MDC2 & ISR Market Report

Multi-Domain Command and Control and Intelligence, Surveillance and Reconnaissance Report

Defence iQ

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EDITORIAL FOREWORD

George Washington the first president of the United States was also America's first intelligence chief. During the revolutionary war, Washington spent more than 10 percent of military funding on intelligence-related activities.

After returning to England with the defeated British army, London newspapers quoted Maj. George Beckwith, the head of British intelligence operations in the colonies as saying, "Washington did not really outfight the British, he simply outspied us."

Despite that seemingly being Maj. Beckwith's responsibility to counter, you will be pleased to hear he continued to rise through the ranks, attained the full rank of General and died Sir George Beckwith in 1823.

The scouts and spies of the 18th century were also no new invention. Shortly before Julius Caesar was stabbed to death he was handed a list of conspirators. His intelligence network had delivered their product. He may perhaps have survived if he had read and acted on it.

This report lists some slightly more contemporary trends in MDC2 & ISR as well as many key developments in what is a buoyant market. However, history should serve as a reminder that the latest gadget, technique and method is only a part. Adversaries must be countered, and information must be acted upon in order to yield results.

Failure to do so may go unpunished for certain individuals (I'm looking at you Gen. Sir George) but could also result in decades of turmoil and overturn the *status quo.*

Read with care.

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Defence iQ

GLOBAL TRENDS

The prospects for the global multi-domain command and control (MDC2) and intelligence, surveillance and reconnaissance (ISR) systems market is positive, despite the likely impact of the Covid-19 pandemic on defence budgets. The development of MDC2 is a critical enabler for wider multi and cross-domain operational concepts, providing effective command and control beyond single or joint domain constructs.

While ISR, including the development of persistent capabilities, is central to domain and battlespace awareness and the find, fix, track, target, engage and assess (F2T2EA) process. The deteriorating global strategic environment, highlighted particularly by the resurgence of great power rivalry, the re-emergence of a Russian challenge to international security, regional instability in the Middle East, and the emergence of grey zone threats, is prompting the development of multi-domain operational concepts, including investment in new command and control (C2) and ISR capabilities.

The US is the lead example of Western investment with its pursuit of Joint All-Domain Operations (JADO), underpinned by a Joint All-Domain Command and Control (JADC2) architecture. China, as part of its comprehensive military modernisation efforts, is pursuing the development of all-domain and 'intelligentised' operations capabilities, whilst Russia's ongoing military reforms are inherently multi-domain in nature.

Emerging from the US Army's earlier thinking on Multi-Domain Battle, Multi-Domain Operations (MDO) are argued as constituting:

> "Operations conducted across multiple domains and contested spaces to overcome an adversary's (or enemy's) strengths by presenting them with several operational and/or tactical dilemmas through the combined application of calibrated force posture; employment of multi-domain formations; and convergence of capabilities across domains, environments, and functions in time and spaces to achieve operational and tactical objectives".

MDO however, was replaced by the concept of Joint All-Domain Operations in early 2020. JADO are defined as:

> "Comprised of air, land, maritime, cyberspace, and space domains, plus the EMS [electromagnetic spectrum]. Actions by the joint force in all domains that are integrated in planning and synchronized in execution, at speed and scale needed to gain advantage and accomplish the mission".

Similarly, Japan has articulated in its Medium Term Defense Program (FY 2019 - FY 2023), its plans for the Multi-Domain Defense Force, which:

> "organically fuses capabilities in all domains including space, cyberspace and electromagnetic spectrum; and is capable of sustained conduct of flexible and strategic activities during all phases from peacetime to armed contingencies".

Capability development, in this regard, 'will further promote joint-ness of the Ground, Maritime and Air Self-Defense Forces in all areas and, avoiding stove-piped approach, optimize their organizations and equipment'.

In essence, multi-domain operations seek to harness the effectiveness of the individual services operating in their respective domains (that is, air, land, sea, plus space and cyber), the potential of cross-domain effects, and the agility – and with it, ability to outmanoeuvre an adversary (physically and cognitively) – that such a posture brings. Such a capability will be dependent on C2 and ISR architectures that can confer the necessary information and decision-making superiority on which the concept as a whole depends.

