ALL SEEING EYES

Armada International's famous Unmanned Vehicles Compendium returns, giving the reader all that they need to know regarding developments in the Unmanned Aerial Vehicles (UAVs), Unmanned Ground Vehicles (UGVs) and Unmanned Surface/Underwater Vehicles (USV/UUV) domains.

2015 was a busy year for the international unmanned vehicles market. Technology in the UAV sector has gone from strength to strength as manufacturers push boundaries in autonomy, endurance and payload sophistication, and customers move ahead with programmes to deploy third-generation systems in new roles while refining requirements across existing ones.

The UGV sector is continuing to develop to meet the requirements of the post-Afghanistan theatre. Still defined by the need to detect and counter insurgent explosives, emerging threats are driving the development of new capabilities, particularly as the focus increasingly shifts to the homeland security and first responder customers regarding Counter-Insurgency (COIN) operations.

The maritime market is also developing new Concepts of Operations (CONOPs), both across the surface and underwater sectors, with the Mine Countermeasures (MCM) mission continuing to drive requirements, and capabilities being sought within the anti-submarine warfare domain. Further details on recent MCM developments can be found in Luca Peruzzi's Dangers of the Deep article inside this issue.

Naval UAVs
The most advanced user of naval UAVs is the US Navy, which operates unmanned aircraft such as the Insitu ScanEagle, the Northrop Grumman MQ-8B Fire Scout and is currently flight testing the larger MQ-8C Fire Scout.

The MQ-8B, with payload weight of 301 pounds/lbs (137 kilograms/kgs) and an endurance of 7.5 hours, has been instrumental in the US Navy's progressive understanding of maritime UAV CONOPs. The UAV, which can perform reconnaissance and illuminate targets with its laser designator, has seen deployment to Afghanistan in support of coalition COIN operations there.

The system has been integrated with the BAE Systems Advanced Precision Kill Weapon System (APKWS). The US government programme of record, which adds semi-active laser-guidance to the previously-unguided Hydra-70 air-to-ground rocket used on the Bell AH-1Z Viper helicopter gunship and UH-1Y Venom light utility helicopter employed by the US Marine Corps, allowing it to engage targets on land or at sea with pin-point accuracy. The MQ-8B has also played an important role in the development of manned/unmanned aircraft teaming operations, allowing the navy to form frameworks for how these CONOPs can be taken forward.

The larger MQ-8C, based on the airframe of the Bell 407 light utility helicopter, is designed to autonomously take-off and land on any aviation-capable ship, and from prepared and unprepared landing zones. This aircraft, which pairs the capabilities of the MQ-8B with the payload capacity and operational parameters of the Bell 407, demonstrated an eleven-hour flight in August 2015 as part of its capability tests for the navy. The system completed its developmental flight test programme earlier in 2015 and is set to undertake operational assessment late in the 2016 as the navy works through how it will fold the aircraft into its mix of assets over the coming decade.

Threat Comprehension

Overwhelmingly, the threat in the naval domain is asymmetric. Unlike the use of UAVs over land theatres, where such aircraft are largely employed to build up a picture of an environment in which ground troops are operating, the naval environment is more reactive. The value in utilising UAVs in this domain lies in their ability to allow crews to investigate potential targets in the vicinity from a stand-off distance, while also providing an extension of shipborne optronics and radar sensors for reconnaissance at a much lower operating cost than manned helicopters.

The advantage of using a UAV in the maritime environment has also largely been driven by threats to national security, and the need for patrol vessels to monitor coastlines and defend against threats that originate from the sea. Such requirements are all the result of the emerging economic, political and cultural challenges within the maritime arena experienced over the past decade. "It is a fact that any country with a proximity to the sea needs to clearly identify threats against it that originate in the maritime arena, and prevent them in time," Dan Bichman, UAV marketing
manager at Israel Aerospace Industries (IAI), told Armada International. “These threats can create small-to-large radar cross sections according to their size and thus the country's defence force needs pin-point detection capabilities to identify them.”

IAI was one of the first companies to address the maritime domain, with its capabilities stretching back to the 1980s when its RQ-2A Pioneer and RQ-5 Hunter UAVs were operating with the US military from aircraft carriers, providing gunnery spotting and latterly reconnaissance for amphibious forces. Today, the company markets two systems in this sector, the Vertical Take-Off and Landing (VTOL) Naval Rotary UAV (NRUAV) and the fixed-wing Maritime Heron UAV, both of which, Mr. Bichman said, are designed to offer users a comprehensive maritime solution, and comply with “every country's current operational challenges”.

The NRUAV is capable of operating at altitudes of 15000 feet/ft (4572 metres/m) at a range of 80.9 nautical miles/nm (150 kilometres/km) and maximum endurance of six hours. It has a maximum speed of 100 knots (185 kilometres-per-hour/km/h), a loiter speed of 60 knots (111.1km/h), and can carry a payload of up to 484lbs (220kgs) consisting of a flexible multi-sensor suite with extended carrying capabilities. This includes day and night optronics with automatic tracking and target range measurement, and a multi-mode radar providing sea surveillance, long range surveillance, Synthetic Aperture Radar (SAR) and Inverse SAR, Moving Target Indication (MTI), navigation and weather avoidance, and air-to-air modes. In addition, the aircraft carries either a Communications Intelligence (COMINT) or ESM (Electronic Support Measure) sensor. The system communicates with its Ground Control Station (GCS) via a direct line-of-sight (LOS) datalink.

