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DEFTECH SCAN

November 2020

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OTH INTELLIGENCE GROUP
Trusted Expertise. Innovative Analysis. Forward Thinking.

Dear Reader,

This is already the last Deftech-scan of the year… wow… time flies, and with the given situation, we are pretty sure that everybody is really looking into the future, whatever the topic of interest !

Despite the pandemic situation, this year was intense in new technological achievements and in the materialization of some concepts into field trials and first-generation products.

The acceleration in the use and the acceptance of different technologies is also reflected in the change of vocabulary adopted to describe and talk about specific systems. You will notice in this edition, that we've moved from "unmanned systems" towards "uncrewed systems".

Are we still talking about the same systems? Maybe yes… maybe no… the perception is however different… Does it mean something with respect to the **acceptance** of such systems? The question remains open, but don't underestimate the power of words and narratives !

It was a pleasure to be on your side along 2020, and we hope you'll take us with you in 2021.

Even if a little bit early (we are in foresight program after all), we wish you from both sides of the Atlantic a very nice Season's Greetings… and a passionate reading !

Truly Yours,

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Introduction and Summary

This DEFTECH SCAN reports on and assesses occurrences in military technology and capability development taking place from late September through late November. This issue in particular reflects the increasing pace and progress of defence technology development and innovation efforts not just in the United States, China, and Russia, but especially in midsized and even small militaries throughout the world. The report includes updates from the Netherlands, the United Kingdom, New Zealand, Israel, Australia, France, Japan, and India in addition to the three large militaries mentioned above.

The following key themes emerged in the research supporting this DEFTECH SCAN:

Uncrewed Systems: Vertical and Horizontal Relevance: Uncrewed systems and robotics are a stand-alone / "vertical" category in all DEFTECH SCANS, given the velocity of demand, variety of missions and designs envisioned for uncrewed systems, and volume of systems being developed by industry.

However, this report highlights just how central uncrewed systems are across nearly every other category of interest to DEFTECH SCAN reports. For example, in this report the Human Performance Enhancement and Protection and C4ISTAR and Cyber categories both feature stories on novel applications of uncrewed systems in support of, in the former case, training, and in the latter case, electronic warfare missions. Both stories included in this report's Energy, Power, and Propulsion section are focused on new technologies that can add to the operational utility of uncrewed systems.

Grey Zone Contingencies and Capabilities: This report has a conspicuous focus on how technologies are being developed both to create new opportunities and to mitigate the effects of grey zone threats that sit between traditional statecraft and kinetic conflict.

At a conceptual level, the C4ISTAR and Cyber section includes a description of a recent released report on how emerging technologies can help deter, detect, and effectively and flexibly respond to the growing number of challenges that blur the line between military and non-military activities. The Missile Systems and Munitions section offers one concrete and practical—if still disputed and controversial—example of how a specific technology / capability area can be leveraged to change the status quo in a "grey zone" – type border dispute without the use of kinetic force.

Progress and Updates: Several items in this report demonstrate how specific technology or capability development efforts or individual companies or universities discussed in previous DEFTECH SCANS over the last two years have progressed or evolved.

Notably, the use of previously emphasized Red 6 virtual and augmented reality training technologies by the pilot of a physical world aircraft shows how this specific technology—and all virtual and augmented reality training technologies—is advancing rapidly.

Similarly, innovations in design approaches by Delft Technical University in the Netherlands featured in the September 2020 DEFTECH SCAN. This volume includes a description of a separate demonstration of an energy capture and storage technology for drones that was also developed by Delft Technical University, signalling not just that this particular university is engaged in interesting and potentially impactful research, but more fundamentally the importance of academia and applied research institutes in the defence innovation ecosystem. Assessment of continued development of Russian exoskeletons and China's drone swarms—both regularly touched on themes in these reports—also appear in this report.

Energy, Power, and Propulsion

Key Insights:

- Developments in academia and commercial aerospace / space are driving innovation in the development of energy capture, storage, and distribution technologies. The successful test of a hydrogen-powered vertical take-off and landing uncrewed system during the reporting period has demonstrated the potential of hydrogen fuel cells as well as hybrid fuel cell / battery technologies to power increased endurance and mission flexibility of uncrewed systems, in particular.
- Small, medium-sized, and large militaries throughout the world have demonstrated a renewed sense of urgency in efforts to electrify fleets of military vehicles. The impetus is largely operational. Electrification of vehicle fleets, both crewed and uncrewed, offer advantages in terms of efficiency, endurance / range and stealth, though there is also a persistent concern about reducing damaging emissions of military vehicles

TU-Delft and Royal Netherlands Navy Test Hydrogen-Powered VTOL Drone: The Royal Netherlands Navy, Netherlands Coast Guard, and Dutch Delft University of Technology (TU Delft) Micro Air Vehicle Laboratory (MAVLAB) successfully tested a vertical take-off and landing (VTOL) uncrewed aircraft that utilized a hydrogen fuel cell. The "NederDrone"[1] was launched from a Coast Guard ship and flew for three-and-a-half hours before returning to the ship and safely landing.

Figure 1: The NederDrone takes off from a Royal Netherlands Coast Guard ship during a recent successful test in which it flew for 3.5 hours using a hydrogen fuel cell. Source: Novel versatile hydrogen drone developed by TUDelft - MAVLab [EN] - YouTube

The fixed-wing drone has a three-meter wingspan, weighs 13 kilograms, and features 12 motor / propeller units distributed on its two wings.[2] The number of propellers offers built in redundancy and resilience. According to a video detailing the test flight, even if several of the motors fail, "the drone can safely perform its flight manoeuvres."[3]

The most novel component of the aircraft is its use of an 800-watt hydrogen fuel cell in conjunction with an on-board battery pack. The drone uses both the fuel cell and the battery pack during the energy intensive stages of take-off and landing. During forward flight the 12 motors are powered solely by the fuel cell, which also charges the battery pack ensuring enough power to safely land the drone.[4] Kltz Pieter Blank MSC, the Innovator with the Royal Netherlands Navy and Netherlands Coast Guard, called the test a "real technological breakthrough."[5] The drone could be used for a range of missions, including surveillance and search and rescue.

