THE TRUSTED SOURCE FOR DEFENCE TECHNOLOGY ANALYSIS

ARMADA INTERNATIONAL

JUNE-JULY 2023. Issue 03.

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CONTENTS

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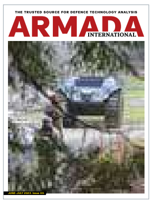

ON THE COVER
Rheinmetall's Mission Master has been trialled in 2023 by the US Marine Corps at Exercise *Talisman Sabre* in Australia and at its combat centre in Twenty-nine Palms, California. Mission Master CXT provides a one tonne payload and can travel to the battle area under its own power at road march speeds of up to 30mph (50km/h). (Rheinmetall)

THE TRUSTED SOURCE FOR DEFENCE TECHNOLOGY ANALYSIS

ARMADA INTERNATIONAL

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Editorial

UKRAINE WAR PROVING KALEIDESCOPE OF UNMANNED POSSIBILITIES

The Russian invasion of Ukraine has demonstrated the largest, continuous and most varied use of unmanned systems in a conflict to date. Recorded examples in the first hours and days show Ukrainian civilians using their own off-the-shelf drones to monitor the initial Russian advances and pass near real-time information back to their own forces thereby demonstrating the utility of even the smallest systems.

Ukrainian forces have been increasingly shown to be widely adept at adapting similar systems to carry and release on command grenades and small bombs onto Russian trench lines and vehicles.

Bigger systems are now commonly used by both sides. Russia's use of Iranian-made Shahed 'suicide' unmanned aerial vehicles (UAVs) to carry out indiscriminate air attacks, which have frequently targeted civilian infrastructure with subsequent loss of life, have only been countered by limited drone strikes which have at best reached Moscow's suburbs and caused little damage.

Ukrainian unmanned surface vessels (USVs) have also been deployed against Russian naval targets, although their success is unclear.

To date there has been little, if any, comment or evidence of the use of unmanned ground vehicles (UGVs). As an article in this issue reveals, international industry is investing in the development of UGVs, and initial trials are being conducted to identify their best use, whether as close support to the infantry (as our cover suggests), or whether mounted with a remote weapons system to offer a level of kinetic support on the battlefield.

The use of unmanned systems is not new, exampled by the Germans use in World War Two of more simple remote control small Goliath tracked vehicles that were packed with explosives and would be driven towards allied lines. However these met with mixed success and were not easy to keep on course, particularly on uneven or difficult terrain.

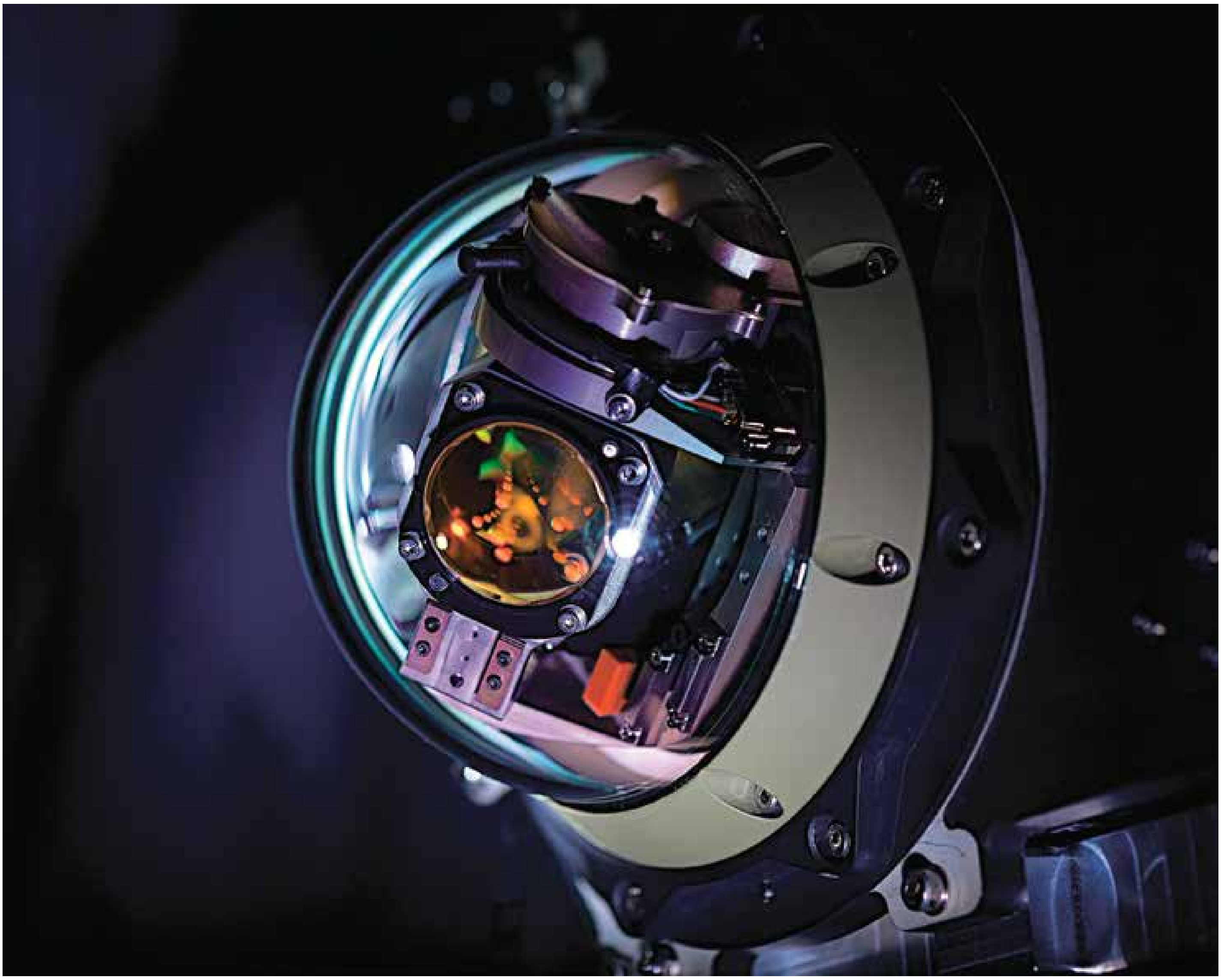
Today however, the technology available through chip-powered digital control, as well as complex sensors, communications and weapons is giving birth to a rapidly increasing variety of unmanned systems that can be deployed in the air, on land, and on or under the sea.

Norwegian company Nammo is beginning to demonstrate the ability of arming a UAV with a pair of M72 anti-armour weapons allowing the weapon's 300m kill range to be extended to that of the UAV. Tests have taken place with the tubes canted downward so that the weapons can target the thinner upper armour of tanks.

At the peak of this UAV revolution is the 'loyal wingman' concept, where unmanned combat aviation assets (initially called UCAVS) will accompany manned platforms to provide a much increased capability package to any planned mission. One manned aircraft is likely to be escorted by one, two or more 'wingmen" that can offer everything from electronic warfare, to communications rely and a much wider range of weapons divided between units in the package.

ANDREW DRWIEGA,
Editor-in-Chief

INDEX TO ADVERTISERS



The French Navy uses LEU for its nuclear-propelled submarines, including the Suffren class submarines

SILENT RUNNING

The increased popularity among navies to own their own submarine fleets are driving new advances in submarine propulsion.

Alix Valenti

If the SEA 1000 submarine programme in Australia has taught the world anything it is that deciding how to power one's submarine fleet is no easy endeavour. Beyond the complexity of what technical and geopolitical compromises may look like in an increasingly tense regional environment, the SEA1000 programme crystallised the many conundrums of submarine propulsion: how to reach the right balance between range, speed and signature.

"Fundamentally, the platform with the greatest range and speed, the best indiscretion ratio and the lowest signature is going to be at an advantage in virtually all environments," Ben Salter, Naval business director at GE Power Conversion, told *Armada International (AI)*. Yet achieving this delicate balancing act is essentially subject to the limitations imposed by today's technologies. "The compromise comes in what a nation is prepared to invest in order to achieve its view of the minimum required capability," Salter continued.

Whether one looks at various types of Air Independent Propulsion (AIP) or nuclear

power, it eventually all comes down to a navy's operational profile and area, as well as to the threats it is likely to encounter.

OPERATIONAL CONUNDRUMS

In their book, *Winning at Sea in the 21st Century. Tactics in the Fifth Age of Naval Combat* (Vaincre one mer au XXIe siècle - La tactique au cinquième âge du combat naval)), Thibault Lavernhe and François-Olivier Corman refer to the underwater domain as an environment that facilitates hiding owing to its inherent opacity. "Opacity to sight as well as electromagnetic waves, and, to a certain extent, opacity to acoustic waves, whose propagation is particularly complex," they write. The consequences of this opacity are uncertainty, surprise and ubiquity.

The key role of a submarine, as main actor in the underwater domain, is therefore to take full advantage of what opacity can offer at tactical and strategic level.

"In such context, the big word in the submarine world is 'signature'," Ian Duncan, principal engineer at BMT, told *AI*. Magnetic signature, of course, but also and most importantly any type of signature created by a submarine's propulsion system: the noise of a diesel engine, the Infra-Red (IR) signature created by the heat of an exhaust, or the electric fields created by the submarine's propeller.

One key solution to some of these issues is the ability to stay submerged and away from the surface as long as possible. If a submarine is below the surface it will be impossible for a radar to pick-up its mast or periscope's Radar Cross Section (RCS), for an IR system to detect its heat signature or for a Magnetic Anomaly Detector (MAD) to perceive its presence just below the surface.

Yet two key challenges remain that have been driving most of the research in the submarine propulsion domain over the last decades: the ability to stay submerged as long as possible, that is, how to store enough energy onboard; and, noise reduction. The latter is particularly relevant as threats continue to evolve. "The threat environment is increasing, not only with continued improvement in conventional sensors, such as towed arrays, sonobuoys, etc, but also with the increasing deployment of USVs [Unmanned Surface Vehicles] and UUVs [Unmanned Underwater Vehicles], deployed from both surface and submarine platforms," Salter explained. Additionally, emerging technologies, such as Artificial Intelligence (AI) and quantum computing, are poised to become critical enablers for underwater sensors, "increasing the challenges faced by submarine fleets," Salter added.

To address these challenges, today, submarine technology offers two different types of propulsion systems: conventional – standard diesel electric and Air Independent Propulsion (AIP) – or nuclear. "Choosing between these two systems is effectively a matter of mobility," according to a Naval Group submarine propulsion expert.

The Swedish Navy's future A26 submarines (Blekinge class) will feature the new type of Stirling AIP propulsion.

STRATEGIC MOBILITY - GOING NUCLEAR

"Nuclear submarines facilitate strategic mobility," the Naval Group expert explained. "They allow navies to move from one theatre of operations to another in less time thanks to a higher speed of advance (without restrictions) and without fuel limitations." In other words, the only limiting factor to a nuclear-powered submarine's permanence at sea is humans' ability to stay submerged for months at a time.

The US Environmental Protection Agency (EPA) explains nuclear propulsion as follows: atoms in a nuclear reactor split to release heat that is subsequently used to create high-pressure steam; the steam then turns propulsion turbines that provide the power to turn the propeller. Once the steam cools, it condenses back into water, which is fed back into the system to start the process again.

There are numerous advantages to nuclear-powered submarines. Firstly, nuclear propulsion is power dense, efficiently delivering the required levels of energy without taking up too much 'real estate' space onboard submarines. Secondly, nuclear propulsion delivers endurance, albeit with some caveats depending on the levels of uranium enrichment used for the reactor.

The US Navy (USN) and the UK Royal Navy (RN), with whom the USN shared the technology, run on Highly Enriched

thyssenkrupp Marine Systems has been working on the development of its own Li-ion batteries, which were on display at UDT 2023

Uranium (HEU) for instance (> 20 percent U-235). According to the World Nuclear Association (WNA), this type of propulsion features a long core life. Depending on operational needs, such as number of weapons and sensors onboard, the core life of a nuclear reactor using HEU can last between 20 and 35 years. For certain submarines this means running on the same nuclear core throughout their entire lifecycle.

Other nations have chosen to use HEU, such as Russia and India.

French submarines, on the other hand, are powered through Low-Enriched Uranium (LEU). According to a special report written by Alain Tournyol du Clos and published by the Federation of American Scientists in December 2016, "France's Choice for Naval Nuclear Propulsion – Why Low Enriched Uranium Was Chosen," this choice was mostly a consequence of financial convenience. When the Navy chose, in the 1970s, to use nuclear reactors to power its submarines, the civil energy domain had already made significant advances on nuclear power, which uses LEU. France's Ministry of Defence simply decided to leverage those advances.

The 'Tournyol du Clos' special report found that the only real difference between the use of LEU and HEU for the nuclear core is the lifetime permitted by the core. Typically, a French nuclear-powered submarine will have to change core approximately every 10 years. Beyond that, the report concludes, "choosing between LEU and HEU [...] does not influence the immediate performance of the submarine".

According to the WNA, China is believed to use LEU fuel, "at least in earlier reactors."

Nuclear-powered submarines are particularly sought after by nations seeking to project power across the globe. The fact that they do not need to snort – that is, come at periscope depth to take oxygen in – means that they can travel long distances while remaining undetected. This is what the Naval Group expert referred to as 'strategic mobility', and it is what motivated Australia's move to cancel its original choice of AIP technology with Naval Group.

But such a technology choice, as Salter told *AI*, "is highly restricted and extremely costly."

This is the challenge faced by nations like Australia who, until very recently, was strictly opposed to nuclear power and therefore lacks critical support infrastructure. By going down the nuclear route, Australia will be heavily reliant, at least in the first decades of the programme and submarine operations, on its US and UK partners. The two AUKUS partner nations will be responsible for training Royal Australian Navy (RAN) personnel, while Australia will also have to invest significantly in the development of nuclear-related skills – from high school education all the way to engineering degrees and... legislation. Additionally, Australia will also have to rely on the UK for the management of its nuclear waste, which carries additional transport and management costs.

TACTICAL MOBILITY – AIP

"Conventional submarines facilitate tactical mobility," according to Naval Group's expert. These submarines rely on AIP systems that typically feature a combination of diesel generators, batteries and either a fuel cell technology or a Stirling engine to power the battery and the gearbox – or, increasingly, the electric drive.

AIP systems do not require submarines to resurface to recharge the battery. In that sense, they afford as much discretion as nuclear propulsion, which is also, effectively, air independent. In contrast, however, AIP systems' autonomy is much more limited, generally between two to three weeks. "This is mainly due to the limited space available onboard to store the resources necessary to create energy," explained Duncan. As such, Stirling engine propulsion will be limited by the amount of oxygen and diesel that can be carried onboard, whereas fuel cell technology will be limited by available oxygen and hydrogen.

Nevertheless, over the past few years, companies like Saab and thyssenkrupp Marine Systems have taken important steps in the development of, respectively, Stirling engine propulsion and fuel cell technology.

"At Saab we have focused on oxygen efficiency, which is stored in liquid form in our submarines and which influences the overall size of the submarine," Mats Abrahamsson, head of Submarine Design at Saab's business area Kockums, told *AI*. In this sense, as it has done for its diesel-electric submarines (SSK), Saab has developed the concept of modular engines: one small, encapsulated module contains the Stirling engine and related auxiliary systems.

"This Stirling module has the approximate size of two washing machines side by side," Abrahamsson explained. "The modular design removes the need to have a dedicated machinery space on the platform." According to their operational needs, navies can choose if they wish to use two, three or more modules, increasing power autonomy. This technology is very stealthy and has been successfully proven on both the Södermanland and Gotland classes of submarines and will feature on the A26. "The A26 will carry three of the newest, and very compact modules. The A26 Stirling system will provide about three weeks of air independence, depending on factors such as water temperature, speed, systems running," said Abrahamsson.

The use of modules also presents two additional benefits. First, it facilitates the containment of noise and fire, making the submarine quieter and safer. Second, it has a lower logistical footprint. "All you need to refuel a Stirling system is the same standard diesel fuel as for the main diesels and a truck with liquid oxygen, which only takes a few hours and increases operational availability," Abrahamsson concluded. This is in contrast with some other AIP systems that have a more complicated and lengthy refuelling process.

FUEL CELLS

Advances are also being made on fuel cell technologies. At UDT2023, AI talked with Peter Hauschildt, head of Research and Technology at thyssenkrupp Marine Systems, who presented the company's latest advancements in fuel cell technology. The new system is based on modular technology, with fuel cell stacks easily replaceable by a small team of three or four crew that can remove the old stack to replace it with the new in just a few hours. "These new fuel cell stacks are produced by thyssenkrupp Marine Systems, are more easily available and can also be carried onboard to increase operational availability," Hauschildt commented.

Less oxygen hungry than other AIP technologies, therefore requiring a smaller oxygen tank, fuel cell technology has a low footprint on a submarine. The new generation fuel cell batteries will be integrated into the German Navy's Type 212CD submarine.

"If you are doing defence of the homeland and EEZ [Exclusive Economic Zone] protection, AIP submarines are very capable platforms that save you the expense and political difficulty of nuclear power," stated Duncan. This type of propulsion is ideal, for example, for navies that operate primarily in coastal areas.

LITHIUM-ION HYPE?

"Lead-acid based energy store coupled to an inverter-fed permanent magnet motor is the state of the art today, [...] however the chemistry of battery energy stores is a rapidly evolving area at the moment," Salter commented. In fact, several nations are looking into the development and fielding of lithium-ion (Li-ion) batteries to replace Lead Acid Batteries (LAB).

"Li-ion technology offers greater capacity thanks to a higher onboard energy density, which promises to increase in the future with the introduction of solid-state batteries," Naval Group's expert commented. Additionally, Li-ion batteries can be charged while at sea, reaching 98 percent State of Charge (SoC) by phase two of the charging process. Although LAB batteries can also be recharged at sea, they produce hydrogen gas thus requiring additional mitigations and requiring battery routines in maintenance periods to achieve 100 percent. Finally, regardless of whether they are fully charged or not, Li-ion batteries release a constant flow of energy thereby offering greater tactical mobility.

Currently, only one submarine fleet in the world is operating with Li-ion batteries, Japan's Soryu class. However, South Korea's Defence Acquisition Programme Administration (DAPA) announced in January 2022 that the ROKN's Batch-II submarines would also feature Li-ion batteries.

Over in Europe, a number of shipbuilders are also looking at the technology. Naval Group started the development of its solution in 2006 to achieve system qualification in 2020, putting particular emphasis on safety, as Li-ion batteries can have safety issues with high fault currents leading to

Navantia is currently testing a new type of AIP propulsion featuring a reformer and bioethanol, which could feature on the Spanish Navy's future S-80 submarines

thermal runaway. "We focused on selecting a chemistry that offered the right balance between energy density and safety," according to the expert. This includes a battery monitoring system that will supervise the behaviour of each element, providing the operator with the necessary parameters for operation and maintenance. It also features a series of non-propagation tests and electrical protection systems that would ensure that, even in the event of incidents, these would not have an effect on the battery as a whole.

Thyssenkrupp Marine Systems is also working on the development of Li-ion batteries in partnership with Saft, a French company. During UDT2023, Hauschildt told *AI* that he company is offering the technology to the Germany Navy for its future 212CD submarines.

Finally, Abrahamsson added that Saab is also running a research and development (R&D) programme on battery technologies, including Li-ion.

POWER OF THE FUTURE

"The implications of [increasing threat environments] is that there will be an increasing emphasis on signature management in all platforms, with even lower signature power systems and motor technology, and on features to improve indiscretion ratios in conventional platforms, such as the adoption of higher energy density batteries," Salter said. Several ongoing R&D programmes focusing on different parts of submarine propulsion, and mostly drawing from the civil domain, confirm this trend.