The NRUAV is based on the IAI Malat Helicopter Modification Suite (HeMoS). The HeMoS can perform automatic VTOL from ships, real-time battle damage assessment, and day, night and adverse weather Over The Horizon Targeting (OTHT). “The naval UAV answers a wide range of operational needs such as illegal fishery, piracy, insurgent activities and any other activity aimed against the country’s sovereignty,” Mr. Bichman said. “The system is highly efficient, and provides an important contribution to completion of the maritime picture without risking human lives.”

The Maritime Heron is designed to operate similarly to the standard Heron, as a land-launched Medium Altitude Long Endurance (MALE) UAV, with the added benefit of being able to take off from and land automatically on an aircraft carrier. The aircraft has a wingspan of 16.6m (54.4ft) and a take-off weight of 2750lbs (1250kgs). It can reach an altitude of 30000ft (9144m) and has an endurance of up to 40 hours depending on the mission and payload configuration. The aircraft can carry a wide variety of sensors, and can operate different payloads simultaneously, to provide real-time information over a wide area for extended periods of time. In its maritime
configuration the UAV carries sensors designed for this environment, including options such as IAI's Tamam Division Multi-mission Optronic Stabilised Payload (MOSP), IAI ELTA's EL/M-2022 Maritime Patrol Radar (MPR) and Automatic Identification Systems (AIS).

For increased operational flexibility, the UAV's GCS can be land-based or ship-borne, with control able to be transferred from one to the other in real time. "When operating within the maritime arena it is crucial to fit the specific surroundings, to operate the system from any maritime platform, and to integrate with the broader mission," Mr. Bichman said. "The (greatest operational benefit) is the capability to complete the full mission circle: detecting, classifying and identifying using one integrated and highly-efficient system."

Ocean Scanning

One of the most successful naval UAV at present is Boeing Insitu's ScanEagle. This fixed-wing UAV can operate at cruising altitudes of 10000ft (3048m) for missions of up to 20 hours in duration, carrying a range of payloads suited to operational requirements including optronics, SIGINT (Signals Intelligence) and EW (Electronic Warfare), communications and communications relay, mapping and radar (with SAR and GMTI) payloads.

The ScanEagle is launched autonomously by a pneumatic catapult and recovered by the SkyHook, a rope snag system that sets it apart from other fixed-wing UAVs in the maritime market. A tensioned vertical rope is hung outboard from the side of a vessel and the UAV is caught by its wingtip hook as it flies past, which triggers the engine to cut, then the UAV is safely brought back toward the vessel for recovery. "The ScanEagle's naval launch and recovery capability is unique; it is really the only well-proven fixed-wing UAV that you can get on and off a ship in the market at the moment, which is why you are seeing so many navies using it," Andrew Duggan, managing director, Insitu Pacific, said. "The catapult launch is not so unusual, it is the SkyHook that really sets it apart. Other fixed-wing UAVs landing on ships tend to use nets, and the problem with that is that if the net is fixed to the ship and the UAV misses it, the aircraft hits the ship instead, whereas with the SkyHook the UAV flies parallel to the ship, so if it misses it simply flies around for another go."

In addition to being used by the navies of the US, Canada, Malaysia and Singapore, ScanEagle has bagged a number of competitions in recent years, including with the Royal Navy and most recently, the Royal Australian Navy (RAN) for operational testing and evaluation purposes. Being deployed by such high-profile users is certainly helping to drive the market forward from Insitu's perspective. "Demand is quite significant, and a lot of that comes down to ScanEagle's unique qualities. There's quite a lot of competition in the land domain, but from the maritime perspective, there is very little out there that can launch and recover reliably from ships," Mr. Duggan continued. "Most of the focus we are seeing is from navies that are watching the system deployed by Canada, the US, Singapore and others, and are
appreciating its value from a tactical perspective." The system has a lot to add in particular for operators who are either space constrained with only a single helicopter hangar on a vessel, or no room on-board at all for a traditional naval support helicopter. "Even if you do not have a helicopter deck, adding the ScanEagle allows you to get a lot more out of that vessel, in the sense that it now has its own aviation capability that can sit out on the horizon for up to 15 hours at a time," noted Mr. Duggan. "The ability of that ship to patrol an EEZ (Economic Exclusion Zone) for search and rescue, illegal fishing or on counter-piracy operations, has suddenly been greatly expanded by having that UAV on board. It gives a lot of extra options that the ship's command can leverage, so it makes a lot of sense for smaller vessels such as corvettes or patrol boats that cannot operate a helicopter."

**Trials**

The move toward smaller vessels manned by fewer crew across navies is also creating opportunities in the VTOL UAV space, something that Schiebel is busy capitalising on with its S-100 Camcopter UAV. The S-100 has been trialled extensively by multiple navies, including most recently the RAN in June 2015, and the South African Navy in October 2015. The trial for the RAN was focused on the S-100's multi-sensor capabilities to demonstrate how the system can be effectively used to support maritime and littoral reconnaissance. Carrying three key payloads, namely a Selex SAGE ESM and PicoSAR radar and the L-3 Wescam MX-10 camera, the RAN was shown how the combination of the S-100 with the SAGE ESM and PicoSAR radar can extend the surveillance horizon of naval vessels and enhance situational awareness.

