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DEFTECH SCAN

March 2020

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Dear Reader,

We are living and experiencing interesting times!

We do hope that you are all in good health. Even if we are limited in our physical freedom of movements, digital capabilities allow us to continue to offer you "business as usual" information and updates. Most of you will probably access this release working from home. If you have time, do not hesitate to write us any feedback or share your vision about the different elements mentioned.

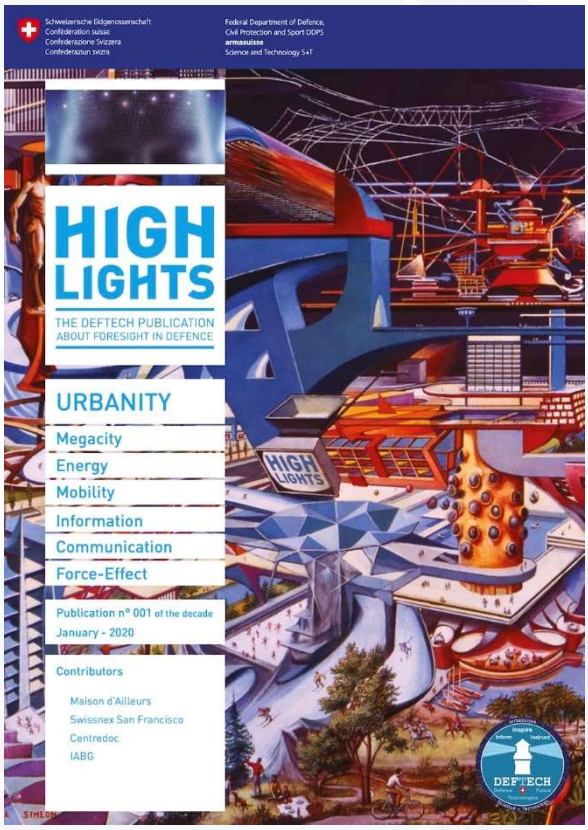
We also would like to make you aware of the latest publication DEFTECH Highlights Urbanity presenting the different innovations and changes taking place in the urban areas, including a special focus on what it could mean for the armed forces.

We have considered the main military capabilities as chapters, dividing each of them into sub-chapters with the aim of answering the following questions:

1. What could be the future of that capability from a science-fiction perspective?
2. How does the innovation landscape look with respect to that argument?
3. What is happening in Switzerland in this regard?
4. How is this matter relevant for the armed forces?

We do hope you will find these "DEFTECH pills" insightful and look forward to any feedback for continuous improvement.

We wish you a very good reading,



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Tate Nurkin
OTH Intelligence Group
CEO
Foresight
tate.nurkin@othintel.com

Dr. Quentin Ladetto
armasuisse S+T
Research director – Technology

quentin.ladetto@armasuisse.ch

Introduction and Summary

This DEFTECH Scan reports on and assesses key developments over the last two – plus months. This reporting period has been dominated by the spread of the coronavirus and this report reflects that focus. The report also includes focused analysis of the UMEX 2020 exhibition in February in Abu Dhabi that Tate attended. The report also includes extensive analysis of other key developments or research that occurred over the course of the reporting period.

Below are key insights emerging from research over the course of this reporting period—to include stories and developments not explicitly featured in this report:

Coronavirus: The Coronavirus pandemic is affecting the discussion and decisions related to military readiness, training, technology investments, and supply chain and manufacturing. This effect is both negative—reducing readiness or slowing production of platforms and systems—and positive—catalysing or investing in capabilities to protect individual soldiers, for example.

Academia: This report includes several stories that feature the role of academia not only in the development of novel capabilities—for example, of a cordless energy source that leverages Wi-Fi and Bluetooth signals—but also in the area of research on critical capability areas. Duke University research into helmet protection against shock wave blasts stands out as a notable example.

Commercial Engagement: Developing specific engagement approaches that encourage commercial and high-tech industry to support defence and security enterprises by speeding up acquisition and enabling a variety of commercial models can be especially useful for acquiring capabilities for human performance enhancement and protection technologies as well as artificial intelligence and unmanned systems capabilities.

Velocity, Volume, Variety: Discussion of unmanned systems and their current and future role for defence and security communities begin with three related concepts that together reflect their growing prominence and importance to military and security operations.

Velocity of demand for unmanned systems—UAVs, of course, but also unmanned surface vehicles (USVs), unmanned underwater vehicles (UUVs), and unmanned ground vehicles (UGVs)—is accelerating as these systems demonstrate value and flexibility in carrying out a wider array of important missions and roles.

This velocity of demand is driving an equally impressive increase in the volume of supply and suppliers, which is introducing new competitors, business models, and competitive dynamics into the market. It is also producing an impressive variety of types of systems and designs of unmanned systems across all domains. Defence and security communities have a broader and differentiated selection of solutions from which to choose when they consider what effects they are trying to achieve.

Energy, Power, and Propulsion

Key Insights:

- The pursuit of endurance and persistence of platforms and people as well as renewable energies to reduce environmental risks and down-time of facilities features innovation in novel power generation technologies and, increasingly, design approaches and new materials.
- The advancement of avionics technologies among others is enabling the development of concepts for energy efficient aircraft that the aerospace industry has invested in for at least a quarter-century, including blended wing body designs and air wake surfing aircraft.
- For small and large militaries, fully realizing the potential of these technologies will require investment in adjacent areas, namely operational concepts and regulation and certification, even in the military context

Energy Efficiency for Aircraft: Airbus revealed it is currently flight-testing a scaled blende wing body (BWB) technology demonstrator aircraft during the Singapore Air Show in February. The test aircraft is known as the Maveric and is 6.5 ft long with a 10.5 ft wingspan. It is powered by twin podded model aircraft turbine engines mounted above the aft deck of the wing.

