% of the waste generated by the global world fleet.

To move all ship-generated waste, approximately 37,500 large trucks would be needed every day.

Author

Konstantin Tchetchine is General Manager, Business Development at Wärtsilä Water and Waste, a part of Wärtsilä providing environmental solutions for various vessel types. An MSc in Mechanical Engineering, he has 24 years' experience in the industry.

Each year over ten million tons of plastic enter the oceans. At this moment there are five large plastic accumulation zones of in our oceans. The largest one is the Great Pacific Garbage Patch, with a surface area seven times the size of the United Kingdom.

If the waste of all the ships mentioned above were to be discharged without proper treatment or management, the impact to the sustainability of our society would be devastating. We would lose many animal species and large segments of marine life. Seaweed would cover the majority of our waters. All in all, sea pollution has a very negative impact on human health and well-being. It poses a significant threat to marine life and it is one of the most serious environmental threats we face today. Maintaining a healthy environment is one of the main tasks of modern society.

International Regulations preventing Marine Pollution

Before the 1960's most ship-generated waste was dumped overboard. In order to reduce the harmful impact on the marine environment, The International maritime Organization (IMO) started a programme of marine pollution prevention. In 1973 maritime nations signed the International Convention for the Prevention of Pollution from Ships, known as MARPOL. The convention includes regulations that prevent or minimise pollution from ships, describing what kinds of waste can be discharged overboard and where it can be discharged. It includes six Annexes dealing with pollution by different substances. These are:

- Annex I - Oil
- Annex II - Noxious Liquid Substances carried in Bulk
- Annex III - Harmful Substances carried in Packaged Form
- Annex IV - Sewage
- Annex V - Garbage
- Annex VI - Air Pollution

The type of waste determines which Annex of MARPOL is applicable. The current convention does not apply to naval ships, nor to any other ship owned or operated by a state. However, the convention does encourage governments to apply pollution controls to such ships to the extent practicable. In practice, many navies have developed their own environmental policy and guidelines, often based on IMO MARPOL requirements. On top of the IMO MARPOL regime, there are many local regulations that deal with wastewater treatment. USCG 33 CFR 159, Alaskan Standards, Great Barrier Reef Standards, Caspian Sea Standards, Canadian Standards, NATO NIAG, Dade County Code (Florida), Zero Discharge Areas, and Class Notations are just some of the rules and standards in force.

A Matter of Honour

These days, more and more navies are operating in international waters, taking part in naval exercises around the world. As the prevention of marine pollution has become essential for the environment, it also reflects on the image of the navies themselves and the countries they represent. The proper treatment of waste and water has become a matter of honour.

Another important driver for naval ships to take proper care of their waste is that irresponsible dumping of waste and wastewater can have a negative impact on stealth.

New environmental technologies and solutions can reduce the amount of waste produced onboard, enhance operational flexibility, decrease carbon emissions and ensure that operations comply with international standards.

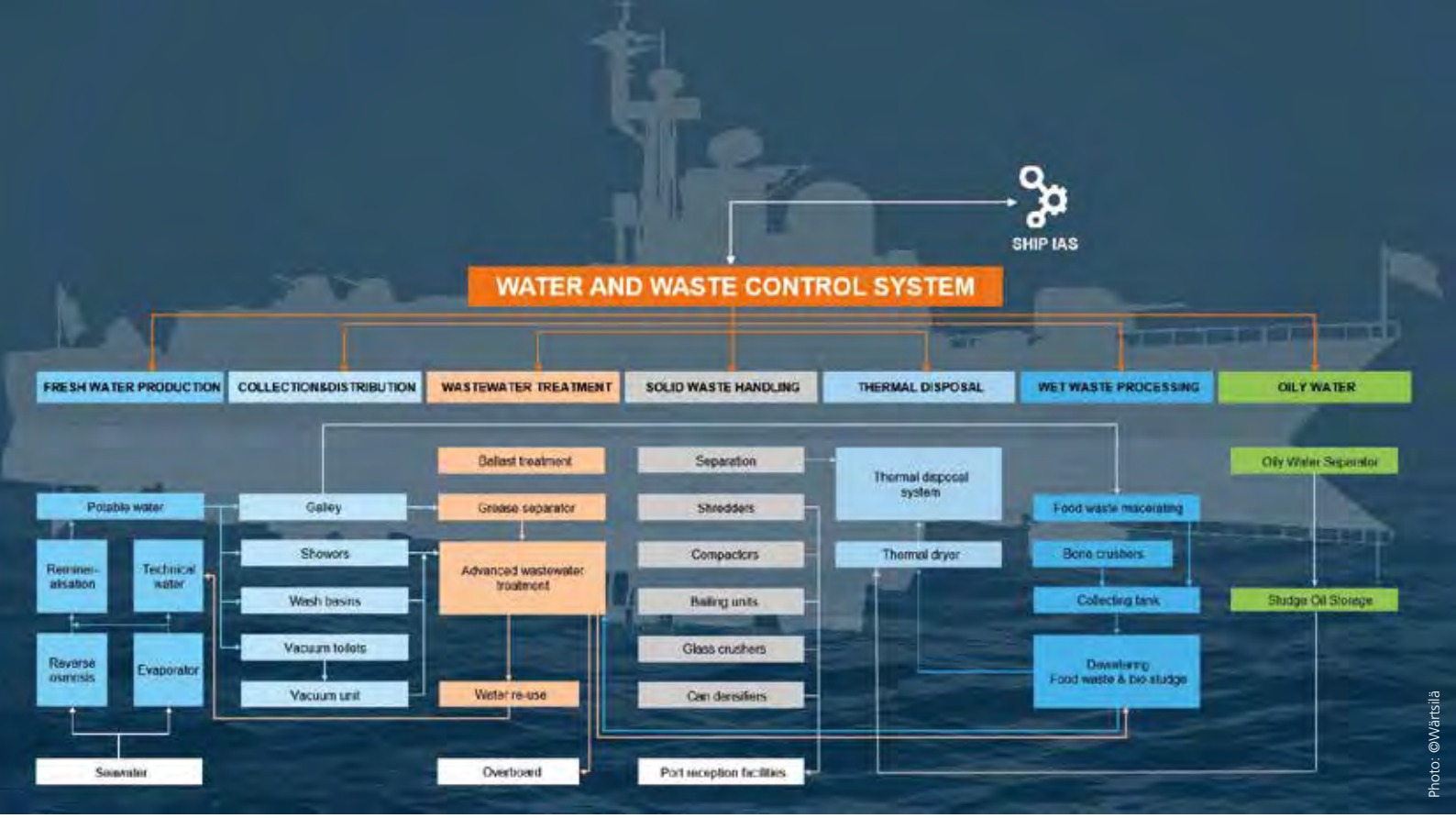
The illustration on the following page is an example of a complete waste management package.

Wastewater Treatment Plants

Wastewater can be classified into two categories: blackwater and greywater. Blackwater, or 'sewage', is wastewater from toilets and sickbays that contain faecal matter and urine. Greywater is the wastewater from showers, galleys and laundries.

The purpose of the wastewater treatment is to remove suspended solids and neutralize organic contaminants in order to comply with regulations. A wastewater treatment plant either uses a biological or a non-biological process.

IMO's MARPOL Annex IV Convention contains a set of regulations prohibiting sewage



A complete waste management package

discharge from ships, except when treated by a Sewage Treatment Plant (STP), or when discharged at over 12 nautical miles from the nearest land. According to IMO MARPOL, only the treatment of blackwater is mandatory. Greywater is not currently regulated. However, it may still contain many pollutants. This, in fact, creates a similar environmental impact as blackwater. It will be only a matter of time before greywater treatment is made mandatory by the IMO's MARPOL regime. Indeed, some local regulations already require it.

The IMO's Marine Environmental Protection Committee (MEPC) has developed guidelines on STP effluent standards and performance test specifications.

There are three main sewage treatment processes: biological, physical-chemical and electrocatalytic oxidation. Of these, the biological type is the most commonly used and suitable for different vessel types whilst physical-chemical and electrolytic plants are more suitable for small and medium size ships.

- Biological treatment uses separation to remove suspended solids and bacteria to completely remove organic contaminants.
- Physical-chemical treatment is based on separation and disinfection to kill off coliform bacteria.
- Electrolytic treatment uses macerating and the oxidation processes, which takes place in electrolytic cells and in a settling tank.

The main characteristic of these three treatment method are set out in Table 1.

Biological wastewater treatment plants come in two types: conventional biological Sewage Treatment Plants (STPs) and Membrane Bioreactors (MBRs). Traditionally, conventional biological STPs are used on smaller ships and MBRs on larger ones.

MBRs utilise an advanced wastewater treatment process based on biological degradation and membrane separation. This delivers the highest quality discharge; without requiring any addition or generation of chemicals that could be hazardous to the environment. The advantages of MBRs can therefore be summarised as:

- High effluent quality
- Low operational costs
- Future proof

Thanks to the high quality effluent, its water can be re-used as technical water after tertiary treatment.

Table 1

DESCRIPTION	BIOLOGICAL	ELECTROLYTIC	PHYSICAL-CHEMICAL
Operational costs	low	high	high
Process	continuous	on/off	on/off
Energy consumption	low	high	medium
Chemical consumption	low	low	high
Suitable ship size	small, medium, large	small, medium	small, medium
Size of equipment	medium	compact	medium
Separate collecting tank	not needed	needed	often needed

Vacuum Toilet Systems

There are two ways to collect blackwater from toilets and sickbays: by gravity or by vacuum. Vacuum toilet systems use differential air pressure to transport sewage from the toilet bowls and other sanitary fittings to an STP or collection tank. Vacuum toilet systems consist of a vacuum collecting unit, which generates the vacuum, a vacuum pipeline system and vacuum toilet valve units. Vacuum technology reduces water consumption for flushing toilets by c. 80% and provides significant flexibility in the design of the collecting system.

- The advantages of vacuum collection are therefore:
- Small pipe size: DN50/DN40 vs DN100 needed for gravity systems
- Light weight and compact size
- Hygienic, no odours
- Smaller holding tanks and smaller sewage treatment plants
- Not sensitive to ship motions

For naval ship systems, size and weight are often critical. Table 2 shows a comparison between vacuum and gravity collection system requirements for a destroyer manned by a crew of 300.

A conventional biological sewage treatment plant

A membrane bioreactor with external membranes

Opting for vacuum technology will reduce the ship's water consumption by 16.6 tonnes of water per day.

Wet Waste Processing

Wet waste mainly consists of food waste and bio-sludge from biological waste treatment plants.

Table 2

Description	Piping volume, m3	Piping weight, kg	Flushing water, l/day
Gravity system (DN100)	10.9	6,900	21,000
Vacuum system (DN50)	2.6	2,200	4,500
Saving, %	**76**	**68**	**79**

A significant amount of food waste is produced onboard. This needs to be collected, processed, and treated. Collection is now often undertaken by the use of vacuum technology, which offers the following advantages:

- No manual work
- Hygienic, no risk of contamination, no odours
- Small pipe size
- Low water consumption

After collection, food waste can be dewatered and stored or treated by thermal disposal.

Bio-sludge is the residue created during the treatment of wastewater. It accumulates in the wastewater treatment plant and is periodically removed from the process. The treatment of bio-sludge is similar to food waste: collecting, dewatering, drying and burning. Bio-sludge can also be discharged overboard when this is allowed. The discharge should not produce any visible floating solids nor should it cause any discoloration of the surrounding water.

Ballast Water Management Systems

Ballast water is sea water used to keep the ship's trim, draught, stability and structural loading within safe limits as the distribution of ammunition, cargo and other liquids shifts during normal ship operations.

At any given time, ballast water can contain an estimated 7,000 different species of organisms comprising of microscopic plants, animals, bacteria and viruses. Approximately seven billion tons of ballast water is transferred globally each year. The purpose of the ballast water management system is to minimise the transfer of non-indigenous harmful aquatic organisms and pathogens from one area of the world to another one. Organisms can become invasive species, causing a change in the ecosystem balance.

Ballast water management is regulated by the Ballast Water Management Convention (BWM), which was adopted by IMO in 2004 and entered into force globally on 8 September 2017.