Members of the 6th Special Operations Squadron use a tablet to upload coordinates during an exercise showcasing the capabilities of the Advanced Battle Management System at Duke Field, Fla., Dec. 17, 2019. During the first demonstration of the ABMS, oper

AIR

Within the air domain, there are three key trends influencing the development of MDC2 and ISR capabilities: a shift toward distributed, multi-domain sensor architectures, or the Combat Cloud; the development of multi-mission ISR platforms; and the continued development of unmanned air systems. The latter includes the emergence of high-speed (supersonic and potentially hypersonic) air vehicles such as the Chinese WZ-8, unveiled at the 1 October 2019 National Day Parade in Beijing. Investment in new C2 and ISR capabilities is being driven principally by the deteriorating geopolitical environment, the requirement to develop enhanced situational awareness (for example, to counter grey zone and non-state security threats), and the replacement of legacy systems. In this regard, NATO, South Korea and Australia have announced plans to acquire replacement airborne warning and control systems (AWACS), whilst additional customers for the P-8A Poseidon maritime patrol aircraft are likely.

The development of multi-role ISR platforms may thus enable the rationalisation of aircraft fleets. The Saab GlobalEye airborne early warning and control system (AEW&C) is intended to provide air, maritime and ground surveillance in a single platform. Moreover, a potential implication of a shift to distributed sensor architectures is that an AWACS-type platform becomes redundant. An added advantage of a distributed sensor network approach to battlespace surveillance would be a reduced reliance on high-value and vulnerable platforms such as the current AWACS, Joint Surveillance Target Attack Radar System (JSTARS), and Rivet Joint electronic intelligence aircraft. Russia and China are both developing and deploying systems, including very-long-range air-to-air missiles such as the R-37M (AA-13 Axehead) and the PL-17/PL-XX, which are intended to target key enablers such as air-to-air refuelling and ISR aircraft.

Unmanned air systems continue to be a major area of investment and constitute a competitive market with multiple suppliers. The recent use of Turkish UAVs in the ISR and strike role in Libya was described by the British Secretary of State for Defence, Ben Wallace, in a speech at the July 2020 Air and Space Power Conference, as 'game changing'. The utility of UAVs in the multi-domain battlespace will likely grow significantly over the coming decade as new technologies and operating concepts are employed, namely, the use of artificial intelligence (AI), manned-unmanned teaming, stealth, and supersonic or hypersonic air vehicles. In this regard, Russia intends to deploy from 2024 the Sukhoi S-70 Okhotnik, a stealth unmanned combat air vehicle (UCAV), which will operate in the reconnaissance and strike roles, whilst China is developing and may have deployed the WZ-8, an air-launched high-altitude, high-speed reconnaissance UAV.

Key Developments

- Australia published its *2020 Defence Strategic Update* and *2020 Force Structure Plan*. This detailed with regard to airborne ISR, plans to acquire additional manned and unmanned air systems, including the MQ-9B Sky Guardian, an eventual replacement for the EA-18G Growler, the expansion of the Jindalee Operational Radar Network, ground control systems to operate in a contested electromagnetic or heavily defended environment, and the upgrade and eventual replacement of the E-7 Wedgetail AEW&C aircraft. A third MQ-4C Triton high-altitude long-endurance UAV was also ordered in June 2020; Australia plans to acquire six Tritons and associated ground-control systems, worth a total of AUS$6 billion. The prototype of Boeing Australia's Loyal Wingman unmanned combat air vehicle, developed for the Airpower Teaming System, was rolled out on 5 May 2020. The Loyal Wingman will have an operational range in excess of 3,700 km and feature a modular, snap on/off reconfigurable nose capable of carrying multiple payloads and sensors. Utilising artificial intelligence, the system will undertake a variety of roles, including ISR.

- Belgium has ordered four MQ-9B SkyGuardian UAVs and two ground stations from General Atomics, via a Foreign Military Sales contract worth $189 million.

- The first Royal Canadian Air Force (RCAF) CP-140 Aurora upgraded to Block IV standard made its first flight, announced by the RCAF on 21 February 2020. Full operational capability should be attained by September 2022.

- China continues to develop its airborne ISR capabilities, unveiling in January a new three-engined variant of the Tengden TB001 armed UAV, whilst in July 2020, it was announced that a maritime variant of the China Aerospace Science and Technology Corporation CH-5 UAV had performed its first flight. The WZ-8 air-launched, high-speed ISR UAV is believed to have entered service. Development of an AEW&C variant of the Y-20 strategic transport aircraft was confirmed in February 2020.

- France has begun development of a new airborne signals intelligence (SIGINT) capability, ARCHANGE, which will replace the current two C-160-based systems with three modified Falcon 8X from 2025. The mission payload will be provided by Thales. The Direction Generale de l'Armement (DGA) awarded Thales and Thales Alenia Space a contract to conduct a concept study for the use of a Stratobus airship-based high-altitude pseudo satellite (HAPS) for ISR.