BWB flying wing aircraft offer several potential efficiency improvements because "lift can be generated across the fuselage." Other benefits include "reduced form drag and greater space above the wing for more efficient higher bypass engines or other propulsion systems."[1]

Figure 1: Airbus' Blended Wing Body Demonstrator shown in Singapore, source: Aviation Week

The Maveric first flew in June 2019 and is still being flight tested to better evaluate flight control systems adapted for delta wing designs. A second round of tests will be conducted to evaluate issues such as "safety, manufacturability, airport compatibility, maintenance and support." It is primarily a demonstrator for commercial aircraft and Airbus believes a single aisle sized commercial BWB aircraft could provide up to 20% lower fuel burn than current designs.[2]

Airbus is not the first company to experiment with BWB designs. Both Boeing and Lockheed Martin have as well, including for military applications. However, innovation has become both more urgent and more possible due to two relevant recent developments. First, and most importantly, increasing pressure on the airspace industry to reduce environmental footprints has led to clear guidance to develop disruptive technologies. According to Jean – Brice Dumont, executive vice president of engineering for

[1] Guy Norris, "Airbus Unveils Blended Wing Body Demonstrator", *Aviation Week,* February 11, 2020, https://aviationweek.com/air-transport/airbus-unveils-blended-wing-body-demonstrator
[2] Ibid.

Airbus, "the pressure we are under and the fact that we need to disrupt to reach emissions objectives in 2050 forces us to drive down avenues we wouldn't have done down earlier."[3]

Successfully navigating these avenues is made possible by the second driver: development in materials and avionics technologies. Again, according to Dumont, "Some technologies have improved; we can make the aircraft lighter and our flight controls and computing capabilities are one level higher. That means we can face the challenges at least a level higher than before."[4]

The development of avionics and flight control systems are also critical to the further development of other technology areas that will increase efficiency of aircraft gas use. Most notably, reporting from February detailed Boeing and Airbus' respective on-going efforts to develop air wave surfing technologies and operating concepts. There has been some degree of research and development of these technologies since the 1980s, but recent development in automatic dependent surveillance-broadcast (ADS-B) avionics has made the technology achievable. According to, Al Sipe, the chief engineer for aviation efficiency at Boeing, "Why now? Automatic dependent surveillance-broadcast (ADS-B) is now mandatory in the U.S., so we have the avionics to make this possible."[5]

What is Air-Wake Surfing?

Air-wake surfing for efficiency has a long pedigree of consistent research results that show an aircraft can save fuel by flying within the updraft created by the wingtip vortices shed by another plane—reclaiming energy left in the atmosphere by the lead aircraft's lift-induced drag.[1]

A Cordless Future: A team of researchers at the Massachusetts Institute of Technology and the U.S. Army Research Laboratory (ARL) have conducted a study describing an antenna that can absorb Wi-Fi, Bluetooth, and cellular signals and efficiently turn it into usable electrical energy. According to Dr. Madan Dubey, a research physical scientist with the ARL, "Wi-Fi is becoming increasingly omnipresent in both indoor and outdoor environments and provides an abundant source of always-on radiofrequency energy." If this energy can be harvested there is the potential for the development and deployment of a means of generating power with any power cords using Wi-Fi, Bluetooth, and millimetre wave used in some 5G communication systems.[6]

Dubey further noted that such a capability has the "potential to revolutionize Soldier's situational awareness and readiness as these materials and devices can be integrated into health and monitoring systems, displays, communication and sensing systems for the Soldier."[7]

Critical to the deployment of this capability is a revolutionary material, molybdenum-di-sulphide (MoS2) that is only a few atoms thick. The technology enables "a transparent, flexible/conformal, self-powered, atomically thin system-on-chip embedded in smart textile", which could constitute a game-changing technology "to power devices that will enable higher Soldier lethality, improve cognitive neuroscience and the novel engineered materials."[8]

[3] Ibid.
[4] Ibid.
[5] Graham Warwick, "Airbus and Boeing Working On Next Steps For Fuel-Saving Wake Surfing", *Aviation Week,* February 14, 2020, https://aviationweek.com/special-topics/sustainability/airbus-boeing-working-next-steps-fuel-saving-wake-surfing
[6] "Army Researchers Imagine Devices Without Cords or Batteries", *army.mil,* March 10, 2020, https://www.army.mil/article/233325/researchers_imagine_devices_without_cords_or_batteries
[7] Ibid.
[8] Ibid.

Human Performance Enhancement

- Synthetic training using virtual and augmented reality continues to be a priority for militaries of nearly all sizes seeking to build enhanced readiness at lower cost. These novel, primarily commercial, technologies offer opportunities for personnel more repetitions in an immersive environment that in many cases better simulates the complexity and dynamics of the tactical and operational environments in which they will be deployed.
- Developing specific engagement approaches that encourage commercial and high-tech industry to support defence and security enterprises by speeding up acquisition and enabling a variety of commercial models can be especially useful for acquiring capabilities for human performance enhancement and protection technologies
- The advancement of performance enhancement and protection technologies is creating "knock-on" technological challenges for both small and large militaries. For example, advancement of body armour and soldier systems have dramatically reduced the risk of death or traumatic pulmonary injury due to blast shock waves. However, these same developments have placed a new emphasis on developing helmets that can protect personnel from brain injuries from these shock waves.
- The coronavirus pandemic has affected training operations, especially in Europe where two large U.S.-led exercises have been cut short and several smaller exercises have been cancelled as a result of concerns over the spread of the coronavirus. However, defence communities are playing a role not only in managing the crisis in several countries throughout the world, but also in developing capabilities that can help militaries of all sizes get ahead of potential future influenza outbreaks.

Virtual Reality Training: The UK Armed Forces are integrating a new virtual reality training platform reportedly built on the same gaming engine as Fortnite as part of an effort to make training for personnel more realistic, intuitive, immersive, and affordable.