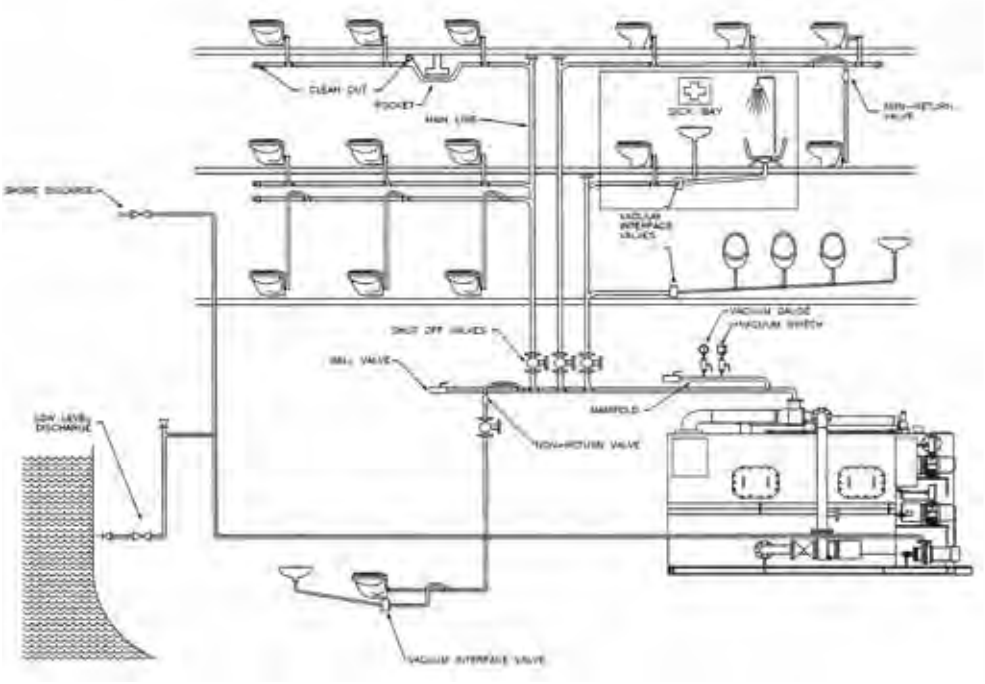
Several Ballast water treatment technologies are currently available. Most of them use a two stage approach involving mechanical separation (1st stage) followed by physical or chemical treatment (2nd stage). The technologies available are summarised in Table 3. Two most common technologies are Ultra-Violet (UV)-based systems and Electro-Chlorination (EC) systems. UV plants use filtration and ultra-violet irradiation to meet the disinfection requirements without hazardous chemicals and toxic by-products. UV systems suit small and medium size vessels. They can easily be scaled up and have no water salinity limitations. Operation in fresh water is possible.

EC plants use filtration and disinfection by the sodium hypochlorite generated from sea water. EC systems are typically the better fit for medium to large sized ships. They scale up well, consume less power than UV systems and offer a smaller footprint. They are also more flexible to install as there is no need for multiple, large UV chambers.

Fresh Water Generators

Fresh water generators convert sea water to potable or technical water. There are two main types of freshwater generators: the membrane type (Reverse Osmosis) and the thermal type (Single Stage or Multi Stage Flash Evaporation). Reverse Osmosis (RO) plants use the principle of osmosis to remove salt and other impurities by transferring sea water through semi-permeable membranes. Thermal desalination plants use heat to evaporate and condense water to purify it. In situations where energy consumption is very critical, a new generation of multi stage evaporators can be used. One example of this is the Horizontal inner Tube Evaporator that realises a 75% energy saving.

RO systems have become significantly more energy-efficient over the past 40 years. The market share of RO plants has grown rapidly in recent years, making them the preferred choice for various



types of ships, including naval vessels.An important difference between RO plants and thermal desalination plants is in energy consumption. If waste heat from the main engines is available, then thermal distillation is the cheapest way to produce fresh water. Thermal distillation is less sensitive to sea water quality (salinity, turbidity and temperature) compared to other technologies. RO plants have modular construction and are easier to fit into available spaces. RO plants are also less susceptible to ship movement because they do not rely on large water tanks.

Solid and Dry Waste Handling

Dry waste generated onboard can be divided into recyclable and non-recyclable materials. According to the IMO's MARPOL Annex V, the discharge of dry waste into the sea is prohibited. Hence it must be stored on board. Installing dry waste collecting and handling systems reduces the volume of needed space and increases storage capacity.

A large amount of waste will be produced during missions that can last 30 days or more, but the storage space onboard of naval ships is inevitably limited. Fortunately, equipment that can reduce the volume of waste by between 80% and 90% is available. Table 4 shows the dedicated systems used to deal with each kind of waste Navies can also reduce the amount of waste by applying a policy for approved packing materials (i.e. source reduction). For example, plastic bottles are often not allowed.

Thermal disposal

The purpose of thermal treatment is to reduce the volume of waste; often by more than 95%. This significantly reduces the need for on-board waste storage.

There are quite a few thermal disposal methods available, including incineration, gasification, thermal hydrolysis, pyrolysis, microwaving and plasma arcing. Of these, the oldest technology is incineration. During incineration, ship waste is burned at high-temperatures – 800-1200 °C – and converted into heat, ash and flue gas. The flue gas must be cleaned of polluting gases and particles before it can be released into the atmosphere.

The use of shipboard incinerators in ports or near urban areas is not allowed. The risk of air pollution from greenhouse gases and CO2 is too high. As a result, incinerators cannot be used for around 50-70% of a ship's operational time. The discharge of incinerator ash at sea is also prohibited. This can only be done at port reception facilities. Moreover, the use of incinerators increases a ship's heat signature and may compromise its stealth.

Ship operators have started looking into more efficient and environmentally friendly alternatives. One state-of-the-art technology is gasification, which thermally breaks hydrocarbons down into waste and transforms them into a small volume – 5% of the original volume – of harmless residue (bio-char) and energy. The process creates a synthetic gas, which is used as the fuel for the process, reducing the need for external fuel sources. Gasification is about 25-30% more efficient than incineration. A clean burning process and closed loop scrubbing system allow 24/7 operation, even in ports and sensitive areas.

Photo: ©Wärtsilä

A ballast water management system based on UV technology

Photo: ©Wärtsilä

A reverse osmosis plant

Integrated Solutions

Waste management poses a serious operational challenge, with potential environmental and health risks. As a result, the process becomes inefficient, laborious and difficult. Each waste stream requires a dedicated sub-system that need to be operated and maintained.

As demonstrated by the first illustration in this article, there is, there is a considerable degree of inter-connectivity and collaboration between these different waste management sub-systems. When these sub-systems are designed and supplied by different vendors, the complete waste treatment system will not be optimised in terms of the size, interface, performance and energy consumption. Typical problems that may arise during onboard waste management include:

- Labour intensive work
- Human errors
- Equipment malfunctions
- Non-compliance with regulations
- Risk of cross contamination, hygienic issues and odours

Consequently, there is demand for integrated waste treatment systems to avoid the problems mentioned above. The integration of the waste management process improves the overall efficiency of the process of collection, recycling and disposal whilst resulting in the lowest impact on the environment. Specific benefits of integrated waste treatment systems include:

Table 3

MECHANICAL	PHYSICAL	CHEMICAL
Cyclonic Separation	Ultra Sound	Electro-chlorination
Filtration	Cavitation	Ozonation
	Ultraviolet	Chlorination
	Heat	Chlorine Dioxide
	De-oxygenation	Advanced Oxidation
	Coagulation	

Photo: ©Wärtsilä

- Optimised size
- No interface problems between systems

A grinder station for food waste

- Compliance with regulations
- Lower operational costs
- Support and After-sales from one supplier

In summary, integrated waste treatment systems can provide a compact and efficient solution for onboard waste management. They arguably have particular relevance for navy and coast guard requirements, as they minimise human involvement in their operation and maintenance, allowing crews to focus on their core mission.

Specific Naval Requirements and Standards

Clearly, the design and operational characteristics of naval vessels are different from those of commercial ships. Factors that have relevance to the specification of waste management systems include:

- Mission duration away from port can be lengthy: for 30 days or few months
- There is less space for waste treatment equipment and the storage of collected waste
- Flammable packing materials increase risk during combat operations
- Combat vessels have very strict requirements for vibration and noise. Their acoustic signature needs to be minimal
- Interactive Electronic Technical Manuals (IETM) and Integrated Logistics Support (ILS) documentation is required
- Equipment must be designed for sustained performance during naval missions with minimum maintenance

Waste management equipment needs to fit the available space and meet specific technical requirements. This limits the types of waste treatment plants that can be used. Examples of the most common standards applicable for naval ships include:

- MIL-STD-167-1 Vibration
- MIL-STD-740-1&2 Noise limits
- MIL-S-901 Shipboard Shock
- MIL-DTL-901E High-impact shock
- MIL-STD-461 EMI and EMC standards

Specific requirements will inevitably depend on the ship type, area of operation and country.

Naval vessels encompass many different categories with varying numbers of personnel. Aircraft carriers can carry as many as 6,000 people onboard. However, as an example, the daily waste generated by a destroyer manned by a crew of 300 can be expected to amount to the volumes set out in Table 5.

It can be seen from this table that a 30-day mission would generate about 1,320 tons of wastewater and food waste and 9 tons of dry waste. The volume of collected dry waste would be more than 100,000 m³. As it is not possible to store all of this waste, effective treatment is clearly essential.

Table 5

DESCRIPTION	WEIGHT, kg/day
Black water (collected by vacuum)	4,500
Grey water	39,000
Food waste	420
Paper	150
Metal	90
Glass	30
Plastics	30
Total, kg/day	**44,220**

Table 4

EQUIPMENT	DESCRIPTION
Shredder	Cuts wood, metal, plastic and bones to much smaller pieces
Glass crusher	Glass is passed through shredder blades and crushed into very small particles
Can densifier	Applies pressure to the waste metal material, crushing it into bales
Bale compactor	Crushes waste into bales, which are palleted for easy storage
Briquetting machine	Mixes waste, shreds it and turns it into waste brick by applying pressure

Future Trends

Amongst trends that may be seen in the future are:

- The treatment of grey water will become mandatory
- There will be continuous monitoring of effluent after treatment
- Treatment operations will be optimised by the use of integrated automation
- Long term service contracts will become common
- Remote monitoring will be possible
- The 3D printing of spare parts onboard will assist maintenance
- There will be changing requirements due to the increased prevalence of unmanned ships

Conclusion

There are many different technical solutions for preventing maritime pollution. Individual waste management systems are available to manage particular waste streams whilst complete waste management packages offer a more comprehensive solution. The specific selection will depend both on the type of ship under consideration and an operator's preferences.

Many navies have taken active steps to ensure compliance with international and local standards governing the control of marine pollution by installing modern waste management technologies. In doing so, they demonstrate the importance of their role as a government body in setting the right example and showing that effective protection of the maritime environment is feasible.

There is still more to be done to protect the world's seas from pollution. Cooperation between equipment suppliers, navies and regulators is crucial. Only together can we save our blue oceans for future generations. ■

Photo: US Navy

A multi-national destroyer exercise in the Tasman Sea. A typical destroyer on a 30-day mission will generate 1,320 tons of waste water and food waste and 9 tons of dry waste.

A New Frigate for the Hellenic Navy

Stephen Barnard

The Hellenic Navy's (HN) new frigate will be a "high end" multipurpose/multimission frigate with advanced capabilities in anti-air, anti-submarine, and anti-ship warfare. These frigates will ensure the navy's core, traditional war-fighting capabilities remain effective for the next 15 – 20 years.

Background

The Greek coastline is around 15,000km, including 227 islands. To the west, Italy; Turkey to the east. Albania, North Macedonia and Bulgaria to the landlocked north: to the north-east a 200km / 120mile land frontier with Turkey. On the three remaining sides are the Adriatic, Ionian, Mediterranean and Aegean seas. Greece shares a Joint Defence doctrine with Cyprus. The Hellenic maritime capability requirement is significant.