The South African Navy trials, conducted at False Bay, Western Cape in South Africa from the deck of the SAS Protea, a 'Hecla' class deep ocean hydrographic survey vessel, used the SAGE ESM system to demonstrate the UAV's maritime surveillance missions and anti-piracy capabilities, the two main areas of interest to the navy. Schiebel is working to expand the type of payloads available for the S-100 to increase mission flexibility. While ESM sensors have the ability to detect other vessels' radar as a means of identifying potential threats in the vicinity, Chris Day, head of capability at Schiebel, told Armada that the company is working to offer improved capabilities in this area. 'We have been flying with a couple of radars for the last few years, but they are not optimised for the maritime environment, they were developed for land and have been given additional capability to work at sea but that is probably too much of a compromise," he said. "There are several companies developing very lightweight state-of-the-art radars that are designed specifically for the maritime environment. Selex is one, and we are continuing our work with them to trial new radars that give us a very long range and the ability to observe multiple targets."
Similarly, in June 2015 Schiebel teamed up with IAI’s ELTA Systems to demonstrate the EL/K-7065 3D (three-dimensional) High Frequency (HF/three to 30 gigahertz) band COMINT interception and geolocation system on-board the S-100. The EL/K-7065 provides quick labelling and identification of HF signals, creating a reliable Electronic Order of Battle and accurate geolocation, while the HF airborne antenna configuration, measuring merely 300mm by 500mm (11.7 inches by 19.5 inches), is optimally suited for the S-100. “The reality is that the challenge we are faced with is that some of the individuals or groups operating in the maritime environment do not want anyone to know what they are up to; their vessels do not have radar and often are not even made of metal, which makes it very hard to collect an intelligence picture,” Mr. Day said. “So, one of the ways to identify threats is to intercept communications. Even if they only have a very simple maritime presence they still have to talk to people, so these communications intercept and geolocation technologies can give the commander some idea of what no other technology can about what is out there.” Schiebel has also recently tested a new heavy fuel engine for the S-100 as it looks to address the requirements of the maritime market. The new engine, which has been adapted from a commercially-available rotary engine core, is designed to overcome the challenges of needing different fuel types in the maritime environment by accommodating JP-5 (F-44), Jet A-1(F-35) and JP-8 (F-34) fuels.

**Outside the box**

A totally new approach to the market is being undertaken by Lockheed Martin, which is working on a re-configurable version of its collapsible wing Vector Hawk UAV as part of its work to develop a maritime canister-launched small UAV. Vector Hawk, which has a take-off weight of 4lbs (1.8kgs) and a vertical profile of 101.6mm (four inches), is designed to switch between fixed-wing, VTOL and tilt-rotor configurations to meet different mission requirements. The company believes the system is well suited to support a man-portable all-in-one solution that includes a fixed-wing aircraft for standard and long endurance missions, a collapsible fixed-wing aircraft that can be launched from a tube from land or water, a vertical take-off and landing aircraft, and a tilt-rotor VTOL. “What we are working on is related to our efforts toward commonality, we want an aircraft that uses the same fuselage, avionics and control systems, but with multiple wing variants so it can be dynamically applied to different mission types,” states Jay McConville, director of business development for unmanned solutions at Lockheed Martin. “One of those wing configurations is an extensible wing that fits nicely into a canister for launch.”

A canister launch is an interesting way to launch a small UAV, and has a lot of applicability in the maritime domain. The benefits of this method include the ability to launch the aircraft from a number of different points that might have difficult environmental challenges. “Consider an air launch where the aircraft is propelled out of the canister and then it establishes itself in flight, for the operator that simplifies the launch of the aircraft,” Mr. McConville said. “It also expands the
number of places where you can launch from; imagine launching from underwater or from the air or multiple other scenarios—all the operator has to do is give the launch sequence command and the system takes care of handling the environmental challenges that exist in that launch scenario." The Vector Hawk lands similarly to the widely-deployed Desert Hawk UAV, entering a deep stall and floating to the ground or, in this case, on the water. It is designed to be able to break apart on landing, float to the surface, be recovered and put back together.

As the naval UAV market gathers pace more refined CONOPs for these systems are emerging. With the multitude of advantages they bring, naval users are rightly seeking their best match from available systems, in order to enhance the capabilities of their naval vessels and to keep their personnel out of harm's way.

**New Developments**

Other developments in the VTOL market include the announcement in December 2015 that Saab would form a Joint Venture (JV) with the UMS Aero Group of Switzerland to market its family of Skeldar UAVs. The JV, named UMS Skeldar, will receive all Saab assets relating to the Skeldar UAV, with the company to retain a 47 percent holding in the new company. According to Saab, the partnership brings increased focus to the marketing of the Skeldar rotary wing UAV, combining Saab's extensive experience within the field of aviation with the smaller company's flexibility. UMS Skeldar went on to announce that its UAVS, including Skeldar, would be supported by Swiss-AS' AMOS integrated maintenance, repair and overhaul software solution.

Elsewhere UAV Solutions of Maryland, United States, continues to see success with its Phoenix-30, with four systems delivered to the Department of the Army of Romania in January 2016 as part of a US government Foreign Military Sale (FMS). The UAV was delivered fitted with the company's Dragon View stabilised optronics payload, along with GC5s, spare parts and ground support equipment. The 14lbs (6.3kgs) Phoenix-30 is an electric-powered system capable of carrying a two-pound (0.9kg) payload. The UAV's endurance is up to 35 minutes depending on its mission profile, with a maximum speed of 24 knots (4km/h) and cruise speed of 15.5 knots (28.7km/h). Typical operating altitudes are up to 500ft (152.4m) with a Mean Sea Level altitude of to 10000ft. In late 2014 UAV Solutions delivered the same system to the Bulgarian Army, also under an FMS. This sale was for four systems, and the company completed customer equipment training in July 2015.
Tactical Robotics of Israel has also announced new developments, with the first untethered flight of its AirMule VTOL UAV at Megiddo airfield in northern Israel in January 2015. The one-ton aircraft is being developed as an unmanned cargo delivery system with internal lift rotors that enable it to fly in obstructed terrain where helicopters are unable to operate, and from vessels that are too small for a standard unmanned helicopter.