SimCentric, a company with offices in the US, UK, Australia and Sri Lanka, was awarded a £300,000 contract by the Defence and Security Accelerator program (DASA) to develop and trial the simulation capability.[9] DASA was established to help the United Kingdom's Ministry of Defence (MoD) better engage start-up and other high-tech companies that might not typically participate in the UK's defence industrial base. Such programs hold particular promise for companies supporting training, human performance enhancement, robotics, and artificial intelligence development. Indeed, DASA featured in the April 2019 DEFTECH Scan, which referenced the MoD's March 28, 2019 £2.5 million ($3.3 million) award to Blue Bear Systems Research Ltd. to develop drone swarm technology as part of the MoD's 'Many Drones Make Light Work' program.[10]

SimCentric's simulator can be used by over 30 personnel simultaneously and uses intuitive gesture control designed to match real actions on the battlefield. Importantly, personnel will be able to practice this

[9] "Gaming technology trialled in training UK Armed Forces", UK MoD, March 6, 2020, https://www.gov.uk/government/news/gaming-technology-trialled-in-training-uk-armed-forces
[10] Jennings, Gareth, "UK Announces investment in swarming 'drone' technology, *Jane's Defence Weekly,* 26 March 2019, https://www.janes.com/article/87534/uk-announces-investment-in-swarming-drone-technology

virtual exercise as many times as needed, gaining valuable repetitions that would be far more expensive to gain through live or more expensive simulator training.[11]

Professor Dame Angele McLean, chief scientific advisor to the Ministry of Defence said "The MoD is committed to developing radical and innovative ways to combat the challenges our armed forces face today and equip them for the threats of tomorrow. This new simulator is just one way we are bringing training into the next generation, using technology drawn from the world of gaming to support our troops in training." [12]

Figure 2: UK MoD personnel using the SimCentric virtual reality simulation system (source: UK Ministry of Defence)

More broadly, the effort constitutes an additional example of how modern militaries of all sizes are incorporating virtual and augmented reality and other commercially developed technologies into training programs. For example, the January 2020 DEFTECH Scan highlighted successful U.S. Air Force testing of an augmented reality pilot training system from Red6 Aerospace known as the Airborne Tactical Augmented Reality System (A-TARS).

Shocking Results of Helmet Tests: Researchers at Duke University demonstrated that, despite advancements in protection from ballistics and blunt impacts, modern military helmets are no better at protecting the brain from shock waves created by nearby blasts than their World War I counterparts. The French Adrian helmet actually performed better than modern designs in providing protection from overhead blasts. The research was originally published online on February 13, 2020 in the journal PLOS ONE.[13]

The study of the damage shock waves can cause on the brain on its own is a relatively new area of study. Helmets have largely been designed to protect personnel from bullets and shrapnel. Moreover, blast waves are more likely to kill soldiers through pulmonary trauma before they cause brain damage. However, modern body armour (such as the new soldier systems profiled in previous DEFTECH Scans and featured in the text box below) offer a greatly enhanced degree of protection from these blasts, meaning that there is a new need to better understand the effects of blasts on the brain and spine. No current deployed helmet has been specifically designed for blast protection.

Researchers placed different helmets on a test dummy's head outfitted with pressure sensors at various locations and tested with shock waves of various strength, each corresponding to a different type of German artillery shell exploding from a distance of one to five meters away. The key finding: "all helmets

[11] "Gaming technology trialled in training UK Armed Forces", UK MoD, March 6, 2020, https://www.gov.uk/government/news/gaming-technology-trialled-in-training-uk-armed-forces
[12] "Gaming technology trialled in training UK Armed Forces", UK MoD, March 6, 2020, https://www.gov.uk/government/news/gaming-technology-trialled-in-training-uk-armed-forces
[13] Joost Op 't Eynde, Allen W. Yu, Christopher P. Eckersley, Cameron R. Bass. "Primary blast wave protection in combat helmet design: A historical comparison between present day and World War I", *PLOS ONE*, 2020; 15 (2): e0228802 DOI: 10.1371/journal.pone.0228802

provided a substantial amount of protection against blast", but researchers "were surprised to find that the 100-year-old helmets performed just as well as modern ones," according to Joost Op't Eynde, lead author of the study.[14] The Adrian helmet was singled out as offering particularly robust protection against overhead shockwaves due to its design. Op't Eynde noted that "the French helmet had a crest on the top of its crown. While it was designed to deflect shrapnel, this feature might also be deflecting shock waves."[15]

A Batsuit for Soldiers

The U.S. Department of Defense is funding research from Florida Atlantic University (FAU) to develop a new type of body fabric that could prove 300 times as strong as today's state-of-art, but just as light, according to *Defense One* reporting during the reporting period.

The FAU team's approach seeks to develop a new type of treatment for nylon fabric, a hybrid mixture of a polymer that is similar to ultra-high-molecular-weight polyethylene and carbon nanotubes.[1]

Ultimately, this research could help inform the design of modern helmets in meeting the challenge of blast protection that will complement advances in body armour, especially given "the modern materials and manufacturing capabilities we possess today."[16]

Coronavirus and Military Preparedness: The coronavirus pandemic is intersecting with military training, organizational efficiency, and technology development relevant to improving human performance and protecting personnel.

Most notably, militaries around the world are taking precautions to limit the spread of the virus, including the cutting short of the U.S.-led cold weather exercise Cold Response 20 after only two days on March 11. The exercise was being held in Norway and included a total of 15,000 troops from the home country as well as the United Kingdom, Netherlands, Germany, France, Belgium, Denmark, Finland, and Sweden. The cancellation occurred after nearly two dozen U.S. soldiers were quarantined after concerns were raised that they may have contracted the virus from a Norwegian service member who tested positive for it.[17]

Similarly, coronavirus concerns are also having effects on the Defender-Europe 2020 exercise, the largest military exercise in Europe since the 1990s. The main components of the exercise were scheduled for April and May, though thousands of U.S. troops had deployed to Europe in preparation for the main exercise components. Germany announced the ending of exercises on its soil on March 16 due to concerns about the coronavirus pandemic.[18]

And while the coronavirus is affecting military readiness, it is also helping to catalyse innovation of novel solutions for helping militaries get ahead of health crises and, especially, protect individual military personnel. On March 3, private-sector company Profusa announced its newest funded study designed to test the effectiveness of an under-the-skin biosensor in detecting flu-like infections even before their symptoms begin to show.[19]

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[14] Joost Op 't Eynde, Allen W. Yu, Christopher P. Eckersley, Cameron R. Bass, "Primary blast wave protection in combat helmet design: A historical comparison between present day and World War I", *PLOS ONE*, 2020; 15 (2): e0228802 DOI: 10.1371/journal.pone.0228802

[15] Ibid.

[16] Ibid.