[1] "NederDrone-a hydrogen powered VTOL UAV", SciNews YouTube site, November 13, 2020, NederDrone - a hydrogen-powered VTOL UAV - YouTube
[2] Ben Coxworth, "Hydrogen-powered VTOL drone flies for 3.5 hours", *New Atlas,* November 12, 2020, Hydrogen-powered VTOL drone flies for 3.5 hours (newatlas.com)
[3] "Novel versatile hydrogen drone developed by TU Delft-MAVLAB [EN]", TU Delft MAVLAB, November 10, 2020, Novel versatile hydrogen drone developed by TUDelft - MAVLab [EN] - YouTube
[4] Coxworth
[5] "Novel versatile hydrogen drone developed by TU Delft-MAVLAB [EN]", TU Delft MAVLAB, November 10, 2020, Novel versatile hydrogen drone developed by TUDelft - MAVLab [EN] - YouTube
[5] Coxworth

TU Delft has had a successful last few months. It's test of a scaled prototype of a flying V-wing aircraft in which the fuselage and wing are integrated into one body featured in the September 2020 volume of DEFTECH Scans. [6]

Electrifying Vehicle Fleets: In October, Textron Systems announced it will deliver an all-electric version of its modular M5 Ripsaw Robot Combat Vehicle to the US Army for experimentation in 2021. The current version of the M5 uses diesel and hybrid electric motors.[7] The all-electric version of the medium robot combat vehicle will be a flat deck variant and will not have a cannon turret like the standard M5 (pictured to the left).

Figure 2: The standard version of the M5 Ripsaw. The all-electric version will have a flat deck design. Source: Textron RIPSAW® M5 | Textron Systems

The announcement comes after the US Army Futures Command directed the Maneuver Capabilities Development and Integration Directorate to start the process of developing requirements for electrifying the service's ground fleet in September.[8]

More recently, in August of 2020, the UK Ministry of Defence announced that hybrid technology is being tested on the Army's MAN SV Foxhound and Jackal vehicles following a £7m investment from the MoD. The UK expects to conduct comprehensive testing at Millbrook Proving Grounds in the first half of 2021.[9] Together these developments indicate the growing priority of new types of energy capture, storage, and distribution for both large and mid-sized militaries throughout the world.

> *"We are really on the precipice of seeing advancement in electric technologies throughout the military." – Michael Howe, Senior Vice President with Howe and Howe, a Textron subsidiary working on the all-electric M5 Ripsaw*

While energy efficiency is certainly a driver of these initiatives, so, too, is performance. According to the UK MoD, hybrid and electric systems will provide "improved silent mobility" by "reducing noise and increasing stealth capability."[10]

Range is another potential advantage. Michael Howe, a senior vice president with Textron subsidiary Howe and Howe, noted that the two 900-horsepower hybrid electric motors and diesel range extender generator enable the electric version of the M5 to travel "to an extended range of out to 300 to 400 miles." Howe also noted that such developments are just the beginning, observing that "we are really on the precipice of seeing advancement in electric technologies throughout the military."[11]

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[6] "Flying-V - Scale model maiden flight", TU Delft YouTube Channel, 1 September 2020, https://www.youtube.com/watch?v=XHFcLfSfJWQ

[7] M5 Ripsaw product page, Textron website, RIPSAW® M5 | Textron Systems

[8] Jen Judson, "US Army gives green light to shape vehicle electrification requirements", *Defense News,* September 21, 2020, US Army gives green light to shape vehicle electrification requirements (defensenews.com)

[9] "Army vehicles adopt electric technology", British Army, August 20, 2020, Army vehicles adopt electric technology | The British Army (mod.uk)

[10] Ibid.

[11] Matthew Cox, "This All-Electric Robotic Combat Vehicle May Accompany Army Units into Battle", *Military.com,* October 9, 2020, This All-Electric Robotic Combat Vehicle May Accompany Army Units into Battle | Military.com

Human Performance Enhancement and Protection

Key Insights:

- Russian demonstrations of the "Stormer" exoskeleton reinforce the growing perception that Russia is a, if not *the,* global leader in the design and development of exoskeletons and soldier systems. Many analysts and observers, both in Russia and outside, believe that the Russian military and defense industry have benefitted greatly from the ability to experiment with new technologies and operational concepts in Syria.
- Virtual and augmented reality training technologies have continued to develop and to be accepted by small and large militaries throughout the world due to their multifaceted benefits ranging from, first and foremost, improved performance of individual operators to increased availability of platforms and systems to reducing risks associated with training during the Covid-19 pandemic.
- Among the most interesting and promising developments during the reporting period was the successful test of complementary technologies that enabled a pilot in a real-world aircraft to engage in a virtual dogfight with a simulated fifth generation fighter using an AI-enabled augmented reality headset. This test constituted an important milestone toward in efforts to merge the physical world of live trainings with the virtual world of simulated trainings in order to improve the performance of human pilots or operators and the machines and AI agents they operate.
- Covid-19 is also affecting the current trajectory of Human Performance Enhancement and Protection by creating new priorities for technological development, especially in military medicine. The announcement during the reporting period of the deployment of customized ventilators by the Israeli Defence Force is indicative of efforts by militaries throughout the world to not only mitigate the risks to forward deployed military personnel of the current pandemic, but also to ensure that emerging technologies are dedicated to improving the quality of military medicine.
- Despite the challenges posed by the current pandemic and the growing interest in virtual trainings, live trainings remain an important component of the training process and are increasingly incorporating niche technologies designed to enhance the ability of personnel to operate in increasingly complex and challenging environments. Many of these systems are designed to increase connectivity between and situational awareness among disparate Blue forces as well as protective equipment designed to increase survivability of human assets in contested environments.