The in-development AirMule is powered by a single Turbomeca Arriel 1D1 turboshaft, but the future production aircraft will be powered by the Arriel 2 variant capable of providing increased take-off power. The current test schedule at Megiddo includes plans to demonstrate the AirMule's autonomous cargo delivery and Beyond-Line-Of-Sight (LOS) flight. The export variant of the system, called Cormorant will be capable of carrying a useful load of 968lbs (440kgs) up to 161.9nm (300km), a payload that will increase over shorter distances. It will have a cruising speed of 100 knots (185.2km/h) and will be able to operate at altitudes of up to 18000ft (5486.4m). According to Tactical Robotics' chief executive officer, Rafi Yoeli, the AirMule is being designed to meet helicopter safety criteria and the company is confident that within the "next few years" the capability will be fielded, providing "breakthrough capabilities to any military force or civil agency that needs to robotically deliver systems, supplies and other provisions in and out of otherwise inaccessible environments."
Fixed Wing

2015 was also a busy year for the US Air Force's Northrop Grumman RQ-4B Global Hawk programme. In May 2015 the RQ-4B obtained milestone-C approval from the US Defence Acquisition Executive, clearing the way for the programme to move ahead with modernisation activities. This upgrade work will be based on a joint Northrop Grumman and US Air Force desire to fly a variety of additional payloads, such as new optronics, on the aircraft to enhance its ability to support COIN, anti-piracy, Humanitarian Assistance and Disaster Relief (HADR), airborne communications relay and information sharing missions. Prior to the approval, the programme had demonstrated a predetermined level of software maturity and the ability to demonstrate interoperability with other relevant systems within Department of Defence spending requirements.

Northrop Grumman was awarded a new umbrella contract worth up to $3.2 billion in September 2015 for work pertaining to the development, modernisation and maintenance of the RQ-4B fleet through to 2020. The award followed a bumpy few years for the aircraft during which the US government went back and forth between plans to scrap the fleet in favour of investment in the air force's manned Lockheed Martin U-2S Dragon Lady reconnaissance aircraft, or vice versa. The RQ-4B's favourable operating costs won this context and now modernisation work will be taken forward by Northrop Grumman. Major Robert Leese, secretary of USAF public affairs, clarified that the indefinite-delivery/indefinite-quantity contract will support future enhancement efforts for the RQ-4B programme identified during the next five years, with upgrades to meet USAF operational needs and maintain or increase operational capability. "Current RQ-4B capability enhancements include sensor upgrades and integration, Ground Segment modification, ice protection ... communications modifications and operational flight programmes," Maj. Leese said. "This particular contract is intended to support future additional enhancements and upgrades that are required by the USAF. These upgrades posture the RQ-4B to meet or exceed operational needs with capability enhancements, in conjunction with sustainment activities, improving overall system reliability and mission effectiveness." This is also likely to include work to increase the aircraft's ability to carry a wider payload capacity to provide greater consistencies with the capabilities of the U-2S via Northrop Grumman's new universal payload adaptor.

Northrop Grumman also demonstrated a new approach to mission management control capabilities in August 2015, with a series of flights undertaken during which the RQ-4B responded to external requests to “dynamically alter its route of flight and sensor functionality”, the company revealed as part of work to break the one-user to one-vehicle UAV paradigm. The work is being carried out in response to customer requirements for standardised command and control systems for multiple UAVs, and in support of broader US Air Force objectives for its Common Mission Control Centre (CMCC) programme. The demonstration, which saw the RQ-4B interface with the CMCC using the UAV C2 (Command and Control) initiative message set an emerging standard that enables interoperability across multiple weapon systems, showed that the aircraft is capable of integrating an advanced mission management capability without changes to the aircraft's software.

Under current plans the RQ-4B is expected to reach the end of its life in the early 2030s. “The service life of the RQ-4B air vehicle can be quantified in three ways, a calendar-based service life of 20 years, 40000 flight hours, and/or 1800 landings,” Maj. Reese told Armada. “At the current usage rate, the aircraft would exit service after 2032 without any actions to extend service life.”

As to where the RQ-4B programme is heading in the meantime, the USAF believes the UAV has a lot of room left to evolve. “The RQ-4B has been the USAF workhorse for (reconnaissance) operations worldwide and its contributions are immeasurable,” Maj. Reese said. "Whether developing targets, relaying (soldier) communications to support operations, or providing support for humanitarian crises, the ... platform has proven effective, dependable, and versatile. (It) offers a wide variety of employment options (over the coming decade). The range and endurance of over 30 hours allow for extreme flexibility in meeting mission requirements. The RQ-4B is the USAF reconnaissance platform for the future, bringing increased operational capability to help realise the USAF's future strategic plans," Maj. Reese concluded.

Export sales of the RQ-4B are also gathering pace. In February 2015 Northrop Grumman began production of the four RQ-4Bs being delivered to the Republic of Korea (RoK) Air Force under an FMS agreement with the US government. The contract, signed in December 2014, will see deliveries of four aircraft, two GCS and supporting equipment commence to the RoK in 2018. The Korean sale marked an
important milestone for the programme, as it was the first sale of the RQ-4B to an allied nation under the FMS Sales route. The sale followed hot on the heels of a January 2015 request from the Japanese government for similar aircraft, also under an FMS, and the selection of the MQ-4C Triton maritime RQ-4B variant in 2014 by the Australian government.

