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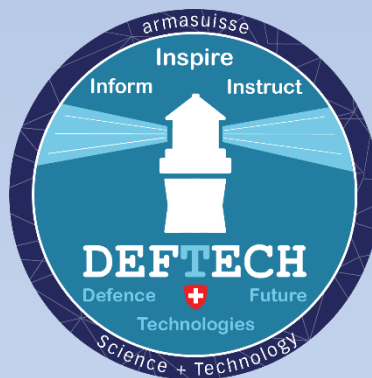
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DEFTECH Military Capabilities Update

April 2019

Dear Reader,

More than surprising you with completely new ideas and technologies, this release will highlight the speed at which what were only concepts months ago are becoming demonstrators and proof of concepts today. Artificial Intelligence and Swarming are finding their way into present and future systems via numerous initiatives in almost all the combat spheres. Budgets are allocated; strategies are drawn by countries to stay ahead in these various runs.

Building on the previous releases of the DEFTECH Update, we are bringing you these latest developments and efforts regrouped in the six initially selected categories:

- Energy and Power
- Human Performance Enhancement
- Cyber and C4ISTAR
- Manned Platforms
- Missile Systems and Munitions
- Robotics and Unmanned Systems

However, knowing that reports today may not be the most appreciated format for a newsletter, we are wondering if rendering its content in a podcast would be something that you, the reader, would be interested in. We would of course keep the PDF for people to check the references and start digging into a topic, but the audio file might simply help reaching a broader audience.

As an example, you can listen to Tate, interviewed for the Chinese Power Project on UAV Technology in China: https://chinapower.csis.org/podcasts/uav-technology-in-china/

Please, let us know!

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 (and listening!),

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Introduction and Summary

Key themes and insights that emerged across categories, both in the developments incorporated into this analysis and other reporting over the reporting period not explicitly covered herein include:

Artificial Intelligence: This report has a particularly strong focus on military efforts to incorporate artificial intelligence (AI) technologies and the capabilities they enable. Demonstrations of and announcements about specific platforms and systems such as the U.S. Air Force's Skyborg and Valkyrie attritable autonomous unmanned aerial systems and Russia's Poseidon nuclear-powered, nuclear-armed unmanned underwater vehicle reflect one—and likely the most controversial—of these applications: lethal autonomous weapons systems. There are many others: from driving big data analytics in support of intelligence activities, to predictive maintenance, to using AI in support cyber defence and attack, simulation and training, enhanced sensing, communications, and electronic warfare to surveillance.

As the range of applications of AI-enabled capabilities expand so, too, does the need for the clear communication of objectives and priorities for AI use at a national level as well as international guidance on ethics and standards for safe and trustworthy AI. The reporting period saw the release of both an executive order on AI from the President of the United States and the release of a U.S. Department of Defense (DoD) AI strategy. It also saw the release of European Union standards for ethical AI use, not just in the military and security domain but more broadly. This guidance could serve as an initial framework to regulate a technology that when applied by malicious or careless actors can undermine stability, security, prosperity, and fundamental human rights.

The Three 'Mergings': Development during the reporting further revealed three critical 'mergings' that are shaping the future of military capabilities and the missions that militaries are required to carry out.

The *merging of states of peace and conflict* is a central theme of this report. General Valery Gerasimov, the Chief of Staff of the Russian military, articulated this concept on 1 March 2019, espousing the value of information operations during "peace time" to undermine adversary and competitor polities and societies.

The *merging of the physical and digital worlds*—of men and machines—is also becoming increasingly relevant to military and security communities whether it is attempts at merging human brains with machines or pairing unmanned systems with manned platforms or more closely linking cyber-attacks with tactical movements of military forces or using augmented reality headsets to enhance training and operations.

The *merging of traditional and non-traditional defence industry* also features in this report, as it has in previous volumes. This merging offers promising potential for the acceleration of development of new technologies and the unlocking of new capabilities. However, it also introduces risk and places a premium on defence and security communities creating and articulating a positive and consistent message about the salutary and ethical nature of non-traditional defence suppliers providing new technologies to militaries.

Ethics and Consequences: The combination of these 'mergings' and the increasing efforts to incorporate AI into military capabilities has refocused international attention on the changing ethics and norms of conflict and military capabilities. The use of lethal autonomous weapons systems and other highly – disruptive applications of various AI technologies are typically at the top of the list of ethical concerns. And these concerns are having real and affecting implications for some military communities, especially those in the West. Protests from engineers at Google led to the company choosing to walk away from a DoD AI contract in 2018 and engineers at Microsoft attempting to scupper contract for HoloLens augmented reality systems with the United States Army.

Of even more immediate concern during this reporting period was India's direct ascent anti-satellite test in March, which shot an ageing satellite out of low earth orbit. The test created approximately 400 pieces of space debris, reportedly threatening the International Space Station along with other space infrastructure. It also highlighted the threats associated with escalating tensions in space, especially among Indo-Pacific powers.