Russian Exoskeletons: In late September Russian state-owned defence company Rostec released a short video showing a Russian soldier performing a series of tasks while wearing the "Shturmovik" or "Stormer" exoskeleton. According to Russian state news media organization TASS, the video's text explains that "the exoskeleton is hidden beneath the clothes and gear. It does not hinder the soldier's movements, but on the contrary eases the strain on the locomotor systems."[12]

TASS also reported that the system enables soldiers to "easily [carry] up to 60 kilograms of combat equipment and weapons, while its own weight is six kilograms."

Samuel Bendett, a research analyst at the Center for Naval Analyses in Washington, DC and expert on Russian military technology told *Task & Purpose* that the new system represents an upgrade in capability

[12] "Defense technology behemoth Rostec releases video of combat exoskeletons in action", TASS, September 28, 2020, Defense technology behemoth Rostec releases video of combat exoskeletons in action - Military & Defense - TASS

over past Russian exoskeletons because it allows the soldier "to move freely more or less." Previous exoskeletons "presented limited features to what a solider can do."[13]

Russian soldier systems and body armour programs, particularly the Ratnik-3 soldier system anticipated to enter service by 2025, have featured in previous DEFTECH Scan reports. The debut of the "Stormer" system further reinforces the progress being made in these systems seen as being critical to the future of human performance enhancement at the tactical level. Both *TASS* and *Task &Purpose* highlighted in their reporting on the video that Rostec had learned valuable lessons from testing combat exoskeletons in Syria.

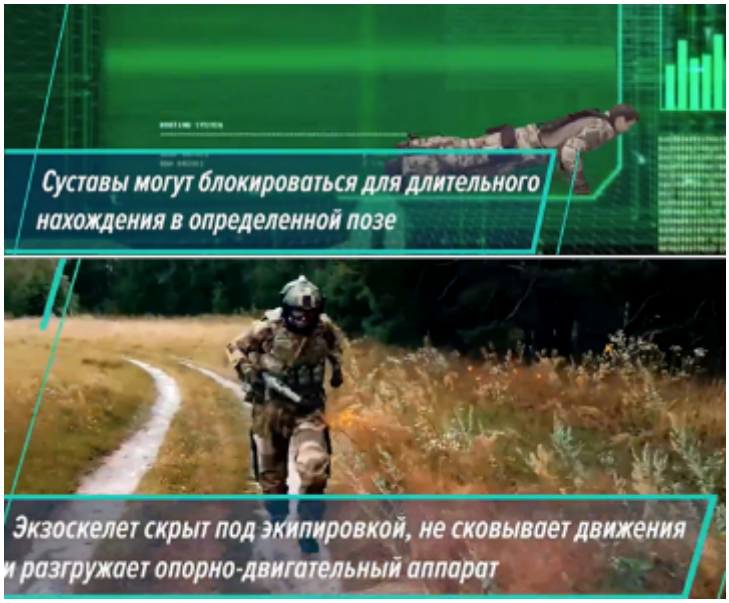

Figure 3: Images from the Rostec video that showed an individual soldier running, jumping, climbing, and performing other exercises in different settings while using the "Shturmovik" or "Stormer" exoskeleton (Source: Rostec, as reported on and included in reporting from Task & Purpose, Russia just released footage of a brand new combat exoskeleton in action - Task & Purpose (taskandpurpose.com))

Training and Simulation: The reporting period saw multiple examples of the continued advancement and penetration of virtual and simulated training solutions in militaries throughout the world, including in small militaries seeking to maximize resources especially during a global pandemic.

In October, Canadian training and simulation firm CAE announced that it had officially handed over a CAE 700MR Series NH90 flight training device to the New Zealand Defence Force (NZDF) and Royal New Zealand Air Force (RNZAF) to support training of NH90 pilots.

The simulator provides "an immersive and realistic virtual training environment ideal for rehearsing challenging tasks such as ship deck and confined area landings. Among other features, the system includes a "revolutionary dynamic seat for vibration and motion cueing" to ensure realism.[14]

However, the benefits of this virtual training go beyond the primary and proximate effect of improving the training of NH90 helicopter pilots. Minister of Defence Ron Mark stated in August 2018 when the contract with CAE was announced that "the availability of in-country simulator-based flight training will also reduce the need to use NH90s for training flights, ensuring the helicopters are available for more operational tasking."[15]

In addition to the increased operational availability of platforms, the virtual training also helps ensure readiness during a global pandemic that has increased risk of travel. While New Zealand has done well in containing the virus' spread in country, training for the RNZAF's NH90 pilots had previously included

[13] Jared Keller, "Russia just released footage of a brand new combat exoskeleton in action", *Task & Purpose,* October 1, 2020, Russia just released footage of a brand new combat exoskeleton in action - Task & Purpose (taskandpurpose.com)
[14] "CAE hands over CAE 700MR NH90 simulator to Royal New Zealand Air Force", *Asian Military Review,* November 20, 2020, CAE hands over CAE 700MR NH90 simulator to Royal New Zealand Air Force - Asian Military Review
[15] Gabriel Dominguez, "RNZAF receives CAE flight simulator for NH90 helicopters", *Janes Defence Weekly,* October 20, 2020, RNZAF receives CAE flight simulator for NH90 helicopters (janes.com)

simulator-based training in Australia and Germany, combined with training flights in New Zealand, which have become less feasible during the pandemic.[16]

An Advance in Combat Medicine:[17] On November 23, Inovytech, a developer of respiratory and cardiac medical solutions, announced the Israeli Defence force (IDF) had deployed the company's Ventway Sparrow MIL Standard model lightweight tactical ventilator for use in forward operational environments.

The Ventway was evaluated in field situations at the annual International Conference on Emergency Disaster and Military Medicine (DiMiMED) held on November 16. IDF Medical Corps Lieutenant Colonel Raphael Gerasi presented the collaboration at DiMiMED, noting that by shrinking the size of traditional ventilator components while maintaining quality, the Ventway was able to effectively balance portability, automation, and toughness.

Another First in Virtual and Real-World Aircraft Interactions

The September 2020 DEFTECH Scan volume reported on the AlphaDogFight challenge in the United States in which an AI agent was able to defeat a human piloted F-16 in a series of five virtual dogfights.