[17] John Vander, "Marines' Cold Response exercise in Norway is latest drill to be nixed over virus fears", *Stars and Stripes,* March 11, 2020, https://www.stripes.com/news/marine-corps/marines-cold-response-exercise-in-norway-is-latest-drill-to-be-nixed-over-virus-fears-1.622016

[18] Christopher Woody, "The US Army is rethinking how to do its largest Europ
ean exercise in 25 years amid a coronavirus lockdown, *Business Insider,* March 17, 2020, https://www.businessinsider.com/army-rethinking-defender-europe-20-amid-coronavirus-lockdown-2020-3

[19] Patrick Tucker, "A Military – Funded Biosensor Could Be the Future of Pandemic Detection", *Defense One,* March 3, 2020, https://www.defenseone.com/technology/2020/03/military-funded-biosensor-could-be-future-pandemic-detection/163497/

The sensor has two parts. One is a 3mm string of hydrogel, which is inserted under the skin with a syringe. The string includes a specially engineered molecule that sends a fluorescent signal outside the body when the body begins to fight an infection. The second part is an electronic component attached to the skin that sends light through the skin, detects the fluorescent signal, and generates another signal that the wearer can send to a doctor.[20]

The recently announced research will test if the sensor can detect influenza outbreaks up to three weeks before it's possible to detect them using current methods. One particularly compelling element of the technology is that it does not emit a signal and therefore does not give away an individual soldier's position. Profusa has received funding from DARPA since 2011 for this program.[21]

Cyber and C4ISTAR

Key Insights:

- The increasing automation and networking of command and control (C2) and battle management systems (BMS) continues to be a priority for small and large militaries as they seek to gain advantage in the crowded and fast-moving operational and tactical environments for which these militaries are planning. The ability to deliver timely intelligence to the correct individual or unit at precisely the right time will be a discriminator in many tactical environments.
- AI continues to be integral to the development of a range of military capabilities, including C4ISTAR capabilities. However, there are concerns about the safe and trustworthy use of AI and calls both within defence and intelligence communities and throughout the world for the development of norms and standards to govern the development and use of AI.
- The coronavirus pandemic is also affecting the cyber and C4ISTAR environment as many militaries implement teleworking policies in order to ensure social distancing and control the spread of the virus. The increased burden on networks as well as cyber-security risks and the inability of remote workers to access classified information all constitute current challenges to efficiency of communications within and among defence and security communities.

Israeli Defence Force Acquires Fire Weaver: On February 3, 2020, the Israeli Defence Force acquired the Fire Weaver networked sensor-to-shooter fire control system. Fire Weaver was developed by Rafael Advanced Defence Systems, Israel's Directorate of Defence Research and Development, and the IDF Ground Forces. It will be deployed in IDF armoured brigades and is expected to become operational this year.

[20] Ibid.
[21] Ibid.

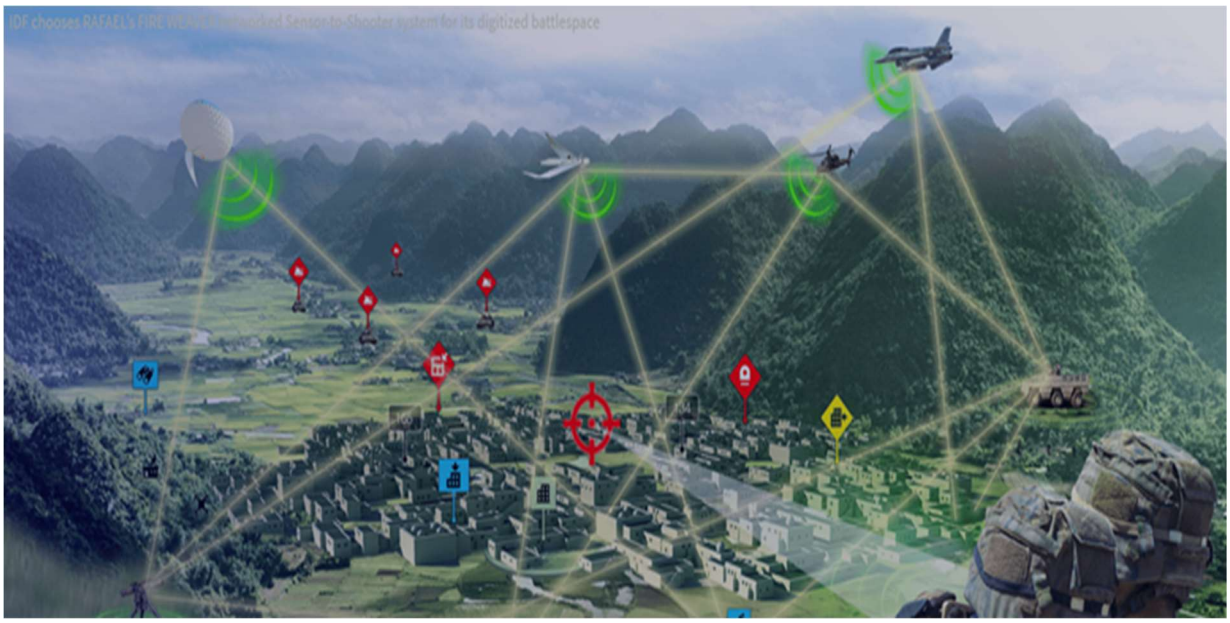

Figure 3: : A diagram of the FireWeaver concept and capability (source: Rafale website)

An IDF representative praised the system, saying that it "creates an 'operational internet' and brings to the battlefield the same innovation that the internet brought to the civilian world, the smart home, and the smart cities."[22]

According to Rafael, Fire Weaver connects "all sensors and shooters in real time, presenting relevant augmented reality information on the weapon sight, and instantly selecting the most relevant shooter for each target-enabling simultaneous, precision strikes"[23] Company marketing material also focuses on the system's artificial intelligence (AI) technology noting that the AI "calculates the Rules of Engagement and directs targeting and firing, using the most appropriate shooter for each acquired target."[24]

A linked, AI-enabled capability such as Fire Weaver could be a crucial capability for both small and large militaries in the fast-moving, highly-complex, crowded, and contested tactical and operational environment. Trials for the system were held with two battalions, each of which was given the same mission scenario and identical equipment other than only one had Fire Weaver. The unit equipped with the system "defeated 70% of its targets before it reached their locations while the other unit still had to engage around 60% of its targets upon arrival."[25]

U.S. Adopts Principles for Using AI: The U.S. Department of Defense (DoD) officially adopted on February 24, 2020 a series of ethical principles for the use of Artificial Intelligence today following recommendations provided to Secretary of Defense Dr. Mark T. Esper by the Defense Innovation Board last October.