Energy, Power, and Propulsion

Developing new battery technologies that enable increased efficiency of power storage, are lighter weight, and maintain high degrees of safety remains a priority for international militaries. And while varying innovation efforts are underway, the reporting period saw a focus on improvements in lithium-ion batteries, which continue to be the most practical approach for development of batteries by commercial industries—especially the automotive industry.

Safer, More Powerful Batteries: In early 2019, the U.S. Army Research Lab filed a patent application with the U.S. Patent and Trademark office for a new way to make lithium-ion batteries more powerful, but still safe. Army researchers have created "cocktails" of new solvents and new battery cells that allow lithium-ion and other rechargeable batteries to safely hold more energy.[1]

The Army is also currently exploring replacements for lithium-ion batteries to include magnesium and zinc-based batteries that reportedly can carry twice the charge.[2] The last volume of this report detailed research into fluoride-ion batteries from car manufacturer Honda that would increase battery storage capacity by eight to ten times over lithium-ion batteries. For Honda, this research–undertaken in conjunction with California Technological University and the U.S. Jet Propulsion Laboratory—could constitute a competitive advantage in the growing electric vehicle market.

For the Army, the intensified interest in battery technologies will support a range of capabilities, including electric and hybrid vehicles and new weapons. As Army Research Laboratory scientist Arthur von Wald Cresce noted in January of this year, "the Army is developing hybrid vehicles for use on the battlefield, and that means that they will also use lithium-ion batteries. Certain high-energy applications such as reactive armour and directed-energy weapons also seem suited for lithium – ion batteries, although those technologies are still developing."[3]

And research into new battery technologies that could provide new defence capabilities is continuing in research institutes and the private sector. In April 2019, Australian company CCT Energy Storage unveiled "the world's first operational thermal energy device" capable of storing renewable energy. The battery can charge and recharge simultaneously and rather than storing an electrical charge, it converts electrical inputs into heat. According to Serge Bonderenko, CEO of CCT Energy Storage, "it's a device that takes any form of electrical input on the front end and converts that to thermal energy. We use silicon as our phase change material, melt it and store the heat from that."[4]

But even as promising as this type of research and innovation is, an examination of the battery innovation efforts reveals one of the primary challenges associated with moving from the *invention* of a novel technology to the creation of a scalable and repeatable capability, especially for military communities: market realities and incentives.

According to analysis released by *Bloomberg* in April 2019, the cost of lithium – ion batteries has greatly decreased over the past decade and is rapidly approaching $100 per kilowatt hour (KwH). Combined with improved performance in lithium-ion batteries, the lowering costs have created an environment, at least in the commercial and applied research sectors, for "tweaking lithium-ion technologies, improving it bit by bit, rather than adopting something else." The existing manufacturing infrastructure also creates more incentive and opportunity for

[1] "Army building safer, more powerful batteries with licensing potential", *TechLink,* 24 January 2019, https://techlinkcenter.org/army-building-safer-more-powerful-batteries-with-licensing-potential/

[2] "Army building safer, more powerful batteries with licensing potential", *TechLink,* 24 January 2019, https://techlinkcenter.org/army-building-safer-more-powerful-batteries-with-licensing-potential/

[3] "Army building safer, more powerful batteries with licensing potential", *TechLink,* 24 January 2019, https://techlinkcenter.org/army-building-safer-more-powerful-batteries-with-licensing-potential/

[4] Parietta, Natalie, "New Thermal Battery Could Be A 'Game Changer' For Storing Renewable Energy", *Forbes,* 3 April 2019, www.forbes.com/sites/natalieparletta/2019/04/03/new-thermal-battery-could-be-a-game-changer-for-storing-renewable-energy/#69f4b4b84f95

lithium-ion batteries. Specifically, as demand for electric cars has grown, the worldwide manufacturing capacity for lithium-ion batteries has tripled in the last five years, according to *BloombergNEF*.[5]

The implications for defence and security communities could be significant. Notably, defence communities will need to balance incremental developments in existing technologies with the need to create incentives for commercial industry and applied research organizations to continue to develop novel technologies that can identify and produce at scale the sort of significant leaps forward in storage, efficiency, safety, and weight.

Human Performance Enhancement

Efforts at enhancing performance and safety of individual soldiers are leveraging a diverse set of Fourth Industrial Revolution technologies, including: virtual and augmented reality headsets for training and operational purposes, new and lightweight materials, and through advancements in neuro and bioscience and, potentially, psychotropic drugs. Of course, many of these efforts are controversial as they exploit the blurred seams between commercial and military industry and the physical and digital world.