Another important milestone in interactions between real-world crewed and virtual aircraft occurred in November. Two US companies, Red 6 (whose augmented reality pilot training solutions have been featured in previous DEFTECH Scans) and EpiSci, successfully completed a live-flight training exercise in which a crewed real-world aircraft engaged in a dogfight against a virtual, computer-generated adversary aircraft projected onto an augmented reality helmet-mounted display worn by the crewed aircraft's pilot.

The pilot flew a Berkut 560 experimental plane and faced a virtual representation of a Chinese J-20 stealth fighter using EpiSci's Tactical AI technology, which was drew upon its previous work in the AlphaDogFight challenge. Red 6's Airborne Tactical Augmented Reality System (ATARS) was used as the mechanism to display the virtual J-20.

According to Daniel Robinson, Founder and CEO of Red 6, "With the additional integration of Tactical AI into our platform, we are now able to interact and respond to any threat aircraft. This opens spectacular possibilities for training."

FN: Thomas Newdick, "Pilot In A Real Aircraft Just Fought An AI-Driven Virtual Enemy Jet For The First Time", *The Drive,* November 16, 2020, Pilot In A Real Aircraft Just Fought An AI-Driven Virtual Enemy Jet For The First Time (thedrive.com)

New Situational Awareness and Protection Kit Used in Training:[18] United Kingdom Royal Marines used new technologies and equipment to support live training exercises in the difficult terrain of Gibraltar, including in the network of tunnels beneath the island. The new equipment included remotely piloted aerial systems and ground-based robots called "throwbots", both of which offered enhanced situational awareness for the Royal Marines as they trained for urban operations and niche missions such as cliff assaults and tunnel operations. Situational awareness was also improved by the use of Android Team Awareness Kit (ATAK). ATAK is a GPS communications and Blue Force tracking tool that runs on mobile devices.

The Royal Marines also used "specialised protective equipment." Ballistic shields, for example, provided marines" a lot more protection going through confined spaces, moving forward as they engage the

[16] Ibid.
[1717] "Invoytec and Israel Defense Forces Partner to Advance Military Ventilator Capabilities", Invoytec Press Release, November 23, 2020, Inovytec and Israel Defense Forces Partner to Advance Military Ventilator Capabilities (prnewswire.com)
[18] "Royal Marines Add New Kit To Daring Exercises In Gibraltar", Royal Navy, November 13, 2020, Royal Marines add new kit to daring exercises in Gibraltar (mod.uk)

adversary; that's worked particularly well in the tunnels", according to Major Tom Baybutt, the Officer Commanding of P-Squadron of the 43 Commando Fleet Protection Group.

Figure 4: Images from the UK Royal Marines recent training on the island of Gibraltar. More than 80 marines from Scotland-based 43 Commando Fleet Protection Group participated in the two-week exercise. The unit is responsible for safeguarding the UK's nuclear deterrent. Source: UK Royal Navy.

Cyber and C4ISTAR

Key Insights:

- Grey zone contingencies have become a more prominent concern for defence and security communities around the world. These contingencies typically blur the line between traditional military and non-military threats, activities, and capabilities and pose a particularly sensitive challenge for strategic, operational, and even tactical decisionmakers. Emerging technologies can play an essential role in capitalizing on grey zone opportunities, but perhaps more saliently, in mitigating the risks of a range of different grey zone scenarios. Most notably, 4IR technologies can help defence and security communities detect when a grey zone challenge is emerging and also create agility and flexibility in creating responses that will defend or restore a status qyo without escalating to a kinetic conflict.
- Large and small militaries throughout the world are acknowledging the growing recognition of the importance of the space and cyber domains and the electromagnetic spectrum to modern conflict and beginning to articulate prioritized technology development requirements that not only emphasize these domains separately but also take into account the increasing convergence of these domains that are so frequently associated with C4ISTAR operations.
- Uncrewed systems have become a critical part of C4ISTAR operations, not only in intelligence, surveillance, and reconnaissance roles, but also in electronic warfare where militaries of all sizes have focused on the development of specialized EW payloads designed to identify, locate, monitor, and jam adversary radio communications for use on even small uncrewed systems.

Technology and Grey Zone Conflict:[19] In September, UK defence firm QinetQ released an in-depth analytical report entitled "Confidence in Chaos: How to use emerging technologies to combat grey zone threats".

[19] "Confidence in Chaos: How to use emerging technologies to combat grey zone threats", QinetQ, September 2020, QinetiQ - Grey Zone Warfare

The report focuses on how 10 technology categories can help deter, detect, and respond to an array of grey zone challenges—understood to be challenges that use economic, societal, political, cultural, cognitive / behavioral and / or military technologies to create security challenges or challenge the status quo in ways that sit between traditional statecraft and traditional military operations.