[22] Samuel Cranny-Evans, "IDF orders Fire Weaver network fire control system", *Jane's Defence Weekly,* February 4, 2020, https://www.janes.com/article/94093/idf-orders-fire-weaver-network-fire-control-system
[23] Ibid.
[24] "About Fire Weaver", Rafale website, https://www.rafael.co.il/worlds/land/multi-service-network-centric-warfare/
[25] Samuel Cranny-Evans, "IDF orders Fire Weaver network fire control system", *Jane's Defence Weekly,* February 4, 2020, https://www.janes.com/article/94093/idf-orders-fire-weaver-network-fire-control-system

According to Secretary Esper, "the United States, together with our allies and partners, must accelerate the adoption of AI and lead in its national security applications to maintain our strategic position, prevail on future battlefields, and safeguard the rules-based international order."[26]

AI ethics has been a frequently cited challenge associated with the incorporation of AI into military and security activities. Much of the focus has revolved around how to maintain a human in the loop in the decision-making processes of AI systems, especially lethal AI-enabled weapons systems. But there are also pressing concerns about the explainability, trustworthiness, and transparency of AI and the data on which it is built. Corrupted data and "black box" neural networks can produce counter-productive outcomes, ranging from the tragic and easy to detect to more subtle but equally impactful and deleterious outcomes in areas such as predictive logistics, cyber-security, training, manned-unmanned teaming, and cognitive sensing.

To this end, the DoD principles will apply to both combat and non-combat functions and will revolve around five main areas[27]:

1. **Responsible:** DoD personnel will exercise appropriate levels of judgment and care, while remaining responsible for the development, deployment, and use of AI capabilities.
2. **Equitable:** The Department will take deliberate steps to minimize unintended bias in AI capabilities.
3. **Traceable:** The Department's AI capabilities will be developed and deployed such that relevant personnel possess an appropriate understanding of the technology, development processes, and operational methods applicable to AI capabilities, including with transparent and auditable methodologies, data sources, and design procedure and documentation.
4. **Reliable:** The Department's AI capabilities will have explicit, well-defined uses, and the safety, security, and effectiveness of such capabilities will be subject to testing and assurance within those defined uses across their entire life cycles.
5. **Governable**: The Department will design and engineer AI capabilities to fulfil their intended functions while possessing the ability to detect and avoid unintended consequences, and the ability to disengage or deactivate deployed systems that demonstrate unintended behaviour.

[26] "DOD Adopts Ethical Principles for Artificial Intelligence", U.S. Department of Defense, February 24, 2020, https://www.defense.gov/Newsroom/Releases/Release/Article/2091996/dod-adopts-%20ethical-principles-for-artificial-intelligence/source/GovDelivery/
[27] Ibid.

Manned Platforms

Key Insights:

- Across the Indo-Pacific there is a growing focus on developing or acquiring submarines in order to better compete in the undersea domain, which is a crucial domain for most countries in the region. While China's submarine development—both diesel-electric and nuclear-powered—is a prime driver, so, too, is the need to keep up with regional rivals and neighbors. Different countries are taking different approaches—from domestic design and production, to partnership, to procurement—in order to keep up with regional trends. The burgeoning "arms race" is interesting in and of itself, but also may reveal how both large and small militaries may seek to engage in critical domain area competitions and how investments in a capability area can be "contagious" across a broader region.
- Active protection system technologies are developing and offering increasingly effective layered approaches to protecting manned armed vehicles from novel new threats. Israel's successful testing of a "miss-to-kill" intercept round, among other new capabilities, demonstrates continued progress in the development of robustness of these systems

Race to the . . . Bottom: The Underwater Arms Race: In January, *Asia Military Review* published an analysis of the on-going efforts of states across East and Southeast Asia to develop or procure submarines in order to keep up with one another in the critical undersea domain.

This "submarine arms race" has been underway for approximately a decade but has accelerated as more navies expand their fleets. There are two main drivers of this dynamic. China's increasing focus on developing advanced submarine—both diesel-electric and longer-range strategic nuclear submarines—in order to address its imbalance in the undersea domain with the United States is a particularly important consideration for states like Japan and Australia that seek to play a frontline role in deterring and dissuading China's boundary pushing—both literally and figuratively—efforts.[28]

Another driver is the "me too" need to keep up with regional rivals and neighbours, a dynamic that is especially prominent in Southeast Asia. According to Dr. Collin Koh of the S. Rajaratnam School of International Studies in Singapore, "for some countries, acquiring a submarine equates to being in the 'club'—one that brings prestige because operating and maintaining a submarine capability becomes testament to the country's financial and technical prowess."[29]

Outside of China and Japan, only South Korea and India stand out as countries seeking to actually develop a domestic submarine design and delivery capability. The KSS-III Jangbogo-class SSK uses a Korean design while the Indian Navy saw its first ballistic missile submarine, INS *Arihant*, commissioned in 2016. Taiwan has also decided to build eight submarines as part of its Indigenous Defense Submarine program.[30]

In 2019 the Australian government signed a Strategic Partnership Agreement with Naval Group to finalize the procurement of the Shortfin Barracuda 1A design while other states have agreed to procure submarine capabilities from a range of suppliers. China is supplying subs to Pakistan, Thailand, and Bangladesh while Malaysia has bought two French-built Scorpene submarines with plans to double the size of its fleet. Singapore has procured four new Invincible-class submarines from Thyssen-Krupp, which are expected to enter service in 2021, 2022, and 2024. Indonesia and the Philippines are both also seeking to expand and develop their respective submarine fleets.[31]

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[28] Tim Fish, "Underwater Arms Race", *Asian Military Review,* January 9, 2020, https://asianmilitaryreview.com/2020/01/underwater-arms-race/
[29] Ibid.
[30] Ibid.
[31] Ibid.

The undersea arms race dynamic across the Indo-Pacific reveals both the growing importance of the domain in the region and, critically, the various ways in which small militaries are trying to compete in critical domain areas dominated by larger, better funded militaries.