At engine level, for instance, Saab has made improvements to its SSKs by moving away from traditional genset set-ups to develop a modernised diesel genset of approximately 500kW with permanent magnet generators. These new engines, like the Stirling engine, are now produced into compact fire and noise proof modules that can be installed on the platform according to mission requirements. "You are effectively sizing your energy generation system," Abrahamsson explained. A Navy can choose the number of modules they need for the dimensional operational profile, and the modules can also be installed next to the Stirling modules without need for a specific machinery space.

Concerning AIP systems, Navantia is currently running trials for a new type of propulsion called BEST (Bio-Ethanol Stealth Technology). This third generation AIP system consists of a bioethanol reformer that produces the hydrogen, which subsequently reacts with oxygen in the fuel cell to produce electricity. According to the company's website, this system enables the vessel to operate independently under water for up to three weeks. "The main advantage of bioethanol is that it is a liquid that is easy to manage and carry, and that can also be used to run the diesel engine, meaning you would only carry one type of fuel on the submarine," Duncan commented. "The system is not yet in service, however if it proves reliable, this new technology could be a game changer for AIP," Duncan concluded.

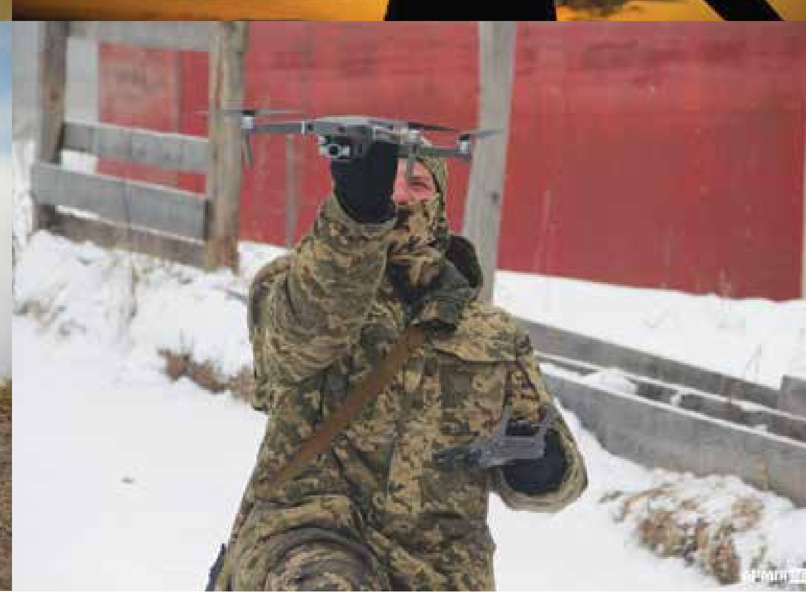
Finally, concerning batteries, although Li-ion is currently the most advanced technology being applied to submarine propulsion, all interviewees noted that chemistries are constantly evolving and research for additional alternatives is ongoing. Hauschildt, for instance, said that thyssenkrupp Marine Systems is also keeping an eye on developments relating to solid state batteries, "which would be far more flexible as the diesel generator would charge the battery and there would no longer be a need for hydrogen and oxygen."

"We constantly have to adapt to new threats and the increasing performance of new threats," Abrahamsson concluded. "These are interesting times because there is so much happening in the civilian world that could be applied to submarine propulsion, and there are no doubts that there will be more than one way, moving forward, to continue increasing power density, reducing footprint and increasing autonomy." A

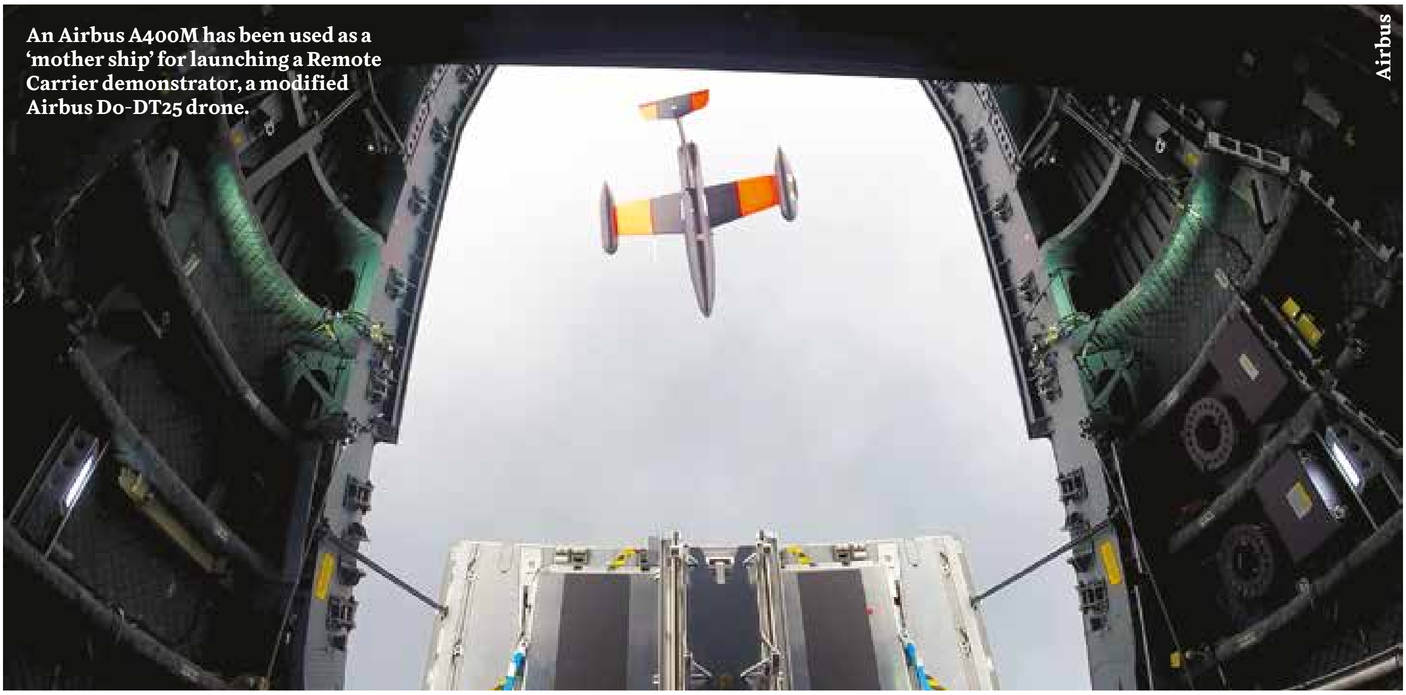
UNMANNED SYSTEMS SPECIAL 2023





ARMADA INTERNATIONAL : THE TRUSTED SOURCE FOR DEFENCE TECHNOLOGY ANALYSIS



An Airbus A400M has been used as a 'mother ship' for launching a Remote Carrier demonstrator, a modified Airbus Do-DT25 drone.

ABOVE AND BEYOND THE TRENCHES

While small UAVs are proving their value on the battlefield in Ukraine for ISR and attack, there is an ongoing drive for larger, longer range UAS and 'loyal wingmen'.

David Oliver

The current focus on unmanned aerial vehicles (UAVs) is being underscored by the ongoing conflict between Russia and Ukraine. This has triggered significant purchases of unmanned systems by European NATO member nations including Poland and Romania.

The Teal Group estimates that worldwide military unmanned aerial system (UAS) production will exceed $162.2 billion over the next decade and it will grow rapidly from $12.1 billion in 2023 to $16.4 billion in 2032. In addition, research and development (R&D) will total $72.5 billion over the period, with more than 60 percent of that coming from the United States.

The global military UAV market remains dominated by the United States and Israel but they are being seriously challenged by China, and even more so by Turkey.

The US will account for 71.9 percent of the unclassified R&D spending on UAV technology over the next decade, and about 34 percent of the unclassified procurement through the forecast decade. By including Teal Group estimates of 'black' programmes the US accounts for 81.3 percent of world R&D on UAVs and 39.3 percent of the procurement.

The market is being driven by costly high-altitude, long-endurance (HALE) systems, low-cost Chinese exports, demand for armed UAVs, the development of the next generation of unmanned combat systems, and potential new applications such as missile defence. Over the ten-year period, Teal Group estimates that Medium-Altitude Long-Endurance (MALE) UAVs will be the largest production type measured by value. Unmanned Combat Aerial Vehicles (UCAVs) will surpass MALE systems in annual production value in the middle of the forecast period.

It is clear that UAVs are already being used on the frontline of military operations, varying in size and scale, but each playing a vital operational role, from tiny handheld surveillance drones (some modified to drop grenades or small bombs) to large-scale remotely controlled UAVs with large payload capacity. Looking forward, the next key phase in UAV development will be autonomously operated air vehicles such as the Boeing Loyal Wingman project aircraft, the MQ-28A Ghost Bat, capable of both flying alongside manned aircraft for support and performing autonomous missions independently using artificial intelligence (AI).

This concept has recently been highlighted by the United States Air Force (USAF) Secretary Frank Kendall

Airbus

After the release, the Do-DT25's engines were started and it continued in powered flight mode controlled by an operator on the ground.

who announced in March 2023 an overhaul of USAF modernisation into an "operational imperative" (OI) model, outlining several mission areas that need investment. The most notable is the creation of the Collaborative Combat Aircraft (CCA) programme, creating up to 1,000 autonomous UAVs that can work as unmanned 'loyal wingman' systems that will fly alongside the Next Generation Air Dominance (NGAD) platform to provide additional sensing, electronic warfare and weapons. For this, the USAF is requesting two new funded projects: $68 million to begin Project Viper Experimentation and Next-Gen Operations Model (VENOM), and $72 million for an Experimental Operations Unit (EOU), along with $394 million for autonomous platform development.

PROJECT VENOM

The aim of Project VENOM will be to help work autonomy into more routine testing as well as refine what is expected of the aircraft developed under the CCA programme. The initiative will outfit six Lockheed Martin F-16s from with autonomy agents that a human pilot will experiment with in flight. The aim of the project will allow the USAF to assess how it can best bridge autonomous and crewed formations while building trust in the autonomy.

These unmanned systems could carry out a variety of missions, including striking targets, intelligence, surveillance and reconnaissance (ISR), or electronic warfare (EW). The USAF envisions that they will be less expensive than manned aircraft, and in some cases being cheap enough that the service could afford to lose them in combat.

Kendall stressed that adopting 'loyal wingmen' will not mean the USAF will have fewer manned fighter aircraft in its inventory. Instead, he said, CCAs can be thought of as remotely controlled versions of the targeting or EW pods or weapons that manned aircraft now carry.

However, it has the be recognised that for many years, the USAF has struggled with a modest training budget to teach fighter pilots to battle large numbers of advanced aircraft. Now the service is seeing whether the answer could lie in the previously untapped potential of UAVs.

In 2022 the USAF awarded North Carolina-based Blue Force Technologies (BFT) an initial $9 million contract to develop unmanned air vehicles optimised for adversary air missions.

The effort, which Air Force Research Laboratory (AFRL) dubbed the Bandit programme, called for BFT to mature its UAV design known as Fury over the next 12 months, culminating in a critical design review and ground testing of the aircraft's engine. If successful, the company could win additional contract options to build and flight test up to four drones. The goal is "to develop an unmanned platform that looks like a fifth-generation adversary with similar vehicle capabilities," said Alyson Turri, who manages the Bandit programme.

In January 2023, BFT conducted a ground test for Fury performed in collaboration with AFRL, which successfully validated the performance of Fury's novel carbon fibre composite propulsion flow-path system. BFT president Scott Bledsoe said: "On an unmanned fighter like Fury, proper integration of propulsion flow-path is the most significant design driver for overall vehicle.

"It was crucial to us to demonstrate, prior to building flight-test aircraft, that we could correctly predict interaction between propulsion flow-path components and Williams International engine."

The test saw the BFT and AFRL team carry out a time-accurate 'computational fluid dynamics (CFD) analysis', using comprehensive computational resources from the US Army Engineer Research and Development Centre and AFRL. Alyson Turri said: "After making engine selection in June 2022, the AFRL and BFT team worked to finalise test objectives and procedures concurrently with BFT's hardware build to ensure this full-scale test came together in under six months."

These widened deployment options are completely in line with the US Air Force Agile Combat Employment (ACE) initiative that ultimately aims to "reduce the


AFRL

Blue Force Technologies has Air Force Research Laboratory contract to develop an unmanned fifth-generation adversary platform, the Fury.


RAAF

The MQ-28A Ghost Bat is being developed by Boeing Australia as a 'Loyal Wingman' for the Royal Australian Air Force.

number of airmen in harm's way in austere environments.

JUST DROPPING IN

Europe has also been looking to the future of advanced UAV capabilities and operations. In February 2023 Germany's Bundeswehr and Airbus jointly carried out the world's first successful launch and operation of a Remote Carrier (RC) flight test demonstrator from a flying Airbus A400M which was developed in just six months.

For the test flight, the UAV was loaded onto the ramp of a Bundeswehr A400M, from which the RC demonstrator, a modified Airbus Do-DT25 drone, was launched. After the release, the Do-DT25's engines were started and it continued in powered flight mode. The crew on board the A400M then handed over control to an operator on the ground, who safely commanded and landed the drone.

Remote Carriers will be an important component of European Future Combat Air System (FCAS) which will consist of a Next-Generation Weapon System (NGWS) as well as other air assets in the future operational battlespace. They will fly in close co-operation with manned aircraft as 'Loyal Wingmen' and support pilots in their tasks and missions. Military transport aircraft such as the A400M will play a role as mothership, to bring the RCs as close as possible to their areas of operation before releasing up to 50 small, or up to 12 heavy Remote Carriers. These will then join manned aircraft, operating with a high degree of automation although always under a pilot's control.

As the use of UAVs grows, so does the need for the capability of conducting safe landings under emergency or contingency conditions. The European Defence Agency (EDA) is funding a project developed by two European companies, GMV Innovating Solutions and Aertec Solutions, to investigate ways to autonomously crash-land an Remotely Piloted Aircraft (RPA) in emergency situations, where the command-and-control data link is lost, avoiding the risk of the RPA falling on urban or populated areas

The Safe Autonomous Flight Termination (SAFETERM) system seeks to allow Medium Altitude Long Endurance (MALE) drones and large tactical RPAs to harness Artificial Intelligence (AI) to develop this capability. The EDA project, which was completed and demonstrated in June 2022, aims to help further develop the technology for automatic recognition and autonomous decision-making of safe areas to land or crash-land. Standardisation and certification of such technology will be central to its wider use.

The safety aspect of operating UAVs is also being addressed. Currently, safe flight terminations by UAVs are based on pre-programmed procedures, so that if the link with command and control is lost, they can automatically follow a contingency flight plan and proceed to a designated landing area.

In the event of the UAV having an additional failure, the EDA has developed SAFETERM's hardware and software suite to identify features on the ground, using its onboard visible and infrared camera sensors. The system's machine-learning algorithms can assess the data collected by the sensors, detect and classify the ground area around the UAV and assess the most suitable areas for an automatic controlled emergency landing. It's basically pattern recognition, and so colour-coded areas can be safe or unsafe for landing. Areas in blue or green that are relatively safe and areas in red or orange are to be avoided, all of which is done autonomously by the UAV.

For the trials, the consortium used a TARSIS 75 fixed-wing UAV, manufactured by Aertec. The EDA project culminated with a real in-flight demonstration of the autonomous capability, delivering a hardware and software package with a Technology Readiness Level (TRL), a measurement system used to assess the maturity level of a particular technology of five to six which meant that it needed further testing in different environments to ensure that the hardware and software is fool-proof.

The inexorable growth of UAVs in defence means the sustainment of these military assets is also firmly under the spotlight, especially given their increasing complexity and operational importance. The support issues include lifecycle sustainment, repair and maintenance, training and obsolescence management, all of which will require next-generation software for planned, and unplanned scenarios using advanced analytics and forecasting. A


Airbus

Remote Carriers will be a component of European Future Combat Air System (FCAS) flying with manned aircraft as 'Loyal Wingmen'

BLUE WHALE - A TRUE SUBMARINE FORCE MULTIPLIER

Fueled by high acquisition costs and ongoing budgetary constraints, naval commanders around the world search for solutions to the universal dilemma – the dearth of sufficient submarines to achieve all mission objectives. "Blue Whale", a "first of its kind" system with onboard capabilities beyond anything seen before on an unmanned underwater asset, addresses this issue by performing an important share of the required submarine workload at low cost, and without putting naval crewman at direct risk.

Developed by the innovative systems & sensors subsidiary of Israel Aerospace Industries, ELTA Systems Ltd., BlueWhale marries a stealthy, high performance unmanned underwater platform together with the company's mastery of integrated systems, including radar, SIGINT, and communications, to achieve a breakthrough in subsurface warfare.

With its advanced sensors suite and powerful onboard processing, Blue Whale supports conventional manned submarine fleets by performing the following missions:

- Intelligence, Surveillance and Reconnaissance (ISR), including covert coastal operations
- Anti-Submarine Warfare (ASW) – hunting submarines in their own domain
- Acoustic Intelligence (ACINT)
- Covert mine detection and other Mine Counter Measures (MCM)
- Special forces support, including scout and mule
- Forward scout and patrol for conventional submarines (underwater "loyal wingman")
- Piracy, terrorism and illegal immigration detection
- Oceanology expeditionary support

ELTA's underwater systems team lead, Col. (Ret.) EE. an experienced naval officer with over twenty-five years at sea in command positions, explains that " Blue Whale's low cost and proven mission capabilities add a new dimension to subsurface warfare. An array of Intelligence, Surveillance, Reconnaissance and other capabilities make it the first UUV to complement larger manned platforms. The system offers unprecedented capabilities. For example, cooperation with ATLAS ELEKTRONIK in the integration of their superb Towed Array Sonar brings submarine hunting to depths traditionally considered detection free zones."

Blue Whale features a patented surface payloads mast that can be configured for a wide range of mission profiles using an array of available sensors and systems, including SATCOM, which facilitates real-time exchange data exchange.

Surface payload options include:

- Radar
- Day/Night EO/IR
- COMINT/ELINT/ESM

Sub-surface sensor options include:

- Towed Array Sonar (TAS) developed by ATLAS ELEKTRONIK
- Active and passive Flank Array Sonar (FAS) for the detection of surface vessels and submarines
- Synthetic Aperture Sonar (SAS) for mine detection and high-resolution sea bottom mapping
- Magnetic sensors for mine detection and verification

Blue Whale is operated and managed via a highly developed Command & Control (C2) system, which facilitates a continuous Situation Awareness Picture, Call-to-Action commands, events blogger, remote operation and more.

ELTA's extensive, operationally proven systems portfolio encompasses multi-mission aircraft, manned and unmanned ground vehicles, UUVs, integrated EW (ESM/ECM), Radar, SAR/GMTI, EO/IR, IMINT, Launch Detection Systems (LDS), and cyber. This diverse expertise is a key factor in the ability to deliver "Blue Whale" – a revolutionary, high end strategic solution that expands the capabilities of your submarine force.

ADCOM

United 40

Span: 17.53m
Maximum take-off weight: 1,000kg
Speed: 108kt
Endurance: 25h
Ceiling: 26,000ft
Payload: 100kg. Retractable EO/ir sensor
Powerplant: Twin hybrid turbine-electric engines
Launch/recovery: conv/conv
Remarks: UAE manufactured MALE sold to Algeria.