HoloLens Contract and Military – Commercial Tensions: In October 2018, the U.S. Army awarded a $480 million contract to Microsoft to provide up to 100,000 customized HoloLens augmented reality headsets for training and operational purposes. The Army-specific headsets will vary from the commercially-available versions and will incorporate thermal sensing night vision. According to a Microsoft spokesperson, "augmented reality technology will provide troops with more and better information to make decisions", thereby improving their performance and lethality and ensuring increased safety and protection of individual soldiers.[6]

The award was not without controversy, though. In February 2019, a group of Microsoft employees called on Microsoft leadership to abandon the contract, citing ethical concerns over supporting the military. The group released a letter that expressed concern the teams that built HoloLens would become "implicated as war profiteers" and that "Microsoft is working to provide weapons technology to the U.S. Military helping one country's government 'increase lethality' using tools we built."[7] In response, Microsoft CEO Satya Nadella refused to stand down from the contract, stressing that Microsoft "made a principled decision that [we're] not going to withhold technology from institutions that we have elected in democracies to protect the freedoms we enjoy."[8]

The protest from Microsoft engineers recalled a 2018 incident in which pressure from employees led to Google refusing to renew its support of the U.S. Department of Defense's Project Maven, a program designed to utilize Google's object recognition software to more accurately identify objects in unmanned systems surveillance images and videos. While Microsoft took the position to continue its contract support with the U.S. Army, the episode reflects a growing and strategically affecting tension between the U.S. Department of Defense and the U.S. high-tech community over whether and how the U.S. defence community will be able to leverage the global leading technologies being produced in the United States.

In fact, on 21 March 2019 the outgoing Chairman of the Joint Chiefs of Staff General Joe Dunford publicly criticized Google for the apparent contradiction of its refusal to work with the U.S. DoD, but on-going AI development support to the Chinese government. General Dunford noted that Google's AI venture in China will—through China's doctrine of military-civilian fusion—end up benefitting China's military and also reinforcing

[5] Baker, David R., "Battery Reality: There's Nothing Better Than Lithium-Ion Coming Soon", *Bloomberg,* 3 April 2019, https://www.bloomberg.com/news/articles/2019-04-03/battery-reality-there-s-nothing-better-than-lithium-ion-coming-soon
[6] Kelly, Makena, "Microsoft secures $480 million HoloLens contract from US Army", *The Verge,* 28 November 2018, https://www.theverge.com/2018/11/28/18116939/microsoft-army-hololens-480-million-contract-magic-leap
[7] Levy, Nat, "Employees call on Microsoft to drop HoloLens-US Army contract: We did not sign up to develop weapons", *Geekwire,* 22 February 2019, https://www.geekwire.com/2019/microsoft-workers-call-company-drop-hololens-u-s-army-contract-not-sign-develop-weapons/
[8] Hruska, Joel, "Microsoft CEO: Selling HoloLens to Military is a 'Principled Decision', 27 February 2019, https://www.extremetech.com/extreme/286504-microsoft-ceo-selling-hololens-to-military-is-a-principled-decision

China's efforts to use AI for domestic surveillance (see Cyber and C4ISTAR section below for more on China's use of facial recognition for domestic surveillance).[9] In its defence, Google noted that it continues to support DoD on projects, particularly "defensive" projects associated with cyber-security and detecting deep fakes.

General Dunford and Google have agreed to meet in the near future to discuss their differing perspectives. But some analysts already believe that the friction between the DoD and Silicon Valley constitutes a strategic vulnerability for the United States (and other Western democracies) that needs to be addressed through a combination of the direct approach taken by General Dunford and a more pervasive strategic communications campaign. For example, an internal Pentagon memo circulated on 28 June 2018 asserted that the DoD had "stumbled unprepared into a contest over the strategic narrative" regarding military use of AI and that the DoD "will not compete effectively against our adversaries if we do not win the 'hearts and minds' of key supporters."[10] An article from the *Atlantic* in December 2018 went even further in its assessment, stating that that "a silent divide is weakening America's national security . . . It's the growing gulf between the tech community in Silicon Valley and the policy-making community in Washington."[11]

Soldier Protection and Enhancement Systems: The U.S. Army rolled out its new Soldier Protection System in March 2019, one of several developments in the field of systems designed to protect and enhance the performance of individual soldiers during the reporting period.