Active Protection System: In January, Elbit Systems' Iron Fist active protection system (APS) successfully engaged a 120 mm armour-piercing fin-stabilised discarding sabot projective under test conditions. The interceptor was reportedly a "miss-to-kill" round launched by the Iron Fist Light Kinetic system.

The round exploded near the incoming round, changing its trajectory and hitting the target vehicle at a less optimal angle and thereby reducing the risk to the vehicle. APSs are part of a layered effort to defend manned armoured vehicles and tanks and are being integrated with new materials, camouflage techniques, and decoys to offer enhanced protection in highly contested environments.[32]

The innovation offers one more layer of defence against rapidly evolving offensive capabilities likely to be integrated with other APS munitions as well as armour made from advanced materials.

Missile Systems and Munitions

Key Insights:

- The conversation about hypersonic missiles is expanding beyond the "usual suspects" of the United States, China, and Russia. Japan has articulated plans for the development of a both hypersonic glide vehicle and a hypersonic cruise missile in order to respond quickly to threats largely to its southeastern islands. Japan's interest in hypersonic missiles and hypersonic glide vehicles in particular demonstrates the broadening interest in these weapons, which will create challenges both in terms of hypersonic missile proliferation and growing interest in hypersonic missile defence in large and small militaries.
- Further development in laser technologies as well as on-going development of a supergun in the United States reflect an on-going effort to develop multiple means of dealing with emerging threats and the realities of emerging operating environments. Laser weapons offer low cost alternatives to meeting the threat of highly-proliferated unmanned systems while superguns offer a long-range precision fires solution to penetrating more sophisticated air defense systems

Japan's Hypersonic Missiles Programs: Japan outlined its research and development roadmap for its domestically – developed standoff hypersonic weapons in a document from the Ministry of Defence's Acquisition, Technology, and Logistics Agency (ATLA) released in March.

[32] Samuel Cranny-Evans, "IAV 2020: Elbit's Iron Fist engages kinetic energy round", *Jane's Defence Weekly,* January 24, 2020, https://www.janes.com/article/93902/iav-2020-elbit-s-iron-fist-engages-kinetic-energy-round

The document outlines development of both an air-launched Hypersonic Cruise Missile (HCM) and a Hyper Velocity Gliding Projectile (HGVP). These weapons are viewed as being particularly important not as a means to balance strategic competition with China, but rather as a component of carrying out a specific defensive mission. Over the past four years, Japan has taken proactive steps to improve its capacity to defend the contested Senkaku Islands in particular, which China also claims. Japan Ground Self-Defense Force (JGSDF) units have been deployed to bases on several islands southwest of Okinawa, and the JSDF also established the Amphibious Rapid Deployment Brigade (ARDB) to respond to fast-

Figure 4: The image describing Japan's hypersonic missile development programs (source: Japan's Ministry of Defense)

moving grey-zone contingencies in these more distant islands.[33] Hypersonic missiles travel at speeds of Mach 5 and above, and can serve as an important component of the rapid defence of these islands.

The ATLA report provided insight into Japan's plans regarding warhead payloads with different warheads being developed for both seaborne and land targets. The document also revealed that the country is taking a staged approach to the development of the HGVP.[34] The first block is an early capability version. Its development period will be shortened by using existing missile technologies and by conducting tests of prototype with JGSDF unit. The Block 2 version will be an enhanced capability version that makes use of the latest technology. The Block 2 HGVP will include a warhead that glides with the shape of a "wave-rider" that gains lift by the shock wave generated at the tip of the warhead. Early versions of the capabilities of both the HGVP and HCM capabilities are expected to be fielded in the 2024 to 2028 timeframe and are expected to enter service in the early 2030s.[35]

Laser Breakthrough: In January 2020, the Israeli Ministry of Defense announced that it had achieved a breakthrough in laser technology that "will prompt a strategic change in the defence capabilities of the state of Israel."[36]

According to the Israeli MoD, collaboration between the DDR&D, Rafael, Elbit, and academic institutions had led to the development of "electric-source laser systems in replacement of chemical laser

[33] Yoshihiro Inaba, "Japan MoD Announces New Deployment and Training Plan For JGSDF With Focus on Island Defense," *Naval News,* December 26, 2019, https://www.navalnews.com/naval-news/2019/12/japan-mod-announces-new-deployment-training-plan-for-jgsdf-with-focus-on-island-defense/.
[34] Mike Yeo, "Japan unveils its hypersonic weapons plans", *Defense News,* March 14, 2020, https://www.defensenews.com/industry/techwatch/2020/03/13/japan-unveils-its-hypersonic-weapons-plans/
[35] Yoshihiro Inaba, "Japan To Develop And Deploy Supersonic Glide Weapons That Can Target Ships", *Naval News*, March 4, 2020, https://www.navalnews.com/naval-news/2020/03/japan-to-develop-and-deploy-supersonic-glide-weapons-that-can-target-ships/
[36] Yaakov Lappin, "Israel announces laser breakthrough", *Jane's Defence Weekly,* January 10, 2020, https://www.janes.com/article/93626/israel-announces-laser-breakthrough

technology." The technology has enabled the MoD to successfully focus on "long-range targets, including overcoming atmospheric disturbances."[37]

The MoD announcement stressed the defensive capacity of these new laser systems, noting that they could be used to intercept unmanned aerial vehicles (UAVs), rockets, and anti-tank missiles. The breakthrough offers a low cost / deep magazine capability to meet the emerging low-cost threat associated with the proliferation of these weapons, especially to non-state actors.

Supergun Test: The US Army conducted tests of a 58-caliber XM1299 cannon using a "supercharged" propellant to fire two types of munitions about 65 kilometres, considerably further than a traditional howitzer's range. The test took place at the Yuma Proving Ground in Arizona on March 6, 2020.

Supergun development and procurement is a reflection of a growing need among many militaries throughout the world—and particularly the U.S. Army—to develop multiple and redundant means of resolving a key operational challenge, namely striking deep into contested or even enemy-held territory in an age of proliferation of more robust and sophisticated air and missile defence systems. Indeed, future precision strike is actually one of six articulated Army Futures Command modernization priorities, along with an expansive future vertical lift program that includes the future attack reconnaissance aircraft, which is explicitly designed to be able to penetrated enemy air defences in crowded and contest "urban canyon" operating environments.