AERONAUTICS

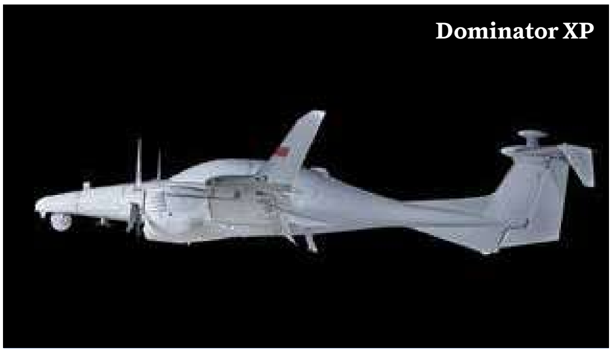
Orbiter 4 VTOL

Length: Wingspan 5.2 m | Length: 1.2 m
Maximum take-off weight: 55kg
Speed: 70kts
Altitude: 18,000 ft.
Powerplant: Spark ignition multi-fuel engine and electric engines
Payload capacity: up to 12 kg
Launch / Recovery: VTOL kit / catapult, parachute and airbag
Remarks: Combat-proven, Orbiter 4 VTOL, offers excellent multi-mission performance for a variety of ISTAR missions. Incorporating Group 4 ISR capabilities within runway-independent Group 2 logistic footprint. the Orbiter 4 is a long-range Tactical UAS that can carry multiple payloads, with VTOL configuration, and offers long endurance and full redundancy

Orbiter 2 Mini UAS

Length: Wingspan 3 m |Length: 0.9 m
Maximum take-off weight: 13 kg
Speed: 50kts
Altitude: 18,000 ft.
Powerplant: Electric engine
Payload capacity: up to 1.8 kg
Launch / Recovery: catapult, parachute and airbag
Remarks: Orbiter 2 Mini UAS: Combat-proven, fixed-wing, electric system with Group 2 ISR capabilities for defense, maritime, and HLS. Offers superior performance, unmatched mission versatility, and operational flexibility in challenging weather conditions with a small logistics footprint
Maximum Endurance up to 3 hrs. Datalink LOS up to 50 km

Dominator XP



Length: 8.6m
Span: 13.5m
Maximum take-off weight: 1,910kg
Range: LOS 300km, BLOS satcom unlimited
Speed: 150kts
Endurance: > 20hrs
Altitude: > 18,000ft
Payload capacity: 373kg. Options include EO/IR and hyper-spectral sensors with laser pointer and designator, maritime radar, SAR\GMTI radars, communications relays, COMINT, ELINT, MAD etc.
Powerplant: 2 x 170hp Austro AE300 jet fuel piston engines
Launch/Recovery: conv/conv
Remarks: Operators include Mexico & Turkey. Operational in GPS-denied environments.

AEROVIRONMENT

Puma™ 3 AE

Length: 1.4 m Span: 2.8 m
Maximum take-off weight: 7 kg
Range: 20 km or 60 km with long range comms antenna
Speed: 26 – 41 kts
Endurance: 2.5 hr with an LE battery
Altitude: 300 – 500 ft AGL
Payload capacity: > 0.85 kg Mantis i45 Gimbaled payload with dual 15 MP EO cameras, 50x Zoom, IR camera and low light camera for night operations, and high-power illuminator
Powerplant: battery electric
Launch/recovery: hand or rail/autonomous or manual deep stall landing
Remarks: Puma 3 AE offers enhancements for land and maritime operations including upgrades for secondary payloads and third-party applications.

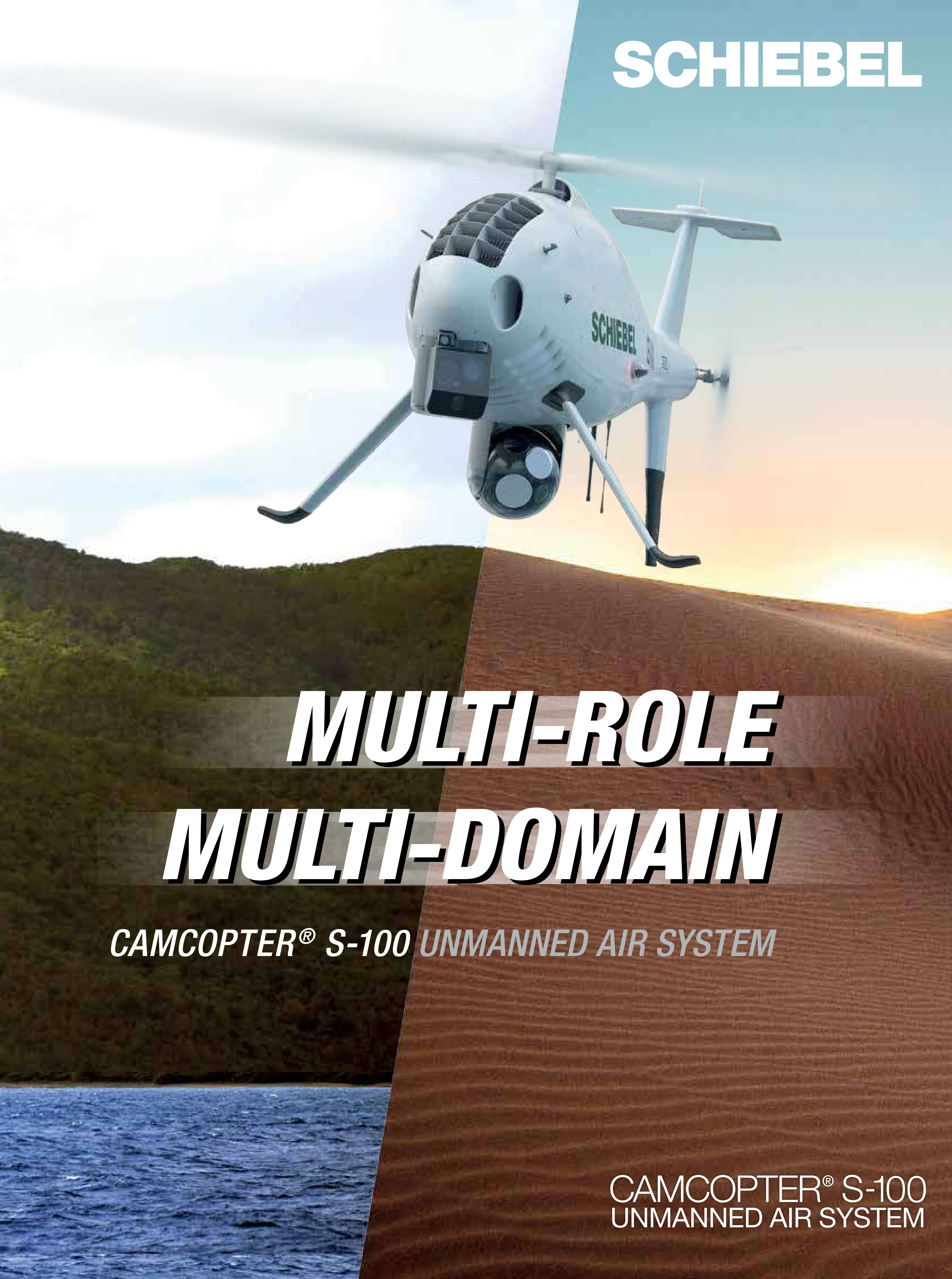
Length: 2.9 m
Span: 5.7 m
Maximum take-off weight: 97.5 kg
Range: 185 km
Speed: 50 kts
Endurance: 14+ hr
Altitude: 17,000 ft DA
Payload capacity: Up to 13.6 kg inc. fuel. Compatible with swappable imaging systems ARCAM-450, TASE 400 LRS, Trillium HD80 and WESCAM MX-8
Powerplant: 1 x 190 cc 4-str engine & 4x electric motors, props for VTOL
Launch/recovery: VTOL, cat launch option
Remarks: Fully integrated payload options – synthetic aperture radar, mapping capabilities, laser designation, anti-jamming, COMINT/SIGINT. The T-20™ is a smaller variant.

Length: 46.2 cm
Span: 73.6 cm
Maximum take-off weight: 1.77 kg
Range: 10 km
Endurance: 20+ min
Speed: 101 – 161 kph
Altitude: < 500 ft AGL, > 15,000 ft MSL
Payloads: Dual front and side look EO cameras and IR nose camera. Stabilized electronic pan-tilt-zoom, Orbital ATK advanced munition warhead.
Powerplant: Electric battery
Launch/recovery: tube/NA Remarks: US Army and USMC are the primary users. Ordered by the UK.

Length: 9.3m
Span: 16.6m
Maximum take-off weight: 1,250kg
Range: 1,000km
Speed: 110kts
Endurance: 12hr at 550nm from base
Altitude: 25,000ft
Payload capacity: 250kg. Synthetic aperture radar with 1 m resolution, Wide-Area Surveillance (WAS) & spot modes, EO/IR turret also with WAS & spot modes, NATO-STANAG-3875-compliant laser designator, panoramic pilot assistance camera.
Powerplant: 115 hp turbocharged Rotax 914 piston engine
Launch/recovery: conv/conv
Remarks: Retired French systems acquired by Royal Moroccan Air Force.

Length: 2.25m
Span: 3.42m
Maximum take-off weight: 161kg
Range: > 140km (on data link)
Speed: 118.8kts
Endurance: 5.5hrs
Altitude: 11,500ft
Payload capacity: 35kg. Thermal imager system (8–12 µm or 3–5 µm), 3 x fixed-focus TV cameras (6 FoV), all 3-axis stabilised. Principal operator is the German Army.
Powerplant: 24kW 2-str engine
Launch/recovery: rato, cat/para
Remarks: Tactical UAS optimised for high speed reconnaissance missions.

Length: 6.2m
Span: 7.2m rotor diameter
Maximum take-off weight: 700kg
Speed: 100kts
Endurance: 8hrs with full tactical payload 80nm from shipAltitude: 19,600ft
Payload capacity: 100kg. Naval-grade EO system, naval tactical radar, AIS, deck finder autoland system.
Powerplant: 155hp diesel and jet fuel engine
Launch/recovery: Automated VTOL
Remarks: Shipborne unmanned helicopter designed to operate alongside other shipborne naval assets.Second prototype ordered in March 2021.



SCHIEBEL

MULTI-ROLE MULTI-DOMAIN

CAMCOPTER® S-100 UNMANNED AIR SYSTEM

CAMCOPTER® S-100
UNMANNED AIR SYSTEM

Length: 6m estimate
Span: > 32m
Maximum take-off weight: 140kg
Range: > 18,500km estimate
Speed: approx 30kts
Endurance: > 45 days
Altitude: > 65,000ft Payload capacity: 20kg. RADAR, LIDAR, ESM/ELINT, Broadband Comms
Powerplant: solar powered electric motors
Launch/recovery: conv/conv
Remarks: Larger variant of Zephyr with greater payload & endurance.

Length: 7.3m
Wingspan: 12m
MTOW: 750kg (1,650lb)
Payload: 150kg (330lbs) EO/IR/LD, SAR/GMTI, MPR, ELINT and COMINT
Maximum speed: 110km/hr
Altitude: 21,000ft
Endurance: 20 hours
Powerplant: 1 x Conventionally-fueled engine driving pusher propeller
Remarks: The SIRTAP project is financed by Spain and Colombia. Spain plans to buy 27 SIRTAPs, and Colombia 18.

AVIATION INDUSTRY CORPORATION OF CHINA (AVIC)

Length: 9.05m
Span: 14m
Maximum take-off weight: 1,100kg
Range: 4,000km
Endurance: 20 hrs
Speed: 150kts
Altitude: 16,000ft
Payload capacity: 200kg on pylons, 100kg for sensors. Reportedly capable of launching guided bombs including the FT-10, FT-9, FT-7, GB-7 and GB-4, and the BRM1 and AKD-10 guided missiles. In service with China and export customers inc Saudi Arabia and Egypt.
Powerplant: 1 x 100 hp Rotax 914 turbocharged piston engine, pusher propeller
Launch/recovery: conventional
Remarks: MALE-class armed reconnaissance UAV in service with the armed forces of China, Egypt, Kazhakstan, Saudi Arabia, Serbia, Turkmenistan, and United Arab Emirates

Length: 11m
Span: 20.5m
Maximum take-off weight: 4,200kg
Range: 4,500nm (estimate based on 140kts cruise & endurance)
Endurance: 32hrs
Speed: 200kts max, 81kts minAltitude: 32,500ft
Payload capacity: 480kg on external stores. Reportedly capable of launching guided bombs including the FT-10, FT-9, FT-7, GB-7 and GB-4, and the BRM1, AKD-10 and BA-7 guided missiles.
Powerplant: turbocharged piston engine
Launch/recovery: conventional
Remarks: MALE-class armed reconnaissance UAV in service with the armed forces of China, Egypt, Nigeria, Saudi Arabia, and United Arab Emirates

Length: 9m
Span: 17.8m
Maximum take-off weight: 3,200kg
Range: N/A
Endurance: 6hrs
Speed: 335kt (ISR), 300kt (strike)
Altitude: 49,000ft (ISR), 46,000ft (strike)
Payload capacity: 200kg (ISR), 400kg (strike)
Powerplant: Single WP-11C turbojet engine
Launch/recovery: Conventional
Remarks: MALE-class armed reconnaissance UAV in development for domestic and export customers

Xianglong

Length: 14.3m
Span: 25m
Maximum take-off weight: 10,000-12,000kg (estimate)
Range: 7,000km (estimate)
Endurance: 10hrs (estimate)
Speed: 405kts cruise
Altitude: 59,000ft
Payload Capacity: 650kg (estimate)
Powerplant: Single 43.1kN thrust WP-13 turbojet engine
Launch/recovery: Conventional
Remarks: HALE-class reconnaissance UAV broadly comparable with US Global Hawk, in service with the PLAAF

BAYKAR

Akinci

Span: 20m
Maximum take-off weight: 6.000kg
Speed: 150kt
Endurance: 24 Hours
Ceiling: 40,000ft
Payload: 1,500kg including EO/IR/LD and multi-purpose AESA Radar
Powerplant: Two 750hp or 450hp turoprop engines iS interanl combustion engine
Launch/recovery: automatic take-off and landing (ATOL)
Remarks: Medium-altitude, long-endurance (MALE) armed UAS.

Bayraktar TB2

Span: 6.5m
Maximum take-off weight: 700kg
Speed: 70kt
Endurance: 27 Hours
Ceiling: 25,00ft
Payload: 150kg including Aselsan CATS EO/IR/LD imaging and targeting sensor or WESCAM MX-15D EO/IR/LD imaging and targeting sensor, Garmin GNC 255A navigation/communication transceiver
Powerplant: One 100hp Rotax 912-iS internal combustion engine
Launch/recovery: automatic take-off and landing (ATOL)Remarks: Medium-altitude, long-endurance (MALE) armed UAS sold to 15 countries and used operationally in Libya, Syria, Azerbaijan and Ukraine.

Kizilelma

Length: 14.7m (48ft 3in)
Wingspan: 10 m (32ft 10in)
Height: 3.3m (10ft 10in)
MTOW: 6,000kg (13,228lb)
Powerplant: 1 x Ivchenco-Progress AI-25TLT turbofan engine 16.9kN (3,790lbf) thrust - no afterburners. (Kızılelma-A)
Cruising speed: 735km/h (457mph)
Combat range: 930km (580miles)
Endurance: 5-6 hours
Service ceiling: 14,000m (45,000ft)
Operational altitude: 11,000m (35,000ft)
Launch/recovery: conv/conv
Armament: 2 × internal stations plus 6 × external stations on wings

BEIHANG UAS TECHNOLOGY

Length: 10m
Span: 18m
Maximum take-off weight: 1,250kg
Range: 6,000km (estimate from cruise speed & endurance)
Endurance: 40hrs
Speed: 150 to 180kph cruise
Altitude: 26,200ft
Payload Capacity: 150kg
Payloads: Electro-optical sensor system under fuselage
Powerplant: Single piston engine, pusher propeller
Launch/recovery: Conventional
Remarks: MALE-class reconnaissance UAV in service with the PLA air, land, and naval services

TYW-1

Length: 9.8m
Span: 18m
Maximum take-off weight: 1,500kg
Range: 6,000km (estimate from cruise speed & endurance)
Endurance: 40hrs
Speed: 200kph max level speed
Altitude: 24,600ft
Payload Capacity: 300kg
Powerplant: Single piston engine, pusher propeller
Launch/recovery: Conventional
Remarks: MALE-class armed UAV in development, export derivative of the BZK-005

BLUEBIRD AERO SYSTEMS

WanderB VTOL

Length: 1.79m
Span: 3.1m
Maximum take-off weight: 13kg
Communication range: 50-80km
Speed: 65kts
Endurance: 2.5hours
Best Operational Altitude: up to 3,281ft AGL
Ceiling: 22,000ft ASL
Payload: 1.35kg. Day and IR stabilised cameras, photogrammetric, multi-spectral or radiometric mapping cameras for airborne ISR or Mapping on Demand.
Poweplant: Four battery driven VTOL electric motors and one electric pusher motor for level flight
Launch/recovery: VTOL
Remarks: Mini UAS optimised to facilitate covert, over-the-hill operations or extensive, day-and-night ISR.

ThunderB

Length: 1.9m
Span: 4m
Maximum take-off weight: 32kg
Communication range: 150km
Speed: 32-72ktsEndurance: Up to 24hrs in standard configuration, up to 12hrs in cargo release configuration, up to 15hrs on station 150km from its ground control position carrying T-STAMP
Ceiling: 16,000ft
Payload: up to 4kg nose mounted with full fuel and additional payload under the wings, examples include Controp T-STAMP triple sensor (CCD/cooled IR/laser)
Powerplant: Advanced two stroke engine with electronic fuel injection
Launch/recovery: auto cat/para airbag, VTOL version available
Remarks: Operational in Israel and by international Defence and HLS customers. Continues mission in GPS denied environment

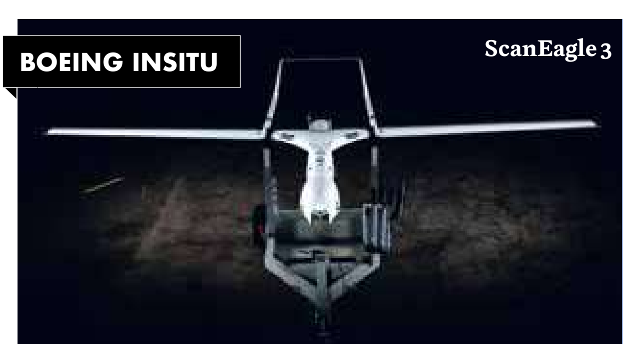
BOEING

MQ-25 Stingray

Length: 16m
Span: 23m
Range: 500nm
Ceiling: 39,000ft
Payload: 6,800kg of fuel
Powerplant: Rolls-Royce AE 3007N tubofan
Launch/recovery: conv/conv
Remarks: Winner of the US Navy Carrier-Based Aerial-Refueling System (CBARS) program.

BOEING INSITU

ScanEagle 3



Length: 2.3-2.5 m
Span: 4m
Maximum take-off weight: 36.3kg
Range: 720nm (estimate based on cruise speed & endurance)
Speed: 40-50kts cruise, 80kts max
Endurance: 18hrs
Altitude: 20,000ft
Payload capacity: 9.1kg. Turret houses EO, EO900 (EO camera and EO telescope), MWIR, Dual Image EO and MWIR), 170W onboard power
Powerplant: 1 x 2-str heavy fuel piston engine burning JP-5/JP-8Launch/recovery: cat/SkyHook vertical wire
Remarks: ScanEagle 3's design doubles the aircraft's payload capacity and is compatible with existing ScanEagle payloads.

Blackjack

Length: 2.5m
Span: 4.9m
Maximum take-off weight: 61kg
Range: 960 nm (estimate based on endurance & cruise speed)
Speed: > 90kts max, 60kts cruise
Endurance: > 16hrs
Altitude: > 20,000ft
Payload capacity: 17.7kg. EO imager with 1.1°–25° optical field of view & 4x digital zoom, mid-wave infrared imager with 2°–25° field of view, laser rangefinder, IR marker. Communications relay and AIS also integrated.
Powerplant: 8 HP reciprocating engine with EFI, burning JP-5, JP-8 heavy fuels
Launch/recovery: cat/SkyHook vertical wire
Remarks: Developed for a US Navy requirement for a small tactical unmanned aircraft system capable of operating from land and sea.