On 5 June 2021 Prime Minister Kyriakos Mitsotakis announced the intention to acquire four heavy frigates, alongside an MLU for the existing HYDRA-class frigates.

Missions and Assets

Generally, the mission of the HN is to deal with any external threats and provide patrol support to the Hellenic Coast Guard (for which latter task a corvette may be a suitable, smaller platform.) Theoretically, heavy corvettes could be procured to replace the four ELLI-class ships not updated in the 2004-2009 MLU programme. The HN is thought likely to acquire modified (larger) Israeli SA'AR 72 corvettes from Israeli Shipyards and their Greek partner, ONEX Neorion Shipyards - the THEMISTOCLES-class - but these are 800-ton vessels outside the scope of this report.

Frigates are the main heavy ships of the HN. There are 13 in service: four HYDRA-class and nine ELLI-class. The HYDRA-class is a modified Blohm & Voss MEKO 200 design, subject of intermittent upgrades from 2007/2008 onwards, as funds permitted.

Author

Stephen Barnard is Publisher of EUROPEAN SECURITY & DEFENCE. Additional comments by William Nilly, a dedicated navel-gazer.

Photo: Babcock International

Babcock's ARROWHEAD 140 has been short-listed by the HN.

The lead ship of the ELLI class is now some 40 years old. Six of the ELLI-class were modernised in 2004-2009; the other four (including one decommissioned in 2013) will be replaced under the new frigate programme.

Regional Security and Challenges

Since 2016 the EU, with additional funding from member nations, has paid Turkey to host the Turkish Facility for Refugees, which currently accommodates some four million people. That programme is funded until 2021-2025, also at €1Bn annually. In early 2020 the Turkish government unilaterally opened its border with Greece, and the influx of refugees by land and sea began again.

Maritime boundaries in the eastern Mediterranean have long been in dispute, particularly over energy resources. The situation was inflamed in early 2021, when Turkish Navy warships opened fire on HN coastguard vessels: it is necessary for the HN to be able to discourage similar actions in the future.

HN Shortlist

In alphabetical order the shortlisted shipyards are:

- Babcock (UK) with the Type 31/ARROWHEAD (approx. 6,000 tons displacement)
- Damen (Netherlands) with the SIGMA 11515 (displacement approx. 4,400 tons)
- Fincantieri (Italy - allegedly with the FREMM) (displacement approx. 6,000 tons)
- Lockheed Martin (USA) with the FREEDOM-class MMSC (LCS) (displacement approx. 3,500 tons)
- Naval Group (France) with the FDI/BELH@RRA (approx. 4,400 tons displacement)
- tkMS (Germany) with the MEKO A200NG (or MEKO A300) (approx. 5,500 tons in Polish Navy configuration – the MEKO 200HN displaced around 3,400 tons)

Early Days

The acquisition of up to four Naval Group FDI BELH@RRA-class frigates from France, with high-end AAW and Deep Missile Strike capabilities was put on hold in July

Arrowhead™ 140

babcock™

Arrowhead 140 is a proven, capable and adaptable platform configured for the Hellenic Navy and primed for building in Greece.

Driven by innovation and backed by heritage.

www.arrowhead140.com

Photo: Lockheed Martin

Lockheed Martin's HF2 variant of the LCS has been proposed to the HN.

2020, reportedly due to the cost - almost €3Bn for only 2 units - the lack of local production opportunities in Greece, and the late proposed delivery of the first unit, in 2025 at the earliest.

The US proposed the acquisition of four Multi-Mission Surface Combatants (FREEDOM-class MMSCs) developed by Lockheed Martin. On November 6th 2020, the HN submitted its acquisition request for four MMSC frigates; part of a package including the HYDRA upgrades, "intermediate solution" ships, and participation of Hellenic Shipyards in the US FFG(X)-type frigate development. The FREEDOM-class is in full production for Saudi Arabia, and "tested and in-service" with the USN. But the class's appalling reliability record is reported to have resulted in the USN declining new deliveries between January and June 2021; a delay to full USN mission capability until "at least" 2023; and early decommissioning by the USN - in the case of the US$300M-US$350M USS LITTLE ROCK less than six years after commissioning.

Two types might replace the ELLI-class. One idea, to purchase heavy corvettes, has gained traction since Greece joined the EPC programme, but the EPC is only half the displacement of some "proper" contenders, and on closer examination can probably be dismissed. Even allowing for a cheaper, faster EPC build (unlikely in a multinational consortium), an earlier in-service date (probably not before 2027), and substantial offset / technology transfer / workshare (wishful thinking), the capability shortfall seems decisive.

tkMS from Germany is offering the MEKO-A200, a new and advanced version of the MEKO-200HN, offering increased homogeneity to the fleet, especially after the upgrade of the ships already in service.

The Contenders

All companies involved were invited to elaborate on their propositions for the HN Frigate Programme. Babcock International and Naval Group are presented alphabetically.

BABCOCK INTERNATIONAL claims that it is creating a "game-changing" approach to global shipbuilding to offer warship design, build and in-service support options to international navies through its ARROWHEAD 140 general purpose frigate. For Greece, supported by the UK Government, Babcock has developed a programme meeting all the HN's requirements, including a) a HYDRA-class upgrade, b) an interim frigate capability and c) four Babcock ARROWHEAD 140 frigates. (ARROWHEAD is the design chosen by the Royal Navy for the Type 31 programme.)

The company offers a package of support and industrial strategy supporting the modernisation of key Greek shipyard facilities, with partnership offers to Greek industry to develop local workforces and transfer knowledge and technology across the wider domestic shipbuilding supply chain.

ARROWHEAD 140 is a proven, adaptable design based upon an in-service hull-form that has been tried and tested in real-world operational environments: a cost-effective, high-value vessel designed for in-country build. Because the design is selected for the Royal Navy's next generation frigates it offers accurate known costs and significant economies of scale. According to Will Erith, Chief Executive Marine, "…The buildability of the ships ensures the effective transfer of a UK design to Greece for efficient manufacture and in-country assembly, while de-risking the build programme… We will work with Greek industry to utilise domestic supply chains, to modernise and equip facilities, upskill and grow local workforces and transfer knowledge and technology to support an in-country build that will stimulate economic growth and prosperity."

Propulsion

The platform can accommodate various propulsion solutions and is big enough to embark sufficient fuel for long-range, independent, global operations.

Armaments

The platform can be fitted with a range of high-end capabilities. Offensive and defensive systems for enhanced air defence, surface and sub-surface warfare, maritime interdiction, self-protection and engagement of long range land targets provide significant strategic, political and operational choice and operational confidence.

Mission Systems

The RN ARROWHEAD 140 incorporates the TACTICOS™ CMS, with open architecture and computing environments to provide a scaleable, upgradeable mission / combat management capability.

Aviation

The flight deck accommodates a wide range of naval aircraft and air systems. The hangar can berth an organic medium naval helicopter such as a MH-60 SEAHAWK, plus various unmanned air systems.

Ammunition Handling

Dedicated facilities to store and prepare air-launched weapons, including ASW torpedoes and Anti-Surface missiles, are provided. The flight deck can launch and recover non-organic aircraft weighing up to 15 tons.

Accommodation

ARROWHEAD 140 can operate with a Ship's Company of fewer than 100 people. It has dedicated accommodation for 180+ personnel, plus additional temporary accommodation, and can carry a significant Embarked Military Force – such as Special Forces, littoral manoeuvre troops or additional C2 specialists.

Photo: Damen Schelde

Damen Schelde's SIGMA 5515 design is regarded as a strong contender for operational and technical reasons.

Photo: Naval Group

iXBlue delivered the first cybersecure navigation system for the French Navy's FDI fleet in September 2020. The BELH@RRA design offered to the HN is reinforced by very positive political factors.

Through-Life Support
Babcock's through-life support assures ship availability, reliability and cost-effective readiness, including optimal integration of people, processes and technology. The latest mobile, remote and connected technology ensures systems can provide operators and maintainers with in-depth understanding of the performance, maintenance and material condition of their assets.

NAVAL GROUP submitted a new offer for the modernisation of the Hellenic surface fleet, as part of the French Team that also includes MBDA. The team described its offer as "comprehensive and robust… designed to ensure Greece has the best capabilities in the shortest timeframe with optimised costs." The package includes: a) four FDI HN - three built in Greece, the first in-service by 2025 along with a "Gap-Filler" solution of two frigates available in early 2022; b) modernisation of the MEKO frigates in Greece; and c) an ambitious Hellenic Industry Participation (HIP) plan. The French offer "will ensure that HN capabilities are enhanced to meet immediate and future needs, while creating and sustaining jobs and economic benefits for the country over decades to come." The FDI HN will be fitted with a weapons mix offering significant control of air and sea space, and autonomy in support of political and military objectives.
The FDI HN incorporates some of the best technologies from Europe's defence industries, particularly MBDA and Naval Group. The ASTER system gives 360° coverage and can counter saturation attacks, and the FDI can accommodate Naval Cruise Missiles and a Deep Strike capability. Physical and digital infrastructures of the FDI offer evolutionary potential for the life of the ships. The first FDI HN would be delivered in 2025. Naval Group offers a reduced-risk solution for the construction of the three subsequent FDI HN in Greece, by Greek shipyards, on time, and with the same quality and performance as the France-built first of class.

Gap Filler Solution
The French offer includes two Anti-Air Warfare (AAW) and Anti-Submarine Warfare (ASW) frigates, to be delivered to Greece in 2022. Both frigates are operational in the French Navy, proving they are fully capable and interoperable.

MEKO Modernisation in Greece
Naval Group has formed a local partnership for the MEKO upgrade that guarantees operational availability and is executed in Greece.

Hellenic Industry Participation Plan (HIP)
The involvement of Hellenic industry "will enhance the country's excellence in the naval domain and create long term economic benefits and jobs as well as ensuring the warships will be maintained in Greece by Greek industry." The HIP will sustain "thousands" of highly qualified jobs and generate long-term economic benefit: "FDI HN: made in Greece, by the Hellenic Industry, for the Hellenic Navy!" The HIP plan will contribute to the revitalisation of Greece's defence shipbuilding industry, by transferring all the necessary technology and knowledge, maximizing Greek industry in-service support for the next 40 years, and participating in the long-term development of profitable, innovative, highly qualified jobs for Greek citizens - not only shipyards but also in electronics, IT, and more. Naval Group is already in contact with most if not all Hellenic companies that might join the FDI HN programme. All qualified Greek companies will be integrated into the French industrial team's supply chains, thus able to participate in and benefit from future international competitions.

A centre for naval innovation.
Naval Group has strong interest in R&D projects with Hellenic organisations in cutting-edge technologies, and is looking to develop a network of technological and research projects upon which to build future naval warfare capabilities.

The Others

tkMS from Germany responded to our invitation, with a polite refusal to reveal specifics of their strategy, solutions or promises. There was no response from Damen or Fincantieri in the time available.

Conclusion

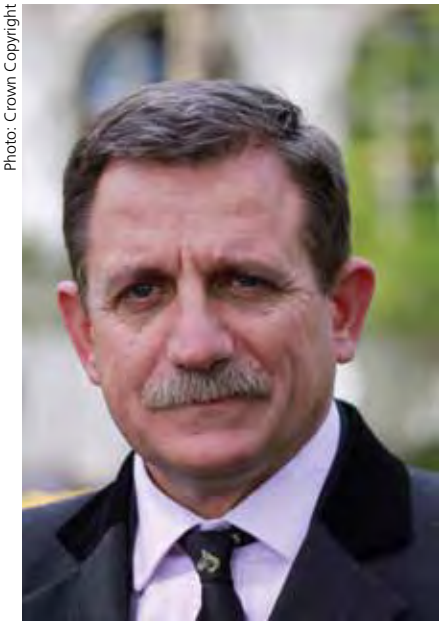
This is an interesting programme, with a range of possible solutions, from sub-3000 ton corvette to frigates double the size. It has clearly taxed the imagination of industry in terms of adding value and creating solutions to problems that mostly revolve around urgency but are significantly challenged by the real world of money, risk and threats. Its successful launch and conclusion will be a hugely positive sign for Greece, the EU, NATO and the eastern Mediterranean.
The final Hellenic Government decision on the type and origin of the new frigates remains scheduled for 2021. ■

Photo: NATO / Royal Navy / Paul Hall

The MEKO200 HN from Germany is one of the shortlisted contenders for the Hellenic Navy frigate programme.