- Germany has cancelled a planned $2.5 billion acquisition of four MQ-4C Triton UAVs for its PEGASUS, or Persistent German Airborne Surveillance System, opting instead to acquire Bombardier Global 6000 aircraft to fulfil the SIGINT requirement. EUR75 million was approved in July 2020 for the procurement of three Bombardier Global 6000 aircraft for the role.

- On 6 May 2020, it was announced that Greece will lease three IAI Heron UAVs for a period of three years with an option to buy at the end of this period. Configured for maritime surveillance, the Herons will principally operate in the border defence role.

- In November 2019, the Indian Ministry of Defence's Defence Acquisition Council revalidated the Acceptance of Necessity for the acquisition of an indigenous AEW&C system, which will be integrated with Airbus A330 aircraft. India's planned procurement of 30 MQ-9B Guardian UAVs may be deferred; ISR systems form part of the bilateral US-India Defence Technology and Trade Initiative.

- IAI unveiled the Heron Mk II UAV, featuring improved performance and new sensor payloads, at the Singapore Airshow, and may pitch the system to the Republic of Singapore Air Force. In June, it was reported that IAI had secured a contract with worth $350 million with an unnamed European state for a special mission aircraft, potentially an upgrade for or an additional order for Italy's G550 Conformal Airborne Early Warning Aircraft.

- Japan's Technical Research and Development Institute has been undertaking work since 2016 for a potential indigenous AEW&C capability to replace its E-2C/D Hawkeyes in the 2030s; a variant of the Kawasaki P-1 may be an option. The Air Development and Test Command is undertaking research and development work on two key programmes: a next-generation air defence radar system incorporating distributed multiple-input/multiple-output technology intended to detect stealthy threats and a C-2-based SIGINT platform. Japan may cancel plans to acquire the RQ-4 Global Hawk due to concerns over the system's cost, survivability, and lack of a maritime surveillance capability.

- The Republic of Korea Air Force (RoKAF) introduced into service its first RQ-4B Global Hawk in December 2019: a total of four are to be acquired. The second RQ-4B arrived in South Korea in April. On 26 June 2020, the Defense Project Promotion Committee approved plans to acquire an undisclosed number of AEW&C and SIGINT aircraft. The RoKAF intends to establish a new reconnaissance squadron in late 2020 ahead of the first deliveries of the indigenous Mid-Altitude UAV (MUAV) due in 2021.

- NATO hopes to achieve initial operating capability (IOC) with its Alliance Ground Surveillance RQ-4D Phoenix UAVs by the end of 2020. NATO has also begun preparatory work toward the eventual replacement in the 2030s of its current force of 14 E-3A AWACS.
- Poland's latest Technical Modernization Programme unveiled in October 2019 includes a dedicated ISR programme covering air and space platforms.

- Russia is investing in developing multiple UAVs, manned-unmanned teaming and integrating UAVs into its wider reconnaissance-strike capabilities. In 2019, it was reported that Iskander missile brigades had received Orlan-10 UAVs for targeting support, whilst the Altius-M high-altitude, long endurance UAV will also contribute to supporting precision strike operations. Another Altius variant, the Altius-RU is under development: it will be a reconnaissance-strike asset, incorporate 'elements of AI', and cooperate with manned aircraft. In April 2020, the first Orion medium-altitude, long endurance UAS was delivered for operational evaluation, comprising three UAVs and associated ground control station. Russia also intends to deploy across UAVs

and its bombers, the OSNOD communications, data exchange, navigation and identification system under development for the Sukhoi Su-57 Felon fighter.

- Saudi Arabia is developing in conjunction with BAE Systems, the PHASA-35 HAPS, which has made its first flight (reported by BAE Systems on 17 February 2020). A formal development programme may follow.

- Spain is due to introduce into service in early 2021 MQ-9B Reaper Block 5 UAVs, and its involvement in the Franco-German-Spanish Future Combat Air System will focus on the Remote Carriers/loyal wingmen component. ISR will be a key role for those loyal wingmen.

- The UAE received its first of three Saab GlobalEye AEW&C aircraft in early 2020, as announced on 29 April. The UAE also has the ongoing Project Dolphin, involving the conversion of two Bombardier Global 6000 business jets for an undisclosed special mission, i.e., ISR, role.