The Army's system includes a modular scalable vest, a ballistic combat shirt, and a ballistic belt along with an Integrated Head Protection System. Overall, the system stresses survivability of the soldier while also increasing functionality and reducing stress from the weight of protection equipment. On this final point, the new system is designed to better distribute the load and stress on a soldier's upper body. According to Lt. Dawn Ward, who was part of the team evaluating the system: "the vest is lighter and cooler, has a greater range of motion, and a better fit."[12]

According to Brigadier General Anthony Potts, the head of the U.S. Army's Program Executive Office Soldier, "I want our experiment to make our soldiers invincible. We're going to do our best to provide [soldiers] the equipment that [they] need to go out there and fight and return."[13]

Similarly, at the International Defence Exhibition (IDEX) 2019 show in Abu Dhabi in February 2019, Arab International Optronics (AIO) displayed its Egyptian Integrated Soldier System (EISS). EISS is an integrated surveillance and aiming capability that delivers images from different electro-optical devices to a head-mounted display. These optics are also linked either to the daylight scope of an RPG-7 or a targeting dot sight on a machine gun or assault rifle, according to *Jane's International Defence Review.* Each system has both a commander and soldier module. An unknown number of units will be delivered to the Egyptian Army in 2019.[14]

[9] Ali, Idress and Zengerle, Patricia, "Google's work in China benefitting China's military: general", *Reuters,* 14 March 2019, https://www.reuters.com/article/us-usa-china-google-idUSKCN1QV296

[10] Fryer-Biggs, Zachary, "Inside the Pentagon's Plan to Win Over Silicon Valley", *Wired,* 21 December 2018, https://www.wired.com/story/inside-the-pentagons-plan-to-win-over-silicon-valleys-ai-experts/

[11] Zegart, Amy, "The Divide Between Silicon Valley and Washington is a National Security Threat", *The Atlantic,* 16 December 2016, https://www.theatlantic.com/ideas/archive/2018/12/growing-gulf-between-silicon-valley-and-washington/577963/

[12] Wellman, Phillip Walter, "This helmet works, and I'm a living testament to it': Army to roll out new protective gear", *Stars and Stripes,* 12 March 2019, https://www.stripes.com/news/this-helmet-works-and-i-m-a-living-testament-to-it-army-to-roll-out-new-protective-gear-1.572234

[13] Wellman, Phillip Walter, "This helmet works, and I'm a living testament to it': Army to roll out new protective gear", *Stars and Stripes,* 12 March 2019, https://www.stripes.com/news/this-helmet-works-and-i-m-a-living-testament-to-it-army-to-roll-out-new-protective-gear-1.572234

[14] Ebbutt, Giles, "IDEX 2019: AIO develops integrated soldier-worn display for Egyptian special forces", *Jane's International Defence Review*, 21 February 2019, https://www.janes.com/article/86767/idex-2019-aio-develops-integrated-soldier-worn-display-for-egyptian-special-forces

Better Soldiering through Chemistry: A novel and controversial approach to performance enhancement was posited in a scholarly article published in the February 2019 edition of the *Marine Corps Gazette* entitled "Microdosing: Improving performance enhancement in intelligence analysis". The main argument of the article is that:

> "The Marine Corps Intelligence, Surveillance, and Reconnaissance Enterprise (MCISRE) may gain an advantage over competitors in intelligence analysis, productivity, and efficiency if it utilizes the innovative cognitive benefits gained through microdosing with psychedelics, which scientists, Silicon Valley executives, disruptors, and biohackers have already harnessed."[15]

A "microdose" is an amount that does not cause perceptual sensory changes such as visual hallucinations and is not strong enough to debilitate the subject that takes it—estimated at "usually between 10 and 20 micrograms of LSD or 100 milligrams of psilocybin."[16] In research cited by the author, Major Emre Albayarak, microdoses were reported to "significantly heighten alertness, creativity, and problem solving, inducing a flow state that aids in lateral thinking."[17]

The article is just one—admittedly provocative—example of on-going efforts in the U.S. military and militaries around the world to leverage advances in neuro-science and understanding of the brain's chemistry to enhance the cognitive functioning of individual soldiers and military personnel. A study authored by U.S. Army scientists and published in the journal *Science Advances* in April 2018 explores the ways in which the brain shifts to different states, from distracted to ordered and aware, based on how different its regions are behaving and communicating with one another.[18] The paper has a particular focus on how the brain—both generally and in specific individuals—arrives at "chimera states", in which several of its regions are focused on one task.[19]

This research is being applied to better understand and act upon the intent of a specific operator in order to respond to a broadening and accelerating threat environment. In short, the research will be applied to enable machines to read operator minds and then act more quickly than humans could to inbound or emerging threats. The article also notes that this research could have broader applicability; for example, predicting brain states far in advance based on sleep, stress, or activity levels of individual soldiers.