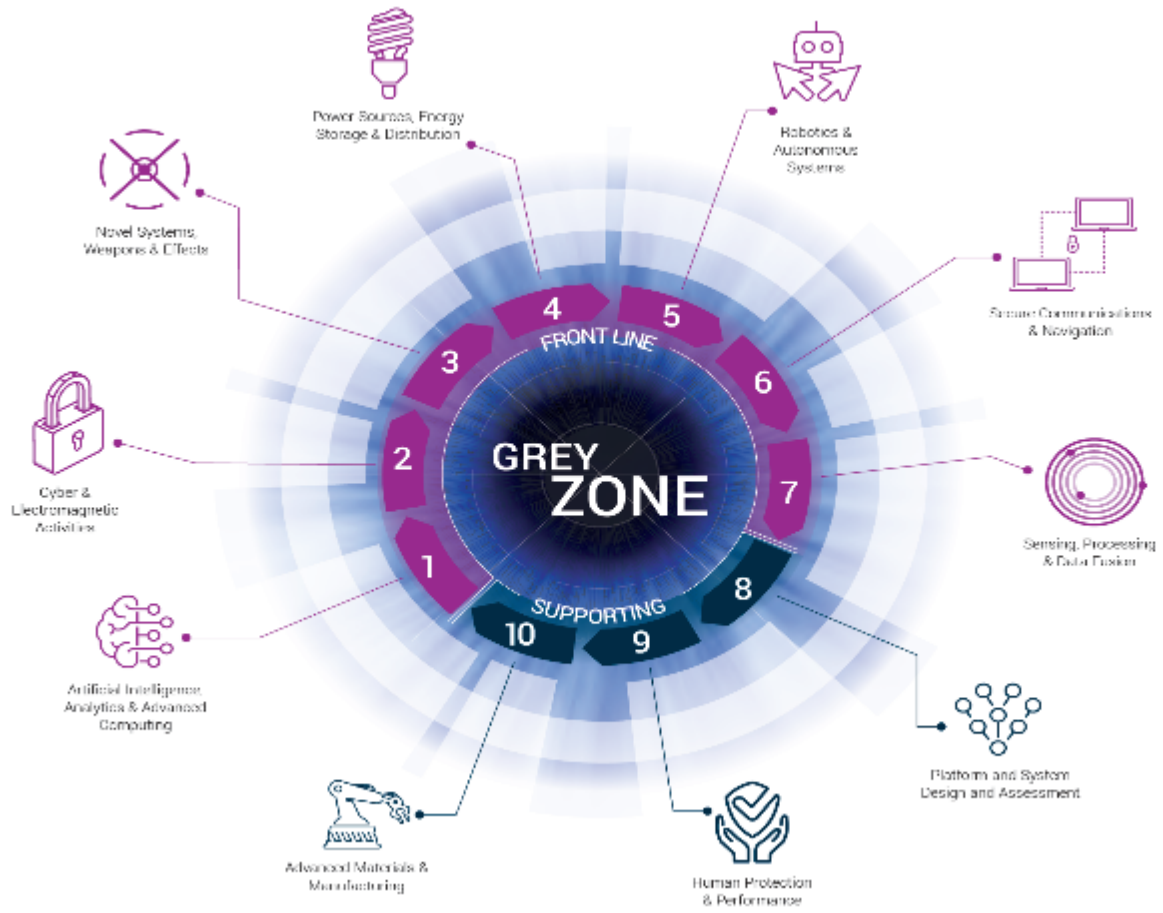

Figure 5: The 10 technology and capability areas discussed in the QinetQ "Confidence in Chaos" report segmented into "front line" and "supporting" technologies. Source: Confidence in Chaos, QinetQ

"Confidence in Chaos" divides the technology categories of interest into "front line" and "supporting" technologies and assesses how these technologies could be leveraged to meet the five "models of grey zone hostility" listed in the table below. Most of these categories intersect or overlap:

Model of Grey Zone Hostility	Indicative Scenarios Included in the Report
Deniable attacks	• Cyber-attack on critical national infrastructure • Electromagnetic attack on a financial institution • Using drones to shut down an airport • An assassination by poisoning
Information operations	• Foreign electoral intervention • Cell site simulators intercept and falsify communications • Erroneous reports of drones shut down an airport
Use of proxy forces	• Hostile state leveraging foreign fighting forces • Terrorism on home soil
Economic coercion	• Adversary leverages ownership of critical assets
Territorial encroachment	• Adversary seizes control of strategic sea lane • Annexation of sovereign territory by a hostile state

Table 1: The five models of grey zone activities included in the QinetQ report as well as specific indicative scenarios for each category. Source: QinetQ, "Confidence in Chaos"

While the report stresses that the utility of the technologies of interest will vary across scenario categories, some commonalities do emerge throughout the report. Specifically:

- **Detection:** Many grey zone challenges will be difficult to detect, much less anticipate, placing a premium on small and large militaries developing and deploying technologies supporting enhanced perception, processing, and cognition such as machine learning, 3D radar, smart sensors, robotics and autonomous systems, secure communications, and data fusion technologies
- **Attribution:** Detection of the presence, scale, and scope of a grey zone challenge is just the first step in crafting an effective response. Accurately assessing *who* was behind the attack is also important, of course, and across all categories of grey zone contingencies there are scenarios in which doing so can be difficult. Even in categories such as "territorial encroachment" that would seem to involve easily identifiable actors, recent history has demonstrated that definitive attribution can be difficult to establish, especially if the likely actors are savvy, vigorously deny their participation, and are persistent and creative in crafting counter-narratives
- **Building resilience:** Many of the scenarios explored in the report involve attacks on critical infrastructure or political institutions that are unlikely to be remedied or resolved quickly. Minimizing disruption and rapidly recovering critical services will be crucial for defence and security communities. And here these communities should balance between exquisite and novel technologies and more mundane, but still useful, ones that reduce dependence on vulnerable or compromised networks. "Secure push-to-talk satellite radio", for example, will "allow recovery co-ordination via offline communication, while standalone electricity generation and energy storage will aid continuity during an attack on the power grid."[20]
- **Flexible response:** Responding to grey zone threats requires decisionmakers to balance reestablishing a threatened or even reversed status quo while also avoiding unnecessary or unintentional escalation placing a premium on targeted, frequently nuanced, and flexible responses. The report highlights the utility of soft-kill counter uncrewed systems and other non-lethal weapons as well as states building the capacity to better respond in the cyber and information domain and electronic magnetic spectrum. It also references the "use of novel weapons" in proxy force and terrorism scenarios that may involve hostages or civilians at risk in order to "intervene covertly."[21]

"More, Together": Australia Places Big Bets on C4ISTAR and Cyber Development: The Australian Department of Defence released a white paper entitled "More, Together: Defence Science and

[20] Ibid.
[21] Ibid.

Technology Strategy 2030" in October that lays out eight high-impact STAR Shot priorities for technological development over the next decade.