Exporting Maritime Britain

Photo: Crown Copyright



Mark Goldsack is the Director of the Department for International Trade UK Defence and Security Exports

Mark Goldsack is the Director of the Department for International Trade UK Defence and Security Exports. He is responsible for maximising British defence, security and cyber exports, as well as attracting foreign direct investment in these areas. Before joining the department in January 2019, Goldsack spent over 30 years in the British Army. There he held a variety of senior roles, particularly in the defence engagement capability and equipment areas in the UK and overseas. Goldsack holds a BA (Hons) in History from the University of York, an MA from Cranfield and an MSc and MPhil from the University of Madras.

Accounting for only four percent of United Kingdom defence and security exports in the decade to 2019, the naval sector has typically enjoyed a lower profile than other aspects of British defence sales. However, things are changing. Export success in the form of the sale of the Type 26 Global Combat Ship design to Australia and Canada has combined with a new emphasis on exportability typified by the Type 31/ARROWHEAD 140 frigate to give the maritime segment new importance. MSD spoke with Mark Goldsack, Director of the Department for International Trade UK Defence and Security Exports about the United Kingdom's recent emphasis on securing naval exports and the country's future plans for the sector.

MSD: Naval exports have formed only a relatively small part of the United Kingdom's overall defence and security sales during the last decade. Given this background, what accounts for the current focus on this market segment?

Goldsack: In recent years much of the United Kingdom's success in defence and security exports has related to fast jet aircraft, reflecting the type of equipment our own armed forces have been acquiring. However, the Royal Navy is now undergoing a major process of recapitalisation, investing significant sums in a large number of different types of new warships. Fortuitously, this period of investment in our own fleet is coinciding with a cyclical upturn in global naval procurement, an event which only occurs roughly every 30 years. We see this situation as providing massive opportunities to build long term relationships with countries with similar naval requirements to our own. We recognise that we will only be successful if these relationships are based on a "win-win" basis and are particularly looking to work with our friends and allies around the world to share our own knowledge and expertise to mutual benefit.

MSD: What is different to the United Kingdom's current approach to naval exports compared with how the market was addressed in the past?

Goldsack: There are a number of differences. First, we now have a sound strategic foundation to our endeavours through

Photo: Crown Copyright 2021

A Eurofighter TYPHOON fast jet overflies the Type 23 frigate HMS NORTHUMBERLAND in 2018. Aviation exports have dominated British defence exports in recent years but there is a new focus on maritime systems as the Royal Navy and many international fleets embark on a period of recapitalisation.

the work that has been undertaken to develop both a Defence and Security Industrial Strategy and a National Shipbuilding Strategy. These two documents focus on the conditions required to achieve export success, not least the emphasis on partnership I have already mentioned. In addition, we are now able to work more cohesively across government than ever before to fashion compelling offers that draw on the wide-ranging and unique advantages the United Kingdom has to offer our partners, be they diplomatic, industrial, financial or the unparalleled training and developmental support the Royal Navy is able to provide. In short, we are able to tailor and scale an offer that is focused on a partner country's particular circumstances and both the security and economic objectives they are looking to achieve.

Photo: BAE Systems

The Type 26 Global Combat Ship has been a recent export success, with the design being sold to both the Royal Australian and Royal Canadian Navies.

MSD: What relevance does the traditional model of selling ships have to the United Kingdom's future naval export model, particularly given much of its recent success has been in equipment, designs or other services?

Goldsack: We see both platforms and also the wider naval sphere as being important export targets. We are determined to be able to offer platform-based options out into the global naval market and believe – perhaps for the first time in a generation – that we currently have a compelling offer in this field. For example, the Type 31 frigate was designed with exportability being a fundamental part of its specification. Its ARROWHEAD 140 parent design has the potential to be a genuine market disruptor, both as a result of the modular capability it is able to provide and also due to its competitive price point compared with rival ships. Of course, we also recognise the substantial value that resides within the supply train and wider support services. What is most important is that we are able to offer what the customer needs, ensuring the maximum opportunity for flexibility of build, industrial benefit through technology transfer and an effective support solution; all at the most competitive price.

MSD: Given the competitive nature of the United Kingdom's own naval industrial sector – with a number of British companies potentially offering similar products – how can you ensure export campaigns are coordinated to the greatest advantage of "Team UK"?

Goldsack: That's an important question. If we were simply to step back because a particular opportunity was subject to rival offers from British companies, the inevitable result would be that a foreign competitor would win the contract due to their own government's support. One important part of the solution has been strengthened coordination – including the establishment of a cross-cutting Maritime Capability Campaign Office – to build a cohesive approach across government and industry. The aim has been to gain a shared view of the future market and take informed decisions of who is going to do what and where. Moreover, the enhanced situational awareness we are gaining from improved market intelligence should help to drive future investment decisions. We have already found that the way the market has stratified has allowed us to undertake a really complementary approach across industry to some campaigns. It's also important to note that the Aircraft Carrier Alliance – that built the two QUEEN ELIZABETH class aircraft carriers – has had an enduring legacy in making pan-industrial cooperation much more the norm than it was previously.

MSD: So how might this approach work in practice? For example, might you see one of the larger industrial companies take a lead 'Team UK' role in an export bid by fostering opportunities for smaller British suppliers?

Goldsack: Yes, I think that's certainly possible. More broadly, I think that there

Photo: Babcock International

The ARROWHEAD 140 – parent design of the Royal Navy Type 31 frigate – is subject to a number of ongoing export campaigns.

Photo: RAF

The UK is one of the original partners in Eurofighter TYPHOON which has seen export success.

has been a growing acceptance that the health of the whole industrial ecosystem will need to be tended to or even the strongest participants will eventually wither and die. The large players recognise their responsibility in ensuring that this does not happen. This has been evident, for example, during the COVID-19 pandemic, where it's been noticeable that cash has continued to flow through to the smaller suppliers in spite of the inevitable strain that the entire industry has been under. I think that's a real demonstration of the collaborative ethos than now exists within industry.

MSD: The sale of the Type 26 Global Combat Ship design to Australia and Canada has been a notable British export success in the naval sphere. What lessons have been learned from this achievement?
Goldsack: Well, to be slightly "tongue in cheek", I'm not going to reveal all my top tips as I don't necessarily want the competition to benefit from them! However, succeeding in two genuinely open and arduous competitive processes has produced many valuable lessons in terms of understanding both our strengths and weaknesses. These have been fed into the Defence and Security Industrial Strategy and, at a more tactical level, been used to develop a "playbook" for government and industry to guide the conduct of future campaigns. I should also note that the fact that we were able to be successful in wining competitions evaluated to the most stringent levels to meet the demanding requirements of two leading navies has exponentially increased our own credibility, bolstering our chances of further export gains.

Photo: Crown Copyright 2021

The CSG21 carrier strike group is providing a valuable opportunity to display the United Kingdom's technological capabilities on the world stage.

MSD: Are you able to be a little more specific about some of the factors that contributed to the United Kingdom's success in these two competitions?
Goldsack: I believe a fundamental part of our success was our ability to build on the close partnership we already had with the two purchasers of the Type 26 design, both members of the 'Five Eyes' intelligence sharing community. This was particularly helpful in making sure that we had a fundamental understanding of their specific requirements and tailored an offer to match. I should also note that an important element of our offer was the ability to work with BAE Systems Australia and Lockheed Martin Canada to maximise local content and the benefits of technology transfer, both fundamental objectives of the partner countries.

MSD: Turning to ARROWHEAD 140, could you say a little about the prospects for this export-driven design?
Goldsack: As I indicated previously, the ARROWHEAD 140 frigate is a genuinely disruptive design due to the adaptability and scalability that are provided by its modular characteristics. This gives us the opportunity to utilise the efforts we are making to understand customer requirements to provide a solution that can be truly optimised to the mission the customer navy is looking to perform. At the same time, the fact that ARROWHEAD 140 is derived from a fully tried and tested baseline design (editor: The Danish IVER HUITFELDT class) means that we can provide confidence in terms of reduced programme risk and known operating costs. We are delighted with the level of international interest this modern, flexible frigate is already generating.

MSD: How will the refresh of the National Shipbuilding Strategy feed into your own export efforts?
Goldsack: We have been working very closely with the Ministry of Defence and

other Government departments to develop the National Shipbuilding Strategy Refresh. Our focus on better understanding and exploiting the many opportunities that exist in the international maritime export markets – both naval and civil – is closely aligned with the strategy's emphasis on delivering a stronger national effort to expand sales of ships, equipment, design and project management services.

MSD: Most of our discussion to date has focused on the defence maritime sector? To what extent does the civil maritime sector feature in your plans?
Mark Goldsack: Developing exports into the civil maritime sector is a fundamental part of our ambitions. The sea is the common factor that unites our efforts and we have to recognise that shipbuilding and many of the subsystems that support it are agnostic as to whether they are serving a naval or mercantile purpose. Limiting ourselves to just the naval market would, in effect, be artificially restricting the business that we might be able to pursue. So, we are working in collaboration with colleagues focused on the commercial sector to, again, obtain a proper understanding of what market prospects are available and how they might play to our strengths. We already have powerful niche skills in segments such as yachts and leisure vessels but also see prospects in emerging sectors, such as offshore wind and maritime autonomous systems. To give another example, we envisage particular opportunities in leveraging the innovative design and technical skillset that are already embedded in the naval SME market across the broader maritime sector.

MSD: It would be amiss not to make reference to the CSG21 carrier strike group deployment. What opportunities does this provide for promoting your own message?
Mark Goldsack: The CSG21 deployment is already having a powerful strategic impact, not least in attracting press comment across the world. It sends out a very strong message to every navy that we want to cooperate with that we have the ability to deploy a potent maritime capability across the planet and to work with our partners when we get there. That creates a relationship of trust that will be the bedrock of future long term collaboration. Moreover, the fact that we are able to showcase our technological strengths up close to each and every one of our allies along CSG21's route inevitably forms a sparking point for a series of conversations as to how we can share this capacity to mutual benefit.

MSD: Do you have any final observations?
Mark Goldsack: Only to say that it is an exciting time to be promoting British maritime exports. We are fortunate to be in that rare space where the capabilities being provided by our own naval recapitalisation programme are closely aligned with the requirements of the global market. That presents huge opportunities both to drive forward our own maritime sector and also to proffer significant benefit to our friends around the world, not least in promoting shared values such as the green agenda. The prospects for developing enduring relationships capable of delivering lasting value are immense.

The Interview was conducted by Conrad Waters

Masthead

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Curing India's Submarine Deficiency

Suman Sharma

At the end of July 2021, the Indian government issued a Request For Proposal (RFP) for the long pending Project-75 (India) – or P-75(I) – deal, reportedly worth US$6Bn for six conventional, diesel electric submarines. The announcement created a buzz among military-industrial complex watchers, as it is India's first defence deal under the Strategic Partnership (SP) procurement model. Moreover, it comes after a long, 17-year gap since India last ordered a batch of submarines.

Vulnerabilities

This substantial delay follows the last similar submarine order (known as P-75), which was won and signed by Naval Group (then known as DCNS) in 2004. A follow-on order for the P-75 (I) has long been expected considering the submarine fleet's dangerous numerical deficit. India's lengthy coastline – the Indian Navy is responsible for the security of over 7,000 km of contiguous seas – makes it imperative that the government addresses falling submarine numbers. Indeed, the current challenge lies in maintaining the absolute minimum – rather than the ideal – number of assets necessary to secure Indian waters.

The unprecedented delay in buying new submarines can be blamed on factors that have not materially changed over the intervening years, viz.

- Long and tedious procurement procedures
- Varying qualitative requirements
- Changes in political leadership, leading to shifting naval priorities

Another deficiency troubling the Indian Navy is the fact that India is not yet able to build boats to its own design. Instead, it is the only major submarine operator that relies on the import of foreign designs to meet its requirements.