This scientific article touches on themes explored in a feature published in *The Atlantic* in November 2018 that outlined efforts by DARPA's Biological Technologies Office to create technologies that create the "merging of minds and machines."[20]

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[15] Emre, Major Albayarak, "Microdosing: Improving performance enhancement in intelligence analysis", *Marine Corps Gazette,* February 2019, https://mca-marines.org/wp-content/uploads/2019/02/Albayrak.pdf

[16] Emre, Major Albayarak, "Microdosing: Improving performance enhancement in intelligence analysis", *Marine Corps Gazette,* February 2019, https://mca-marines.org/wp-content/uploads/2019/02/Albayrak.pdf

[17] Emre, Major Albayarak, "Microdosing: Improving performance enhancement in intelligence analysis", *Marine Corps Gazette,* February 2019, https://mca-marines.org/wp-content/uploads/2019/02/Albayrak.pdf

[18] Bansal, Kanika et al., "Cognitive Chimera States in Human Brain Networks", *Science Advances*, 3 April 2019, https://advances.sciencemag.org/content/5/4/eaau8535

[19] Tucker, Patrick, "The Army Wants AI to Read Soldiers' Minds", *Defense One,* 8 April 2019, https://www.defenseone.com/technology/2019/04/army-wants-ai-read-soldiers-minds/156147/

[20] Gross, Joseph Michael, "The Pentagon Wants to Weaponize the Brain: What Could Go Wrong?", *The Atlantic,* November 2018, https://www.theatlantic.com/magazine/archive/2018/11/the-pentagon-wants-to-weaponize-the-brain-what-could-go-wrong/570841/

Cyber and C4ISTAR

Cyber and C4ISTAR continue to be the most active area of development as militaries intensify efforts to compete in the information domain and cope with the merging of states of peace and conflict. The period also included considerable activity in the development of national artificial intelligence strategies / plans and of artificial intelligence capabilities that will support cyber and C4ISTAR missions, particularly surveillance.

Information Operations in an Age of Perpetual Conflict: On 1 March 2019, General Valery V. Gerasimov, the chief of Russia's armed forces gave a speech in which he further outlined and endorsed hybrid warfare tactics, especially the use of operations in the information domain as a means of undermining political, economic, and military power of adversaries and competitors. During the speech, General Gerasimov cited the Syrian civil war as an example of the effectiveness of the combination of "classical" and "asymmetrical" operations, pointing to the combination of a small expeditionary force with information operations.[21]

This is not the first time General Gerasimov has spoken about the importance of information operations in military operations. In a 2013 article in the Military – Industrial Courier, described by *The New York Times* as a Russian Army journal, General Gerasimov highlighted the lack of clear boundaries between war and peace in the modern world. In such an environment in which states are always at different levels of conflict, efforts to influence the political systems and societies of adversaries become critical means to either achieve objectives without resorting to kinetic conflict or to undermine the capability of targeted adversaries to resist traditional military advances, such as in Crimea.[22]

General Gerasimov's speech was delivered only a few days before the cyber-security firm Recorded Future released a report asserting that Western social media firms remain unprepared to counter offensive information operations from Russia and, increasingly, China. While each country takes a different approach to influencing Western political debates and policy discussions, the report stressed that both states are taking active measures to achieve these goals and that there is little focused effort on the part of most social media companies to address these strategic disinformation campaigns.[23]

Australia Reveals a Cyber 'First': An example of the potential power of combining traditional military force with information operations was revealed on 27 March 2019 when the Directorate General of the Australian Signals Directorate (ASD) Mike Burgess announced that Australia had achieved an impressive 'first' in cyber-warfare. During a speech at Australia's Lowy Institute, Mr. Burgess recounted that in mid-2016 as coalition forces were advancing to take the northern Iraqi city of Mosul from Daesh, cyber warriors in Canberra, Australia were actively degrading Daesh's encrypted communications. "Daesh communications were degraded within seconds" ensuring that "terrorist commanders couldn't connect to the internet and were unable to communicate with each other" and therefore unable to effectively respond to the coalition assault. According to Mr. Burgess, the operation "was the first time that an offensive cyber operation had been conducted so closely synchronized with the movements of military personnel in theatre."[24]

NATO Cyber Exercises: The importance of the information domain and the urgency of the ability to defend against even very targeted cyber and catfishing attacks is not lost on NATO, which took steps to identify and mitigate against vulnerabilities during the reporting period.

[21] Kramer, Andrew E., "Russian General Pitches 'Information' Operations as a Form of War, *The New York Times,* 2 March 2019, https://www.nytimes.com/2019/03/02/world/europe/russia-hybrid-war-gerasimov.html

[22] https://www.nytimes.com/2019/03/02/world/europe/russia-hybrid-war-gerasimov.html

[23] Inskit Group, "Beyond Hybrid War: How China Exploits Social Media to Sway American Opinion", Recorded Future, 6 March 2019, https://www.recordedfuture.com/china-social-media-operations/

[24] Grigg, Angus, "Australia claims world first in cyber war", *Australian Financial Review,* 27 March 2019, https://www.afr.com/technology/technology-companies/australia-claims-world-first-in-cyber-war-20190326-p517q6

In February 2019, *Wired* reported that NATO's Strategic Communications Centre of Excellence, a NATO-affiliated research group, was able to catfish NATO soldiers during a military exercise. The research group was operating as a 'red team' as part of an exercise to answer three questions: "What can we find out about a military exercise just from open source data? What can we find out about the participants from open source data? Can we use all this data to influence the participants' behaviours against their given orders?"[25]

The red team testing targeted an unidentified NATO military unit participating in an unnamed exercise. Exercise leaders knew of the red team effort, but service members were not. Over four weeks, the researchers developed fake pages and closed groups on Facebook that looked like they were associated with the military and fake profiles of service members. The red team was able to recruit service members into closed groups through targeted advertising and Facebook's Suggested Friends feature and also tracked down service members Instagram and Twitter accounts.