Five of the eight STAR Shots are focused on enhancing Australia's C4ISTAR capabilities, including:[22]

- **Resilient Multi-Mission Space:** Providing resilient global communications, position, navigation, and timing (PNT) and geospatial intelligence capabilities direct to Australian Defence Force users, enabled by a low-earth orbit (LEO) SmartSat constellation
- **Information Warfare:** Delivering blended awareness and resilient effects across the human, information, and physical realms through a contested information environment
- **Agile Command and Control:** Developing a force-level capability edge at all levels to understand, shape and dominate the future multi-domain battlespace
- **Quantum Assured PNT:** Assuring PNT in a contested environment
- **Remote Undersea Surveillance:** Developing above/below water sensors, information processing, communication and data fusion systems to provide remote surveillance of undersea enironments over Australia's area of maritime responsibility

The other three programs of interest are disruptive weapons effects, operating in CBRN environments, and battle-ready platforms.

The white paper's focus on C4ISTAR capabilities is consistent with the requirements and prioritized procurements articulated in the Defence Strategic Update 2020 and Force Structure Plan 2020 reports released in June 2020.

The former document described an expanding and deteriorating Indo-Pacific threat environment; one in which US-China competition is taking center stage but that also includes a range of other geopolitical, technological, and grey zone threats. Together these documents also highlight the importance of the space, cyber, and information domains to modern conflict, both the need to protect tactical and operational communications and the growing relevance of strategic communications and disinformation operations.[23]

French Electronic Warfare System: The French Ministry of Defence (MoD) has initiated a program to develop an electronic warfare (EW) payload for use in a mini uncrewed aerial vehicle (UAV) that will be able to detect, locate, and identify radio communications transmitters as well as potentially jam them.[24]

According to *The Drive,* France's Defence Innovation Agency released a request for proposals for the system calling for the development of a system small enough to be carried by uncrewed systems weighing less than 55 pounds. The system itself should weigh less than 11 pounds, have an energy requirement of less than 50 watts and be able to detect, locate, and track one or more types of radio communications transmitters operating the bands between 30 and 6,000 megahertz. The French MoD also expects the payload to be able to track multiple transmitters simultaneously and mapping the radio-frequency environment in the area of interest accordingly.

Interestingly, the MoD RFP stated "we are not only interested in new technologies" and that "the innovative nature of the proposals may consist of 'diverting' the use of existing technologies"[25], leaving

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[22] "More, together: Defence Science and Technology Strategy 2030", Australian Department of Defence, October 2020, More, together: Defence Science and Technology Strategy 2030 | DST

[23] "2020 Defence Strategic Update," Australian Department of Defence, July 2020, https://www.defence.gov.au/StrategicUpdate-2020/docs/2020_Defence_Strategic_Update.pdf. And [23] "2020 Force Structure Plan," Australian Department of Defense, July 2020, https://www.defence.gov.au/StrategicUpdate-2020/docs/2020_Force_Structure_Plan.pdf.

[24] Thomas Newdick and Joseph Trevithick, "French Army To Test Small Drones That Can Detect, Intercept, And Possibly Jam Communications", *The Drive*, November 13, 2020, French Army To Test Small Drones That Can Detect, Intercept, And Possibly Jam Communications (thedrive.com)

[25] Ibid

open the possibility of repurposing existing solutions in order to achieve the difficult engineering challenge of placing an EW payload on a mini UAV.

Manned Platforms

Key Insights:

- The combination of China's aggressive behaviors, challenging of the status-quo—especially regarding contested borders and boundaries—and accelerating military modernization is driving investment in new capabilities across the region, especially in the maritime domain.
- Japan's commitment to a new class of submarine and multi-mission frigate are representative of investments in several states across the region that are seeking to shore up both their own undersea and maritime operations and anti-submarine warfare capabilities.

Japan Unveils New Naval Vessels: The Japanese Maritime Self-Defence Force (JMSDF) unveiled two new naval vessels during the reporting period. The new vessels signal a renewed focus on enhancing maritime deterrence and the ability to respond to a growing range of maritime-based threats in the Indo-Pacific, including China's rapidly advancing military modernization and, especially, the People's Liberation Army Navy's (PLAN) massive shipbuilding campaign.

Figure 6: The newly-revealed JMSDF Frigate (top) and submarine, both introduced during the reporting period and expected to come into service in March 2022

On October 15, the JMSDF unveiled the *Taigei*—which is the first in the new Taigei-class category of submarines. The vessel is scheduled to go into service in March 2022. It will be the 22nd submarine in the JMSDF fleet.[26]

Taigei is equipped with lithium-ion batteries for extended underwater endurance and range. Japan is the first country to field diesel-electric submarines that employ lithium-ion battery technology rather than conventional lead-acid batteries.

The submarine will employ a new combat management system that incorporates integrated command and control, sensors, and weapons systems. Named systems to be integrated include the OYNX-1 processing system, ZQX-12 submarine tactical display system, ZQQ-8 fibre-optic array sonar system, NZLR-2 electronic support measures (ESM) system, and ZPS-6H radar system. Three more Taigei class boats have already been commissioned and funding for a fifth boat was requested on September 30.[27]

The JMSDF also launched the first of a planned fleet of 22 multi-mission frigates on November 19. As with the *Taigei,* the 30FFM *Kumano* is expected to be commissioned in March 2022.[28]

[26] Jr Ng, "Japan launches first Taigei-class diesel-electric attack submarine", *Asian Military Review*, October 15, 2020, Japan launches first Taigei-class diesel-electric attack submarine - Asian Military Review
[27] Ibid.
[28] Jr Ng, "Japan's new multirole frigate hits the water", *Asian Military Review*, November 23, 2020, Japan's new multirole frigate hits the water - Asian Military Review

The frigate features a stealthy design for reduced radar cross-section and the ability to launch, operate and recover uncrewed surface and underwater vessels. The 30FFM frigate is being made available for export with Indonesia reportedly signing up to acquire four 30FFMs.[29]