CHINA AEROSPACE SCIENCE AND TECHNOLOGY CORPORATION (CASC)

Cai Hong 4

Length: 8.5m
Span: 18m
Maximum take-off weight: 1,330kg
Range: 3,500km
Endurance: 40hrs
Speed: 127kts max, 97kts cruise
Altitude: 23,600ft
Payload capacity: 345kg. Compatible armaments include AR-1, AR-1B, AR-2 air-to-surface anti-armour missiles, CS/BBE2 high-explosive bomb, and LS-6-50 small-diameter bomb, and FT-series precision bombs.
Powerplant: 100hp piston engine, pusher propeller
Launch/recovery: ConventionalRemarks: MALE-class armed reconnaissance UAV in service with the armed forces of Algeria, Egypt, Indonesia, Nigeria, Saudi Arabia

Cai Hong 5

Length: 11.3m
Span: 21m
Maximum take-off weight: 3,300kg
Range: 6,000km
Endurance: 40+hrs
Speed: 157kts max, 97kts cruise
Altitude: 23,600+ft
Payload capacity: 1,200 kg (200 kg internal, 1,000kg external). Compatible armaments include AR-1, AR-1B, AR-2 air-to-surface anti-armour missiles, CS/BBE2 high-explosive bomb, and LS-6-50 small-diameter bomb, FT-series precision bombs, undisclosed 100 kg-class laser guided bombs.
Powerplant: 300hp piston engine, pusher propeller
Launch/recovery: Conventional
Remarks: MALE-class armed reconnaissance UAV for domestic and export customers.

Cai Hong 7

Length: 10m
Span: 22m
Maximum take-off weight: 13,000kg
Endurance: 10+hrs
Speed: 500kts max, 400kts cruise
Altitude: 42,650ft
Powerplant: Single turbofan engine
Launch/recovery: Conventional
Remarks: HALE-class low-observable unmanned combat aerial vehicle in development

DENEL DYNAMICS

Seeker 400

Length: 5.77m
Span: 10m
Maximum take-off weight: 450kg
Range: 250km
Speed: 81kts
Endurance: 16hrs
Altitude: 18,000ft
Payload: 100kg. S400 can carry dual imaging EO/IR payloads with gimbal diameters of up to 530mn with day TV, thermal imaging, colour/monochrome spotter camera, night spotter camera. Laser illuminator and LRF, electronic intelligence payload.
Powerplant: 1 x 85hp two-cylinder, air-cooled 4-str engine
Launch/recovery: conv/conv
Remarks: Seeker 400 is an evolution of the battle-proven Seeker II UAS. Operational in Algeria.

INDIA: DEFENCE RESEARCH AND DEVELOPMENT ORGANISATION (DRDO)

Rustom-2

Length: 9.5m
Span: 20m
Maximum take-off weight: 1,800kg
Endurance: 24hrs (estimate)
Speed: 135kt cruise
Altitude: 35,000ft
Payload Capacity: 350kg
Powerplant: Two 100hp Saturn 36T turboprop engines, tractor propellers
Launch/recovery: Conventional
Remarks: MALE-class reconnaissance UAV being developed for the Indian armed forces.

EDGE

Garmoosha

MTOW: 600kg
Payload: 150kg
Maximum speed: 140km/hr
Altitude: 3,050m (10,000ft)
Range: 150km line of sight
Endurance: 8 hours
Launch/recovery; VTOL
Remarks: UAE-built UAS with Adasi autonomous systems

ELBIT

Hermes 450

Length: 5.7m
Span: 10.5m
Maximum take-off weight: 550kg
Range: 250km
Speed: 95kts
Endurance: 17hrs
Altitude: 18,000ft
Payload capacity: 180kg. Options include EO/IR, SAR/GMTI & maritime patrol radars plus AIS, ELINT, EW, COMINT, COMJAM. Forms the basis of the UK/Thales WK450 Watchkeeper system.
Powerplant: 1 x 52 hp UAV Engines R802/902 rotary
Launch/recovery: conv/conv
Remarks: Multi-role, high-performance tactical UAS operational worldwide.

Hermes 900

Length: 8.3m
Span: 15m
Maximum take-off weight: 1,180kg
Range: 2,500km estimate
Speed: 119kts max, 60kts cruise
Endurance: 30-36hrs
Altitude: 30,000ft
Payload capacity: 350kg. Options include Leonardo Gabianno T-200 maritime & SAR/GMTI radar, AIS, Elbit D-CoMPASS EO/IR/Laser turret, AES 210 V – ESM/ELINT, Skyfix / Skyjam – COMINT/DF & optional COMJAM system and a communications relay. Users include the Israeli Air Force, with exports to Brazil and other Latin American countries.
Powerplant: 1 × 115hp Rotax 914 4-str engine
Launch/recovery: conv/conv
Remarks: Next-generation MALE UAS equipped with a variety of high-performance sensors to detect ground or maritime targets over a wide spectral range.

Hermes 900 Starliner

Length: 8.8m
Span: 17m
Maximum take-off weight: 1,600kg
Range: 2,500km estimate
Speed: 119kts max, 60kts cruise
Endurance: 36hrs
Altitude: 30,000ft
Payload: 450kg
Options include Leonardo Gabianno T-200 maritime & SAR/GMTI radar, AIS, Elbit D-CoMPASS EO/IR/Laser turret, AES 210 V – ESM/ELINT, Skyfix / Skyjam – COMINT/DF & optional COMJAM system and a communications relay. Users include Switzerland reported. Designed to comply with civilian airspace regulations.
Powerplant: 1 × 115hp Rotax 914 4-str engine
Launch/recovery: conv/convRemarks: Next-generation MALE UAS qualified for flight in and transit through civilian air space.

EMT PENZBURG

Rheinmetall Luna

Length: 3.0m
Span: 5.3m
Maximum take-off weight: 110kg
Range: > 100km data
linkEndurance: > 12hrs
Speed: 48.5kts
Altitude: > 16,400ft
Payload: Tiltable sensor platform with up to 7 colour and IR zoom video, -hyperspectral, pilot colour video, SAR/GMTI, SIGINT-sensors, ESM, CBRN. Optional sensors: Data link relay for BLOS operations, encryption, GCS hand-off function, transponder.
Powerplant: 1 x 10 kW, fuel-injected multi-fuel engine
Launch/recovery: cat/para or net
Remarks: Purchased by the German Army.

Aladin

Length: 1.57m
Span: 1.46m
Maximum take-off weight: < 4kg
Range: > 15km
Endurance: > 1hrs
Speed: 21.5-38kts
Altitude: 98ft AGL minimum, 30-90ft typical, 14,700ft density alt max
Payload: Daylight: 4 x colour CCD video cameras: 1 pilot view, 2 x downward looking, 1 downward looking on left side used in circling mode, plus high-res forward looking zoom camera, 2 x daylight video cameras. Night: 1 x IR video, 1 x colour video CCD camera
Powerplant: battery & electric motor driving tractor propeller
Launch/recovery: hand or cat/auto
Remarks: High performance mini UAV in operational service with several NATO countries.

ENICS

Length: 0.6m Span: 1.47m
Maximum take-off weight: 5.5kg
Range: 25km with comms link, 50km off line Endurance: 1hr 40min
Speed: 30-70kts Altitude: 16,400ft
Payload: Option 1: 3-axis stabilised turret with a 10x optical magnification-enabled video camera and digital photo camera with minimum 10.2mpix resolution. Option 2: Stabilised turret with 10x thermal imaging and video camera. Digital camera with minimum 10.2Mp resolution.
Powerplant: battery & 1 x electric motor driving pusher propeller Launch/recovery: cat/para
Remarks: Designed for round-the-clock aerial electro-optical surveillance. Can be supplied with Russian "Acceptance 5" quality standard certification.


Eleron-10SV (T-10 air vehicle)

Length: 87cm Span: 220cm
Maximum take-off weight: 12kg Range: Up to 30km
Endurance: 2hrs 30min Speed: 30-70kts
Ceiling: 13,100ft
Payload: Option 1: 3-axis stabilised turret with a 36x optical magnification video camera, plus a 10mpix digital camera. Option 2: 3-axis stabilised turret with an uncooled thermal imager and a video camera, plus a 10mpix digital camera, drop containers optional
Powerplant: battery & electric motor driving pusher propeller
Launch/recovery: cat/para
Remarks: Larger member of Eleron range. Used by Russian Ground Forces for local ISR.

FLIR SYSTEMS

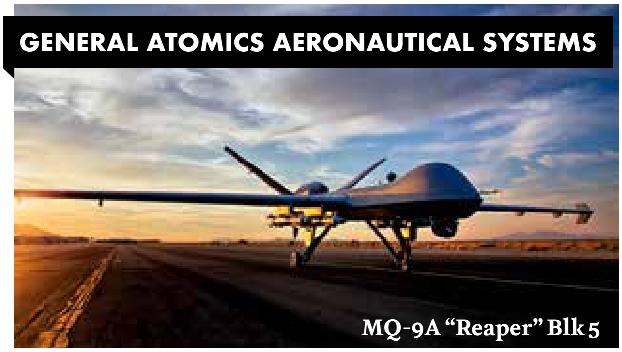

Teledyne FLIR Black Hornet

Length: 168mm or 6.6in Maximum take-off weight: 33grams or 1.16oz
Speed: 6 m/sec ground speed (~20 ft/sec) Altitude: >rooftop
Powerplant: Battery and electric motors driving two-blade main and tail rotors
Payload capacity: Day – 2x EO cameras, 1 video, 1 high-resolution snapshot. Night – fused, thermal and EO
Launch / Recovery: VTOL
Remarks: The Black Hornet PRS equips the non-specialist dismounted soldier with immediate covert situational awareness (SA). Game-changing EO and IR technology bridges the gap between aerial and ground-based sensors, with the same SA as a larger UAV and threat location capabilities of UGVs. Extremely light, nearly silent, and with a flight time up to 25 minutes, the combat-proven, pocket-sized Black Hornet PRS transmits live video and HD still images back to the operator. Sold to qualified purchasers.


Teledyne FLIR SkyRanger R70

Length: 1.35m (53") propeller tip to propeller tip Maximum take-off weight:
Speed: Ground speed 50kph (31mph)
Max ascent speed 4m/s (13ft/s)
Max descent speed 3m/s (9ft/s
Altitude: N/A
Powerplant: Battery
Payload capacity: Up to 3.5kg or 7.7lbs
Launch / Recovery: VTOL
Remarks: Developed for the most demanding UAS operations, the SkyRanger R70 establishes a new benchmark for small UAS performance and reliability. With its expanded carrying capacity, open architecture, and advanced autonomy and artificial intelligence, the R70 is redefining what's possible with a small VTOL UAS.

GENERAL ATOMICS AERONAUTICAL SYSTEMS


MQ-9A "Reaper" Blk 5

Length: 11m Span: 20m
Maximum take-off weight: 4,763kg Range: LOS/global
Endurance: 27hrs Speed: 240kts max
Altitude: 50,000ft MSL
Payload Capacity: 1,701kg (181 kg internal, 227 kg external, not simultaneous)
Payloads: MTS-B EO/IR, Lynx multi-mode radar, maritime radar, SIGINT/ESM system, Automatic Identification System (AIS), comms relay, dual ARC-210 UHF/VHF radios, other customer specific payloads.
Weapons: Hellfire missiles, GBU-12, GBU-38, GBU-49 smart bombs
Powerplant: Honeywell TPE331-10 turboprop 3-blade propeller
Launch/recovery: conv/conv
Remarks: Operated by U.S. Air Force, U.S. Marine Corps, the UK Royal Air Force, the French Air Force, the Spanish Air Force, the Royal Netherlands Air Force, the Indian Navy, and the Polish Air Force.

Gray Eagle Extended Range

Length: 9m
Span: 17m
Maximum take-off weight: 1,905kg
Range: LOS/global (comms)
Endurance: 42hrs
Speed: 167kts
Altitude: 29,000ft
Payload Capacity: 181 kg int, 227 kg centerline. EO/IR, SAR/GMTI radar, communications relay.
Powerplant: HFE-180 HP heavy-fuel engine
Launch/recovery: conv/conv
Remarks: The U.S. Army is integrating an array of new capabilities onto the versatile GE-ER platform as part of an ongoing effort to modernize the platform for Multi-Domain Operations.

MQ-9B SkyGuardian®

Length: 11.7m
Span: 24m
Maximum take-off weight: 5,670kg
Range: LOS/global
Endurance: 40hrs
Speed: 210kts
Altitude: 40,000+ft
Payload Capacity: 363kg internal, 1814kg external. Raytheon MTS-B EO/IR, GA-ASI Lynx multi-mode radar, VHF/UHF certified radios
Powerplant: Honeywell TPE331-10 turboprop driving pusher propeller
Launch/recovery: conv/conv
Remarks: First deliveries of MQ-9B SkyGuardian are being made to the UK Royal Air Forces as the Protector, while MQ-9B SeaGuardians are being flown for the Japan Coast Guard and Japan Maritime Defence Force.

HENSOLDT SOUTH AFRICA

Astus

Wingspan; 5.2m
MTOW; 115kg
Payload: 10kg Argos-8 electro-optical/thermal option
Cruising speed; 60kts cruise
Altitude: 16,000ft
Endurance: 8 hours
Range: 200km line of sight
Powerplant: 210cc two-stroke fuel injected piston engine
Launch/recovery: conv/conv

HESA

Ababil-3

Length: 3.5m
Span: 5m
Maximum take-off weight: 83kg
Speed: 108kt
Endurance: 4h
Ceiling: 16.500ft
Payload : 40kg
Powerplant: 25hp WAE-342 twin-cylinder piston engine
Launch/recovery: conv/conv
Remarks: Iranian tactical UAV.

Shahed-129

Length: 8m
Span: 16m
Speed: 81kt
Endurance: 24h
Ceiling: 24,000ft
Payload : 400kg including Oghab-6 EO/IR sensor
Powerplant: Rotax 914 Twin piston engine.
Launch/recovery: conv/conv
Remarks: Iranian armed MALE. The naval version is called Simorgh.

HINDUSTAN AERONAUTICS

RUAV-200

MTOW: 200kg when fully loaded with fuel and payload.
Payload: 40kg
Range of 100km
Maximum speed: 100 km/hr
Altitude: 6,000m
Endurance: 3 hours
Powerplant: 34 kw piston engine.
Launch/recovery: VTOL

HAI

Archytas

Archyntas (Photo 8)
Wingspan: 6.4m
Payload: 25kg
Maximum speed: 158km/h
Cruising speed: 120km/h
Altitude: 27,000ft.
Powerplant: A thermal engine, pusher propeller plus four electric motors
Launch/recovery: VTOL

IAI

Tactical Heron

Length: 7.3m
Maximum take-off weight: 600kg
Speed: 120kts max, 60-80kts loiter
Altitude: > 23,000ft
Powerplant: Rotax 912
Payload capacity: 180kg
Launch / Recovery: conventional runway automatic take-off and landing system
Remarks: Multi-mission, multi-payload tactical unmanned aerial system (UAS) based on the proven Heron UAS legacy

Heron Mk2

Length: 8.5m
Maximum take-off weight: 1,430kg
Speed: 140kts max, 60-80kts loiter
Altitude: > 35,000ft
Powerplant: Rotax 916 iS
Payload capacity: 490kg
Launch / Recovery: conventional runway automatic take-off and landing system
Remarks: Updated version of Heron enabling new configurations with long-range observation sensors

Heron TP

Length: 14m
Maximum take-off weight: 5,670kg
Speed: 220kts max
Altitude: > 45,000ft
Powerplant: 1,200hp Pratt & Whitney Canada PT6 Turboprop
Payload capacity: 2,700kg
Launch / Recovery: conventional runway automatic take-off and landing system
Remarks: Turbine-powered MALE UAV with large internal volume for a variety of payloads, certified to STANAG 4671 and compatible with NATO standards.

INDRA


Pelicano

Length: 3.4m
Span: 3.3m rotor dia
Maximum take-off weight: 200kg
Range: 100km
Endurance: 4-6hrs
Speed: 100kts
Altitude: 11,811ft
Payload: 30kg
Gyro-Stabilised MMP EO/thermal camera, Automatic Identification System (AIS)
Powerplant: Heavy fuel engine burning JP5
Launch/recovery: VTOL
Remarks: Maritime unmanned helicopter designed to support surveillance and law enforcement tasks from a ship or a ground base.

IRAN AVIATION INDUSTRIES ORGANISATION


Fotros

Length: 9m
Span: 21m
Maximum take-off weight: 1,000kg
Speed: 117kt
Endurance: 30h
Ceiling: 45,000ft
Payload : 200kg EO/IR sensor
Launch/recovery: conv/conv
Remarks: The largest Iranian armed MALE UAV.

SOUTH KOREA: KOREAN AIR AEROSPACE DIVISION (KAL-ASD)

Length: 3.7m
Span: 4.5m
Maximum take-off weight: 150kg
Range: N/A
Endurance: 3hrs
Speed: N/A
Altitude: N/A
Payload Capacity: N/A
Powerplant: 35hp rotary engine, pusher propeller
Launch/recovery: Conventional
Remarks: Tactical-class reconnaissance UAV in service with the Republic of Korea Army


KUS-FS/Mid-Altitude UAV (MUAV)

Length: 13m
Span: 25m
Maximum take-off weight: N/A
Range: 1,852km (estimate)
Endurance: 24+hrs
Speed: N/A
Altitude: 42,650ft
Payload Capacity: 150kg
Payloads: Electro-optical sensor system under fuselage
Powerplant: 1,200hp turboprop engine, pusher propeller
Launch/recovery: Conventional
Remarks: MALE-class reconnaissance UAV in development for the Republic of Korea Army Ground Operations Command

KRONSTADT GROUP


Orion-E

Span: 16m
Maximum take-off weight: 1,000kg
Speed: 65kt
Endurance: 24h
Ceiling: 24,600ft
Payload : 200kg including an optoelectronic station with two thermal imagers, a wide-angle TV camera and a laser rangefinder/target designator
Launch/recovery: conv/conv
Remarks: First Russian armed MALE UAV, undertook combat evaluation in Syria.

LEONARDO

Falco Evo

Length: 6.2m
Span: 12.5m
Maximum take-off weight: 650kg
Range: > 200km
BLOS: Dual Band SATCOM
Endurance: 20+hrs
Max Speed: 115kts
Altitude: > 21,000ft
Payload: 120 kg. EO/IR turret with laser designator up to 16", SAR/GMTI multi-mode surveillance radar, AIS, ELINT, COMINT, UHF-VHF Communication relay, ASW sonobuoys receiver/processor. Delivered to 8 international customers.
Powerplant: 100hp turbocharged Jet-A1 engine
Launch/recovery: conv/conv
Remarks: Heavy tactical UAS to be offered as both an integrated platform and as a fully-managed information-superiority service for ground and maritime surveillance missions.

Astore

Length: 6.2m
Span: 12.5m
Maximum take-off weight: 650kg
Range: 200km
Endurance: 20+hrs
Max Speed: 115kts
Altitude: > 21,000ft
Payload: 120 kg. EO/IR turret with laser designator up to 16", SAR/GMTI multi-mode surveillance radar, AIS, ELINT, COMINT, UHF-VHF Communication relay, N. 2 Semi Active Laser Guided Missiles.
Powerplant: 100hp turbocharged Jet-A1 engine
Remarks: Operational with undiscloseable Customers
Launch/recovery: conv/conv
Remarks: Medium altitude, medium endurance tactical UAV intended for Close Air Support missions.