Nora Biteniece, a software engineer who helped design the project, revealed that "We managed to find quite a lot of data on individual people, which would include sensitive information. Like a serviceman having a wife and also being on dating apps."[26] Of course, this information can subsequently be exploited by malicious actors to affect decision-making of individual service members. The red team was also able to get service members to reveal details about their unit in the closed Facebook conversations. Researchers "identified 150 soldiers, found the locations of several battalions, tracked troop movements and compelled service members to engage in undesirable behaviour, including leaving their positions against orders." The reported total costs and fees incurred by the red team during the operation was $60.[27]

NATO is also holding the world's largest live-fire cyber exercise known as Locked Shields 2019 from 9 – 12 April. A team of nearly 40 NATO cyber security experts will participate as a team in the competition, which will include more than 1,000 "cyber defenders and decision-makers. The event is organized by the NATO Cooperative Cyber Defence Centre of Excellence in Estonia.[28] The goal of the exercise is to use a game-based / scenario simulation approach to assess a crisis situation, maintain services and defend networks that have fallen victim to cyber-attacks. The scenario focuses on cyber-attacks against a fictious country's civilian infrastructure during national elections.

Stealth-Detecting Radar: China Electronics Technology Group Corporation (CETC), one of China's state-owned enterprises that dominate its defence industrial base, announced that it has developed a prototype terahertz radiation radar in March 2019. CETC also announced that a second-generation prototype is already in development. The development was reported first by the *Global Times*, a publication that is closely aligned with the Chinese Communist Party and frequently reports favourable on the activities of China's defence industrial base and People's Liberation Army.

Terahertz radiation has wavelengths between those of infrared rays and microwaves, a wide spectrum that would be able to detect stealth aircraft by penetrating stealthy composites and "exposing metal parts within the aircraft." The *Global Times* did point out, though, that many experts are sceptical of the counter-stealth functioning of the radar as terahertz radiation decays quickly in the atmosphere, reducing the effective range of the counter-stealth function.

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[25] Lapowsky, Issie, "NATO Group Catfished Soldiers to Prove a Point About Privacy", *Wired,* 18 February 2019, https://www.wired.com/story/nato-stratcom-catfished-soldiers-social-media/

[26]Lapowsky, Issie, "NATO Group Catfished Soldiers to Prove a Point About Privacy", *Wired,* 18 February 2019, https://www.wired.com/story/nato-stratcom-catfished-soldiers-social-media/

[27]Lapowsky, Issie, "NATO Group Catfished Soldiers to Prove a Point About Privacy", *Wired,* 18 February 2019, https://www.wired.com/story/nato-stratcom-catfished-soldiers-social-media/

[28] "NATO team takes part in one of the world's most challenging cyber exercises", NATO, 8 April 2019, https://www.nato.int/cps/en/natohq/news_165640.htm

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Still, the technology can be useful in other missions, particularly air-to-ground reconnaissance. Another of China's state-owned defence enterprises China Aerospace Science and Industry Corporation (CASIC) reportedly successfully tested a terahertz radiation video synthetic aperture radar in December of 2018. The radar will be used to provide reconnaissance of complex environments clouded by smoke, smog, or poor lighting or to detect camouflaged targets on the ground.[29]

Advancement of China's research and development in advanced radars has been another consistent theme of this report, including reporting on CETC displaying a model of quantum radar during a closed – door information session on the technology at the Zhuhai Air Show in November of 2018.

Artificial Intelligence Plans and Policies: The United States made two important announcements regarding its strategy for the development and deployment of AI during the week of 11 February 2019. On 11 February, President Donald Trump released an executive order on AI that established priorities and objectives of development of AI within the United States and laid out at a general level of ways in which the U.S. government could facilitate constructive development that will support U.S. economic, social, and security interests. The executive order declared that "It is the policy of the United States Government to sustain and enhance the scientific, technological, and economic leadership position of the United States in AI R&D and deployment through a coordinated Federal Government strategy"[30], though the order did not elucidate a specific strategy or set aside any dedicated funding for specific AI development programs.