- The Royal Air Force declared IOC for the P-8A Poseidon MRA1 maritime patrol aircraft on 1 April 2020. On 15 July 2020 at the Virtual Air and Space Power Conference, a deal to acquire the first three Protector (a UK-specific variant of the MQ-9B, UAVs) worth £65 million was announced by the Secretary of State for Defence. An initial batch of 16 are sought, with a requirement for 20; the first Protectors are due to enter service in 2024. In addition, on 15 July, the Royal Air Force showed how a planned multi-domain Combat Cloud will function, with a Voyager acting as an airborne cloud hub for testing purposes. The UK will face a capability gap following the planned retirement of the Sentinel Airborne Stand-off Radar system in 2021: options to meet the Persistent Wide Area Surveillance (Land) role are being reviewed. The Chief of the Air Staff also announced on 15 July that trials of swarming drones and loyal wingmen under the auspices of 216 Squadron, the RAF's experimental squadron exploring swarming and related concepts, will commence flight trials from the *Queen Elizabeth*-class carriers before the end of 2020.

- The US Air Force (USAF) is developing its Advanced Battle Management System (ABMS) and may advocate for it to provide the foundation for JADC2. In 2018, the Next Generation ISR Dominance Flight Plan 2018-2028 was approved and is intended to position the USAF for operations against high-end adversaries and exploit emerging and disruptive technologies. The USAF has awarded Lockheed Martin a $50 million contract for an Avionics Tech Refresh for the U-2S, which will enable the aircraft to integrate with systems across domains; it is the first component of a wider programme, Dragon STAR (Sensors Technology and Avionics Refresh). On 3 June 2020, the USAF issued a request for information for a next-generation medium-altitude UAV for the ISR and strike roles and is also interested in a potential follow-on to the MQ-9 Reaper. The US Navy announced on 26 January 2020 that it has deployed the MQ-4C Triton Broad Area Maritime Surveillance UAV for the first time. This initial deployment is from Andersen Air Force Base on Guam and supporting operations in the Indo-Pacific. The US Army has deployed a Bombardier Challenger 650 as part of the Airborne Reconnaissance Target Exploitation Multirole Intelligence System (ARTEMIS), a component of Army efforts to develop a jet-powered fixed-wing

ISR capability under the Multidomain Sensor System programme. ARTEMIS is intended to support the High-Accuracy Detection and Exploitation System (HADES): the US Army intends to begin acquiring aircraft from Fiscal Year 2023.

The sun rises over an MQ-9 Reaper remotely piloted aircraft at Holloman Air Force Base, N.M., Dec. 16, 2016. The 49th Aircraft Maintenance Squadron supports the 6th Reconnaissance Squadron as well as the 9th and 29th Attack Squadrons, enabling the graduation of pilots and sensor operators in support of the Air Force's largest formal training unit. Additionally, Airmen with the 49th AMS continuously deploy in support of intelligence, surveillance and reconnaissance requirements. (U.S. Air Force photo by J.M. Eddins Jr.)

LAND

The evolving operational environment, in particular the resurgence of great power rivalry, and with it a shift from a focus on counter-insurgency operations to high-intensity combat against peer threats, prompted the development within the US Army of the concept of Multi-Domain Battle. This subsequently evolved into Multi-Domain Operations and then Joint All-Domain Operations. Whilst the Russian use of 'little green men' in its annexation of Crimea in 2014 highlighted the challenge posed by grey zone, or sub-threshold, threats. For land forces, developing multi-domain ISR capabilities enhances both effectiveness within the specific domain and contributes to wider operational effectiveness. For example, the US Army and Marines Corps have experimented with ground-launched anti-ship missile strikes; this was vividly demonstrated in the 2018 Rim of the Pacific (RIMPAC) exercise in which a US Army HIMARS rocket artillery system was used as part of a multi-domain anti-ship exercise. The US Army, as part of its efforts to deploy an enhanced post-INF (Intermediate-range Nuclear Forces) Treaty long-range strike capability, is developing an AI-enabled all-domain kill-chain, bringing together a network of sensors with planned and already-fielded long-range artillery and missiles. It is intended that this capability will enable the US Army, alongside the other US armed services, to overcome anti-access and area denial threats, including degrading an adversary's air defences or anti-ship forces constraining Air Force or Navy operations.