Global Horizons

The Australian MQ-4C aircraft will be used for high altitude maritime patrol and surveillance duties by the Royal Australian Air Force (RAAF). Up to seven aircraft will be based at the RAAF's Edinburgh airbase in South Australia from around 2020 where they will operate in conjunction with the Boeing P-8A Poseidon maritime patrol aircraft when it enters service to replace the ageing Lockheed Martin AP-3C Orion fleet later this decade. As with the US Navy's aircraft, for which the MQ-4C has been under development since 2008, the RAAF's aircraft will incorporate reinforcements to the airframe and wings, and will feature de-icing and lightning protection systems to allow the aircraft to descend through cloud layers to get a closer view of vessels and targets at sea.

The latest updates from the US Navy on the MQ-4C development programme were released in November 2015, when Naval Air Systems Command announced that the aircraft had begun operational assessment. This assessment, which is set to complete in mid-January 2016, will see the aircraft undertake six flights and execute various operational test scenarios to assess its operational performance at this stage of the programme. This will include scenarios reflecting three of the aircraft's expected missions: intelligence, surface warfare, and amphibious warfare. It will be put through its paces in its ability to detect, classify and track targets in day and night operations, while also identifying risk areas for the Initial Operational Test and Evaluation phase to follow. Milestone-C approval is expected in early 2016. The navy's programme of record calls for 68 MQ-4Cs, with the aircraft to be a forward-deployed, land-based autonomously operated system that provides persistent maritime reconnaissance using a multi-sensor payload. The first three aircraft are expected to be purchased by the navy in 2016 with the first aircraft currently expected to be operational by 2017.
UGVs

The ground vehicle market remains buoyant as technologies mature in the Explosive Ordnance Disposal (EOD) sector, and innovative technologies enter the marketplace. For example, in August 2015 Sarcos of Utah, United States unveiled a new 3.6kg (eight pound) Guardian-S snake robot. The system, which the company believes to be the first of its kind to be commercially available, is designed for use in a range of industries including public safety (tactical, bomb squads, hazardous materials, fire, search and rescue), security, disaster recovery, infrastructure inspection, aerospace, maritime, oil and gas, and mining. The system can operate for up to 48 hours travelling several miles between battery changes, and can carry a suite of sensors within its cargo bays, externally on top of the track bodies, or within its centre section (including multiple cameras), into dangerous or challenging environments, transmitting real-time video and other data over multiple wireless protocols across substantial distances. Sensors from third party providers can also be integrated.

Sarcos has designed the system with a mobile phone communication interface to support real-time teleoperation control using both WiFi for distances up to 200m (656ft) in unobstructed environments, and the cellular network, which extends the communication range to anywhere cell phone coverage is available. The Guardian-S' linear track allows it to reliably negotiate challenging terrain that other traditional parallel-track UGVs cannot, including climbing stairs or passing through narrow culverts and pipes. It can also scale the inside and outside of storage tanks, pipes, maritime vessels, vehicles and other vertical surfaces. “The robot was originally developed as part a US Defence Advanced Research Projects Agency (DARPA) robotics programme, which was aimed at producing innovative UGV capabilities to carry out search and rescue operations in a variety of complex urban environments,” a company spokesperson told Armada. “Additional projects resulted in a snake for carrying out mine rescue, and for performing 3D tunnel mapping in border security situations. In all cases, it was recognised as being a sensor platform with superior access capabilities.”

The Guardian-S has been delivered to a number of classified customers, and Sarcos is positive that the system’s ability to be configured for a wide variety of reconnaissance, search and rescue, local surveillance, and persistent surveillance applications presents interesting opportunities in the market. “We have tremendous interest from commercial and government customers due to the robot’s superior performance,” the spokesperson said. “It can travel where other robots cannot, and go further, faster, and perform surveillance for longer periods than any other robot of similar size that is commercially available. We believe that the market
opportunities are enormous for robots with the size and capability of the Guardian-S. We think the global market opportunity exceeds tens of thousands of robots over the next decade.”

A new UGV has also emerged from the Estonian company Milrem, on display for the first time at London’s Defence and Security Equipment International exhibition in September 2015. The system, not known by any specific name, is being designed for defence operations under funding from the Estonian Ministry of Defence. The vehicle has a weight of 700kgs (1540lbs) and is powered by a diesel-electric drive with an efficient work period of eight hours, and can also be operated as a fully electric system. Although designed to be remotely operated, it also has an autonomous function via pre-determined way points.

Elsewhere, Nexter Robotics released details of the new functionalities of its Nerva robot family in February 2015. Two new mission modules were introduced: a 3D vehicle scan and two-channel audio intercom, along with a new mobility kit with tracks that aim to extend the system’s deployment zone in difficult terrain, allowing it to traverse stairs. A lighter portable control station was also introduced to facilitate deployed operations. Meanwhile, semi-autonomous assistance functions, including personnel tracing, autonomous navigation and multi-robot supervision, have been developed.