Paralysis by Process

The Indian Navy's most senior submariner, Vice Admiral (ret.) AK Singh vows, "I will believe (it), only when the contract is signed, and the metal is cut."

Author

Suman Sharma is a Delhi-based journalist covering foreign policy and defence. Previously, she was an instructor at the Indian Military Academy.

Active Indian Navy Submarine Assets

The Indian Navy currently operates 14 submarines: seven Russian Project 877EKM KILO class boats, four German Type 209 SHISHUMAR class submarines and the first three of six French-designed SCORPÈNE class boats being built by MDL under the original P-75 programme. This compares with 24 non-strategic submarines required under Indian Navy planning. It should be noted that the bulk of these submarines are over 30 years old, with the heavy refit and maintenance burden that this involves.

JD Patil, Senior Executive Vice President at L&T says, "The Indian Navy surely is suffering due to nearly 17-18 years of delay [since the P-75 deal was agreed]. Under the plan to build 24 conventional submarines by 2030, two lines of submarine production were to be established. The P-75(I) was immediately to follow-on from the P75. However, a Request For Information (RFI) was not released until 2008 after much delay, and the RFP did not follow until this year. This has caused the navy fleet to deplete considerably."

Photo: Naval Group

The lead Project 75 SCORPÈNE type submarine INS KALVARI. It has taken 17 years to issue the tender for the follow-on Project 75(I) programme.

The process of the submission of responses to the tender is expected to takes 18 months. Following a review, another couple of years can be expected to be taken up with negotiations. However, India will be entering a General Election cycle in April/May 2024 and the Model Code of Conduct prevents contracts being signed nine months prior to this process. Even if the current administration expects to win the election, signature could be held up until "the other side of 2024", particularly if the contract contains any contentious elements that might suffer from public scrutiny. This could, of course, leave the contract exposed to the appointment of a new government that might delay or cancel the programme altogether.

Another potential risk is a public budget crunch for any one of a number of reasons, such as infrastructure programmes to repair flood-damaged roads or the diversion of defence spending to meet the army's requirements on a tense land border. The impact of the current pandemic on India's economic performance is certainly likely to exacerbate delays in obtaining approval for "big ticket" items.

P-75(I): Made in India

Besides being the maiden SP model deal, the P-75(I) is hailed as setting the standard for the *AtmaNirbhar Bharat* (Self-Reliant India) mandate passionately promoted by India's Prime Minister Narendra Modi. The SP model brings together Indian private and public defence manufacturers to partner with foreign Original Equipment Manufacturers (OEMs) in a joint venture to "Make in India". The Indian MoD will choose from one of two Indian shipyards – Mazagaon Dock Ltd. (MDL) and Larsen & Toubro (L&T) – for construction and from one of five foreign OEMs to provide designs. MDL is a Government owned shipyard, currently building the six SCORPÈNE submarines under P-75, of which three are delivered and three are in trials or under construction. L&T is a private shipbuilder, involved in the Indian Navy's strategic nuclear submarine programme. The five foreign OEMs that received the RFP for P-75(I) are:

- France: Naval Group, SCORPÈNE class
- Germany: TKMS, Type 214
- Russia: JSC Rosoboronexport, AMUR 1650 class (LADA class derivative)
- South Korea: DSME Type 3300
- Spain: Navantia, S-80

Project-75(I) envisages the indigenous construction of six modern conventional submarines incorporating state of the art equipment, weapons and sensors. This is to include a fuel cell-based Air Independent Propulsion (AIP) plant. The programme is to include associated shore support, an engineering support package, spares and training. As well as providing the Indian Navy with the latest submarine technologies, the programme should provide a major boost to India's capabilities to design and build submarines.

The RFP demands Transfer of Technology (ToT) arrangements under which the selected OEM is required to set up a dedicated manufacturing line for its submarines in India. An aim is to boost India's core shipbuilding industrial sector and enhance medium, small, and micro enterprises by developing an eco-system for building associated spares, systems and equipment related to submarines. The RFP mentions key requirements such as a mandatory level of indigenous manufacture of the platforms, ToT for the design, maintenance and manufacture of a number of critical systems in alignment with the government's "Make in India" initiative.

Photo: Navantia

The Spanish S-80 PLUS submarine ISAAC PERAL in the course of being launched. The Navantia-built submarine is one of the contenders for Project 75(I).

New Threats From Old Adversaries

The drive to modernise India's submarine flotilla comes against the backdrop of increasing Chinese naval activity in the Indian Ocean, as well as the supply to Pakistan of new Chinese-designed submarines. There are mixed voices about the level of threat China poses. Vice Admiral Singh warns, "Only 60% per cent of our operational submarines can be sent out to sea on patrols, all can't be sent out together… Given the Indian Navy's submarine shortage, whether a one-front war is fought or a two-front war, if India does not have enough submarines, our Sea Lanes of Communication (SLOC) will be cut. If you can't occupy that area, someone else will. China is constructing 25 units per year, which includes warships and submarines."

Former Chief of Naval Staff, Admiral (ret.) Sureesh Mehta is less pessimistic. He argues, "The number of submarines coming up now is at a better rate. We can't equate ourselves with China, as ours is a large country with a lot of expenses. But the Indian Navy has sufficient surface navy and aviation assets, which the Chinese Navy doesn't have; so, there is nothing to be concerned about."

A more nuanced view is provided by Vice Admiral (ret.) Pradeep Chauhan, currently the serving Director General of the National Maritime Foundation. He observed: "If the entire naval holdings of China

Photo: Naval Group

The SCORPÈNE class submarine VAGIR will be one of just a handful of submarines to join the Indian Navy during the 2020s.

are to be compared with those of India, we come off very poorly…our effort at the strategic level is to ensure that the Chinese remain focused (on) the Pacific Ocean and the US Navy…(and) unable to bring their entire naval holdings to bear against us." His analysis is that if "push comes to shove" in the Indian Ocean, the Indian Navy is strong enough to repel the Chinese Navy.

Other Programmes

At the current time, only six out of the 24 non-strategic submarines projected for acquisition under the Indian Navy's 30-year submarine construction plan that was formulated the end of the 1990s are expected to join the fleet on schedule. Between now and 2030, it seems likely that only three conventionally-powered diesel electric submarines will join the fleet.

Vice Admiral Singh cautions against the acquisition of second-hand submarines to bridge the gap, "A second-hand submarine should be avoided, as it's already 30-40 years old and will keep demanding refits all the time. It doesn't serve any useful purpose. There are no shortcuts. Brand new submarines are expensive to buy and second-hand ones should be avoided; hence they should be made indigenously in India."

Some of the pressure may be relieved by other assets. These include nuclear-powered attack submarines (SSNs). CHAKRA I, a Soviet Project 670 CHARLIE class was leased in 1987, a contract which ended in 1991 with the collapse of the Soviet Union. Another SSN, the Project 971I AKULA class CHAKRA II, followed in 2012 but was returned to Russia in June 2021. A deal for a CHAKRA III was signed in 2019 and the submarine should join the Indian Navy in the latter half of the decade. In the longer term, the navy plans to operate six SSNs as part of its 24 submarine construct. The government recently gave the nod for plans for the so-called P-75(A) to progress but exact timescales remain uncertain.

Meanwhile, the first Advanced Technology Vessel (ATV) – INS ARIHANT – built under the strategic nuclear-powered submarine (SSBN) programme was launched in 2009 and commissioned in 2016. With the exception of a period undergoing refit, she is believed to have spent much of the subsequent time at sea. India's second indigenous strategic submarine, INS ARIGHAT, is scheduled for commissioning later this year.

The Way Ahead

Although the RFP process has now started, it is clear that the way ahead for the P-75(I) programme remains tortuous. Indeed, the timeframe for P-75(I)'s conclusion is anyone's guess. Even after completion of the usual path of bid receipt, bid opening, Technical Evaluation Committee, General Staff and Technical Oversight Committee evaluation, and negotiation with the preferred bidder, a lengthy period of design and construction will follow. The minimum expected time calculated by industry experts is 12-13 years for the entire programme, with the first submarine possibly rolling out approximately seven years after contracts are signed. It looks set to be a long time into the future before India's submarine deficiency is finally cured. ■

IMDS 2021

Showcasing the Main Trends in Russian Shipbuilding & Naval Systems

Dr. Nikolai Novichkov

The 10th International Maritime Defence Show 2021 (IMDS 2021) was held in Saint Petersburg between 23 and 27 June. For the first time this event was conducted at two new facilities: the main exhibition was located at the Expo Forum conference centre, while the attending ships were moored at the Passenger Port of Saint Petersburg. Due to COVID-19 limitations, visitor access to the forum was restricted.

Prior to IMDS 2021, the Director of the Military Service for Military-Technical Cooperation, Dmitry Shugaev, had reported the results of export sales for 2020 to President Vladimir Putin. The total amount of Russian military-technical cooperation projects for the year had exceeded US$15Bn or 102 percent of the target. All in all, Russia had secured an order backlog of contracts exceeding US$50Bn. Amongst this portfolio of contracts, aviation and air defence systems maintained their traditional lead, with Rosoboronexport's naval portfolio of US$5.5Bn accounting only for around 10% of the overall export total.

IMDS showcased the main trends in Russian shipbuilding's recent development, including the results of the gradual resurrection of the Russian Navy after the decline that followed on from the era of Perestroika under Mikhail Gorbachev in the late 1980s. The adaptation of naval platforms acquired by the Russian Navy as part of this process of renewal for the needs of foreign customers is seen as one potential way to increase the volume of naval exports.

Photos: Nikolai Novichkov

The 10th International Maritime Defence Show 2021 (IMDS 2021) was held in Saint Petersburg between 23 and 27 June. This picture shows a range of torpedoes exhibited by the Tactical Missiles Corporation at the event.

Adapted Project 22160 Light Corvette

To this end, the Northern Design Bureau – a subsidiary of United Shipbuilding Corporation (USC) has designed an export-oriented 2,200 tonne missile corvette on the basis of the Russian Navy's Project 22160 patrol ship. Six of these vessels have already been ordered for the Russian Navy's Black Sea Fleet, of which three are in service.

The new corvette can carry a versatile armament suite that includes KALIBR-NKE surface-to-surface and 3K96-3E RESURS surface-to-air missile systems. The KALIBR-NKE vertical launch systems (VLSs) are mounted in two separate four-cell modules located to the port and starboard sides of the amidships part of the vessel. The two, 3K96-3E eight-cell VLSs – which can accommodate an ammunition load of 16 9M96E or 64 9M100E surface-to-air missiles – are mounted below deck in the forward part of the hull. At the customer's request, the corvette can also be reconfigured as a naval air defence platform with as many as 24 9M96E or 96 9M100E missiles. According Almaz-Antey, the developer of RESURS, the different loadouts are possible because each of the system's launch cells can house either a single 9M96E missile or a canister with four 9M100E missiles. RESURS has the ability to engage up to five targets simultaneously at horizontal ranges out to 28 km (for the 9M96E) or 10 km (for the 9M100E) and at altitudes of 20 km (9M96E) or 4 km (9M100E).

The Project 22160-based light corvette is 94 metres long, 14 metres wide, and has a draught of 3.4 metres. It is capable of a full speed of 27 knots, has a cruising range of 4,500 nautical miles, and an endurance of 30 days. The ship is powered by a 16,000 kW propulsion plant.

Author

Following an earlier career in engineering, **Dr. Nikolai Novichkov** is an international defence journalist writing about topics that include aircraft, missiles and naval technologies.

A model of the upgraded Project 22160 guided missile corvette being marketed for export sales.

SERVAL Project 750B Submarine

Turning to underwater systems, the Saint Petersburg Naval Machine-Building Bureau Malakhit unveiled a mock-up of the SERVAL (P-750B) small, offshore submarine. The P-750B has a displacement of 1,450 tonnes and is 65.5 metres long, 7 metres wide and has a draught of 5.2 metres. Its 2,500 kW propulsion motor provides a maximum underwater speed of 18 knots and the boat has a maximum range of 4,300 nautical miles. Endurance is 30 days. The submarine is also equipped with an AIP system that allows it to sail underwater for up to 1,200 nautical miles at an efficient speed of four knots. Maximum diving depth is 300 metres. The submarine is armed with 12, 533 mm torpedoes, missiles, and mines.