AW HERO

Length: 3.9m
Rotor Diameter: 4m
Maximum Take-off Weight: 200kg class
Endurance: up to 6 hours
Data-Link Range: 100km
Max. Cruise Speed: 90kts
Powerplant: Heavy Fuel
Payload: 20kg (Nose Bay), 40kg (Underbelly)
Payload Options: Maritime Radar (Leonardo Gabbiano TS Ultra-Light), EO/IR Turret, AIS, ESM, IFF, Communication Relay, LIDAR, hyperspectral camera.
Launch and Recovery: Full Automatic TOL (including deck take-off and landing from moving ships)
Remarks: Marinized rotary UAS developed for embarked operations and capable to cover a wide range of roles in the maritime domain. Military Certification, based on STANAG 4702, obtained in 2021. Since 2019, AWHero has been conducting maritime surveillance capability demonstrations on ships as part of OCEAN2020 initiative implemented by the European Defence Agency.

LOCKHEED MARTIN

Desert Hawk III

Span; 1.5m
Maximum take-off weight: 3.72kg
Range:
Endurance: 1.5hrs
Speed: 50kts
Altitude: 11,000ft
Payload: 0.9kg. Includes 360-degree colour EO and IR video camera systems, plus other interchangeable, snap-on "Plug and Playloads"
Powerplant: battery & electric motor driving tractor propeller
Launch/recovery: hand/conv skid
Remarks: Small UAS that provides day and night support to small unit ISTAR and related operations.

Stalker XE

Span: 3.66m
Maximum take-off weight: 10.9kg
Range: 370 km (aircraft), 93km comms
Endurance: > 8hrs
Speed: 30.4kts cruise, 39kts dash
Altitude: 12,000ft max launch alt
Payload capacity: 2.5kg. EO/IR with cursor-on-target, integrated tracker with scene lock moving target tracking, auto-track and follow navigation
Powerplant: solid oxide propane fuel cell & electric motor driving tractor propeller
Launch/recovery: cat/conv glide, VTOL option
Remarks: VTOL capability provided by four electric motors driving vertical propellers mounted in pairs mid-span

RQ-170 Sentinel

Length: 4.5m
Span: 19.99m
Maximum take-off weight: 3,850kg
Speed: 108kt
Endurance: 25h
Ceiling: 15,000ft
Payload: 100kg including an EO/IR sensor and possibly an AESA radar
Powerplant: Garrett TFE731 turbofan engine
Launch/recovery: conv/conv
Remarks: Classified stealthy HALE UAV

LUCH

Korsar

Length: 4.2m
Span: 6.5m
Maximum take-off weight: 400kg
Speed: 81kt
Endurance: 12h
Ceiling: 6,600ft
Payload: Components based on the mission requirement
Powerplant: 70hp piston engine
Launch/recovery: conv/conv
Remarks: Russian medium weight tactical UAV.

MILKOR

Milkor 380

Length: 9m
Wingspan: 18.6m
MTOW: 1,300kg
Payload: 210kg ISR, COMINT and SIGINT payload integration
Cruising speed; 110-150km/hr
Altitude: 30,000
Endurance: 35 hours
Powerplant: Turboprop engine driving pusher propeller
Launch/recovery: conv/conv

TAIWAN: NATIONAL CHUNG-SHAN INSTITUTE OF SCIENCE AND TECHNOLOGY (NCSIST)

Length: 5.3m
Span: 8.7m
Maximum take-off weight: 450kg
Range: 120km
Endurance: 10hrs
Speed: 97kts max level speed, 60kt cruise
Altitude: 15,000ft
Payload Capacity: 51kg
Powerplant: Single piston engine, pusher propeller
Launch/recovery: Conventional
Remarks: Tactical-class reconnaissance UAV in service with the Republic of China Army and Navy

Teng Yun (Cloud Rider)

Length: 8m
Span: 18m
Range: 1,000km+
Endurance: 24hrs
Altitude: 25,000ft
Powerplant: Single turboprop engine, pusher propeller
Launch/recovery: Conventional
Remarks: MALE-class reconnaissance UAV in development for the Republic of China Air Force.

NORTHROP GRUMMAN

MQ-8C Fire Scout

Length: 12.6m
Span: 10.7m dia
Maximum take-off weight: 2,722 kg
Range: 278km radius from ship, 2,556km) estimate based on endurance & cruise speed
Endurance: 12hrs
Speed: 135kts max, 115kts cruise
Altitude: 16,000ft
Payload capacity: 318kg
Payloads: EO/IR/LRF, comm relay, AIS, maritime radar COBRA mine detector (future). Multiple payloads and configuration available
Powerplant: Rolls-Royce 250-C47E turboshaft engine driving main and tail rotors
Launch/recovery: automatic VTOL
Remarks: US Navy declared the MQ-8C mission capable and ready to deploy aboard Littoral Combat Ships in 2021

Global Hawk

Length: 14.5m
Span: 39.8m
Maximum take-off weight: 14,628kg
Range: 22,780km (ferry)
Endurance: > 34hrs
Speed: 310 kts loiter
Altitude: 60,000ft
Payload capacity: 1,360kg
Payloads: All-weather synthetic aperture, radar/moving target indicator, high-resolution electro-optical (EO) digital camera, and a third-generation infrared (IR) sensor working through common signal processor
Powerplant: Rolls-Royce AE3007 turbofan generating up to 3,856 kg thrust
Launch/recovery: conventional runway, automatic
Remarks: HALE UAV in service with USAF since 2001. Gathers near-real-time, high-resolution imagery of large areas of land, 24/7. EQ-4B version carries the Battlefield Airborne Communications Node (BACN) payload.

Triton

Length: 14.5m
Span: 39.9m
Maximum take-off weight: 14,630kg
Range: 15,186km (ferry)
Endurance: 30hrs
Speed: 320kts
Altitude: 56,500ft
Payload capacity: 1,452kg max internal, 1,089kg external
Payloads: Multi-Function Active Sensor Active Electronically Steered Array (MFAS AESA) radar, MTS-B multi-spectral targeting system
Powerplant: Rolls-Royce AE3007 turbofan generating up to 8,500 lbs thrust
Launch/recovery: conventional runway
Remarks: Developed under the US Navy's Broad Area Maritime Surveillance programme, Triton's role is to provide ISR over vast ocean and coastal regions, conduct search and rescue missions, and to complement the P-8 Poseidon MPA.

NOSTROMO DEFENSA

Yarara

Length: 2.465m
Span: 3.98m
Maximum take-off weight: 35kg
Range: > 50 km LOS link range
Endurance; 6hrs
Speed: 90kts max
Altitude: 9,843ft
Payload capacity: 5.5kg
Payloads: IAI MicroPOP EO/IR turret
Powerplant: 1 x 8hp Cubewano Sonic 35 multi-fuel rotary engine driving 3-blade pusher propeller mounted above the wing.
Launch/recovery: conventional, unprepared runway
Remarks: Operated by the Argentinian Air Force, system comprises three UAVs, GCS and support equipment in three boxes weighting less than 250kg.

QODS

Mohajer-4B

Length: 3.75m
Span: 6.5m
Maximum take-off weight: 242kg
Speed: 110kt
Endurance: 6h
Ceiling: 15,000ft
Payload : 20kg including a gimbal-mounted EO/IR sensor
Powerplant: 50hp Limbach L550E piston engine
Launch/recovery: cat/para
Remarks: Iranian tactical UAV.

THAILAND: RV CONNEX


RTAF U-1

Span: 6.2m
Range: 100-150km
Endurance: 6hrs
Altitude: 10,000ft
Payload Capacity: 30kg
Powerplant: 25hp piston engine, pusher propeller
Launch/recovery: Conventional
Remarks: Tactical-class reconnaissance UAV in service with the Royal Thai Air Force, derived from Sky Scout UAV.

SAFRAN


Patroller

Length: 8.5m
Span: 18m
Maximum take-off weight
Range: 200 m LOS
Endurance: 20hr
Speed: 110kts max
Altitude: 20,000ft
Payload capacity: 250kg
Payloads: Safran Euroflir 410 EO/IR turret plus COMINT, SIGINT, radar and other sensors.
Powerplant: 1 x 115hp Rotax 914F 4-cyl turbocharged liquid cooled engine
Launch/recovery: conv/conv
Remarks: The French Army has 14 on order, was due to receive the first 5 at the end of 2019, 14 in 2020 and two more in 2024. No deliveries yet reported.

SCHIEBEL

Camcopter S-100

Length: 3.11m
Span: 3.4m rotor diameter
Maximum take-off weight: 200kg
Range: 50, 100 or 200km data link range
Endurance: > 6hrs with 34kg payload, > 10hrs with external fuel
Speed: 120kts dash, 55kts estimate endurance
Altitude: 18,000ft
Payload capacity: 50kg
Payloads: EO/IR gimbals standard, with wide area search sensors, Synthetic Aperture Radar (SAR), Light Detection and Ranging (LIDAR) scanners, Signal Intelligence (SIGINT) & Communication Intelligence (COMINT), communications relays, loudspeakers, transponders, dropping containers and under-slung loads as options.
Powerplant: 50hp rotary engine
Launch/recovery: VTOL
Remarks: Delivered to 40 customers worldwide.

SPECIAL TECHNOLOGIES CENTER

Orlan-10

Length: 1.8m
Span: 3.1m
Maximum take-off weight: 18.7kg
Speed: 92kt
Endurance: 4h
Ceiling: 16,404ft
Payload: 6kg
Powerplant: Piston engine
Launch/recovery: cat/para
Remarks: Russian Ground Force's standard multirole tactical UAV.

SUKHOI

S-70 Okhotnik-B

Length: 14m
Span: 20m
Maximum take-off weight: 20,000kg
Speed: 432kt
Range: 5,000km
Payload: 2,000kg weapons carried in internal weapons bay
Powerplant: Saturn AL-31F turbofan
Launch/recovery: conv/conv
Remarks: Russian advanced strike UAV.

SURVEY COPTER

Aliaca

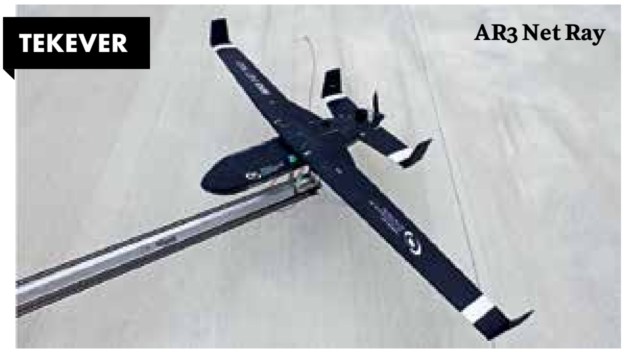
Length: 1.85m
Span: 3m
Maximum take-off weight: 12kg
Range: 50km
Speed: 52kts
Endurance: 3hrs
Altitude: 9,843ft
Payload capacity: 1.1kg
Payload: T120 gyrostabilised EO/IR turret
Powerplant: battery & 1 electric motor driving a single tractor propeller
Launch/recovery: cat/belly
Remarks: Developed for ISR, protection & monitoring missions in military and civil applications. Currently deployed by the French Army and Navy, overseas land & naval forces, SOF, police & gendarmerie.

Tracker 120

Length: 1.54m
Span: 3.3m
Maximum take-off weight: 8.7kg
Range: 25km
Speed: 17 to 25 m/sec
Endurance: 90 mins
Altitude: 985ft cruise, 8,200ft max
Payload capacity: 1.1kg
Payloads: T120 gyrostabilised EO/IR turret
Powerplant: battery & 2 x electric motors driving twin tractor propellers
Launch/recovery: hand/belly landing
Remarks: Designed for ISR, coastal surveillance, convoy protection, monitoring of sensitive areas

Length: 2.27m
Span: 3.3m
Maximum take-off weight: 22.5kg
Range: > 50km
Speed: 65kts
Endurance: 7hrs
Altitude: 32,300ft
Payload capacity: 2kg
Payload: Survey-Copter's own T120 gyrostabilised EO/IR turret
Powerplant: 1 x fuel-injected 2-str engine
Launch/recovery: cat/conv
Remarks: Designed for military and civilian intelligence, surveillance and inspection missions

TEKEVER



Length: 1.7m
Span: 3.5m
Maximum take-off weight: 23kg
Speed: 65kt
Endurance: 16h
Payload: 4kg including EO/IR sensor
Powerplant: Piston engine
Launch/recovery: cat/para
Remarks: An optional VTOL capability with dual side-looking SAR called GAMASAR is available.

TEXTRON UNMANNED SYSTEMS

Length: 2.1 m
Span: 3.6 m
Maximum take-off weight: 47kg
Range: 140km comms range
Endurance: 10hrs with multi-INT payload
Speed: 65kts
Altitude: 10,500ft density altitude with multi-INT payload
Payload capacity: 6.8kg
Payloads: Can carry Cloudcap TASE 400 two-axis stabilised turret with EO/MWIR with continuous zoom optics with multiple 3rd bay and laser options, integrated GPS/INS, onboard video processing
Powerplant: Lycoming EL-005 two-stroke Heavy Fuel Engine plus 4 electric vertical rotors
Launch/recovery: VTOL
Remarks: Runway independent development of Aerosonde

Length: 3.66m
Span: 26.2m
Maximum take-off weight: 212kg
Range: 125km LOS
Endurance: 9hrs
Speed: 62-65kts / Max 98kts dependent on mission profile
Altitude: 18,000ft ceiling, 10,000ft max take-off elevation
Payload capacity: 43kg
Payloads: EO/IR, communications relay, optional laser designation,etc.
Powerplant: UAV Engines model 741 rotary engine
Launch/recovery: cat/conv, arrested
Remarks: Operators of this and earlier versions include the US Army, US Marine Corps, the Australian Army, the Italian Army, and the Swedish Army

THALES

Length: approx 5.7m
Span: 10.5m
Maximum take-off weight: 550kg
Range: 200km
Endurance: 16hrs
Speed: 95kts
Altitude: 16,000ft
Payload capacity: 150kg
Payloads: Elbit Compass turret with visual, Infra-Red (IR) laser rangefinder and designator, Thales I-Master SAR/GMTI radar, radio relay, COMINT. Principal operator is the British Army.
Powerplant: Powerplant: 1 x 52hp UAV Engines R802/902 rotary
Launch/recovery: conv/conv
Remarks: Based on Elbit Hermes 450, Watchkeeper is British Army tactical UAV system, latest version offered for export by Thales is Watchkeeper X

Length: 1.76m (estimate)
Span: 3.9m
Maximum take-off weight: 14kg
Range: 30km (comms limited)
Endurance: 3hrs
Speed: 49kts
Altitude: 14,764ft (t/o)
Payload: 1.2kg
Powerplant: battery & DC brushless electric motor
Launch/recovery: cat/belly
Remarks: French Army acquired a fleet of 210 Spy'Rangers for reconnaissance and observation missions

TTX UNCREWED SYSTEMS

Length: 6.50m (21ft 4in)
Wingspan: 15m (49ft 3in)
MTOW: 472.5kg (1,042lb)
Payload; 75kg
Powerplant: 1 × 60kW (80hp) Rotax 912ULS four cylinder, liquid and air-cooled engine.
Cruising speed: 240 km/h (150mph, 130km/hr)
Endurance: 10 hours
Launch/recovery: conv/conv
Based on the Czech Pure Flight's U-15 Phoenix motor glider

TURKISH AEROSPACE

Length
Wing Span: 24 m
Lenght: 12.5 m
Height: 3.84
Maximum take-off weight: 3300 kg
Speed: 127 kts @ 20 kft
Altitude: 40.000 ft
Powerplant: Dual Turbo Diesel
Payload capacity: 750+ kg

Remarks:
- Common Avionics Structure and GCS with ANKA
- ISR (Intelligence, Surveillance and Reconnaissance)
- Targeting
- Air to Ground Strike
- Maritime Surveillance
- Border and Coastal Protection
- Communication Relay
- Electronic Warfare & Signals Intelligence
- High Payload Capacity
- All Weather Operational Capability
- Segregated Mission and Flight Control Architecture
- High Level of Flight Safety
- Autonomous Flight & Navigation
- INS Fix & Radar Tracker Take-Off/Landing
- Return Home and Landing Capability for Total Link Loss Emergency

Length
Wing Span: 17.5 m
Lenght: 8.6 m
Height: 3.25 m
Maximum take-off weight: 1700 kg
Speed: 131 kts @ 20 kft
Altitude: 30.000 ft
Powerplant: Turbo Diesel Engine
Payload capacity: 350+ kg

Remarks:
- Common Avionics Structure and GCS with AKSUNGUR
- ISR (Intelligence, Surveillance and Reconnaissance)
- Targeting
- Air to Ground Strike
- Maritime Surveillance
- Border and Coastal Protection
- Communication Relay
- Electronic Warfare & Signals Intelligence
- High Payload Capacity
- All Weather Operational Capability
- Segregated Mission and Flight Control Architecture
- High Level of Flight Safety
- Autonomous Flight & Navigation
- INS Fix & Radar Tracker Take-Off/Landing
- Return Home and Landing Capability for Total Link Loss Emergency

Length
Wing Span: 12.5 m
Lenght: 9.5 m
Height: 2.5 m
Maximum take-off weight: 6500 kg
Speed: 425 kts / 0.7 M @ 30 kft
Altitude: 44.000 ft
Powerplant: Turbofan
Payload capacity: 1200 kg

Remarks:
- Common Avionics Structure and Ground Control Segment with ANKA and AKSUNGUR
- Low Radar Observability
- High Subsonic
- High Payload Capacity
- 2 Internal and 5 External Payload Stations
- Internal/External Fuel Tanks
- Air-to-Ground, Air-to-Air and Air-to-Sea Strike Capability
- Air-to-Air Radar
- EOTS and IRST for Targeting
- Electronic Warfare Measures
- Close Air Support, Deep Strike, Strategic Attack, NEAD/SEAD and SUW/ASUW Missions
- Communications Relay
- Manned-Unmanned Teaming (MUM-T)
- Swarm Technologies combined with AI

SUPER ŞİMŞEK

Length Wing Span: 1.75 m
Lenght: 4 m
Height: 0.7 m
Maximum take-off weight: 200 kg
Speed: 0.85 M
Altitude: 35,000 ft
Powerplant: Jet Engine
Payload capacity: 35 kg (Up to 50 kg)

Remarks:
- Carried under and launched from AKSUNGUR or ANKA-III Wings
- Reconfigurable payload options according to mission requirements
- Warhead Integration capability
- Electronic Warfare Measures
- Intelligance, Surveillance and Reconnaissance
- Chaff and Flare
- Hot Nose Infrared Augmentation Device
- Miss Distance Indicator (MDI)
- Swarm Technologies combined with AI and Machine Learning

ROTARY WING CARGO UAV

Length Length: 6.5 m
Height: 1.7 m
Rotor Diameter: 5.6 m
Maximum take-off weight: 275 kg
Range 80+ km
Altitude: 10.000 ft
Powerplant: Two Stroke Engine
Payload capacity: Up to 80 kg Cargo

Remarks:
- Mission Flexibility with "one switch takeoff"
- Easy to load and unload cargo
- Waterproof and shock-proof cargo payload case
- Fully Autonomous Operation
- Emergency Landing / Return to Base
- Redundant Navigation with CRPA antenna
- Portable and Light Ground Control Segment
- Low Signature
- Composite Structure
- External Payload Capacity
- EO/IR Camera Option

TURGIS & GAILLARD

AAROK

Span: 22m
Length; 14m
Maximum take-off weight: 5,500kg
Cruis speed: 250kts
Ceiling: 30,000ft
Endurance: 24-30 hours
Payload: 1,500kg optronic gimbal, electronic warfare systems, guided bombs
Powerplant: 1,200shp Pratt & Whitney Canada PT-6 turboprop
Launch/recovery: automatic conv/conv
Remarks: First flight planned for end of 2023.

UAV FACTORY

Penguin C

Length: 2.3m
Span: 3.3m
Maximum take-off weight: 22.5kg
Speed: 62kt
Endurance: 20h
Ceiling: 16,400ft
Payload : 10kg including Single sensor gyro-stabilized gimbal with Epsilon 135 EO sensor
Powerplant: 28hp EFI piston engine
Launch/recovery: cat/para
Remarks: US/Latvia manufactured long-endurance mini-UAV ordered by the Latvian National Armed Forces.