Explosive Threats

Northrop Grumman Remotec also introduced a new UGV, unveiling the Andros-FX in June 2015. It has been designed to build on the success of Remotec’s F6 family while addressing capability gaps in the marketplace. “A combination of factors led to the design of the FX as we looked at the marketplace, including looking at the documents put out by the US National Bomb Squad Commanders Advisory Board on a yearly basis to identify the areas where they had capability gaps in currently fielded systems,” Mark Kauchak, director sales and customer support at Remotec, told Armada. “We also had discussions with our customers which gave us a good feel for where we wanted to go next with our products, and we also looked at some of the international markets and opportunities, and from there we developed the requirements for the Andros FX. The main threat we saw emerging in the US and other parts of the world is the (vehicle bomb), so we focused on the dexterity of the arm while increasing its lift and vehicle mobility.”

The system’s design improvements include four track pods that replace the traditional Andros articulators and a new arm design that adds roll joints to provide nine degrees of freedom for greater dexterity and increased lift capacity. It also features updated electronics, mobility improvements for increased speed and manoeuvrability, and a new touchscreen operator control unit with 3D system graphics, advanced manipulator controls and an improved user interface.

Although addressing the vehicle bomb threat, the FX’s capabilities are not limited to this mission; rather, it is designed for the EOD mission of militaries and first responders as a whole. Requirements in the US, where bomb squads typically do a lot of work supporting SWAT (Special Weapons and Tactics) teams, have led to the integration of SWAT accessories. For example, the FX can use chemical and radiation sensors; as well as stair climbing capabilities to allow it to enter a building as a multi-purpose tool for users. “We used the user interface of the Northrop Grumman Titus UGV as a baseline and made improvements there, and also spent a lot of time on improving life cycle costs and making sure the system is easy to support, maintain, repair even upgrade in future at the user location,” Mr. Kauchak said. “And when we bundled that up there is really nothing like it in the marketplace.”

Remotec has undertaken a number of demonstrations for US and international users, including disrupters commonly employed by the UK Ministry of Defence (MoD). “The feedback we received from the manufacturer was that the FX was the most stable platform that they have seen their disrupters fired from,” Mr. Kauchak added. “On the whole we are getting positive feedback on the new capabilities of the system and that it is a real break from what is being done to address this threat.”

Remotec has also taken a much more open architecture approach to FX’s design, in response to the demands it sees filtering into the marketplace. “One of the things we are seeing particularly in the US from a requirement standpoint is the ability for systems to easily integrate sub-systems from other manufacturers,” continued Mr. Kauchak. “It is one of the key components of the US military’s Advance Explosive Ordnance Disposal Robotic System (AEDRS) programme, so from a market
perspective, coming in with a Remotec-only, an iRobot-only or a QinetiQ-only solution is not the best approach these days, and the ability to integrate subsystems from other vendors is what customers are going to be expecting down the road.”

AEORDS
The US Navy's Naval Sea Systems Command's (NAVSEA) AEORDS programme is developing a new family of interoperable EOD robotic systems. The interoperable approach is based on a government-owned architecture that utilises common physical, electrical, and logical interfaces. This enables the creation of a family of UGVs with a high degree of interoperability and interchangeability to enable the rapid integration of new technologies across three AEORDS EOD robots: small, medium and large.

Increment One entered the integration phase in October 2015, following a contract award to Northrop Grumman in September 2015 as prime systems integrator. This is the first of the three increments of the programme, and will see development of the smallest variant, weighing circa 15kgs (35lbs) for dismounted operations that must be light enough to carry in a backpack with a primary mission focus on reconnaissance. As prime contractor Northrop Grumman, supported by Remotec, will procure and integrate components including its handheld operator control unit and its communications plus mobility, master, power, manipulator, end effector, visual sensor and autonomous behaviour capability modules and other minor components that comprise the dismounted operations system, all of which will be provided by other vendors. “The programme is set up so that the prime system integrator cannot provide any of the nine capability modules; we are a systems integrator and have to build the system and provide the logistics support for it,” Mr. Kauchak said. “We have specifications we are required to meet from the government and we have to ensure that when the nine capability modules are all put together that the system meets those requirements.”

In the short term, the Northrop Grumman team is chartered with delivering six prototype EOD versions of the robot in 2016. According to Walt Werner, managing director of Remotec, the programme is moving quickly with a set of Critical Design Reviews (CDRs) scheduled for February to allow the customer to ensure the capability modules meet requirements, at which point Northrop Grumman and Remotec will proceed with integrating the modules to meet the system requirements. “This is the world's first interoperable robot so the challenge upfront is to hit the ground running, so even before contract award we had to prepare to ensure all the blocking and tackling of the subcontracts was done because the schedule is very aggressive,” Mr. Werner said. “From a rigour standpoint it forces the traditional system engineering to make sure everything gets flowed down, that all requirements are covered, and that everything is derived down to the module level. It is early days, but so far, so good.”
iRobot continues to address the needs of the US military with its range of UGVs, with a number of new contracts announced in 2015. In August 2015 the company disclosed that it has received an order from the US Navy for its 110 FirstLook system and accessories, with deliveries to run through to February 2016. The FirstLook robot is designed to provide situational awareness, persistent observation and reconnaissance to soldiers and emergency response teams. The 2.2kgs (five pounds) robot has been designed to be rugged enough to be thrown into a room or building, through a window or down stairs, surviving falls of up to 16ft (4.8m) onto concrete. The system can self-right if it lands on its back or gets flipped over, and it can also climb obstacles up to 177.8mm (seven inches) in height, climb curbs and turn in place. The robot has a range of optronics, as well as an expanding array of sensors to provide real-time detection of trace explosives. Together, this functionality allows the user to send the UGV into confined spaces, such as tunnels, compromised buildings, damaged vehicles, underground vaults and industrial facilities, to locate and identify hazards or perform route/building clearance and enable responders to develop an intelligent and actionable entrance plan.
Also in August 2015 the company received an order from the US Marine Corps for its Small Unmanned Ground Vehicle (SUGV). Deliveries of 75 units will be complete by the second quarter of 2016. The back-packable 13.6kgs (30lb) SUGV can climb stairs, manipulate objects, and provide bomb squad investigators and EOD teams with non-destructive inspection and detection of explosive materials in luggage and suspicious packages.