SERVAL has a complement of 18-20 crew and can carry up to 20 further personnel, such as Special Forces frogmen. Its nose incorporates a compartment for the TRITON-2 compact submersible. Constructed of aluminium-magnesium alloy, TRITON-2 is 9 metres long and 1.6 metres wide. Powered by an electrical propulsion system drawing energy from batteries, it is capable of an underwater speed of 6 knots, a range of 60 nautical miles and an endurance of 12 hours. TRITON-2 can deploy up to six frogmen and is able to carry outboard mounted torpedoes and other weapons systems.

According to Malakhit's representatives, the SERVAL submarine can be customised to meet the detailed requirements of foreign customers. They suggest that these submarines can be particularly effective when deployed in skerry-type regions, such as many coastlines within the Baltic Sea.

PREDEL-E Radar

In addition to surface and underwater platforms, developments in combat systems and sensors were another important area of naval-science displayed at IMDS 2021. One example was provided by the Morinformsistema-Agat business concern, which displayed a new variant of the PREDEL-E mobile stealth radar designed by NPP Salyut. A spokesperson for the concern told MSD that this radar is the latest of a series designed to detect ships at over-the-horizon (OTH) ranges.

PREDEL-E's OTH capacity is achieved by virtue of anomalous propagation of radio waves in shore areas creating the so-called waveguide of evaporation (Editor: A phenomenon known as ducting in the West). The evaporation waveguide is located between the surface and altitudes of up to several dozen metres. The waveguide is defined by meteorological conditions – it emerges over the surface during a rapid decrease in the humidity of the neighbouring air layer – and dramatically increases the range of onboard and shore-based radars with frequencies of more than 3 GHz. The use of modern active electronically scanned arrays allows a narrow beam to be created that can be guided to the upper edge of the waveguide, thereby blocking dispersion of its energy. This allows a dramatic increase in an ability to detect targets in certain latitudes; perhaps by between 10-15 times as much as when compared with the normal radar horizon. The PREDEL-E radar is based on this effect. The manufacturer claims that PREDEL-E has a target detection range of no less than 400 km.

The PREDEL-E radar detects and automatically tracks targets at visual and over-the-horizon ranges whilst operating in a stealthy mode. It supports the BASTION mobile coastal defence missile system, as well as other air/surface defence, identification and control systems.

Propulsion Systems

Another important area showcased by IMDS 2021 was the progress that Russia has made in developing and manufacturing power plants for the latest Russian-made ships. According to United Engine Corporation (UEC) Deputy CEO Viktor Polyakov, UEC "has created a line of marine gas turbines ranging from 7,000 to 27,500 HP that satisfies the navy's needs for warships both under construction and in development for the short and medium term." The corporation's expertise in marine gas turbines now extends from competencies in design and batch production through to after-sales servicing and overhaul.

UEC – a subsidiary of the state-owned corporation Rostec – has mastered production of marine engines for a wide range of warships powered by gas turbines. It can offer the navy engines for Project 12061 and 12322 air-cushioned amphibious assault craft, Project 20386 corvettes, Project 11356, 22350 and 22350M frigates, as well as for the upgrade of older classes.

A model of the SERVAL submarine housing a compact TRITON 2 submersible in its bow section.

A model of the PREDEL-E mobile over-the-horizon stealth radar

A particularly important programme is production of 20 MW M90FR turbines used in the combined M55R diesel and gas turbine power plant that are being installed in the latest Project 22350 ADMIRAL GORSHKOV class frigates. USC delivered the first two M55R systems for installation in the frigate ADMIRAL GOLOVKO being built by the Severnaya Verf Shipyard in 2020. In addition, the third engine – for the frigate ADMIRAL ISAKOV – has successfully completed testing and the fourth engine – destined for the same ship is currently completing trials. GOLOVKO and ISAKOV are respectively, the third and fourth members of the Project 22350 class. A representative of UEC told MSD that "the schedule of delivery volumes for M90FR turbines encompasses some 20 engines". Moreover, Russian-made ships with foreign-supplied engines are able to receive M90FR turbines during modernisation.

UEC has developed a modification of the M90FR engine for use in the future Project 20386 corvettes. Two engines have already been manufactured and successfully tested and are ready to be handed over to the customer. The M90FR will also be the basis for the development of future marine engines.

In particular, the UEC is considering options for creating a 25 MW engine based on the M90FR designs.

Work is also underway to create a series of M70FRU turbines with a capacity of between 8-10MW for various smaller ships, such as small artillery ships and air-cushioned landing craft. A combined gas turbine arrangement could see the M70FRU being used as the main engine for a future frigate, with the M90FR being used to provide boost power.

Current Success

Finally, it was revealed in the course of IMDS 2021 that 2020 was a very successful year for USC's overall activities. "In 2020 the corporation handed over a record number of ships – nine brand-new and two modernised vessels. It is the best result in the history of the corporation since it was first established in 2007," said USC Deputy Director for Military Shipbuilding, Vladimir Korolyov. According to Korolyov, this strong performance will continue in the current year, when USC is scheduled to deliver a further ten vessels to the Russian Navy – seven brand new warships and three upgraded units.

Troubled Waters and Freedom of Navigation

Nick Childs

The principle of freedom of navigation and the issues surrounding it are, of course, nothing new. However, the revival of state-based competition has given them a renewed prominence as the sea has become a much more congested, contested and complex domain. In strategic and security terms, the sea is potentially a more consequential arena than it has been for some time, and certainly since the end of the Cold War. Equally, among the United States and its allies in particular, defence of the freedom of navigation has been wrapped up in a broader narrative of the need to uphold a rules-based international order.

This is notwithstanding the fact that the maritime domain has all along been universally acknowledged as being host to the primary arteries of global trade, even perhaps of globalisation itself thanks among other things to the dramatically increased significance of the global undersea cable networks. However, for much of the period since the end of the Cold War, challenges and the threats to all that appeared limited, and the sea seemed in strategic terms to be an essentially uncontested, almost benign conduit for the projection of chiefly Western power.

It was, of course, never quite that simple. Equally, the continued reliance of certain established maritime powers, and the United States in particular, on the maritime domain to project power and presence and thus exert influence at range is a key friction-point now, not least from the perspective of China and to some extent Russia too. However, there is a more general sense in which there appears to be a greater likelihood now of confrontation between states manifesting, at least initially, in the maritime arena than at any period since the Cold War era. Nor should it be forgotten that non-state-based threats at sea have not gone away, but have rather evolved themselves.

Author

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The views expressed represent those of the author and not necessarily of the IISS.

Photo: Public Domain / Wikipedia Creative Commons

On 12 February 1988, the US Navy cruiser USS YORKTOWN while exercising the "right of innocent passage" for a spy mission in Soviet territorial waters (claimed 12 nm), was rammed by the KRIVAK-1 class frigate BEZZAVETNIY (811). BEZZAVETNY's mission was to push USS YORKTOWN into international waters. This action has been called "the last incident of the Cold War".

Much of this has found expression in the issue of freedom of navigation. Significant developments in the reach of maritime law and the modern migration of more economic activity offshore in the search for valuable resources have also been critical.

So too the arrival of China on the global stage as a key factor in the shift in the centre of global economic power and activity to Asia, an inherently maritime arena with more than its share of maritime disputes. So, a major impetus in the renewed focus has been here, and especially the increasing assertiveness of China of its maritime claims in the South and East China Seas and of the historic rights it assumes over the South China Sea more broadly.

However, it is not exclusively about the South China Sea. Nor has it just been about the United States Navy pursuing a formal programme of freedom of navigation operations (FONOPs). The friction points are more varied and dispersed than that. The language of freedom of navigation has also been deployed more broadly than that and by many parties, to affirm rights and also

Photo: Curtsy photo LPhot Dan Rosenbaum, HMS Kent

Combined UK-US Freedom of Navigation Operation in the Arctic. The Type-23 DUKE-class frigate HMS KENT (F-78), the ARLEIGH BURKE-class guided-missile destroyer USS ROOSEVELT (DDG-80), the ARLEIGH BURKE-class guided-missile destroyer USS PORTER (DDG-78), the ARLEIGH BURKE-class guided-missile destroyer USS DONALD COOK (DDG-75), and USNS SUPPLY (T-AOE-6) conducting joint operations to ensure maritime security in the Arctic Ocean.

to exercise influence more generally from the sea in areas that would not be disputed as a matter of law as being in the open ocean but which powers have nevertheless regarded as part of their strategic backyard and strategic depth.

Defining freedoms

At least from the early 17th Century, the concept widely associated with the views of the Dutch jurist Hugo Grotius of the high seas as a global resource and transportation commons has grown to hold sway, and with it the notion that the free use of them is a critical right. This has always been qualified by the fact that certain areas around coasts and the littorals have accepted as been sovereign to and the responsibility of particular states. Moreover, the modern development of maritime law, and especially the United Nations Convention on the Law of the Sea (UNCLOS), has extended those areas, with twelve-nautical-mile territorial waters, exclusive economic zones out to 200 nautical miles and the potential factor of extended continental shelves.

While UNCLOS was meant to help rein in excessive maritime claims, its provisions have in certain cases helped generate a number of disputes and fueled others, not just over sovereign rights as such, but also about what are the rights of and restrictions on shipping in general but naval forces more particularly in these areas. These are dividing today's major global competitors. Also, behind a broad consensus in many areas, to differing degrees there are different interpretations of what is allowable that divide not just competitors but allies and partners as well.

To FONOP or not

The FONOP, or more precisely the regular exercise of FONOPs, has become the main acknowledged mechanism for parading and underpinning particular interpretations of disputed rights and restrictions. Strictly speaking, FONOPs also involve very particular deployments of vessels in specific bodies of water to either assert or contest particular claims. And the most notable practitioner is the US Navy.

The United States has long been a vocal and active supporter of the notion of freedom of navigation, although paradoxically still has not ratified UNCLOS, something which both US allies and critics alike feel undercuts Washington's position as an advocate if upholding the rules at sea. The formal US FONOP programme was established under President Jimmy Carter in 1979. These continued to some extent even during the years when the sea was perceived as a relatively benign, low-priority domain from a strategic point of view. More recently, in its latest report to Congress on FONOP activities, the US Department of Defense listed 19 countries it had challenged over what the US regards as excessive maritime claims.

These included Iran, Venezuela and Yemen, but also US allies and partners like South Korea and Japan. However, it has been those directed against China that have attracted most attention of late.

Perhaps the main catalyst for the multiple challenges that the US Navy has in recent years conducted against maritime rights claimed by China was the spurt of land reclamation or island building and military development in the South China Sea from about 2014/15. In response, the Obama administration initiated a number of FONOPs. However, these amounted to barely more than a handful, and were criticized as being ineffectual and inadequate. In contrast, after some initial uncertainty and hesitation, the Trump administration ramped up the number of FONOPs in 2019 in this connection to a record level – reportedly nine missions in all – as the atmosphere

Photo: US Navy

USS KEARSAGE (LHD-3) escorting a merchant vessel in the Strait of Hormuz during the tensions in May 2019.

of competition between the US and China became more hard-edged, and they have continued at a high tempo since, including into the Biden administration, including an increased on transits o the Taiwan Strait as tensions over Taiwan have risen.

Yet, despite growing concern internationally about the increasing assertiveness of China in the South China Sea, Washington has struggled to gain broader active support for its FONOPs in response. There have been a number of reasons for this.

One is that they have had a somewhat chequered record in execution, at least early on, when it was unclear on occasions what precise mission had been undertaken and what specific rights or claims had been challenged. Some concerns were expressed that some of the FONOPs might tacitly have acknowledged certain of China's disputed territorial claims. More recently, there has been a growing tendency for recipients of FONOPs (Chinese and Russian) to claim to have chased the encroaching vessel or vessels away, thus potentially adding another ambiguity in the 'battle of the narrative'. These are something of a structural weakness of formal FONOPs.

Photo: US Navy

The famous encounter of USS DECATUR with a PLA-N destroyer.

Secondly, as has been mentioned, even amongst allies and partners there are differences in interpretation on certain rights and requirements in UNCLOS, making concerted actions more difficult to achieve.