The proliferation of air and missile threats, ranging from small unmanned air systems through to advanced ballistic and cruise missiles, will require enhanced integrated air and missile defence (IAMD) capabilities to counter such threats. A robust ISR capability will be central to IAMD in order to provide the critical F2T2EA necessary to defeat complex threats. The US Army is developing its IAMD Battle Command System (IBCS), which is intended to link Army, and eventually other service assets, and radars with air and missile defence systems. It is intended that ICBS will form a component of the wider JADC2 architecture. As with the air domain, new technologies such as AI and machine learning, and unmanned systems will play an increasingly important role in land-based ISR: the development of nano and small UAS will, for example, provide improved situational awareness, whilst unmanned ground vehicles (UGVs) could provide forward scouting in high-risk areas. Further, as in the air domain, adversaries will likely focus on the targeting of ISR assets in order to undermine situational awareness and gain advantage: this is highlighted by the proliferation of long-range precision strike systems, such as the Russian Iskander-M tactical ballistic missile which is intended to target C2 posts. In this context, a distributed C2ISR architecture will potentially offer enhanced resilience in the face of targeting.

Key Developments

- In its *2020 Force Structure Plan*, Australia affirmed the importance of 'technologically advanced, networked and integrated systems – including land intelligence, surveillance and reconnaissance and electronic warfare capabilities – for joint and coalition operations'. Continued investment in battlefield command, control, communications and computer (C4) systems, battle management systems and deployable computer networks is planned.

- An upgraded version of the Israel Defense Forces' (IDF) Digital Army Program C4I system, developed by Elbit, and intended to provide a multi-domain and branch capability, entered service in early 2020.

- Japan will establish a new electronic warfare unit in March/April 2021 to contribute to the defence of its southern islands. The unit will undertake roles including the detection of adversary air and naval communications and radar emissions, jamming, and defending Japanese Ground Self Defense Force communication links. A truck-mounted Network Electronic Warfare System to be procured in 2020 and intended to undertake electronic reconnaissance and degrade adversary C3 may be linked to the new unit.

- The Russian Ministry of Defence announced on 21 March that Orlan-10 UAVs had been integrated with 2S5 152mm self-propelled howitzers in the Eastern Military District to assist with targeting. A weather radar system has also been utilised to further improve accuracy.

- In Exercise Clockwork held in Norway in March 2020, Royal Navy Wildcat and British Army Apache helicopters conducted joint operations as part of Attack Reconnaissance Teaming, whereby Wildcats locate targets utilising their reconnaissance capabilities for Apaches to prosecute.

- The US Army is pursuing multiple MDC2 and ISR programmes (for example, the aforementioned Multi-Domain Sensor System) under the rubric of developing its contribution to JADO. In 2019, the US Army established an ISR Task Force, which is focused on four modernisation priorities: space; the multi-domain sensor system; terrestrial layer system (connecting SIGINT, electronic warfare and cyber capabilities in a holistic information warfare capability); and the tactical intelligence targeting access node (TITAN) to form an integrated sensor-shooter network for JADO. On 1/2 July 2020, an Orange Flag Evaluation saw the US Army and Air Force demonstrate the ability to integrate F-35 ISR data with a U-2 and IBCS, whilst in August 2020, in an exercise at the White Sands Missile Range, IBCS successfully orchestrated the interception by Patriot PAC-3 missiles of two cruise missile targets in a jamming environment.

MARITIME

In the maritime domain, the evolving geopolitical environment, in particular the growing strength of Chinese maritime power and the resurgence of the Russian Navy, is prompting navies in Europe, the Asia-Pacific and the US Navy and Marine Corps to develop new technologies and operational concepts. In order to counter the threat posed by Chinese and Russian A2/AD, the US Navy is pursuing the development of Distributed Maritime Operations, whilst the Marine Corps is exploring Expeditionary Advanced Base Operations (EABO), whereby expeditionary ISR, anti-ship, IAMD, and aviation capabilities are forward deployed to austere locations. A2/AD and counter-A2/AD approaches are both dependent on supporting MDC2 and ISR capabilities to ensure battlespace awareness, provide F2T2EA and effective command and control over dispersed assets in order to provide concentrated effect.

The prosecution of long-range precision strikes, especially against mobile or relocatable targets, is dependent on a robust supporting ISR capability and an area where manned-unmanned teaming will be increasingly important. Russia has undertaken tests using Forpost UAVs to operate in conjunction with aircraft to locate and attack ships and submarines, plus in April 2020, a Forpost provided targeting data to a submarine for an anti-ship strike. Moreover, Russia intends to utilise the Iskander tactical ballistic missile as a component of a reconnaissance-strike capability whereby UAVs and other ISR platforms provide targeting data, including whilst the ballistic missile is in flight for retargeting, to prosecute strikes against mobile targets including ships.