The class will be multi-mission with a strong focus on undersea missions such as anti-submarine warfare and mine-countermeasures. The undersea domain has become a growing preoccupation in maritime East Asia and across the Indo-Pacific as more countries acquire submarines and China continues to advance its surface and undersea capabilities. Notably during the reporting period, Taiwan began construction on its first indigenously designed and built submarine on November 23. According to Taiwan President Tsai Ing-wen, who attended a ceremony commemorating the start of construction, "Submarines are important equipment for the development of Taiwan's navy's asymmetric warfare capabilities and to deter enemy ships from encircling Taiwan."[30]

Missile Systems and Munitions

Key Insights:

- India's recent spate of missile tests are another indication of the growing tensions in the Indo-Pacific region and also offer insight into the country's intensifying efforts to capitalize on emerging technology development to create new and enhanced capabilities.
- China's alleged use of a non-lethal microwave weapon in its border stand-off with India could constitute an important milestone in the development and deployment of emerging technologies, particularly in grey zone and sub-threshold situations. The effective use of non-lethal directed energy weapons—while denied by India—could offer flexibility to states seeking either to change an existing status quo or respond to efforts to do so while minimizing risks associated with escalation.

Flurry of Indian Missile Tests[31]: The September 2020 DEFTECH SCAN volume highlighted the successful test of the hypersonic technology demonstrator vehicle (HSTDV) on September 7. That test was the first in a series of 12 missiles tests between September 7 and October 24 designed to meet tank and maritime threats and extend the country's conventional and nuclear deterrent between, reflecting growing concern about a tense and complex regional security environment.

The flurry of activity included several tests of anti-tank weapons designed to better cope with border incursion scenarios along India's contested borders with both Pakistan and China. There were two successful launches of a laser-guided anti-tank guided missile in late September and early October as well as of a Stand Off Anti-Tank (SANT) missile with both "lock on before launch" and "lock on after launch" capability; and final trials of the shoulder-launched Nag anti-tank missile.

In addition, the Indian military also tested the extended range and naval versions of the Brahmos supersonic cruise missile; the nuclear-capable Shuarya hybrid missile system; night tests of the Prithvi-2 short-range ballistic missile; and a test of the Rudram air-launched anti-radiation cruise missile designed to hit adversary radar systems.

India's Defence Research and Development Organization (DRDO) also tested the supersonic missile assisted release of torpedo (SMART) system. The system uses a supersonic missile to carry a torpedo over long ranges and drop the torpedo into the ocean close to the intended target in order to find and attack

[29] Mike Yeo, "Japan launces first ship of new frigate class", *Defense News*, November 19, 2020, Japan launches first ship of new frigate class (defensenews.com)
[30] Gabriel Dominguez, "Taiwan begins construction of first indigenous submarine", *Janes Defence Weekly,* November 25, 2020, Taiwan begins construction of first indigenous submarine (janes.com)
[31] "12 missile tests in 45 days: Is India in overdrive mode", *Times of India YouTube channel,* October 24, 2020, 12 missile tests in 45 days: Is India in overdrive mode? - Bing video Research also included the DRDO website and other open sources

an identified undersea target such as a submarine. The weapon has a maximum range of 650 km, greatly increasing the ability of the Indian Navy's anti-submarine warfare operations.

The Beginning of the Age of Directed Energy Weapons?: On November 17, the *Times of London* reported that China's People's Liberation Army (PLA) had used a non-lethal microwave weapon against Indian forces during its border stand-off with India in Ladakh in the Himalayas.[32]

According to *The Times*, Professor Jin Canrong, a professor of international relations at Beijing-based Renmin University, revealed in a lecture that the PLA had used a microwave weapon to drive Indian forces off two strategic hilltops without using conventional kinetic weapons, which are banned along the contested Himalayan border.

Figure 7: Poly Group's WB-1 Microwave Weapon on display during the November 2014 Airshow China exhibition. The weapon reportedly projects a millimeter-wave beam to heat water molecules just below the skin, resulting in intense pain. Source: Top81 webpage, via Jane's.

The weapons were reportedly used as a means of circumventing hand-to-hand combat with highly trained Indian mountaineering forces who were far more accustomed to the harsh conditions of the Himalayas than the Chinese forces stationed in the area. Jin asserted that within "15 minutes, those occupying the hilltops all began to vomit. They couldn't stand up, so they fled. This was how we retook the ground." He also commented that the weapon "solved the problem beautifully."[33]

The Indian Army emphatically denied that the event took place posting on Twitter that "The news is FAKE."[34] Several observers—including Jin—have pointed out that India may not want to draw attention to a military defeat in the on-going border conflict.

If the weapon was used, it would mark the first known use of microwave weapons in combat. Raytheon developed a similar weapon known as the Active Denial System, which was deployed to Afghanistan with US forces in 2010 but never used due to the risk of bad publicity. There have been suspicions that microwave weapons were used in an attack against US diplomats and their families in the southern Chinese city of Guangzhou in 2018, though these suspicions have not been formally confirmed.[35]

The use of microwave weapons against civilians, of course, raises important ethical and moral questions. However, the use of a non-lethal microwave weapon against other military forces could add a layer of flexibility for strategic, operational, and tactical decision-makers seeking to manage the growing range of sub-threshold military contingencies and grey zone situations as they seek to avoid unwanted or unnecessary escalation.

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[32] Didi Tang, "China turns Ladakh battleground with India into a 'microwave oven'", *The Times of London,* November 17, 2020, China turns Ladakh battleground with India into a 'microwave oven' | World | The Times
[33] Ibid.
[34] David Hambling, "India Disputes Claim That China Routed Their Troops With Microwave Blaster", *Forbes,* November 20, 2020, India Disputes Claim That China Routed Their Troops With Microwave Blaster (forbes.com)
[35] Didi Tang, "China turns Ladakh battleground with India into a 'microwave oven'", *The Times of London,* November 17, 2020, China turns Ladakh battleground with India into a 'microwave oven' | World | The Times

Robotics and Uncrewed Systems

Key Insights:

- The reporting period saw progress in drone swarming technologies, tactics, and operational concepts in multiple countries, including the demonstration of a drone swarm capability in China that can launch up to 48 loitering munition drones and a UK test of an autonomous swarm to carry out electronic warfare missions
- Both small and large militaries are examining new ways of employing uncrewed systems to carry out a broader range of missions, including in support of new concepts of logistics and refurbishment. The US Navy's use of a drone to resupply a ballistic missile submarine is a narrow example of a broader theme: that uncrewed systems of all sizes and designs can support the resupply of forward deployed forces in contested and challenging environments and even, potentially, carry out command, control, and communications missions in environments in which networks and the electromagnetic spectrum are denied. .