Thirdly, all states inevitably are grappling with complicated relationships both with the US and China, not necessarily wanting to be associated with certain aspects of Washington's policy and at the same time balancing economic interests and security concerns in respect of Beijing.

There are, of course, also potential risks of an incident at sea that could escalate. In 2018, a close encounter between a Chinese destroyer and the US Navy destroyer USS Decatur attracted much international attention. When the Chinese vessel appeared to manoeuvre dangerously close, there was much speculation that this could be a precursor to a more robust Chinese approach to US tactics in the future.

Having said all that, and while others do not have a formal FONOP programme like the United States, the United Kingdom did conduct a FONOP-like operation in waters off the Paracel Islands in 2018, much to the annoyance of China, with the amphibious assault ship HMS Albion. And, as general concern about Chinese assertiveness has gown, and the stakes have been raised, there has been a greater willingness by others to undertake what might be described as 'other freedom-of-navigation-related' or 'freedom of maritime manoeuvre' activities. These have been more high-profile deployments by groups through the South China Sea on more general missions by the likes of Japan, Australia and India.

These could be portrayed as demonstrating support for the general principle of freedom of navigation without necessarily crossing any particular 'red lines'. The deployment this year of a UK-led carrier strike group to the region headed by the aircraft carrier HMS Queen Elizabeth, which included a foray into the South China Sea, might also fall into that category.

France, another major European naval power that is also a Pacific power, has also shown signs of a more robust yet at the same time measured approach to supporting the principle of freedom of navigation. In 2019, a French frigate conducted a transit of the Taiwan Strait that incurred Beijing's displeasure and more recently deployed a nuclear-powered attack submarine to the South China Sea.

Indeed, there have been further indicators of increased European attention to maritime issues in the Indo-Pacific, a reflection of their acknowledged economic and security stakes in the region. Yet, the subtle differences in the details of both their interests and approach are also on display. So, for example, the Netherlands has deployed a frigate with the UK carrier strike group. On the other hand, Germany has dispatched the frigate Bayern on essentially an independent deployment, and just what its posture will be on its deployment remains somewhat uncertain, and therefore its impact on the debate.

Beyond the South China Sea

The fact is that the renewed era of great-power competition has in some ways increased the premium on concerted multilateral action to support international norms like freedom of navigation, but at the same time added to the policy complications of creating and sustaining such alignments. This became apparent in the context of the threats to freedom of navigation in and around the Strait of Hormuz in the summer of 2019, which were either attributed to or overtly carried out by Iranian forces.

There may have been a general consensus that there was a global stake in a threat to freedom of navigation in this waterway. However, there was much less agreement on the appropriate way to respond, not least because of concerns about becoming embroiled in the bilateral dynamic between Washington and Tehran and fears of inadvertently subscribing to the Trump administration's strategy of 'maximum pressure' on Iran.

This made the mobilization of a co-ordinated maritime response much more challenging and prolonged, albeit in the end that – in various ways – a significant but rather disparate set of actors either in different groupings (one led by the US and the UK, the other made up of a collection of European states driven chiefly by France) or unilaterally did commit naval capabilities to demonstrate a concern about the threat. However, the resources were not committed on the scale that they were, for example, when the threat to navigation was from a non-state source at the height of the counter-piracy operations off Somalia. That may also be in part a reflection of the fact that navies are just busier, with fewer resources.

Freedom of navigation issues and how to deal with them, and FONOPs in particular, do not just cause challenges with alignments between governments, but

also within them. In June 2021, the UK destroyer HMS Defender sailed through waters claimed by Russia as a result of its annexation of Crimea, sparking an incident with Moscow, and it became clear that the UK Foreign, Commonwealth and Development Office had expressed concerns that the action – although under the auspices of innocent passage through waters internationally recognized as Ukrainian – would provoke Russia. The ebb and flow of US FONOPs in and around the South China Sea can also be attributed in part to to internal policy debates in Washongton.

The recent Black Sea incident was also against a backdrop of some complaints that the West has struggled with an effective response to the maritime challenges being posed by Russia in the Kerch Strait and the Sea of Azov as it has applied pressure to the authorities in Kiev, including the seizure of Ukrainian navy units by Russian Federal Security Service units in the Kerch Strait in November 2018. As a general response, the US and its NATO allies have increased the number of high-profile warship deployments into the Black Sea. This could be seen as an assertion of freedom of navigation as part of a deterrent posture against Russia.

Likewise, two deployments into the Barents Sea in 2020 by UK and US surface warships (joined on the second occasion also by a Norwegian vessel) were portrayed in part as freedom of navigation exercises. They were re-establishing a presence that, in the case of US surface warships, had lapsed since the 1980s, and clear signalling to Moscow but also to some extent to key NATO allies as well. While notable, they appeared to aim to strike a balance between pressing a point, balancing clear mssaging without being unduly provocative, and being sensitive to some extent of the concerns of some other NATO allies as well.

These forays also reflected a growing interest once again in demonstrating both the ability and interest to operate in the High North and the Arctic. And the new and unfolding dynamics of this region, the melting of sea ice and the likely increased attractiveness of trans-Polar sea routes, is posing a set of questions about freedom of navigation here too. There are both practical and geostrategic challenges.

With Russia claiming unilateral rights over at least parts of the Northern Sea Route, there was talk during the Trump administration in 2019 of a US FONOP in the Arctic. But, so far, one has not materialized, amid questions over whether the US has adequate capability at the moment to carry one out, plus concern that this also too high a risk of raising tensions and provoking some kind of escalation. However, in 2018, the French Navy conducted a freedom-of-navigation-style operation along the Northern Sea Route, using a support ship, Rhone, in part perhaps to minimize the rik of provocation.

U.S. Navy photo by Mass Communication Specialist 3rd Class Keenan Daniels/Released

Recent US FONOPS in the South China Sea. Aircraft from Carrier Air Wing 5 and Carrier Air Wing 17 fly in formation over carrier strike force. The USS NIMITZ (CVN-68) and USS RONALD REAGAN (CVN-76) Carrier Strike Groups conducting dual carrier operations in the Indo-Pacific.

Future FONOPs?

With the likelihood that the maritime domain will continue to become more contested, the demand signal to uphold maritime elements of the rules-based international order, and not least freedom of navigation, is also likely to grow.

Having said that, the potential for evolving patterns of global maritime trade, the increasing 'blue-water' aspirations of China and other emergent naval powers, and the changing environment, for example in the High North, could see the patterns and hierarchies of maritime hotspots change, and also alignments on freedom of the seas issues could alter. While Western and NATO powers may keep an eye on the transits by China, Russia, and others in certain European waters, sensitive to what such missions may mean as far as long-term intentions to maintain a presence in these waters are concerned, these encounters – such as they are at all – are of a different character to some of those in, say, the South China Sea. However, that may change if in the future such transits become more of a test of differing interpretations of maritime law than they have been hitherto.

Be that as it may, more formal FONOPs are unlikely to be the complete answer to the issues at hand, and at the very least will need to be part of a wider strategy or set of approaches.

In part that is a reflection of the fact that FONOPs have their limitations. Also, as the stakes likely rise at sea, the premium on greater multilateral efforts perhaps in rather different forms acceptable to a wider array of participants for demonstrating enduring presence and the common practice of rights, may be the way ahead. There is a growing acknowledgement, even from the US Navy, that the forces of individual states cannot be everywhere at once.

There may also be a premium on more innovative approaches to joint action and the sharing of burdens to sustain presence and freedom of manoeuvre and navigation. Advances in technology, including uninhabited maritime systems and further development of the use of the seabed and threats to seabed capabilities, will challenge existing maritime law. At the very least, new protocols or codes of conduct might arguably be required, if the diplomatic environment allows.

In terms of more comprehensive strategies, greater intelligence-sharing between like-minded nations, and more co-operation on situational awareness and capacity-building, could help shine a political and diplomatic spotlight more effectively on challenges to the maritime status quo.

There is also the underlying issue that, while FONOPs and broader activities to assert freedoms at sea are essentially viewed primarily as diplomatic tools, they do in the end carry with them the implication that parties will be prepared to back their positions with action if bluff is called on one side or the other. In the Cold War, the US and the Soviet Union were able to draw up pragmatic protocols in response to growing concerns about the risks of 'incidents at sea', that were at least partial responses to alleviate the chances of unintended escalation. Depending on the trajectory of global competition more generally, that could become an increasing and sobering consideration in weighing up courses of action. ■

MUM-T at Sea

The US Navy Experiments with Manned-UnManned Teaming

Sidney E. Dean

Unmanned (or uncrewed) military systems have become standard features in the air and on the ground, and are increasingly being introduced for surface and sub-surface naval missions as well. As technology progresses, uncrewed assets are transitioning from stand-alone, remote-controlled or pre-programmed applications to more sophisticated roles. A major goal of the world's leading armed forces – including the US Navy – is the seamless integration of these assets into fleet operations. The concept of Manned-UnManned Teaming or MUM-T (a term first coined by the US Army) is seen as a major element shaping future fleet structures and operational doctrine.

At its core, the synergy achieved through MUM-T is expected to boost offensive and defensive combat power by leveraging the respective advantages of both crewed and uncrewed systems, while mitigating their respective weaknesses. Advantages will include longer range and more accurate sensor data for the joint fleet, cross-platform sharing of tactical data, integrated fire control, and greater lethality than can be achieved through manned or unmanned platforms alone. Building on the extensive experience with Unmanned Aerial Vehicles (UAVs), the Navy has initiated intensive experimentation programs for Unmanned Underwater Vehicles (UUVs) and Unmanned Surface Vehicles (USVs).

A number of dedicated testing units have been set up to this end. Unmanned Undersea Vehicle Squadron 1 (UUVRON 1) was established in 2017 at Naval Undersea Warfare Center Keyport, near Seattle. It is co-located with Development Squadron 5 (DEVRON 5) which is responsible for the US Navy's submarine force tactical development, including unmanned undersea vehicles and naval special warfare. Surface Development Squadron 1 (SURFDEVRON 1) was inaugurated in 2019 at Naval Base San Diego. Centred on the manned destroyer USS ZUMWALT (DDG-1000), its focus is on integration of USVs and support of experimentation toward the goal of accelerated delivery of new warfighting concepts and capabilities to the fleet.

Photo: US Navy

In April 2021, the US Navy conducted the large-scale Unmanned Integrated Battle Problem 21 (IBP21) exercise off the California coast to test MUM-T concepts. USS MICHAEL MONSOOR (DDG-1001) was the exercise flagship.

Unmanned Integrated Battle Problem 21

These squadrons have begun testing individual unmanned systems with operational fleet units. Much of this activity has been confined to small-scale experiments. Until now. From 19–26 April 2021 the US Navy conducted the large-scale Unmanned Integrated Battle Problem 21 (IBP21) exercise off the California coast. The exercise was hosted by the US Pacific Fleet (USPACFLT) and executed by the Commander, 3rd Fleet, both based in San Diego. This was the first large scale US Navy exercise/fleet experiment fully integrating unmanned and manned platforms in real-world combat drills at sea.

Rear Admiral Robert M. Gaucher, Director of Maritime Headquarters at USPACFLT, defined the overarching goal of IBP21 as the integration of unmanned capabilities across all domains to demonstrate how they solve CNO (Chief of Naval Operations) and fleet commander key operational problems. Answers were sought to key questions including:

- How can unmanned and manned systems work together effectively in diverse operational scenarios?
- How can unmanned systems be seamlessly integrated into existing platforms?
- What is the best way to train Sailors and Marines to use such complex, evolving technologies?
- And, simply, what works and what doesn't?

"Large-scale exercises such as IBP21 are critical for the Navy and Marine Corps to make the transition to a hybrid manned-

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An MQ-9 Sea Guardian UAV flies over USS CORONADO (LCS-4) during IBP21. This was the first large scale US Navy exercise integrating unmanned and manned platforms in real-world combat drills at sea.

unmanned force in the future," added Rear Admiral Lorin Selby, Chief of Naval Research, in June. "These demonstrations ensure that what works in theory will work in the fleet—in an environment that is messier, dirtier and wetter than a lab. They also allow us to get valuable feedback from the Sailors and Marines themselves."