Sea Surveillance
The naval USV market initially found its feet with the application of unmanned technology to MCM, but new developments here are seeing manufacturers branching out into new areas, propelled by emerging military customer requirements. In September, Ocius of Australia announced that it will produce a proof-of-concept Anti-Submarine Warfare Unmanned Surface Vessel (ASW-USV) demonstrator under a $3 million Capability Technology Demonstrator contract from the Australian Department of Defence (DoD). The company will work with Thales’ Australian subsidiary to demonstrate a “low-cost, long-range, persistent detection capability that enhances the ability of navy surface forces to detect and track modern submarines and torpedoes at realistic standoff distances.” The work will see the development of a Bluebottle USV coupled with an integrated thin line towed array sonar. The demonstrator will be acoustically covert and capable of deploying autonomously at tactically significant distances from a naval
task group. Effectively acting as a complementary off-board ASW system, it will enhance situational awareness through remote sonar data, increasing the threat detection window for the task force, and allowing commanders to make more effective decisions to fight the submarine threat. Being unmanned and with autonomous functions, the system will demonstrate the possibilities to lower the expense and manpower resources of manned ASW platforms, such as frigates and submarines towing arrays, or aircraft, while providing persistent, long endurance monitoring.

Ocius will begin the work by building a longer version of its 2.8m (nine feet) oceanographic Nemo USV, evolving the system into a 5.8m (19ft) craft called Stinger. The company's vessels are known as 'Bluebottles', named after the Australian jellyfish that use their bodies to sail. The USVs harvest the energy available from the sun, wind and waves for power, allowing them to remain at sea for weeks or months at a time. The economic and operational advantages of the design include reduced capital costs per square mile of ocean coverage, reduced operational costs, continuous coverage, elimination of errors due to human fatigue, all the while keeping personnel out of harm's way.

Sub Hunters
While the Australian government is just dipping its toes into unmanned anti-submarine warfare applications for USV technologies, DARPA is further down the research track in the US. Under its ASW Continuous Trail Unmanned Vessel (ACTUV) programme, it is developing an unmanned vessel optimised to robustly track quiet conventional submarines. The programme's goals include the demonstration of a USV freed from the design constraints of manned vessels, with a high performance that can provide 'propulsive overmatch' against conventional hunter-killer submarines at a fraction of their size and cost. USV autonomy is also hoped to be advanced under the programme in order to enable independently-deploying systems to undertake missions; "spanning thousands of kilometres of range and months of endurance under a sparse remote supervisory control model," DARPA expands. This will include the ability to autonomously comply with maritime laws and conventions for safe navigation, autonomous system management for operational reliability, and autonomous interactions with an intelligent adversary.

The ACTUV programme has emerged in response to the perceived threat posed by virtually silent conventional submarines. With an operating noise some 75 decibels quieter than a humpback whale, these submarines are notoriously difficult to detect and track even for technologically advanced navies, and they are also becoming increasingly prolific with countries such as Russia selling the technology. As a result, these submarines are becoming a significant threat to naval operations and the commercial shipping industry.

In 2012, SAIC (now Leidos) was awarded the contract by DARPA to design, build and test the prototype vessel for the programme, based on its work in the first phase of the programme to create a wave piercing trimaran. The vessel, which for the purpose of the programme will be based on Leidos' phase one concept design, must
be capable of independently deploying under sparse remote supervisory control as a 'game changing' anti-submarine warfare tool. Ultimately, the programme must be able to facilitate the rapid transition of the capability to fill the operational demand of the navy.

The vessel prototype, consisting of a maritime autonomous system installed on a 12.8m (42ft) work boat serving as a surrogate vessel, completed its first self-guided voyage between Gulfport and Pascagoula, Mississippi, in January 2015, showing that it is able to operate under sparse remote supervisory control and safely follow the collision avoidance ‘rules of the sea’ known as COLREGS. During the 35nm (62km) voyage the boat avoided all obstacles, buoys, land, shoal water and other vessels in the area without pre-planned waypoints or human intervention. Development and testing continues.

ASW is also a potential application for the Bonefish concept USV under development by Saab's Australian subsidiary, along with mine-countermeasures, surveillance and counter-piracy applications. This system is being designed to be adaptable to suit customer requirements, with a mission system including digital radar, sonar and photo realistic sonar; thermal and situational awareness cameras; and weather and position sensors. The vessel will be equipped with a searchlight, long distance microphones and a loudhailer, local Very High Frequency (VHF/30-300MHz) communications, WiFi and Satellite communications, a vessel Automatic Identification System (AIS), voyage data recorder and an engine monitoring interface. It will also be capable of being integrated with a combat management system. The Bonefish is being built with multiple levels of autonomy, including remote control/teleoperation, independent emergency stop and waypoint navigation. Meanwhile, research and development work is evolving collision detection and avoidance, and cooperative operation capabilities. Unveiled in 2014, the Bonefish mission system technology is set to be applied to surface vessels such as trimarans, catamarans and monostable hulls, allowing operators to conduct missions to address emerging naval threats remotely while keeping sailors out of harm's way.