The order also highlighted the connections between AI development and data. It specifically called for government agencies to share the data they possess with each other and AI scientists in the applied research and commercial sectors while also balancing the need for individual privacy. This portion of the executive order is best viewed both as an independent recommendation and through the lens of intensifying U.S.-China competition in many technological areas, especially AI. Access to large amounts of accurate / uncorrupted data is critical to improving the quality of AI technologies and applications. The more data available to support algorithm development, the more the algorithms will accurately reflect real-world patterns and behaviours.

China is viewed as having an advantage in the collection and exploitation of data as it is able to gather information from a range of sources on a population of 1.4 billion people, nearly 1 billion of whom have access to cell phones and use those phones to communicate, post on social media, and buy products and services. Moreover, whereas privacy and civil liberties are viewed as central concerns in most Western states, China's largely authoritarian political system enables the sharing of data with and exploitation by not just commercial companies, but also the central government.

Indeed, China is already using AI-enabled capabilities –particularly facial / object and voice recognition – and big data analytics to surveil and collect highly-sensitive data on its citizens as a means of preventing or managing perceived societal and political dissent and tracking individual citizen patriotism and trustworthiness.[31]

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[29] "China develops anti-stealth radars", *Global Times* as published on *China Mil.com,* 19 March 2019, http://english.chinamil.com.cn/view/2019-03/19/content_9452332.htm
[30] "Executive Order for Maintaining American AI Leadership", The White House, 11 February 2019, https://www.whitehouse.gov/presidential-actions/executive-order-maintaining-american-leadership-artificial-intelligence/
[31] Chandler, Clay, "China's Year of the Big—Big Brother, That Is", *Fortune,* 6 February 2019, http://fortune.com/2019/02/06/china-new-year-surveillance-travel/

AI-fuelled domestic surveillance is especially prominent in the Western Chinese province of Xinjiang where the compulsory collection of biometric data has provided a larger and more accurate database that can be leveraged to identify and monitor Uighur Muslims. Similar in some ways (but very different in most) to the EU iBorderCtrl program discussed in the December 2018 volume of this report, the combination of different types of AI technologies and big data analytics is enabling Chinese authorities to detect departures from "normal" behaviour among Muslims in the country's Xinjiang region—and then to identify each suspected individual for further state attention.[32] And some of the risks of this data collection have already been revealed. In February 2019, a Dutch cyber-researcher revealed that Chinese facial recognition company SenseNets accidentally released a database with facial recognition and other personal data collected through their software's use in China.[33]

Moreover, China's state-owned enterprises and private companies are seeking to export these AI-enabled tools of domestic surveillance. At the IDEX show in February 2019, Poly Group—another of the state-owned enterprises that comprise China's domestic defence industry—displayed multiple facial recognition and big data analytics systems for export.[34] According to Kara Frederick, an Associate Fellow at the Center for New American Security (CNAS), "it's no secret Beijing is exporting its authoritarian toolkit to like-minded countries."[35]

Figure 1: An image of Poly Group's facial recognition system on display at IDEX (source: Nurkin)

The day after the release of the executive order, the U.S. Department of Defense released its artificial intelligence strategy entitled "Harnessing AI to Advance Our Security and Prosperity". Like the executive order, the DoD strategy offers a set of objectives for the DoD's use and development of AI, namely:[36]

- Support and protect U.S. servicemen and civilians around the world
- Protect the country and safeguard its citizens
- Create an efficient streamlined organization
- Become a pioneer in scaling AI across a global enterprise

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[32] Mozur, Paul, "Inside China's Dystopian Dreams: AI, Shame, and Lots of Cameras, *The New York Times,* 8 July 2018, https://www.nytimes.com/2018/07/08/business/china-surveillance-technology.html

[33] "IntelBrief: Chinese Facial Recognition Database Inadvertently Exposed, The Soufan Center, 1 March, 2019, http://www.soufangroup.com/intelbrief-chinese-facial-recognition-database-inadvertently-exposed/

[34] The author attended the event

[35] McLaughlin, Jenna, "In the Middle East, a booming market for spy technology", *YahooNews,* 1 March 2019, https://finance.yahoo.com/news/in-the-middle-east-a-booming-market-for-spy-technology-171100179.html

[36] "Summary of the Department of Defense AI Strategy: Harnessing AI to Advance Our Security and Prosperity", U.S. Department of Defense, 12 February 2019, https://media.defense.gov/2019/Feb/12/2002088963/-1/-1/1/SUMMARY-OF-DOD-AI-STRATEGY.PDF

Unlike the executive order, though, the DoD strategy also laid out specific components of its strategic approach to AI development and use, such as: 1) delivering AI-enabled capabilities that address key missions; 2) scaling AI's impact across DoD through a common foundation that enables decentralized development and experimentation; 3) cultivating a leading AI workforce; 4) engaging with commercial, academic, and international allies, and partners; and 5) leading in military ethics and AI safety. It also identified the Joint Artificial Intelligence Center, established in June 2018, as the focal point of the DoD AI strategy.[37]

The back-to-back announcements were well-received within the U.S. policy community. Since Canada released its Pan-Canadian AI Strategy in March 2017, 16 countries and two regions (the EU and the Nordic – Baltic region) have been released.[38] The U.S. was not one of these 16 countries, meaning that the global leader in AI technology development had yet to develop any guidance on how this development could be leveraged for economic transformation and growth, societal stability, national development, and national security. While neither plan constitutes a comprehensive plan with funding guidelines such as the *Next Generation Artificial Intelligence Development Plan* released by China in July 2017, the two announcements do reflect more active and sophisticated thinking by the U.S. government on this critical technological area.