Investment in maritime ISR capabilities is also being driven by the requirement to enhance maritime domain awareness (MDA). The growing importance of littoral areas for economic activity, increasing criminal use of the sea (for purposes such as people, arms and drug smuggling), and grey zone challenges associated with contested maritime rights, access and territorial claims highlights the importance of MDA. Japan's Medium Term Defense Program (FY 2019 - FY 2023) defines investment in persistent ISR 'at sea and in the air around Japan' as a core priority, integrating surface vessels, submarines, manned ISR aircraft, UAVs, mobile air defence radars and over-the-horizon radar systems. This is intended to counter both traditional military threats and grey zone challenges.

There is growing interest in and efforts to develop unmanned systems for maritime operations. China, Russia, the US, UK and others are pursuing advanced unmanned underwater vehicles (UUVs); the US, UK and China are developing carrier-borne UAVs; and a number of countries, including China, the US, UK, and Israel are developing unmanned surface vessels (USV), including armed vessels. The use of AI for various applications in maritime systems is being explored, for example, AI-enabled C2, missile

systems, and unmanned systems. Manned-unmanned teaming is likely to be a key element of future maritime forces, including for ISR, where long-range UAVs could provide a persistent outer early warning and surveillance capability as part of a distributed network architecture. The US Navy's Naval Integrated Fire Control-Counter Air (NIFC-CA) is an example of such an architecture.

Key Developments

- Australia, as outlined in its *2020 Future Structure Plan*, is investing in systems to enable decision superiority in the maritime domain, including 'enhanced secure satellite communications, advanced tactical networks, mission data support for surface combatants and new acoustic analysis capabilities'. It was also announced on 4 August 2020 that Australia will adopt a five-yearly investment cycle from 2024 to enhance its maritime UAS capabilities. From 2024 to 2028, the Royal Australian Navy will acquire UAS to be embarked on its *Anzac*-class frigates and the *Arafura*-class offshore patrol vessels.

- The French DGA confirmed that the Schiebel Camcopter S-100 unmanned air system (UAS) has been integrated with the *Mistral*-class LHD, *Dixmude*, allowing the video output from the UAS to be fed to the ship's combat information system, enhancing its ISR capabilities.

- The German Navy has begun trials aboard the K-130 corvette *Braunschweig* of a Skeldar V-200 unmanned rotary-wing air vehicle. This follows a 2018 contract for the supply of a V-200 air system comprising two air vehicles, the ship-air interface and training of personnel. It is intended to provide the German Navy with an unmanned airborne reconnaissance system.

- On 1 April 2020, the Republic of Korea Defense Acquisition Program Administration announced the development and installation of a port surveillance system to detect, identify and respond to low-noise underwater threats approaching South Korean ports.

- On 10 June 2020, the Russian Central Design Bureau for Marine Engineering disclosed that it is working on a network of unmanned underwater, surface and air vehicles in order to provide early warning and control and enhance other capabilities. This reflects wider Russian interest in the development of network-enabled reconnaissance strike capabilities as part of its efforts to develop precision strike forces.

- The UK Royal Navy First Sea Lord, Admiral Tony Radakin on 5 March 2020 disclosed the award of a contract worth £1 million to MSubs for the development of a manned S201 submersible to serve as a testbed for an extra-large unmanned underwater vehicle (XLUUV). It is intended to inform thinking on the contribution of an XLUUV capability to anti-submarine, ISR and other maritime operations.

- The US Navy has requested $280 million for Fiscal Year 2021 to support ISR sensors and processor development as part of its information warfare capabilities. The US Navy is also pursuing the development of a Medium Unmanned Surface Vessel, or MUSV, which will undertake C4I and electronic warfare roles as part of a distributed sensing capability. This reflects the wider US Navy interest in the development of Distributed Maritime Operations. On 13 July 2020, the US Navy awarded L3 Technologies a $35 million contract to develop a prototype MUSV; if options for a further eight vessels are exercised, the contract value will increase to $281 million. The US Navy has awarded Logos Technologies a $6.7 million contract for the delivery of two prototype wide-area motion imagery (WAMI) sensors to equip the RQ-21 Blackjack UAV. The integration of a WAMI sensor on the Blackjack would enable it to simultaneously monitor 5 square miles, providing the US Navy and Marine Corps with a significantly enhanced tactical ISR capability. The US Marine Corps is developing a Marine Corps ISR Enterprise (MCISRE) 2025 strategy to pursue innovation and disruptive technologies in support of the Marine Corps' evolving mission. ISR will be central to EABO. The Marine Corps also works with the US Navy on unmanned surface vessels, utilises Navy airborne assets and its own F-35s.