Swarms of Swarms: The reporting period saw several examples of the advancement of drone swarm technologies and tactics. Drone swarms have become increasingly in-demand both as a stand-alone capability posing novel challenges for modern air defence systems as well as in support of related force multiplying capability areas such as loyal wingman.

In October, Chinese state-owned enterprise China Electronics Technology Group Corporation (CETC) released a video claiming to show the successful test of a "barrage swarm" of 48 drones designed to overwhelm and saturate a target.[36]

The drones were launched from a vehicle based on the Dongfeng Menshi—derived from the US Hummer H1—using compressed air. Immediately after launch, the drone unfolds its wings. The short video appeared to stress the drones' utility as loitering munitions / kamikaze drones.[37]

Figure 8: Screenshot from the CETC video capturing, on the left, the launch of the drone from a specially designed truck and, on the right, the moment after launch when the drone's wings unfold. Source: CETC YouTube

According to open source reporting, the "secret of the new Chinese system is . . . a 'multifunction processing unit for swarm intelligence', which CETC announced last October." CETC claims that the

[36] David Hambling, "China Releases Video Of New Barrage Swarm Drone Launcher", *Forbes,* October 14, 2020, China Releases Video Of New Barrage Swarm Drone Launcher (forbes.com)
[37] Ibid.

chip includes a complete flight control system, mission planning, intelligence decision-making, and dynamic networking between drones, as well as the ability to recognize targets and other objects.[38]

China was not the only country to show progress in drone swarming. During the Kavkaz 2020 strategic command-staff exercise held from September 21 – 26, Russia integrated swarmed UAVs for the first time in order to test tactics related to targeting of enemy forces. It is unclear from reporting whether these swarms were networked together or just operating jointly, however, it is clear that the swarms were used in intelligence, surveillance, and reconnaissance (ISR) missions.[39]

In addition, the UK Royal Air Force conducted a successful demonstration in cooperation with Italian defence contractor Leonardo as well as smaller uncrewed technology firms Callen-Lenz and Blue Bear of an autonomous swarm of uncrewed aircraft, each carrying a variant of Leonardo's BriteCloud expendable active decoy as an electronic warfare payload. Using the BriteClouds, which contain electronic warfare jammers, the uncrewed systems were able to launch a mock non-kinetic attack on radars acting as surrogates for a notional enemy integrated air defence network.[40]

A press-release from Leonardo—that was later removed from the website—noted that "during the demonstration, a number of Callen Lenz drones were equipped with a modified Leonardo BriteCloud decoy, allowing each drone to individually deliver a highly-sophisticated jamming effect." It also noted that "the decoy packages were programmed and navigated to work collaboratively to cause maximum confusion."[41]

Who Needs Amazon? Drone Delivery on the High Seas:[42] The United States Navy used a quad-copter-type drone to deliver a small payload to the Ohio class ballistic missile submarine USS *Henry M. Jackson* as it sailed on the surface of the Pacific near Hawaii on October 19. The submarine was on a nuclear deterrent patrol at the time of the drone replenishment operation.

According to the US Navy, the test was "designed to evaluate the tactics, techniques, and procedures of U.S. Strategic Command's expeditionary logistics and enhance the overall readiness of our strategic forces." This is, of course, a specific objective that most militaries in the world do not have to worry about, given that few militaries have nuclear-capable of ballistic missile submarines.

However, the test also reveals opportunities for militaries throughout the world—both large and small—to use drones in replenishment and emergency missions to forces operating in harsh or contested environments. For example, even small drone such as the one used in the test could be used to deliver critical items such as medicine, rations, replacement parts, or even hand-written messages in environments in which the electromagnetic spectrum is denied.

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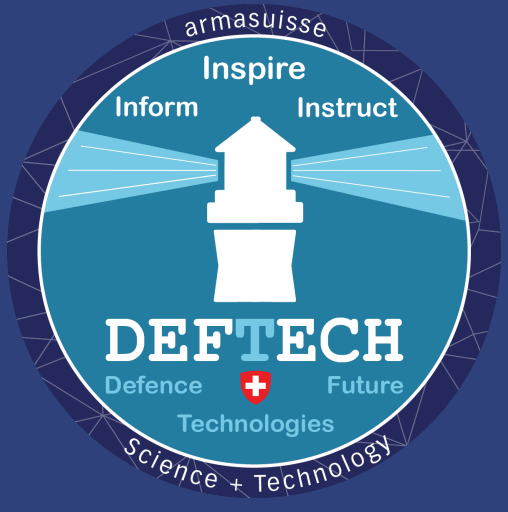
[38] Ibid.
[39] Roger McDemott, "Russia's Armed Forces Test UAV Swarm Tactics in Kavkaz 2020", *Eurasia Daily Monitor Volume: 17 Issue: 136,* The Jamestown Foundation, September 30, 2020, Russia's Armed Forces Test UAV Swarm Tactics in Kavkaz 2020 - Jamestown
[40] Joseph Trevithick, "RAF Tests Swarm Loaded With BriteCloud Electronic Warfare Decoys To Overwhelm Air Defenses, *The Drive,* October 8, 2020, RAF Uses Autonomous Drone Swarm Loaded With Decoys To Overwhelm Mock Enemy Air Defenses (thedrive.com)
[41] Ibid.
[42] Joseph Trevithick, "The Navy Just Sent A Drone To Deliver Cargo To One Of Its Ballistic Missile Submarines", *The Drive,* October 21, 2020, The Navy Just Sent A Drone To Deliver Cargo To One Of Its Ballistic Missile Submarines (thedrive.com)



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