UKRSPECSYSTEMS

Span: 4m
Maximum take-off weight: 40kg
Speed: 72km/hr
Endurance: 7 hours
Range: 500km
Ceiling: 3,000m
Payload: 10kg including USG-212 EO/IR gimbal or USG-211 EO gimbal.
Powerplant: 61cc 2-cylinder 4-stroke engine with 100 W electric generator system
Launch/recovery: cat/conv or VTOL PD-2
Remarks: Can be converted to the VTOL PD-2 in 15 minutes.

UMS SKELDAR

SKELDAR V-150

Length: 3.2 m
Maximum take-off weight: 150 kg
Speed: 120 km/h
Altitude: 3000 m
Fuel: Heavy Fuel
Payload capacity: 10 kg in the nose; 30 kg in the center bay
Endurance: 5+ hours
Remarks: The SKELDAR V-150 is suitable for deployment in various operating scenarios. It has been designed to support emergency response, tactical surveillance, homeland security, and time-critical, high-risk search operations. Deployable from non-permissive sites and ideally suited for irregular environments, the SKELDAR V-150 heightens situational awareness by delivering real-time intelligence for extended periods in high-threat scenarios.

SKELDAR V-200

Length: 4.6 m
Maximum take-off weight: 245 kg
Speed: 140 km/h
Altitude: 3000 m
Fuel: Heavy Fuel
Payload capacity: Multiple 40 kg
Endurance: 6+ hours
Remarks: The SKELDAR V-200 is the platform of choice for multiple NATO naval forces, thanks to its superior intelligence-gathering capabilities when equipped with numerous sensors. Flight times can exceed six hours, and the heavy-fuel engine, combined with efficient maintenance procedures and ease of access to the engine compartment, allows for highly efficient routine service processes. Rugged components designed to withstand harsh saltwater conditions, ship-based Automatic Take-Off and Landing (ATOL), and ship-specific Remote Pilot Station (RPS) integration options are just some of the features that make the SKELDAR V-200 the ultimate NATO-aligned rotary platform.

UWCA

Forpost

Length: 5.85m
Span: 8.55m
Maximum take-off weight: 450kg
Speed: 80kt
Endurance: 18h
Ceiling: 23,000ft
Payload : 120kg
Powerplant: Limbach L550 piston engine
Launch/recovery: conv/conv
Remarks: Russian license-built IAI Searcher III tactical UAV.

VESTEL DEFENSE INDUSTRY

Karayel

Length: 6.5m
Span: 13m
Maximum take-off weight: 630kg
Speed: 80kt
Endurance: 20h
Ceiling: 18,000ft
Payload : 70kg including EO/IR sensor
Powerplant: 97hp piston engine.
Launch/recovery: conv/conv
Remarks: Turkish armed MALE UAV designed and produced according to STANAG-4671. Is being built under license in Saudi Arabia.

VIETTEL

VT-Patrol

Length: 2.8m
Span: 3.3m
Maximum take-off weight: 26 kg
Range: 50km
Altitude: 14,763ft
Powerplant: Piston engine, pusher propeller
Launch/recovery: Conventional
Remarks: Mini-class reconnaissance UAV in service with the Vietnamese armed forces.

ZALA AERO GROUP

ZALA 421-16E5G HD

Length: 1.85m
Span: 4.64m
Maximum take-off weight: 29.9kg
Range: 1200+ km
Endurance: 12+ hr
Speed: 65-110 km/h
Altitude: 200-5000 m
Payloads: Interchangeable ZALA payloads
Gyro-stabilized EO/IR HD sensors: Full HD video with 60-x optical zoom, 42Mp photo, HD thermal imager with 8x zoom, LiDAR, gas detector, dosimeter, relay module
Powerplant: Hybrid (buffer storage battery and combustion engine)
Launch: Pneumatic catapult
Recovery: Parachute, airbag
Remarks: ZALA 421-16E5G is a serial hybrid powerplant that provides a guaranteed flight time of more than 12 hours.

ZHONG TIAN GUIDE CONTROL TECHNOLOGY COMPANY

Length: 2.2m estimate
Span: 20m estimate
Maximum take-off weight: 3,200kg
Speed: 125kt
Endurance: 25h
Ceiling: 26,245ft
Payload:1,400kg
Powerplant: Rear-mounted heavy fuel engine.
Launch/recovery: conv/conv
Remarks: Chinese MALE designed to operate in China's high altitude regions for border patrol and SAR missions..

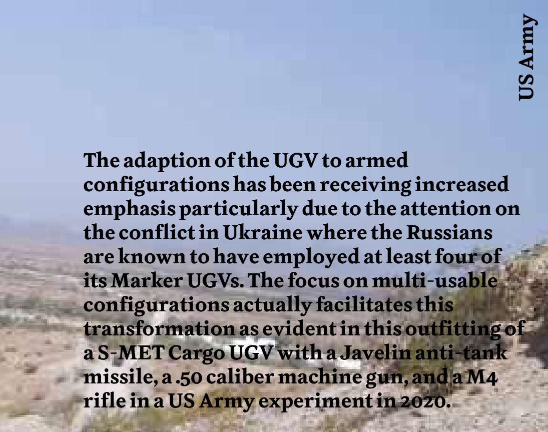
SETTING THE RIGHT HEADING FOR UGVS

Unmanned Ground Vehicles (UGVs) have undeniable potential on the battlefield, but matching design to customer expectation is not necessarily an easy obstacle to overcome.

Stephen W. Miller

Deploying unmanned ground vehicles (UGV) on the battlefield is receiving increasing attention by militaries worldwide. Although not as mature nor as widely fielded as their airborne counterparts, UGVs have the potential to offer many benefits in executing missions on the ground. However, UGVs face challenges that include technical, operational, logistical and maintenance issues. Although there is general agreement among UGV developers that most of these are either already being solved or, at least, are seeing progress, these developers concur that perhaps the most difficult questions relate to how to control, support, and integrate UGVs with existing ground forces. These reflect issues that must be largely resolved by the military users themselves.

One of the issues facing UGV developers is that there is often a gap between client expectations regarding what they anticipate the UGV should be able to accomplish, and what is currently possible. This is largely the result of the lack of hands-on practical operational exposure and the limited experience of UGVs in field use. Raul Rikk, Science and Development director at Milrem Robotics, a leading UGV developer in Estonia and recently acquired by the UAE's EDGE Group, said that this knowledge gap is understandable and "parallels that experienced in the commercial introduction of the electric vehicle." It is common that users may attempt to employ a new system like a UGV in the same manner as they do with other types of equipment, which may not reflect


US Army

The adaption of the UGV to armed configurations has been receiving increased emphasis particularly due to the attention on the conflict in Ukraine where the Russians are known to have employed at least four of its Marker UGVs. The focus on multi-usable configurations actually facilitates this transformation as evident in this outfitting of a S-MET Cargo UGV with a Javelin anti-tank missile, a .50 caliber machine gun, and a M4 rifle in a US Army experiment in 2020.

the new capabilities offered by the UGV. Thus, it could be either under utilised to its potential or be asked to perform beyond its capacity. Both situations result in a potentially false appreciation of what the UGV can contribute operationally.

RISK REDUCTION

The rationale most often stated by both developers and end users for developing and fielding UGVs is "to provide a system that can execute tasks thereby reducing the risk to the human soldier". This was and remains the principle behind the earliest military UGVs, those designed and employed in Explosive Ordnance Disposal (EOD). Yet this factor is increasingly being surmounted by additional fielding drivers. These include their capacity to carry substantial loads on a platform that can travel over difficult terrain and even accompanying infantry. This role parallels that of the pack mule in the past. Another is providing a mobile platform for weapons and sensors, replacing what previously required an often-large team of soldiers. Their capacity to carry heavier weapons, ammunition and equipment is also valuable to infantry units typically from platoons to companies (perhaps modern cousins of the ubiquitous manned Universal Carrier of World War Two fame). In these roles, the UGV augments the existing organisations and equipment.

Increasingly, however, the UGV is being viewed by some as a candidate to replace human soldiers! This is particularly attractive to militaries facing manning concerns. Here the UGV may allow for manpower reductions and economic savings by substituting machines to maintain operational capabilities. The technical demands, organisational impacts, and operational implications of each approach can be quite different.

PLATFORMS

Having a single platform able to accomplish a wide range of tasks and applications would be ideal, simplifying training, maintenance, and support. However, as Sara Willett, program director Land Systems at Textron Systems explained:


Textron has developed its M3 UGV based on the core of its earlier and heavier M5 Ripsaw. The M5 at 10.6 tonne combat weight is intended for higher payload mission requirements. The M3, just introduced in 2022, is both smaller and lighter and can be transported in cargo helicopters. Both utilise a common control system and navigation.

Textron Defense

"The mission requirements as defined by the users directly influence the payload. This, together with mobility/transportability parameters drives the platform configuration. The objective is to strike a suitable balance." Textron's UGVs use a common core platform that adapts to various mission modules to achieve this. The classification of UGVs by payload weight capacity is becoming typical in various programmes. Rheinmetall, according to Alain Tremblay, vice president for Business Development and Innovation at Rheinmetall Canada, is coalescing toward its Mission Master CXT which offers a demonstrated high mobility, including amphibious, for a range of modular mission packages. They have found wheeled configurations often with 'over-size' adaptable tires to offer both lower maintenance and enhanced mobility including swimming. In addition, Rheinmetall "has successfully demonstrated up to 31 miles per hour (50 kilometres per hour) road speeds (with a goal of around 44mph - 70+kmph) reaching levels allowing practical road-march self-deployment."

HYBRID POWER

A consensus appears to be forming that hybrid power is the most appropriate approach for powering UGVs which require operations of extended duration. All-electric, though suitable for smaller UGVs, does not yet have sufficient battery life. The diesel-electric hybrid offers extended ranges, 'silent' running (when necessary), self-charging and available exportable power possibilities. Practical battlefield uses in tactical scenarios, versus a base support role, dictates a degree of self-sufficiency in a UGV so as to not present a logistics support burden on the host unit. This reflects not only extended ranges but also the system's totally independent operational mission time. The latter could include not only traveling but also time in static positions while still operating at full capability, such as conducting surveillance.

It is in the control of the UGV that the greatest advances have been made but also where significant additional efforts are being focused. A relevant key question is how much autonomy is needed in the UGV? Sten Allik, Milrem Robotics Concept Development and Experimentation director explained: "The degree of autonomy necessary is partly a function of the UGV's intended use. Is it in tactical close support or a more independent operational role? A balance needs to be struck between man and machine with a focus on accomplishing simple tasks. Thus, it is necessary to consider the minimal level of autonomy needed to accomplish the task or provide new effects on the battlefield. This 'adapted autonomy' recognises it is not necessary to have highest level of autonomy in the majority of tasks." The degree of functionality and practical capability of the UGV on the battlefield and in military roles is more than the vehicle itself and is primarily a software development effort.

The level of independent control is also a function of the environment in which the unmanned system will be required to operate. For example, autonomous driving vehicles are already successfully demonstrated. Current autonomous vehicles, however, as Rheinmetall's Tremblay explained, "operate most efficiently along routes that are well defined with recognisable edges and consistent travel paths and roadways." Within such parameters, autonomously operated vehicles are fully capable of reliably performing largely independent travel across extended distances. Logistics convoys using driverless vehicles are a practical possibility today and have been demonstrated by Rheinmetall, Oshkosh Defense, and the US Army which has logged over 2,000 hours of unmanned travel in its Expedient Leader Follower programme. The German, British, and Australian militaries

UGV forerunner - 2-inch mortar being fired from a Universal Carrier in Britain, 10 May 1943

are also aggressively pursuing similar initiatives. The military is further seeking to capitalise on commercial developments such as the US Army's $49.9 million contract with Kodiak Robotics, a California autonomous truck startup with an established record, to develop "autonomous vehicle technology to navigate complex terrain, diverse operational conditions, and GPS-challenged environments". Kodiak is to deliver on the contract in 2024.

UGV CANDIDATES

The potential promise of the UGV has driven not only their investigation by world militaries, but has also induced a number of companies to fund research and development. This has resulted in industry in some cases getting ahead of the military end users in projecting capabilities rather than responding to formal issued requirements. Milrem's Rikk, explained that based on their experience "The traditional military development and acquisition process has shown difficulty providing a process able to address the possibilities presented by unmanned system concepts." As a result, many of the industry designs have absorbed lessons from earlier experience, thus offering evolved configurations reflecting both responses to identified field challenges and incorporating technology advances. These industry initiatives have offered up a range of state-of-the-art UGVs.

RHEINMETALL MISSION MASTER

Rheinmetall's Mission Master is a family of Autonomous-UGVs (A-UGV) using modular configurations for logistical battlefield support. The Mission Master SP model has a low-profile, quiet electric motor and eight-wheels suited to its small unit support role. The latest Mission Master CXT will tackle the most extreme terrain and conditions with over-size adaptable tires adjusting pressure on demand, diesel-electric hybrid power, amphibious capability, 2,200 pounds (1000 kilograms) payload, and 280 miles (450 kilometres) range (including 31 miles / 50km on electric only). In addition, it offers the similarly capable diesel-powered Mission Master XT A-UGV traveling 466 miles (750km) without refuelling, The XT can optionally be operated by a soldier onboard. Rheinmetall UGVs use a common Rheinmetall PATH autonomy kit (A-kit) that provides a wide range of advanced controlled modes, such as a smart Rheinmetall tablet enabling safe firing as well as an ATAK-compatible soldier system. It also offers many teleoperation options including a smartwatch and single-hand controller to meet the operational objectives of multiple scenarios. These enable follow-me, convoy, and autonomous navigation modes. Mission Master has been acquired by militaries including the British Army and a number of European armies. In May 2023, it was announced that the US Marine Corps would be trailing Mission Master in both Exercise Talisman Sabre in July-August 2023 in Australia and conducting autonomous convoying in October at its combat centre in Twenty-nine Palms, California.

THEMIS

Milrem Robotics in Estonia has been one of the pioneers in UGVs with its multi-mission capable THeMIS being widely introduced. Presently 16 counties use its UGVs, eight of which are NATO militaries: Estonia, France, Germany, the Netherlands, Norway, Spain, the United Kingdom, and the United States. Using a tracked chassis with hybrid diesel-electric power the system can move at 12.5mph (20km/h) operating up to 15 hours with 1.5 hours using electric power only. THeMIS is optimised toward filling tasks in close support of dismounted operations. As such, Milrem has designed variants to carry cargo and supplies for small units, a mortar carrier, and Casualty Evacuation (CASEVAC) while also demonstrating its possibilities as a heavy machine-gun and/or reconnaissance sensor platform. Wireless tele-operated control is possible to around one mile (1.5km) line-of-sight, while waypoint navigation allows a pre-programmed route without human intervention. Raul Rikki shared that "a key objective in the design and development of THeMIS and our other UGVs is assuring the system is an asset for the user and not a burden."

RIPSAW

Textron Systems previous unmanned experience has covered air and maritime platforms. This is now extended with the addition of its Howe & Howe subsidiary, and the team's extensive collaboration on its M5 and M3 vehicles. Willett explained that "common principles and software can be applied across unmanned systems for all three environments which offers advantages. However, the ground application is the most challenging." RIPSAW uses a common core platform approach which can be adapted to various modules. Willet suggested that "the actual configuration that a UGV will take is largely driven by the payload that the mission role demands." Accommodating these requirements Textron Systems' M5 vehicle, in its fifth generation, provides a 10.6-tonne combat weight platform for mission loads up to 8,000lb (3,636kg). Defined as a Multi-Domain Mission platform, it has been equipped for route clearance and breeching, as a reconnaissance surveillance and target acquisition (RSTA) system, and as a weapon platform with up to a medium caliber turret. In 2022, Textron debuted its RIPSAW M3

technology demonstrator striking a balance for lower mission load needs. Drawing both lessons and some components from the M5 vehicle, the M3 vehicle focuses on transportability with a size/weight that can be carried internally in the Boeing CH-47 Chinook transport helicopter. M3 also has a 30+mph (48+km/h) top speed and is designed to swim (the only other UGV with the exception of Mission Master with that ability).

PERUN

Poland is aggressively exploring UGV development with the consortium of local companies Tarnow Mechanical Works (Zakłady Mechaniczne Tarnów; ZMT) together with the Warsaw's Military University of Technology and STEKOP independently developing the Perun, an autonomous four-wheeled robotic system. Intended to conduct reconnaissance and advanced security it is electrically powered with 10 hours of silent operation. The system weight is up to 1,980lb (900kg), and it has been demonstrated with a RSTA package and a medium machine-gun remote station. It can be controlled remotely by one soldier with a maximum control range of just over three miles (5km) with a stationary unit.

I-MPUGV

South Korean company Hanwha Defense's Intelligent, Multi-Purpose Unmanned Ground Vehicle (I-MPUGV) has been conducting operations with the 5th Infantry Division of the Republic of Korea Army (RoKA) since October 2021. A two tonne, six-wheel, artificial-intelligence (AI)-enabled vehicle includes a locally developed remote-controlled weapon system (RCWS). It is designed to provide infantry support, the transportation of supplies and ammunition, reconnaissance and surveillance, casualty evacuation, and close combat support. South Korea's Defense Acquisition Program Administration (DAPA) shared that the new vehicle has a road speed of around 25mph (40km/h) and cross-country speed of 12.5mp/h (20kmh) with a range of 62 miles (100km) on a single electric charge. It has a payload capacity of 1,100lb (500kg).

UGV EMPLOYMENT

The UGV offers capabilities that have few existing parallels regarding how they might be best employed. Real-world experience, for example, with the General Dynamics Land Systems Small Multipurpose Equipment Transport (S-MET) which entered production for the US Army in 2020 has resulted in a rethink of even this seemingly straight forward logistics support role. As a result, requirements issued for the follow-on acquisition of S-MET Increment 2 reflect key changes from the original Request for Proposal (RfP). This illustrates the depth of the learning curve faced in determining how to best employ UGVs. Though they may appear like other vehicles their unique potential value will be significantly diminished, if not largely negated, should they be utilised tactically in the same manner.