SPACE, CYBER AND EMERGING TECHNOLOGIES

Alongside the traditional environmental domains – air, land, and maritime, the 'new' operating domains of space and cyber are of increasingly critical importance. Both the space and cyber domains play a central role in MDC2 and ISR and are growing markets. Three particular trends warrant mention with regard to the space domain: the development of low-cost space access; the impact of great power rivalry on space access and use; and the growing number of states with or seeking militarily relevant space capabilities. Commercial actors, for example, Virgin Orbit and SpaceX, are developing low-cost space access capabilities, including the former's airborne satellite launch service, which could offer operationally responsive options to military customers. This could be especially important as space becomes an increasingly contested domain with the US, Russia, China and others developing hard and soft-kill counter-space capabilities.

In this regard, emerging systems such as high-altitude pseudo satellites (HAPS) will provide valuable C2ISR capabilities. The growing diversity of counter-ISR systems, including space-based assets, will require distributed systems offering enhanced resilience against both hard and soft-kill threats. Defensive cyber capabilities to defend networks will be critical; conversely, offensive cyber operations will provide a valuable means of disrupting and degrading adversary kill-chains. However, the cyber domain will not be a panacea; a multi-domain perspective will be valuable in developing cyber capabilities as their utility in support of and in context with other capabilities can potentially be better discerned. AI and machine learning (ML) are perhaps the most significant emerging technologies. A variety of applications for AI in defence are being explored. In the context of ISR, AI and ML offer the potential to significantly enhance the processing of data being acquired and enable human operators to focus on the analysis of the most valuable and timely information. Consider, for example, a distributed sensor network linking manned and unmanned systems operating persistently; such a network, utilising AI could provide multi-domain information superiority. Similarly, consider the challenge posed by a multi-directional air and missile attack encompassing low-observable threats, supersonic and hypersonic cruise missiles, and ballistic missiles: to what extent would an AI-enabled F2T2EA process enhance the ability to defend against a complex multi-directional threat? In 2019, Yang Wenzhe wrote about the impact of AI on military operations, and with it, the emergence of the cognitive domain alongside the physical and informational domains (encompassing land, air, sea, space, the electromagnetic and cyber). Should the cognitive domain be included in multi-domain operations?

Key Developments

- Australia intends to invest AUS$15 billion over the next decade in enhanced information and cyber capabilities, including as detailed above in the air, land and maritime domains. The *2020 Force Structure Plan* mentions the importance of joint offensive and defensive cyber capabilities from the tactical to strategic levels. Additional funding will be provided for an 'enhanced architecture to allow the coordination and integration of intelligence, surveillance, reconnaissance, and electronic warfare capabilities across the Joint Force'. In the period up to 2040, up to AUS$2.5 billion will be spent on emerging technologies, such as AI. Australia will also invest 'around' AUS$7 billion over the next decade on the development of space capabilities, encompassing space situational awareness, terrestrial operations in contested space, satellite communications assurance, and satellite communications. On 24 April 2020, the Australian Defence Minister announced the Space Surveillance Telescope has captured its first image. Due to officially enter service in 2022, the Space Surveillance Telescope, developed by the US, will contribute to space situational awareness for Australia, the US and allies. The system will be operated by the Royal Australian Air Force with oversight and management provided by the US Space Force.

- The French Direction Generale de l'Armement awarded Thales and Thales Alenia Space a contract to conduct a concept study for the use of a Stratobus airship-based HAPS for ISR.

- Japan intends to establish a Space Domain Mission Unit by 2022 to improve space situational awareness. Japan established its first Space Operations Squadron on 18 May 2020, the squadron will operate a space surveillance system and should become operational in fiscal year 2024. In December 2019, the Japanese Cabinet provided $460 million for space-related defence activities. The Japanese Ministry of Defense will spend $235 million in fiscal year 2020 on cyber-security related programmes including an AI-based system to counter cyber-attacks. It will also invest in a system to collect data on the tactics, techniques and procedures underpinning cyber-attacks launched against Japan.