Derek Rogers, programme and engineering manager at Saab's Australian centre of excellence in autonomous vessels, told Armada that in early October 2015 the company demonstrated an operational Bonefish USV Mission System at Pacific 2015, the major naval exhibition in Australia. "The USV Mission System comprised the portable control station and the maritime electronics, the latter installed on two (towers) suitable for a Rigid Hulled Inflatable Boat (RHIB)," Mr. Rogers said. "Substantive interest was shown in the work both from within Australia and internationally including from the Netherlands, the People's Republic of China, Singapore and the US. "In terms of command and control we (have) demonstrated ... the preliminary integration of the Bonefish USV control station with the latest Saab 9LV Combat Management System (CMS), although we emphasised that the design is such that it can be integrated with any sufficiently open combat management system." Mr. Rogers has also presented the Bonefish concept at several conferences and events in 2015, emphasising the need to employ a flexible mission system across a wide variety of hulls, the need to work with existing mature maritime standards instead of developing new standards; and the need to develop solutions that integrate with, in a military context, existing naval systems for C2, launch and recovery, and sustainment.

The Bonefish team has been progressing a number of initiatives related to enhanced C2 integration, higher levels of autonomy, mission planning and post mission analysis, and on-water aspects. "For C2 we are in the process of integrating a communications solution used by the Royal Australian Navy for communications between the CMS and the Bonefish USV control station," Mr. Rogers said. "For higher levels of autonomy we are working in collaboration with universities on a number of areas related to collision regulations, specifically machine vision and multi-sensor data fusion. With regard to mission planning and post mission analysis, the second iteration of tools are now under development with a specific emphasis on MCM, ASW and health monitoring." For the on-water aspects the team is in the process of designing a series of modules for RHIBs that allow them to be rapidly reconfigured for manned or unmanned operations, as well as for missions such as surveillance, anti-submarine warfare, and mine countermeasures.

Mr. Rogers said that civilian interest in the technology is growing, but that this is in the early stages of discussion. The team has also started to consider spectrum allocation as it applies to USVs in the future, in the continuation of involvement in the regulatory issues associated with such vehicles.
Mine Countermeasures

Interest in the MCM mission for autonomous systems is keeping this corner of the market busy, with a number of recent developments. In September 2015 ASV, based in southern England, announced that it would work as part of the Thales-BAE Systems consortium offering an unmanned MCM system to meet the UK/French Maritime MCM (MMCM) requirement. The programme aims to demonstrate the maturity of industry-developed autonomous unmanned systems capable of providing an MCM solution, with two identical systems to be built that will be evaluated against a number of predefined operational scenarios.

The programme is being undertaken in a number of phases. With an initial de-risking study already undertaken, detailed design work has now begun and will run until the end of 2016. This will comprise a design study prior to construction, and will involve working with the end user/s to “define the requirement and place consideration on other external factors”. This will be followed by system manufacture and demonstrations under stages two and three. ASV will supply a USV capability for the Thales-BAE consortium developed from its Halcyon design, evolved to offer greater efficiency, stability and an increased payload capability. The autonomous capabilities of the Halcyon USV were demonstrated to the UK MoD in September 2014.

ASV has also been working with BAE Systems to apply unmanned technologies to RHIBs to allow them to carry out tasks including high speed reconnaissance and remote surveillance. The team conducted a successful demonstration of a boat modified with unmanned technologies in October 2015. According to ASV, the boat is capable of operating autonomously for up to twelve hours at a time on either a pre-planned route or via remote control. It can reach speeds in excess of 38 knots (70km/h), providing unique ship-launched manoeuvrability and enhanced situational awareness to support the decision-making of its operators. The vessel's autonomous capability comprises an array of sensors, including navigation radar, a 360-degree panoramic infrared camera array and laser range finder along with software algorithms, which offer operators a detailed picture within a significant range of the vessel. The next stage of the project will see the sensor suite integrated with the combat management system of the parent vessel.

AUVs

Staying in the UK, Sonardyne International bagged a new contract in January 2016, with an order from the Danish Defence Acquisition and Logistics Organisation (DALO) for its Solstice side-scan sonar. The sonar has been procured to be fitted on the Danish Navy’s Saab Seeye Double Eagle SAROV (Semi-Autonomous Remotely Operated Vehicle) to support MCM activities. A company spokesperson told Armada that the order encompassed one system to fit one ROV. Delivery has already taken place and the system is now being used. The sonar is a low-power, compact side-scan sonar that uses full dynamic focus and multi-ping integration techniques to gather high fidelity imagery of the sea floor beneath it, fully corrected for vehicle motion.
Saab Seaeye's Double Eagle SAROV enables autonomous mine reconnaissance missions to be conducted over vast areas. With the addition the Solstice sonar the Royal Danish Navy will be able to view high definition side-scan imagery and bathymetry in real-time without the need for time-consuming, post-mission data analysis. If a contact is identified in the sea bed, the vehicle is able to deliver a disposal charge before moving away to a safe distance to allow the mine to be destroyed.

With these projects underway and requirements continuing to emerge from military forces, 2016 is set to be another exciting year in the unmanned vehicles world. Areas of interest are likely to include increased work in manned-unmanned teaming in the air, land and sea domains, and the ongoing integration of unmanned technologies in national airspace and waterways. With governments continuing to tinker with technologies approaching unmanned combat capabilities, this is set to be another interesting development to keep an eye on.

By Claire Apthorp

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