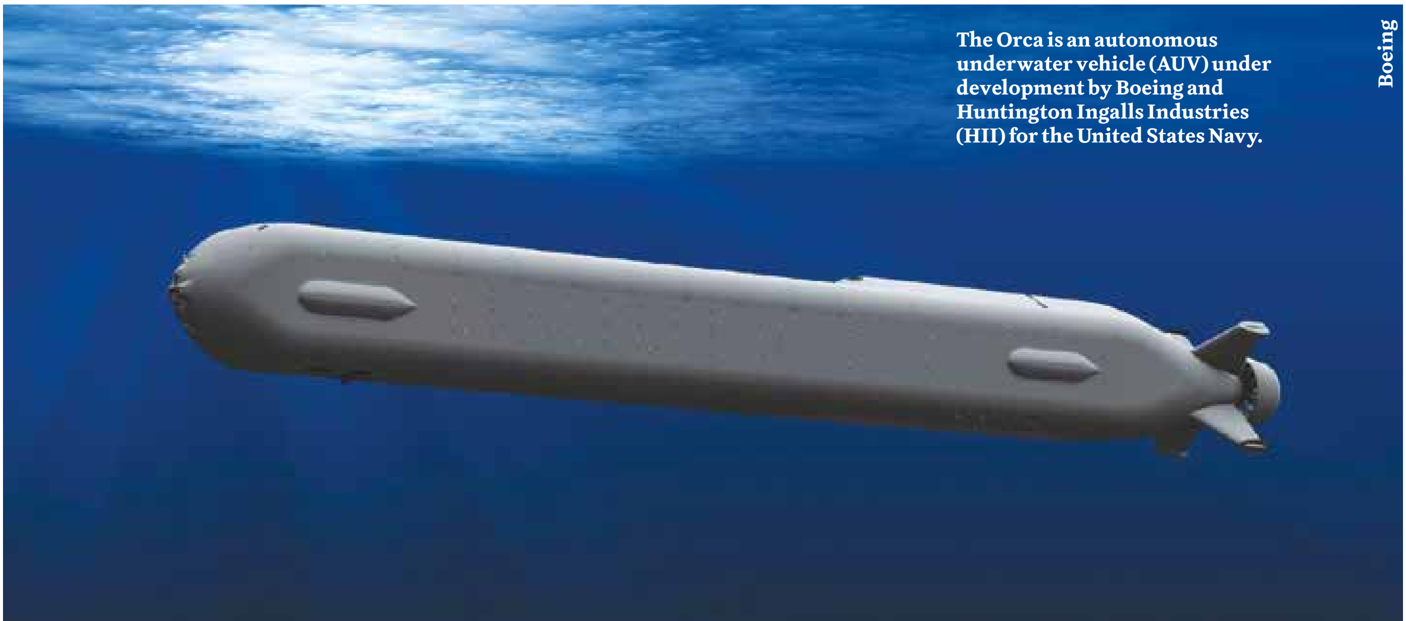
Armies aspiring to gain advantage in fielding UGVs are attempting to determine how to best use them. The US Army conducted operational experiments for light and medium Remote Combat Vehicles from June to August 2022 at Ft. Hood, Texas to gain insights into their battlefield use. The British Army has been undertaking its own experiments with its Armoured Trials and Development Unit (ATDU) completing 'heavy UGV' trials in March 2023. With the British commitment toward fielding unmanned systems into a battalion group by 2024 there is some urgency in these efforts. The UGV can be utilised in a manner similar to other supporting weapons though with greater inherent mobility and enhanced carry capacity. Another employment option is the 'tactical wingman' approach which teams a manned and unmanned system. Unmanned systems also may allow for a single manned control system to remotely operate multiple unmanned systems.

The challenges faced extend beyond the tactical realm. A key concern, particularly for light units, remains how to maintain and provide support for UGVs particularly when deployed with light units. By their nature, these units are not organised with assets to support vehicles. Even simply transporting UGVs from rear areas to where they will be used tactically requires consideration and dedicated assets.

UNMANNED OPPORTUNTIES

The emphasis currently placed on developing the UGV in kinetic combat roles, with both its technical and procedural issues, maybe having an unfortunate effect of drawing attention from the more straight forward yet equally valuable applications. It should be recognised that obtaining field use clearance of weaponised UGVs can be a lengthy process. Other options for unmanned ground platforms may include combat breeching, assault bridging and mine-clearance, CBRNE detection or their use as rapidly displaceable platforms for radar, signal, and EW systems. In addition, the UGV is ideally suited for better accommodating the loads light infantry, supporting arms and fire support/observer teams. Incorporating UGVs would enhance their mobility and sustainability while reducing team/crew size. Though possibly seemingly less exciting than direct combat systems, these could be readily fielded offering immediate capabilities with minimal development risk while offering hand-on exposure to potential UGV fielding issues.

The military that identifies that right combination of unmanned (likely including integration of ground UGV and airborne UAV capabilities) and manned, with an appropriate structure and operational concepts, will likely set the standard for the next evolution of the battlefield. 🅰



The Orca is an autonomous underwater vehicle (AUV) under development by Boeing and Huntington Ingalls Industries (HII) for the United States Navy.

Boeing

UUV OFFENCE AND DEFENCE

Unmanned underwater vehicles (UUVs) provide a capability that Western navies must both capitalise on and counter.

Dr Lee Willett

In the maritime domain, the underwater world is a primary focus in developing unmanned capabilities. Unmanned underwater vehicles (UUVs) emerged initially as a tool for mine counter-measures (MCM) operations, with navies seeking to remove operators from harm's way. The MCM requirement has become increasingly significant, in the context of the Russo-Ukraine war and its strategic effect on Europe's maritime domain.

The UK Royal Navy (RN) is meeting an emerging, urgent operational requirement (UOR) to counter mine-based threats in coastal and offshore waters with the rapid acquisition and delivery into service of RFA *Stirling Castle* (formerly a commercial offshore support vessel). The vessel arrived in January, and has completed conversion work prior to conducting trials. When the ship arrived, the RN said in a statement that underlined the significant nature of the threat that its "capability will assure freedom of access for UK ships and submarines (including the continuous at-sea deterrent)".

In a further statement issued in April as *Stirling Castle* readied for trials, the RN explained that the ship will "harness ... technology using a series of unmanned systems - the joint French-UK Maritime Mine Counter Measures (MMCM) system, the Combined Influence Sweep (SWEEP) system and Medium Autonomous Underwater Vehicles (MAUVs)) to locate, identify and neutralise mine threats."

In parallel with providing MCM capability, UUVs are playing another increasingly significant role in the underwater domain in anti-submarine warfare (ASW), to help counter the growing threat from peer competitor submarine capability. AUVs, for example, feature centrally in operational and technological concepts for building ASW barriers designed to picket maritime choke points.

UUVs' MCM and ASW capabilities are also key in countering risks to critical underwater infrastructure. In other words, conducting seabed warfare.

US NAVY ASSESSES ORCA

To date, using UUVs in these contexts primarily provides defensive capability. However, navies such as the US Navy (USN) are assessing how UUVs can be used in offensive contexts. The USN is developing its Boeing-built Orca extra-large UUV (XLUUV) capability to conduct clandestine mine-laying operations in forward-deployed locations. One Orca is already in the water, conducting sea trials. Such offensive capability will be brought together in 'teaming' constructs between crewed and unmanned systems.

Speaking at the 'West 23' AFCEA conference in San Diego in February, USN Chief of Naval Operations (CNO) Admiral Michael Gilday noted that crewed/unmanned teaming will be integral to building UUVs' offensive capability, particularly given that crewed and unmanned platforms will be operating increasingly in a distributed network. Part of the navy's development process here will involve constructing command-and-control (C2) architectures for integrating crewed and unmanned systems, CNO explained. "This is manned and unmanned teaming .... Whether they're under the sea, on the sea, and in the air, ...

The RFA *Sterling Castle* is the Royal Navy's new asset to carry unmanned mine warfare systems.

we're going to have to bring that orchestra together."

In April, when speaking at the Navy League's annual Sea-Air-Space symposium in National Harbor, Maryland, CNO said the navy is "moving very, very rapidly" to deliver offensive capability for UUVs, highlighting their role in key offensive tasks like ASW and electronic warfare.

GROWING THREAT

The United States is increasingly concerned over the threat that adversary unmanned systems could pose to the security of its own submarines. In March, in testimony to the US House Armed Services Committee on Strategic Forces, General Anthony Cotton, Commander US Strategic Command, stated: "The advancement of unmanned surface and underwater vehicles may soon emerge as a threat to our SSBNs [nuclear-powered ballistic missile submarines] and supporting infrastructure, requiring a comprehensive force protection system to defend both pier-side and in-transit SSBNs."

While the implication of this statement is that USN SSBNs on deterrent patrol in the deep expanses of the North Atlantic and North Pacific oceans remain relatively secure, maritime choke points surrounding port access present a potential vulnerability. In similar geostrategic contexts, Western naval forces may be able to use forward-deployed UUVs to provide sensing or other capabilities to restrict adversary SSBN operations in times of conflict.

UUVs sit centrally in emerging US conceptual thinking about offsetting adversary submarine capability. In a speech at the Royal United Services Institute's (RUSI's) Seapower conference on 27 April, Bryan Clark, senior fellow at the Hudson Institute, and a former USN submariner, pointed to how Russia is developing much quieter SSBNs and nuclear-powered attack submarines (SSNs), along with deploying different types of UUVs, while China is producing nuclear boats in numbers. "The challenge of scale, as well as more sophisticated and quieter undersea threats, is going to challenge our traditional ways of doing ASW," said Clark.

UUVs can provide mass to support traditional ASW concepts, for example providing presence at ASW barriers across key choke points like the Greenland-Iceland-UK Gap. This offers capability to detect, harass, and prospectively attack adversary boats trying to transit such choke points.

Clark also explained how, in the new ASW environment, UUVs can play key roles in offensive operations. "When it comes to offensive undersea operations … the undersea environment is becoming more contested." Here, he explained, Western attempts to push SSNs forward into adversaries' submarine bastions will need to overcome the seabed sensors, submarines, surface ships, and maritime aviation that will be deployed as a layered response.

"This … has created the need for suppression of undersea defences, just like we do suppression of air defences when we conduct strike operations," Clark explained. "The bastions are now something you've got to fight your way into rather than just make your way into …. You're going to have to use unmanned systems increasingly to conduct attacks against undersea infrastructure like undersea sensors … and you're going to have to use decoys and jammers to confuse undersea sensors so you can protect your submarine operations and prevent them from being degraded."

How to suppress undersea defences is something Western forces must think about, Clark continued. "How do we get those [UUVs] in there, how are they going to operate with the manned platforms they're going to be deploying with or protecting, and how do we manage this operation from a C2 perspective?" Clark asked. "These are all challenges we're working through." A

The US Navy's Orca XLUUV programme is being developed to deliver offensive MCM operational capability. Depicted is an artist's rendering of Boeing's Echo Voyager, the platform providing the XLUUV capability under the Orca programme.

US Marines, low-altitude air-defense gunners with 2nd Low Altitude Air Defense Battalion (LAAD), send an electronic signal to jam a drone with the Light Marine Air Defense Integrated System, or L-MADIS, during an exercise on 18 October 2022. The L-MADIS is an electronic-attack system that counters unmanned-aircraft system by non-kinetic means.

BROADENING C-UAS DETECTION AND TAKE-DOWN

While the Counter-Unmanned Aerial Systems developers steadily increase in numbers and expertise, it can be the detection of low, slow and small UAVs that poses the biggest challenge.

Jon Lake


USMC

One of the main contributors to today's ever more congested and contested battlespace is the proliferation of unmanned aerial systems (UAS). Once the preserve of large and sophisticated military forces, and deployed and controlled by higher command echelons, the development of smaller, cheaper, tactical systems means that they can now be deployed at platoon or even squad level. These systems are already being deployed, making life more difficult on the frontline in Ukraine by dropping everything from grenades to small bomblets, for example, having previously seen use against Armenian forces in the Nagorno-Karabakh War.

In this issue's Unmanned Systems listings, more than 90 unmanned aerial vehicles (UAVs) have been included, ranging from man-portable systems with an endurance measured in minutes to aircraft-like, long endurance systems with continental range. And with the rapid development of new systems, and the increasing use of hastily-modified commercial drone systems, the listed aircraft represent the tip of an ever growing iceberg.

At the top end of the UAV 'food chain' many systems can directly deliver effect, attacking targets and launching their own weapons, or on a smaller scale being fitted with a warhead themselves and being used as 'suicide drones' (such as the Iranian-made HESA Shahed 136 being used by Russia against Ukraine).

But even where an unmanned system does not represent a direct lethal threat, it cannot be ignored, as it can provide an enemy with vital intelligence and may be used to cue enemy artillery or an air attack.

In some environments, the mere presence of a drone may represent a threat – unauthorised civilian drone use may present a safety risk in airport/air base environments, because of the risk of collision between manned aircraft and the UAS. A drone incursion at London's Gatwick airport in December 2018 effectively closed the airport for three days disrupting 1,000 flights and more than 140,000 passengers and cost the airport $1.7 million (£1.4 million), with airlines losing even more (an estimated $65m). More recently Gatwick was closed again for nearly one hour on 14 May due to suspected drone activity. Because this latter kind of threat affects commercial airports in peacetime, it has led to the development of dedicated counter-UAS systems that may also have military applications.

Tactical UAS systems offer particular challenges. Group 1 and 2 systems weighing less than 121 pounds (55 kilograms) and operating at 3,500 feet (1,066 metres) or less above ground level, are large enough to represent a lethal threat, while being able to operate from dispersed locations, close to the front line, often well hidden by the clutter of the battlefield and difficult for traditional air defence systems and forward ground based air defences (GBAD) to detect and counter. These defences could also be otherwise engaged, committed to protecting particular critical or high value assets. And they often will be unavailable, as there will seldom be sufficient air defence assets available to protect every potential target.

In Ukraine, it is now recognised that there is always a possibility that a UAS could be watching every move, and this is a constant concern and a psychological burden.

Group 1 and 2 UASs are difficult to detect in the first place, with vertical take-off and landing (VTOL) systems able to operate from restricted and inconspicuous sites, without needing a separate launcher in a large open area and then following an unpredictable flight path. There are now a number of hybrid designs which can take off vertically, but which have fixed wings allowing higher air speeds and longer range.

Serious effort and investment is now being made in the field of Counter-UAS (C-UAS) research and development. In FY2023, for example, the US Department of Defense (DoD) plans to spend at least $668 million on research, and a further US $78 million on C-UAS procurement.

KNOWING WHAT'S THERE

The first step in countering a UAS lies in detecting, identifying and tracking it! This may be far from straightforward, as smaller tactical UAS systems may have only a relatively short mission duration, during which they may represent a very low signature target. Consequently, many smaller UASs cannot be detected by traditional air defence systems due to their size, construction, and flight profile and altitude. Consequently, great attention is being paid to the development of effective detection, tracking and identification sensors, techniques and processes.

There are a range of sensors available that can detect tactical UAS targets, including radar, electro-optical (EO), infrared (IR), acoustic and radiofrequency (RF) sensors, though their small size and limited signature can make them hard to detect, and a combination of sensors can be useful, particularly if fused.

Doppler radars can be well suited to detecting a UAS since they detect speed differences and are thereby able to detect and track moving objects while ignoring or discarding static objects. The Dutch Robin EVIRA, a Frequency Modulated Continuous Wave (FMCW) radar, is a mini-doppler radar that offers accurate and fast tracking with a quick update rate, making it a good choice for finding and tracking small agile targets.

Danish company Weibel Scientific, a specialist radar company with decades of research has developed its Multi-Frequency Surveillance Radar XENTA-series, based on Continuous Wave (CW), Frequency

Weibel's Xenta-C is part of a new generation of X-Band CW-FMCW Counter-UAV drone detection radars particularly suited to the detection, tracking, and classification of low, slow and small (LSS) UAV targets.

Modulated CW (FMCW) and Multi-Frequency CW (MFCW) 3D Air Surveillance and Tracking Radar technology. This dual capability technology has been particularly developed for Short Range Air Defence (SHORAD) requirements, in addition to a lighter version primarily applied for detecting, tracking and classifying Low, Slow and Small (LSS) targets within the C-UAS threat band.

The XENTA-C radars have the ability to distinguish hovering drones from ground clutter through the detection of micro-Doppler generated by the rotors of the drone, allowing drone detection even when just hovering in the air.

Small AESA (active electronically scanned array) radar systems can also be most effective, with the Ascent Vision RADA Multi-mission Hemispherical Radar (MHR) providing a good example of the kind of compact and energy-efficient technology available for detecting small UASs out to a range of 3-4 miles (5-6.5 kilometres). The latest version, the ieMHR from DRS RADA Technologies offers users offers enhanced SWaP-C and On-The-Move operation capabilities.

Optical and electro-optical systems are frequently used in C-UAS systems, including high resolution colour and heat sensing infra-red cameras. Their use is most frequently for providing positive identification, rather than initial target detection. Optical sighting systems are also frequently used for tracking and for aiming whatever weapon is used to engage the UAS target.

Infra-red Search and Track (IRST) can provide continuous scanning to detect targets from their thermal emissions. They can be useful for search and surveillance, and even for target recognition and identification if a target's heat-signature is sufficiently distinctive. The HBH Infrared Systems Spynel-X series of IRSTs has already demonstrated its usefulness for perimeter surveillance. IRSTs are fully passive and are often quite compact, and may be useful against a wide range of threats.

Acoustic sensors, already in use in vehicle-mounted 'shot' and gunfire detection systems have shown some ability to detect the presence and even the bearing of a UAS by its sound signature. When networked, these systems can provide accurate geolocation through triangulation of the detected sound signature. When used in conjunction with a digital threat library acoustic signatures may even be used to identify the specific type of UAS target, giving the operator an idea of threat capabilities and helping with target prioritisation and the selection of the most appropriate countermeasures.

RF (radio frequency) sensors can be used to identify the wireless signals used to control the UAS, using triangulation to accurately geolocate the threat system, and perhaps even its control station. This can allow the control site to be engaged by direct or indirect fires, or even to facilitate the physical capture of the enemy operator and his equipment.

By combining several sensor types, a more effective, layered detection capability can be leveraged, maximising the chances of defeating the threat in the shortest possible time.

Having detected and located a UAS target, the next step is to stop it achieving its mission goals. This can entail physically destroying the drone, or simply preventing it from completing its mission. Both of these approaches are referred to as 'interdiction'.

One of the ways in which a UAS can be 'interdicted' is by jamming – using transmitted electronic energy to disrupt, interrupt or entirely block the communications and control links with its operator, or by interfering with the GNSS/GPS signals on which it relies to navigate. This may cause the drone to crash, or to enter a 'loss of contact' procedure – perhaps simply landing, or perhaps returning to its launch point. Jamming devices can be light enough to be man-portable but are more usually heavier, and limited to use in fixed locations or mounted on vehicles. Some drones may even be disrupted by 'dazzling', especially by using laser energy, effectively blinding them or their sensors.

Alternatively, and arguably more subtly, a UAS may be 'spoofed', with the spoofer takong over the UAS's communications link and sending a false GPS signal that mimics a legitimate signal, duping the onboard GPS receiver.

Jamming or spoofing has the advantage of being effective against difficult targets, including multi-direction swarm attacks, and against manually controlled drones.

Sometimes, though, it may be necessary or desirable to achieve a 'Hard Kill', physically destroying the drone, or capturing it. UASs can be neutralised or destroyed using guns, including by traditional air defence (anti-aircraft artillery) systems. There have even been C-UAS systems based on the use of nets to capture drones in flight, or interceptor drones designed to collide with the target system.

Alternatively, directed energy weapons, including laser or high-powered microwave systems might be employed. High Power Microwave (HPM) Devices are a high cost/high impact technology and use an intense microwave beam sufficiently powerful to destroy a small drone within seconds. They can target either individual drones or even swarms of autonomous drones because they employ a wide beam effective over a wide area. One high-power microwave experiments, the Tactical High Power Microwave Operational Responder (THOR), is being developed by the US Army and US Air Force, to disable swarms of small drones. It is already undergoing testing, with several prototype Leonidas systems built by Epirus.

Often, a co-ordinated combination of systems will be used to achieve a full spectrum C-UAS solution, operating as a system of systems, and including fixed sites, mobile and man-portable systems.

Perhaps unsurprisingly, the US armed forces are at the forefront of Counter-UAS efforts. In December 2019, the US Department of Defense (DoD) named the Army as the executive agent tasked with overseeing the Department's various counter-small UAS (C-sUAS) programmes and developmental. The implementation of a new office, known as the Joint C-sUAS Office, was approved by the Secretary of

Defense on 6 January 2020. The DoD also plans to establish a Joint C-sUAS academy at Fort Sill, Oklahoma by FY2024. This academy will be tasked with synchronising training in counter-drone tactics across all of America's military services.

Up to now, US C-UAS efforts had been piecemeal and largely undertaken by the individual services. The Navy fielded the world's first operational directed-energy weapon, the 30-kilowatt Laser Weapon System (LaWS), aboard the USS Ponce (LPD-15) in 2014. The US Navy also deployed an optical dazzler, Odin, designed to interfere with UAS sensors, and later Helios, a 60-kilowatt laser, aboard the USS Preble (DDG-88) in 2021.