- The Republic of Korea intends to acquire five reconnaissance satellites by 2023 at a cost of $1 billion: a satellite tracking and monitoring system will also be acquired. On 20 July 2020, SpaceX launched South Korea's first dedicated military communications satellite. More broadly, on 25 April, the Defense Acquisition Program Administration announced a 15-year military technology plan, encompassing autonomous and AI-based ISR; intelligence and C2; 'high-speed, high-power' precision strike; stealth technologies; unmanned combat systems; a personal combat system' cyber capabilities; and advanced future technologies.

- In July 2020, Russia allegedly conducted a space-launched anti-satellite test, launching a projectile from a satellite.

- Airbus announced in a 19 July 2020 press release that it has a contract worth over £500 million with the UK Ministry of Defence for the supply of a Skynet 6A satellite and updates for the current Skynet 5 communications satellite fleet. The Skynet 6A satellite should be launched in 2025 and have a minimum design life of 15 years. On 14 August 2020, it was announced that the UK has joined the US-led Operation Olympic Defender and will have access to the US Space Force's Standardized Astrodynamics Algorithm Library, and for the UK's Space Operations Centre to share data. This is aimed at improving space situational awareness and the security of space-based assets. In the cyber domain, a new regiment, the 13th Signals Regiment, was stood up on 1 June 2020. It will form the basis of the British Army's Cyber Information Security Operations Centre and cooperate with the Royal Navy and Royal Air Force. The UK is investigating the application of AI, including in the maritime domain: BAE Systems, for example, is looking at the use of AI in surface ship combat management systems, and the Royal Navy is pursuing Project PAEAN which will utilise an AI-enabled system to monitor platform health. The Defence Science and Technology Laboratory and Roke Manor Research have developed an AI-based application – STARTLE – to provide situational awareness and threat analysis for ships in combat zones. The Defence and Security Accelerator has provided seed funding to nine companies to explore AI and automation technologies for future warships and wider defence capabilities under the Intelligent Ship programme.

- On 18 May 2020, the USAF awarded Northrop Grumman a contract potentially worth $2.4 billion for the first two Next-Generation Overhead Persistent Infrared polar satellites, which will provide improved missile early warning capabilities. The US Air Force and Space Force have begun adding cyber sensor data to create a comprehensive picture of the battlespace in support of all-domain operations. The US Space Force published in August its capstone doctrine articulating the strategic contribution of space power. Japan and the US are reportedly planning to deploy a constellation of small satellites in low-Earth orbit to provide missile early warning capabilities, at a cost of $9 billion and to become operational in the mid 2020s. The US Department of Defense (DoD) is investing in the development of advanced technologies to maintain an edge over potential rivals, namely Russia and China. In fiscal year 2021, the DoD has assigned $2.3 billion for AI, ML and 5G. The individual services are investing in particular in the potential uses of AI, for example, the Army Futures Command is examining autonomy and AI in support of wider force modernisation; the Navy is developing the Operator Decision Aid to support decision-making on the bridge and in the combat information centres of warships and a tool to support logistics personnel – Causal Adaptive Decision Aid; whilst the Air Force is developing hardened AI technology suitable for autonomous unmanned combat air vehicles, such as those under development for Skyborg, to use in combat conditions.

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Though each approach to MDO takes as its starting point the inherently integrated nature of the future operating environment - where forces would be required to operate across multiple domains and to deliver decisive effects in each of them – they continue to differ in their conceptual, organizational and technological outlook and thereby fall short of true integration. In 2020, there is an opportunity to define a unified path forward. The adoption of Joint All-Domain Command and Control (JADC2) as a core component of the US Joint Staff's upcoming Joint Warfighting Concept provides unprecedented potential to enhance integration – both intra-service and inter-service. There is an opportunity to re-design C2 frameworks from the ground up with cross-domain operations in mind, and to develop ISR assets and technologies that can be leveraged right across the joint force – no matter which service "owns" those capabilities.

C2ISR USA Online will support that discussion. **Day One** will address the operating environment in which cross-domain capabilities will deploy, seeking to determine a new command framework in an era where the principle of 'centralised command, decentralised execution' has been overturned by the demands of the contested battlespace. **Day Two**, meanwhile, is committed to assessing those enabling technologies – including artificial intelligence, data analytics and machine learning – that are integral to building the JADC2 architecture and the "Family of Systems" approach on which it depends. As information systems-driven decision making emerges as a distinct technological possibility, it provides scope for debating the role of AI and ML in speeding up the decision loop, as well as the inherent risks of using machines to reduce the cognitive burden on the future joint warfighter.

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Please get in touch with the Editor, Alex Stephenson, at alexander.stephenson@defenceiq.com to discuss submission proposals.

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