Brigadier General John Rafferty Jr, the director of the Long Range Precision Fires Cross Functional Team at Army Futures Command note that the gun "allows commanders to attack differently, provides them a weapon system other than helicopters and armed drones to go after targets that are deeper on the battlefield."[38]

The Army has ordered 18 XM1299s from BAE Systems and to be sent to a battalion in 2023, which will offer the Army the opportunity to "evaluate the operational concept for support fires at the division level."[39] While the Army claims to have proven the capability and range, the on-going engineering challenge is the development of an autoloader that will enable the cannon to fire six to eight rounds per minute.[40]

[37] Ibid.
[38] Patrick Tucker, "The Army Just Tested Its New Supergun", *Defense One,* March 6, 2020, https://www.defenseone.com/technology/2020/03/army-just-tested-its-new-supergun/163604/
[39] Ibid.
[40] Ibid.

Robotics and Unmanned Systems

Key Insights:

- The unmanned systems market is marked by an increasing velocity of demand as unmanned air, ground, surface, and undersea vehicles all demonstrate their value in a range of difficult operational environments. As a result, new systems are being asked to take on a wide-range of new missions, including in some cases missions that have ethical, legal, and strategic implications that likely require further consideration by both large and small militaries. The demand for unmanned systems to take on more missions is also driving interest in modular systems with flexible approaches to payload development
- The increasing velocity of demand is driving an increased volume of supply, as more companies – both private and state-owned—develop and make available more unmanned solutions. The UMEX show in February in Abu Dhabi was especially notable for the diversity of suppliers, including domestic suppliers and private companies from China. These companies are increasingly making their solutions available to both large and small militaries
- In some emerging demand areas, there is likely to be fierce competition between domestic industrial bases and concerted efforts to ensure secure supply bases. The commercial drone industry stands as an example of a country's industry that was able to achieve a dominant market position in a market that has become strategically important for defense and security communities throughout the world
- The combination of increasing velocity of demand and volume of supply is creating a growing variety of solutions available to large and small defense and security communities throughout these worlds. These solutions may seek to address similar missions or challenges facing defense and security communities, but they are still highly differentiated by design features or incorporation of different technologies. For example, design features such as solar-power or orb-shaped UGVs offer novel means of addressing urgent operational requirements of both large and small militaries.

UMEX 2020[41]: Estonian manufacturer Milrem Robotics displayed its fifth generation Tracked Hybrid Modular Infantry System (THeMIS) unmanned ground vehicle (UGV) at the UMEX 2020 held in Abu Dhabi from February 23 – 25, 2020.

THeMIS has featured in previous DEFTECH Scans. The platform is considered among the leaders in the global UGV largely due to its highly modular structure and Milrem's willingness to partner with local manufacturers to develop and integrate payloads for the UGV, including remote weapons stations, tethered unmanned aerial systems, electro-optical / infrared sensors, missiles, and counter-improvised explosive device payloads. The version on display at UMEX is specifically designed for use in hot climates, clearly a priority for the UAE military and other militaries across the Middle East. This iteration of the system has been deployed as part of the French-led operation 'Barkhane', during which the THeMIS has travelled more than 1,000 km and operated in temperatures exceeding 50°C.[42]

[41] The author attended this event. The below analysis is a combination of reporting on UMEX 2020 and the author's reflections and observations.
[42] Melanie Rovery, "UMEX 2020: Milrem showcases updated THeMIS UGV, *Jane's International Defence Review,* February 24, 2020, https://www.janes.com/article/94497/umex-2020-milrem-showcases-updated-themis-ugv

Figure 5: The next-generation THeMIS on display at UMEX 2020 in Abu Dhabi (source: Tate Nurkin)

The UMEX show reflected several prevailing trends in unmanned systems more broadly such as: the increasing velocity of demand of unmanned systems; the growing volume of suppliers; and broadening variety of systems available. Indeed, the show revealed the growing prominence of UAE's domestic unmanned systems industry to meet the growing demand in country and across the region. For example, the Garmousha vertical-take-off-and-landing UAV was on prominent display at the show. Made by ADASI, a subsidiary of government-owned defence industry conglomerate EDGE, the Garmousha is designed for missions such as detecting pipeline leaks, survey infrastructure, and search and rescue operations. The Garmousha can simultaneously carry a wide variety of payloads, including a stabilized electro-optical sensor for day and night intelligence, surveillance and reconnaissance missions. The Garmousha is also designed for export. According to CEO Ali Al Yafei, "We have received considerable interest from many prospective international clients and are currently engaging with them."[43]

The exhibition also had an impressive variety of suppliers and systems from outside the region, including UMS Skeldar's V-150 vertical-take-off-and-landing UAV produced by a joint venture between SAAB and Switzerland's UMS Aero Group. On March 3, the companies subsequently launched an enhanced version of the V-150 "to support tactical operations including defence forces, surveillance, blue light forces, and homeland security." The new platform has a current endurance of 2.5 hours with a 12 kg payload capacity. On-going modifications are expected to increase the endurance to four hours.[44]

Several Chinese manufacturers displayed at the show as well, including both state-owned enterprises and private companies. Unmanned systems are one of the few areas in which China's private industry has been able to compete with the large state-owned enterprises that constitute China's defence industrial base.

Several of these Chinese companies' marketing materials emphasized various types of "intelligent swarming" capabilities, including Ziyan, a private company that produces the Blowfish drone. The swarming capacity of the Blowfish was featured in a May 2019 YouTube video.

Among the many other notable Chinese drones on display during the event were:

- The Hummingbird personal reconnaissance nano UAV, which is modelled after the FLIR Black Hornet
- The Flying Loong-3 solar-powered HALE UAV, which advertises near space cruising altitude, extra-long endurance and vast coverage for both military and civilian application

Figure 6: The Garmousha rotary wing UAV made by ADASI, a subsidiary of UAE government owned consolidated defense industry conglomerate EDGE (source: Tate Nurkin)

Unarmed Unmanned System Report: In March, the Center for the Study of the Drone at Bard College released a report entitled "Armed and Dangerous: The Lethal Applications of Non-Weaponized Drones."