Exercise Conduct: According to Rear Admiral Gaucher, a total of 29 unmanned systems were involved in the exercise. By category they comprised circa 50 percent USVs, 30 percent UUVs and 20 percent UAVs. Some uncrewed systems were controlled from ships at sea, others from land-based control centres, while yet others deployed under full autonomy. Crewed assets included ten warships representing most major ship classes (except aircraft carriers), plus various aircraft. The exercise "flagship" was the ZUMWALT class destroyer USS MICHAEL MONSOOR (DDG-1001) which – like its sister ships – is equipped with unique, advanced capabilities for command and control.

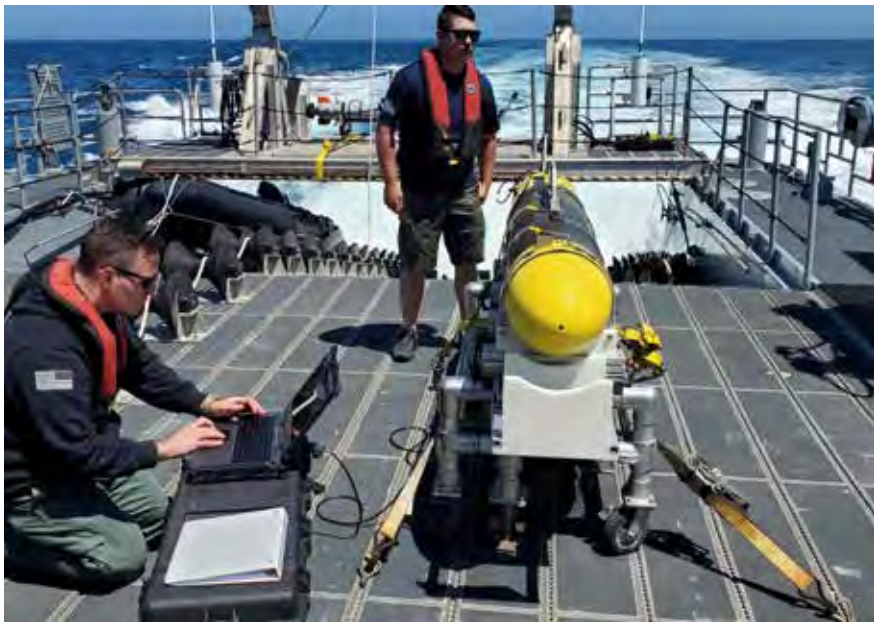
During a 26 April press teleconference, RA Gaucher and Rear Admiral James Aiken, Commander, Carrier Strike Group 3, discussed several of the operational scenarios or "vignettes" conducted during the exercise. These scenarios were designed to provide a broad spectrum picture of the MUM-T capabilities to conduct different mission types. They included an Anti-Submarine Warfare (ASW) segment during which a MQ-9 SeaGuardian UAV detected and tracked a submerged target using sonobuoys, and uplinked the targeting data to a manned P-8 maritime patrol aircraft; deployment and retrieval of an IVER-4 UUV by an attack submarine, providing Intelligence Surveillance and Reconnaissance (ISR) preparatory to the submarine engaging undersea and seabed targets; and an over-the-horizon strike vignette.

Discussing the latter, Admiral Aiken said "we successfully teamed air and surface manned and unmanned capability to put [an SM-6 missile] from [the destroyer USS] JOHN FINN on a target." Several uncrewed platforms acquired and tracked the target using passive sensors to avoid detection, and electronically transmitted the sensor date to the destroyer's combat system The JOHN FINN engaged the target from far beyond its own sensor range and "struck the target very, very successfully," said Admiral Aiken, who acted as technical manager for the exercise.

A fourth vignette demonstrated the ability of unmanned swarm attacks to destroy surface targets. In this scenario a USV conducting ISR employed electronic support measures to detect a surface target. It transmitted the target location and data to the information warfare commander aboard the MONSOOR, which deployed a swarm attack that destroyed the surface target.

First Impressions: The Department of the Navy (DoN) is currently producing an after-action review of IBP21. Detailed results and lessons learned are yet to be released. However, in June the US Navy summarised major initial takeaways which confirm the overall validity and benefits of the concept. These include: Unmanned systems are resilient, enable better beyond-line-of-sight targeting, and improve battlespace awareness and command and control. They also provide significant advantages in ISR and Targeting and Fires capabilities, without creating additional risks to the mission or personnel. Integrated manned-unmanned operations resulted in more effective offensive and defensive postures.

Even earlier, directly after the exercise concluded, RA Gaucher summarized his impressions: "I know that unmanned can proved me video from overhead. I know I can put a towed array sensor on a medium-sized unmanned surface vessel, and I can control it from the shore for theatre ASW. I know that I can operate a system



Personnel assigned to Unmanned Undersea Vehicles (UUV) Squadron 1 prepare a CARINA unmanned undersea glider for launch during IBP21.

An ADARO unmanned system participates in IBP21. Future MUM-T could see swarms of such unmanned vessels operate in conjunction with manned warships in line with the "Loyal Wingman" originally devised for aerial missions.

in and out of the torpedo tube of a submarine to support seabed warfare. From a [Pacific Fleet] perspective, we were very pleased about how the Integrated Battle Problem came out, in particular with our ability to integrate unmanned systems into that battle problem in a contested environment."

Operational Implications of MUM-T

The integration of unmanned systems will require changes to current operational concepts. Reflecting this realisation, in March 2021 the US Navy in released the unclassified Unmanned Campaign Framework. The document outlines the necessary steps to align unmanned system acquisition with the overarching goals of the National Defense Strategy. Key aspects cited in the Framework include development of innovative MUM-T operational concepts, and integrating these concepts into the operational planning process. This integration is expected to lead to new and unpredictable ways to achieve operational goals.

The benefits of Manned-UnManned integration go beyond enhanced capabilities for US forces. The Framework specifically calls for developing allied partnerships and training combined forces for missions using MUM-T systems in joint operations. Unmanned technology and MUM-T concepts are to be integrated into joint exercises as well as strategic planning and employment schemes developed with allies.

One manifestation of MUM-T is the "Loyal Wingman" construct originally conceived for air forces. Loyal Wingman calls for the direct operational teaming of manned and unmanned aircraft conducting a joint mission. Given the different capabilities and configurations of manned and unmanned aircraft, each would make unique contributions to the mission. Operational scenarios include an unmanned aircraft conducting Intelligence, Surveillance, Reconnaissance, and Targeting (ISRT) for the manned aircraft, which could launch stand-off weapons from outside the enemy air-defence zone. Alternately, an armed UAS could neutralise air defences, clearing a corridor for manned aircraft. Such missions are plausible for carrier based aircraft as well as for land-based units.

Looking beyond the label, the Loyal Wingman concept is applicable to surface and sub-surface naval forces. The US Navy has already successfully tested unmanned armed speedboats as escorts for manned vessels, deploying them as a defensive cordon against enemy boat swarms. The planned introduction of large and extra-large UUVs has led to proposals that they be teamed with manned attack submarines as "wolf packs" to hunt enemy submarines. Similarly, manned warships could form strike groups with armed USVs, increasing firepower and permitting simultaneous engagement of targets from multiple angles. One important aspect of MUM-T is that the human operator, not artificial intelligence, will be the final arbiter of weapon release by armed unmanned systems.

Force Structure Implications

MUM-T will ultimately require adding a large number of uncrewed (and in some cases attritable) platforms. The Navy's latest Long-Range (30-year) Shipbuilding Plan was released in June 2021. While budgetary uncertainty and outstanding requirements studies inject considerable variability into the plan, it calls for a target range of 59-89 uncrewed surface vessels

Sailors attached to Unmanned Undersea Vehicles Squadron 1 monitor a UUV during the course of IBP21. The creation of reliable communications networks, battle management aids, common control systems and data formats will be key to the success of MUM-T.

and 18-51 uncrewed undersea vessels to complement 321-372 crewed combat force vessels (including 78-84 submarines and 160-184 surface warships).

"Results from our Future Surface Combatant Force Analysis of Alternatives and Future Navy Force Structure study both show the value in USVs and support continuing investment, prototyping and experimentation to mature this capability for future force integration," said Rear Admiral Paul Schlise, Director, Surface Warfare Division, N96, Office of the CNO, in a December 2020 interview with SEAPOWER magazine. "[Large] USVs, as a distributed fires platform, can increase the fleet's missile carrying capacity and [Medium] USVs, as a distributed sensor platform, improve the commander's battlespace awareness. Our Surface Development Squadron (CSDS-1) is involved in testing these concepts using current prototypes in fleet exercises and experimentation. The lessons learned from CSDS-1 and [through war gaming] will help us refine concepts and inform further platform development to provide the fleet with a capability that can and increase lethality and capacity."

Current consensus within the US Navy is that capabilities rather than platforms should be at the centre of future force planning. Rather than developing an unmanned aircraft or vessel with a fixed capabilities profile, the future emphasis will be on enabling a wide variety of platforms to be modified with whatever capabilities are required by the mission and operational environment. This aligns with statements made by the CNO, Admiral Mike Gilday, that IBP21 will "further inform our understanding of where we need to go with unmanned. Particularly the capabilities and then eventually the numbers [of platforms to acquire]. It's easy to get seduced by the numbers, and we shouldn't," Gilday said, referencing both crewed and uncrewed vessels. "What we really need to be focused on is capabilities [that] then translate into platforms."

In addition to – and of equal importance with – the actual operational systems are the communications networks, battle management aids, common control systems, and data formats which will enable the full integration of manned and unmanned systems. For this reason, artificial intelligence remains a major defence sector research priority. "Advancements in technology have created the opportunity to provide our military with an operational advantage by developing improved manned/unmanned command and control capabilities," said Dorothy Engelhardt, Director of Unmanned Systems for the Deputy Assistant Secretary of the Navy for Ships. "This enables our military to be more agile, lethal and decisive."

A SEAHAWK medium displacement unmanned surface vessel sails past a Arleigh Burke (DDG-51) class destroyer during the course of IBP21. The US Navy believes it is getting closer to where it wants to be in developing MUM-T concepts.

Flexibility and modularity will gain in importance. So will the need for rapid design, development and testing, to ensure that new technologies are fielded before they are overcome by yet newer developments. Rapid acquisition is also vital operationally; when a high priority need is recognised, the fleet cannot wait years for traditional R&D pipelines. Operator feedback will increasingly become a vital source of guidance during system development, with fleet personnel becoming involved early in prototype testing, or even providing input during concept development.

Long-Term Goals and Doctrine

The US Navy continues to emphasise that, from an operational standpoint, enhanced MUM-T is a necessity, not an option. This is made clear in the new maritime strategy introduced in December 2020, *Advantage at Sea: Prevailing With Integrated All-Domain Naval Power*. Regarding MUM-T, the document states: "Consistent with the findings of recent force structure assessments, we will generate a balanced, hybrid fleet that includes undersea, surface, air power, aircraft carriers, and expeditionary land forces. Cost-effective platforms and manned-unmanned teaming will increase the capacity of the fleet and expand our ability to distribute our forces. We will leverage the lethality of submarines in sea denial and focus on enhancing long-range fires including aircraft and missile ranges, and manned-unmanned teaming in all domains."

As great power competition becomes more intense, the US Navy is intent on accelerating the integration of unmanned systems. To this end, IBP21 was the first of many planned exercises and tests designed to determine whether theoretical concepts and lab-tested technologies actually work under wartime conditions. According to the Department of the Navy, future steps include:

- Continuing to leverage fleet experimentation exercises to execute the DoN Unmanned Campaign Plan
- Creating a more iterative experimentation process to tighten the "test fast, operate, learn fast" concept
- Improving industry partnerships and participation in fleet experiments and exercises
- Improving the integration of secure communication networks to maximize effectiveness of manned-unmanned teaming
- Developing concepts of operation and employment to quickly operationalise unmanned systems

"We are not yet where we want to be," said Admiral Selby during the IBP21 exercise, "but we are getting closer. As our potential adversaries go all-in on unmanned platforms, we must and will maintain a dominant force that can meet and defeat any challenge." ■

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