In 2019, the US Marine Corps completed testing of the Marine Air Defense Integrated System (MADIS), mounted on the 4×4 Joint Light Tactical Vehicle (JLTV). There are two MADIS variants, the Mk 1 employing a combination of turret-launched Stinger missiles, a direct-fire weapon (a 30-mm cannon) on a remote weapons station, multi-function electronic warfare capability with an SNC Modi II system, and a Lockheed Martin Electro Optical/Infra-Red (EO/IR) turret. The MADIS Mk 2 is optimised for the C-UAS role, and adds a 360° RADA RPS-42 radar and C2 suite, but lacks Stinger and uses a six-barrelled 7.62-mm M134 Minigun, as its direct fire weapon. The Marine corps also fields the Light MADIS (LMADIS) on Polaris MRZR all-terrain vehicles. These have the same radar and EW suite and served as a testbed and interim C-UAS solution before the fielding of the full standard MADIS Mk1 and Mk2.

As part of its suite of GBAD systems, the US Marine Corps is now procuring the first DoD-approved ground-based laser, the so-called Compact Laser Weapons System (CLaWS), available in 2-, 5-, and 10-kilowatt variants and built by Boeing. CLaWS is a vehicle-mounted laser designed to disable or shoot down small unmanned aerial systems, mounted on the new Joint Light Tactical Vehicle. The CLaWS laser is designed to burn off parts of the drone's body or ignite its onboard fuel supply or explosive warhead, "like applying a blowtorch to a drone," according to one Boeing engineer and taking just 15 seconds for the laser to down a flying target.

The Air Force is heavily involved in a "directed energy experimentation campaign," with a Directed Energy Combined Test Force (DE-CTF) inaugurated at Kirtland AFB in New Mexico in 2018. In October 2019, the Air Force received delivery of a vehicle mounted High-Energy Laser Weapon System (HELWS) C-UAS prototype which then underwent a year-long overseas field test. When connected to a generator HELWS can produce "a nearly infinite number of shots" and the system is now certified for use in combat. Multiple additional systems have now been deployed.

The ieMHR is a cutting-edge, ground-based, multi-mission radar for Counter-UAS, Very Short-Range Air Defense (VSHORAD), Counter Rocket, Artillery and Mortar (C-RAM), and Hemispheric Surveillance operational missions.

Raytheon Intelligence & Space (RI&S) has conducted a capability demonstration HELWS at White Sands, destroying nine Group 1 and Group 2 drones in the live-fire exercise, during which the system was paired with the National Advanced Surface-to-Air Missile System (NASAMS) for firing cues. The USAF is now testing HELWS2 (High Energy Laser Weapon System 2).

While vehicle-mounted systems are now being deployed, man-portable C-UAS technologies have proved problematic. Commandant of the Marine Corps David Berger testified to Congress that they "have not panned out" due to weight and power requirements.

For future threats, the Defense Advanced Research Projects Agency (DARPA) is funding a host of C-UAS technology development programmes intended to develop systems for defeating autonomous systems of the future, including CounterSwarmAI. 🅰

WEAPONS THAT WATCH AND WAIT

Loitering munitions may be increasingly morally questionable, but their effectiveness is undeniable.

Jon Lake

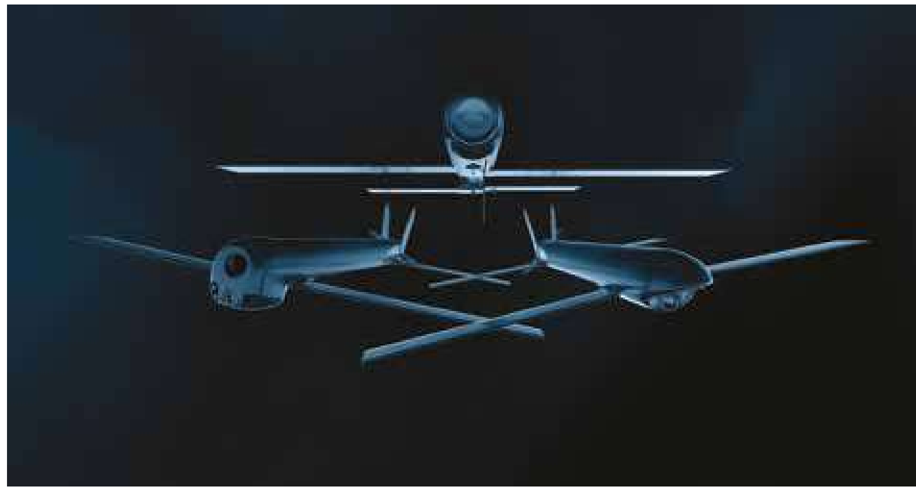
The use of loitering munitions during the 2020 Nagorno-Karabakh war, during Russia's intervention in Syria, and now in Ukraine, have brought this emerging technology into the limelight, demonstrating their potential on the modern battlefield, and highlighting some of the issues surrounding their use.

Loitering munitions are not a new concept, however, dating back to the 1980s, when a number of loitering weapons were developed for use in the suppression of enemy air defences (SEAD) role. Their ability to persist in the target area provided a simple solution to the problem of a target emitter simply being 'switched off' to defeat conventional anti-radiation missiles, since they could wait for the radar to be 'switched back on' and then attack. The IAI Harpy was the classic example of these first-generation loitering munitions. Usually transported and launched from a truck-mounted canister, the Harpy is a 'fire-and-forget' weapon programmed before launch to fly to a pre-defined area, where it then loiters and searches for hostile air-defence radars to attack.

Even before the Nagorno-Karabakh War, some analysts were enthusiastic about the

USMC

US Marine Corps rifleman launches a Switchblade munition during a training exercise at Camp Lejeune, 7 July, 2021. The 1st Battalion, 2nd Marine Division is tasked with testing new equipment, operating concepts and force structures.



Aerovironment's trio of loitering systems: the Switchblade600 (top); the Switchblade 300 (left); and the Blackwing reconnaissance system

potential of this class of weapon, describing loitering munitions as 'a form of unmanned system that will impact the character of warfare more substantially than the introduction of the machine gun did at the turn of the last century.'

The term 'loitering munition' today covers a wide range of weapons, with very different characteristics and roles, and produced at very different 'price points'. Some employ a man in the loop, while others are pre-programmed and a few incorporate some measure of autonomy. All are indirect fire weapons, designed to engage a target without relying on a direct line of sight between the launcher and its target, allowing targets to be engaged even if they are behind cover. Such systems are able to 'loiter' or persist in the target area to engage fleeting or emerging targets, able to receive real-time target information from a range of sources, and able to follow an unpredictable course rather than following a set trajectory like a mortar or artillery round.

Some have compared loitering munitions to airborne landmines, placed into an environment where they are then responsive to characteristics they can detect with their onboard sensors. But this is simplistic, and minimises the military value of this class of weapon. Loitering munitions enable faster reaction times against concealed or hidden time-sensitive targets that may emerge for short periods, and they can be recalled or aborted right up until the final strike, and they do so without needing to place or maintain higher-value carrier platforms close to the target area.

CLOSE FIGHT

The smallest loitering munitions are designed for the 'close fight', providing company or even platoon leaders with an expendable organic strike system capable of precision attacks at beyond-line-of-sight, man-portable and cheap enough to be dispersed around the battlefield with small units and expended at the same kind of rate as mortar or artillery rounds. This kind of loitering munition typically requires only a small anti-personnel warhead or, at most, a warhead capable of disabling a lightly armoured vehicle. They will generally have a range of at least five miles (eight kilometres), and a loitering endurance of 15-45 minutes.

Loitering munitions designed to support the close fight are proliferating globally, and include the class-leading, US-made AeroVironment Switchblade 300, the DefendTex Drone 40, the Elbit Lanius, the

Athlon Avia

The Ukrainian developed Athlon Avia ST-35 Silent Thunder has an operational radius of 30km, a flight time of one hour and can carry a 3.5kg warhead.

The WB Warmate is a self-contained, lightweight loitering munition with an operational radius of 30km and an operational speed of 50 miles per hour (80km/h). It can be deployed by a single user.

IAI Rotem, the Turkish STM Kargu and Alpagu, the Polish WB Electronics Warmate, the UAE's ADASI QX-1, and the Indian EEL Nagastra-1.

The next step on the capability ladder is provided by larger, longer range loitering munitions that may be used against more critical targets in support of a wider campaign, and that give battalions and brigades the kind of capability that is normally provided by modern rocket artillery systems and that are generally reserved for a division or a corps. These systems need a longer loitering endurance – of perhaps 1-3 hours – allowing them to engage critical enemy assets as they unmask. They will also tend to have a longer range, upward of 50 miles (80km). Systems like these have to be capable of destroying almost any battlefield target, and so require robust anti-armour capabilities.

These systems can allow a relatively small, dismounted team to perform some of the tasks of artillery, launching long-range attacks and disrupting operations across an entire theatre by finding and destroying headquarters, resupply convoys, and fuel dumps, and tanks 'dug in' in defensive positions, and not just those exposed during manoeuvre operations. In some respects, loitering munitions challenges longstanding assumptions about the survivability of armoured vehicles, and raises questions about their primacy on a modern battlefield.

The Aerovironment Switchblade 600 is typical of this class of munition. Heavier than the Switchblade 300, it is still man portable, but has a 25 miles (40km) range and a loiter time of over 40 minutes. And it has a warhead capable of killing tanks.

HIGH END, LONG LOITER

The most high-end loitering munitions have loiter times of 6-12 hours and ranges in excess of 100 miles (160KM) These systems are typified by the Israeli Harpy and Harop, and they are generally used to 'shape the battlefield'.

In 2020, Azerbaijan's Harop loitering munitions played a significant role in overwhelming the Armenian military, providing a persistent air threat to Armenian forces with its nine-hour endurance and anti-armour capability. Azerbaijan used its Harops to destroy Armenian air defences and then to attack other heavy equipment, including tanks, with relative impunity.

Cheap enough to be attritable, and usable without risking of costing the lives of expensively trained aircrew, these more exquisite loitering munitions represent an alternative to traditional tactical air power, and can effectively deny the enemy his use of operationally essential terrain.

Unlike traditional unmanned aerial vehicles (UAVs), these kinds of loitering munition are optimised to make quiet, high speed, high angle diving attacks, with forward facing cameras for targeting, and are designed to be single-use, expendable weapons.

These high end loitering munitions, can fulfil a dual purpose as reconnaissance platforms, using their sensors to relay target information back to the operator, and may be sufficiently valuable for recovery options to be considered (usually using a parachute) if they are not expended in an attack.

Not all loitering munitions are aimed at surface targets. In recent years a number of systems have emerged whose primary purpose is to target other unmanned aerial systems. These 'drone killers' include Raytheon's Coyote, and the Transvaro-Havelsan Fedai.

RETURN OF THE KILLER ROBOT

Loitering munitions can hunt for a target under human control, or increasingly may fly autonomously, with authority to strike designated targets or target types, or with a man-in-the-loop giving 'consent' for weapons employment.

Direct human control may not be necessary, or even desirable, since these weapons are designed to operate in challenging battlefield conditions, including GPS-denied environments and in the face of impaired or jammed communications. Instead, they may be programmed to fly around a defined search area autonomously highlighting potential targets to the operator. Once an attack has been consented to, the weapon itself can use AI to select the best attack direction, angle of impact, and timing. It may even be able to select the best target from a group – though this may be getting close to the point at which ethical concerns about the limits of autonomy start to become an issue.

But ethics aside, there is no reason why a loitering munition can't search for and find an enemy convoy at a safe standoff distance, and then decide whether to hit the lead resupply vehicle or another vehicle, and whether to hit it before it reaches a bridge, as it crosses the bridge or after crossing the bridge.

A QUESTION OF ETHICS

For decades, loitering munitions have been at the very outer edge of 'acceptable/permissible levels of autonomous lethality'.

While they were primarily targeted against air defence radars, this didn't matter much, but as they are increasingly being used to target humans (whether soldiers or insurgents) they are increasingly raising moral and ethical concerns, and could even be seen as having the potential to violate international humanitarian law.

Loitering munitions that are capable of making autonomous, 'man out of the loop' attack decisions are particularly problematic, because no human being is involved in making the actual decision to attack and potentially kill other humans. Many missiles can be locked on after launch or may be sensor fuzed, but they tend to have a very limited flight time, and will only be launched where enemy activity is underway, whereas an autonomous loitering munition may be launched at an area where enemy activity is only probable, and will then loiter (potentially for hours) searching autonomously for targets. Many believe that such weapons should be subject to the same sanction as landmines that cannot discriminate between legal military combatants and innocent civilians.

Some have called for moratoria or limits on use, while others have called for direct human input into targeting and consent for attack, effectively making autonomous weapons subject to human supervision. It has been argued that this would undermine the military utility of these weapons, especially in GPS-denied or communication-degraded environments.

It should come as no surprise that both sides have made extensive use of loitering missions in the war in Ukraine.

Russia's autonomous Lancet, made by Kalashnikov subsidiary the ZALA Aero Group was used in Syria in 2021 by Russian special operations forces, and the latest Lancet-3M variant is claimed to have destroyed 10 towed artillery guns, seven self-propelled guns, six surface-to-air missile launchers, four radar vehicles, and a radio relay station used to control Bayraktar TB2 drones, together with six hits on tanks and eight on armoured personnel carriers and other light armoured vehicles.

Russia has also been using the ZALA Kyb munition, but this has reportedly enjoyed little success, some failing to detonate and others being brought down by Ukrainian air defence systems or by electronic warfare systems.

Ukraine has been supplied with large numbers of AeroVironment Switchblade 300 systems, (each consisting of a handheld ground control station, a launcher, and several Switchblade air vehicles) with at least 700 delivered. The US Department of Defense (DoD) then procured the larger Switchblade 600 system for Ukraine. This incorporates an anti-armour warhead for use against larger, hardened targets. The US government has also supplied the Phoenix Ghost family of systems which are reportedly similar to the Switchblade system but with a longer endurance of more than six hours and effective against medium armoured vehicles, which it can target by day or night using infrared sensors.

Ukraine has also developed and deployed its own loitering munitions, including the electrically powered, catapault-launched CDET RAM II, and the UAV-launched Athlon Avia ST-35 Silent Thunder.


IAI

The IAI Harop was used by Azerbaijan's forces against the Armenian military, providing a persistent air threat due to its nine-hour endurance and anti-armour capability.

SHAHEDS IN UKRAINE

The most prominent loitering munitions used in Ukraine have been the Iranian-built Shahed-131 and 136 UAVs supplied to Russia and named Geran 1 and 2 in Russian service, though these delta-wing missiles rely primarily on GNSS or GPS satellite-based navigation systems to attack specific geographic co-ordinates, and do not loiter while searching for targets using their own onboard sensors. This means that they are effective only against pre-selected stationary targets and act as 'kamikaze' drones and not as true loitering munitions. The Shaheds seem to have been used principally against civilian targets and particularly against Ukraine's electricity infrastructure. There is some evidence that Russia has started to employ these weapons in tandem with Mohajer-6 'spotting drones' operating as an integrated reconnaissance-strike complex. The 'spotter' relays target co-ordinates to the Shahed or to a centralised UAV command unit, reducing the delay between target identification and engagement and allowing the Shaheds to be used against mobile or even moving targets. It is unlikely that Russia has the capacity to establish these procedures widely or routinely, or to regularly deploy UAVs and loitering munitions together in the near term, at least.

The military utility of loitering munitions, as demonstrated in Nagorno-Karabakh and now Ukraine seems likely to stimulate demand for these systems, though a growing public distaste for autonomous unmanned systems ('killer robots') accompanied by questions and concerns about the morality of their use could still blunt this demand. The performance of these systems on a modern battlefield, in the face of heavy countermeasures and denied communications, remains to be fully assessed. 🅰

EMBRAER PREDICTS INTERNATIONAL C-390 TACTICAL TRANSPORT GROWTH

In May, *Armada International* was invited to learn of Embraer's plans for international growth during a visit to its subsidiary OGMA's MRO and production facility at Alverca in Portugal.

David Oliver

Embraer

Embraer President and CEO, Defence & Security Bosco da Costa expects around 490 orders of its C-390 tactical transport.

Embraer's President and CEO, Francisco Gomes Neto announced in Portugal that the Brazilian aerospace manufacturer had a profitable 2022. It registered a 19 percent increase in revenue and an order backlog of $17.46 billion, although he added that there had been challenges with the supply chain. In 2023 the Defence & Security revenue is up by 50 percent on 2022 and is growing towards the $1 billion milestone.

The President and CEO of Embraer Defense & Security, Bosco da Costa Junior, told AI that the company was predicting the sales of 490 C-390 Millennium tactical transport aircraft worth a potential $60 billion. With sales of 31 Millennium, which achieved Full Operational Capability (FOC) in March this year with the Brazilian Air Force, the sale of five NATO configured aircraft to the Netherlands to replace its Lockheed Martin C-130H Hercules, was significant. The C-390M scored higher than the C-130J on a number of operational and technical requirements, it requires less maintenance and can provide more effective flights hours, and the estimated life-cycle costs are within the allocated budget.

South Africa as well as Austria, the Czech Republic, Egypt, India, Rwanda, South Korea, and Sweden are potential buyers for the KC-390. A Brazilian Air Force KC-390 was demonstrated to the

Embraer President and CEO Francisco Gomes Neto briefing at OGMA.

Embraer

Portuguese Air Force Airbus C-295 undergoing MRO at OGMA's Alverca engineering facility.

Peruvian military high command during the multinational Cooperation IX exercise that took place in May. Earlier this year, an order placed by Peru for An-178 military transports was cancelled by the Ukraine manufacturer Antonov following damage to production facilities after Russia's invasion. With a team including Raytheon Technologies and L3Harris, Embraer have responded to a Request for Information (RfI) for the USAF 's Agile Tanker programme with the KC-390 equipped with a flying boom, which according to Bosco da Costa Junior, highlights the flexibility for the Millennium's development. The company recognises the new Brazilian government's support of its international defence campaigns

He also introduced the latest development of the Super Tucano which is in service with 16 air forces worldwide. The NATO compatible multirole A-29N will include equipment and features to fulfil NATO's operational requirements, such as a new datalink and single-pilot operation.It is being marketed as an advanced trainer or light attack aircraft with potential sales of $6.5 billion.

The Defense & Security division is also leveraging on the success of Embraer's executive jets including the Phenom 100 in the military multi-engine training role and the Praetor in the Airborne Early Warning (AEW) and MRI roles.

MILITARY MRO

With more than 100 years of experience, OGMA Services & Support division includes MRO, modifications, engine overhauls, composites production and aerostructures. Employing 1,700 personnel its defence aviation unit has more than 60 customers from 30 countries and a services contract backlog of nearly $2.7 billion. It carries out checks, repairs and modifications on C-130H, P-3, AC-295, Embraer ISR, Super Tucano and F-16 aircraft,

as well as SA330 Puma and EH-101 helicopters. In future OGMA will be responsible for full KC-390 fleet support, including heavy checks, avionics, major structural repairs and engineering and logistic support.

Its main customer is the Portuguese Air Force and it is currently carrying out Mid-Life Updates (MLU) to three F-16AMs to Block 70 configuration, a task that will take over 20,000 man hours over three years. The MLU will extend the life of the F-16s from 5,000 to 8,000 hours and may be applied to the rest of the fleet.

Its engine MRO unit covers Rolls-Royce T56 turboprops, and AE1107 turboshafts which power the Bell/Boeing V-22 Osprey and the PW127 turboprops. A new test bench facility is being built to opens the possibility for the addition of the A400M's TP400 turboprop.

The aerostructures unit contributes 25 percent of Support & Services revenue producing composite structures including the central fuselage of the Airbus C-295, currently building those destined for the Indian Air Force, and the central fuselage, elevators, sponsons and doors for the C-390 Millennium.

While Embraer's success had been built on the sales of more than 2,000 E-Jets and 1,650 executive jets, it military sector, boosted by the production of the Saab Gripen E, is experiencing healthy growth. A

Embraer has launched a NATO compatible version of its Super Tucano, the A-29N.