[43] Agnes Helou, "Meet Garmousha: A New Rotary-Wing Drone Made in the UAE", *Defense News,* February 25, 2020, https://www.defensenews.com/unmanned/2020/02/25/meet-garmousha-a-new-rotary-wing-drone-made-in-the-uae/
[44] Gareth Jennings, "UMS Skeldar launches enhanced V-150 VTOL UAV", *Jane's Defence Weekly,* March 4, 2020, https://www.janes.com/article/94681/ums-skeldar-launches-enhanced-v-150-vtol-uav

The report focused on the many ways that unarmed drones—even small, inexpensive, and proliferated unmanned aircraft—can be used in a variety of roles to directly enable lethal strikes by other weapons. Use of unmanned systems in this strike-enabler role can significantly expand the effectiveness of strike by other weapons and, as a result, raises ethical, legal, strategic, and tactical questions." According to the report, these unarmed strike-enabling unmanned systems are proliferating, a trend that will be amplified by advances in miniaturization and autonomy will make these strike-enabling capabilities cheaper, more accessible, and more formidable.[45]

One of the central concerns of the report was the combination of technological advancement, especially the miniaturization of sensors, the proliferation of small drones that can now carry these smaller sensors, and the increasing importance of unmanned systems on the modern battlefield. The intersection of these trends could lead to two potentially disruptive and deleterious outcomes for modern militaries. First, the proliferation of small and inexpensive drones capable of carrying small, but capable sensors, "could even place many of the strike-enabling capabilities described in this report in the hands of non-state groups." Second, increased accuracy of sensors and use of drones to collect detailed information could "give even upstanding operational units a false sense of confidence that a target is right and just", shortening validation processes and possibly leading to an increased risk of "high-regret action."[46]

Figure 7: The Ziyan Blowfish UAV at the Ziyan stand at UMEX. The stand prominently features "intelligent swarming" capability (Source: Tate Nurkin)

ORBs and the Future of Unmanned Systems (Part I): The United States Air Force released a request for proposals (RFP) for the Agility Prime program on February 25. The program seeks to develop a highly modular vertical-lift aircraft that could play a variety of roles. The Air Force has dubbed the aircraft organic resupply buses or "ORBs."

According to the RFP, "given their flexibility, an ORB could act as an organic resupply bus for disaster relief teams, an operational readiness bus for improved aircraft availability, and an open requirements bus for a growing diversity of missions. ORBBs could enable distributed logistics, sustainment, and manoeuvre with particular utility in medical evacuation, firefighting, civil and military disaster relief, installation and border security, search and rescue, and humanitarian operations."[47]

The acquisition program will feature a "challenge-based acquisition plan" that will feature different durations of flight and payloads that have to be carried. As contractors pass various tests they will "move down the wickets of getting safety certified and moving onto a procurement contract."[48]

Critically, the program's focus is broader than merely developing a novel capability. The Air Force also seeks to catalyse the development of U.S.-based capability in a new industry area that the Department of Defense sees as being particularly strategically important to establishing and maintaining future operational advantage. If the U.S. DoD investment can stimulate U.S. companies to develop innovative and certified flying car designs, perhaps this initial development can help create trust that will in turn

[45] Arthur Holland Michel, "Unarmed and Dangerous: The Lethal Applications of Non-Weaponized Drones", Center for the Study of the Drone, Bard College, March 2020, https://dronecenter.bard.edu/projects/unarmed-and-dangerous/unarmed-and-dangerous-2/
[46] Ibid.
[47] Patrick Tucker, "Will Flying Cars Help the US Beat China? The Air Force Hopes So", *Defense One,* February 25, 2020, https://www.defenseone.com/technology/2020/02/will-flying-cars-help-us-beat-china-air-force-hopes-so/163331/
[48] Ibid.

stimulate a broader market. According to Peter W. Singer, a strategist at New America Foundation, "Pentagon leaders are putting far more thinking into supply chains than they were in the past, in both already established programs of record as well as what might be the programs 20 years from now."[49]

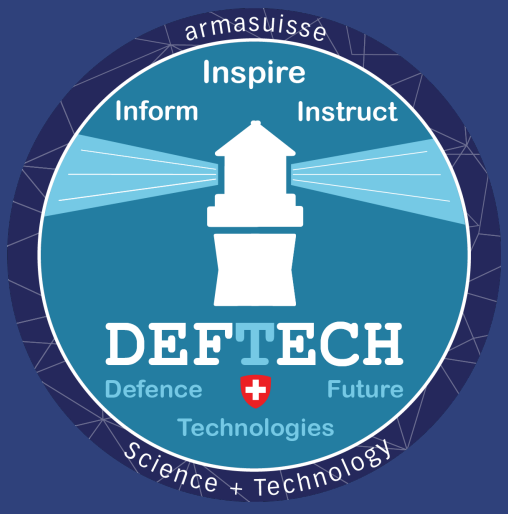
Orbs and the Future of Unmanned Systems (Part II): In February 2020, GuardBot Inc announced that it was teaming with Aquiline Drones to further develop its spherical surveillance and reconnaissance unmanned system by building in cloud connectivity.

The orb shaped GuardBot system was trialled by the United States Marine Corps (USMC) in 2012 and 2014 without traction from the USMC. The development of both scale and modularity have made the security-focused system more appealing in 2020. According to Aquiline Drones CEO Barry Alexander, "we have multiple units which have been totally redesigned to enable scalability. As such GuardBots are now modular in design with swappable side pods and have been tested with laser sensors, infrared, thermal imaging, etc. This has made GuardBot extremely versatile but also highly adaptable with the ability to cater to a wide variety of cases." One use case is for a Soldier or Marine to "deploy [a GuardBot] from their field kit and use it to scout ahead", much like nano- and micro-UAVs are currently being deployed.[50]

Figure 8: The GuardBot (source: GuardBot Inc.)

The system is amphibious and runs from 6.5 inch in diameter to 7-feet in diameter with models at 8.5, 9.5, and 12.5-inches and one that is 3-feet in diameter.[51]

[49] Ibid.
[50] Kelsey D. Atherton, "Are orbs the future of security drones", *C4ISRNet.com,* https://www.c4isrnet.com/unmanned/robotics/2020/03/06/are-orbs-the-future-of-security-drones/
[51] Ibid.



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