Russia also released more information about their efforts to develop a national AI strategy during the reporting period. On 27 February 2019, Russian President Vladimir Putin ordered "the Russian government" to deliver a national strategy in the field of AI by June 15, 2019 as part of a list of instructions published after Putin's State of the Nation Address to the Federal Assembly. The move comes after several months of government-directed activity related to the development of a coherent Russian approach to AI development, including the release of a draft 10-point plan in July of 2018.[39]

The European Union also released important guidance in AI during the reporting period. On 9 April, the EU released guidelines for ethical AI designed to help companies and government organisations better develop AI applications that will have salutary effects for peace, stability, security, prosperity, and freedom rather than those that enabled lethal autonomous weapons systems and the curtailing of privacy and personal freedom. Key components of the EU standards include:[40]

- Human agency and oversight
- Robustness and safety
- Privacy and data governance
- Transparency
- Diversity, non-discrimination, and fairness
- Societal and environmental well-being
- Accountability

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[37] "Summary of the Department of Defense AI Strategy: Harnessing AI to Advance Our Security and Prosperity", U.S. Department of Defense, 12 February 2019, https://media.defense.gov/2019/Feb/12/2002088963/-1/-1/1/SUMMARY-OF-DOD-AI-STRATEGY.PDF

[38] Dutton, Tim, "Artificial Intelligence Strategies", *Medium,* 28 June 2018, https://medium.com/politics-ai/an-overview-of-national-ai-strategies-2a70ec6edfd

[39] Bendett, Samuel, "Russia Racing to Complete AI Strategy by June 15", *Defense One,* 14 March 2019, https://www.defenseone.com/threats/2019/03/russia-racing-complete-national-ai-strategy-june-15/155563/

[40] "Ethics guidelines for Trustworthy AI", the European Union, 8 April 2019, https://ec.europa.eu/digital-single-market/en/news/ethics-guidelines-trustworthy-ai

Manned Platforms

Activity in manned platforms largely remained focused on three key themes raised and explored in previous volumes of this report: 1) the importance of unmanned systems for the future of manned platform operational effectiveness; 2) the persistent demand for multi-mission platforms; 3) and the need to develop

Unmanned Systems and the Future of Manned Platforms: The reporting period included two important announcements that reflected one of the primary roles and missions of future manned platforms: operating in conjunction with and controlling large numbers of unmanned systems.

On 20 February, Russian President Vladimir Putin announced that Russia will launch its first nuclear-powered submarine capable of carrying the nuclear-capable underwater drone 'Poseidon'. President Putin declared during his annual address to the Russian Parliament that "Nothing has been said about this so far, but it is possible to do so today. In the spring of this year the first nuclear powered submarine armed with this unmanned vehicle will be launched. The work is proceeding in accordance with the schedule."[41]

According to *The Diplomat*, Russia is expected to receive up to 30 Poseidon unmanned underwater vehicles (UUVs) starting in the late 2020s. *The Diplomat* reported in March 2019 that U.S. intelligence assesses the Poseidon will enter service in 2027. While its main function will reportedly be as a delivery system for nuclear warheads of about two megatons[42], some have speculated it could also be used as an ISR asset. The 2018 U.S. Nuclear Posture Review refers to the Poseidon as "Kanyon" and classifies it as a "new intercontinental, nuclear armed, nuclear -powered, undersea autonomous torpedo."[43]

To date, underwater tests of the Poseidon have been conducted by a B-90 *Sarov*-class Project 20120 diesel-electric submarine. Nuclear-powered submarine candidates to carry the Poseidon torpedo include the Project 09852 submarine, based on the 949A *Oscar II*-class nuclear-powered guided missile submarine and the Project 09851 submarine. "A Russian defence industry source claimed in January 2019 that "two Poseidon – carrying submarines are expected to enter service with the Northern Fleet and the other two will join the Pacific Fleet."[44]

President Putin's announcement, along with demonstrations of the Skyborg and Valkyrie unmanned aerial systems discussed in the Robotics and Unmanned Systems section below, offer insight into the growing intersection between the roles and operations of manned and unmanned systems and the resulting growing need to design manned platforms to accommodate different ways of manned-unmanned teaming.

The Multi-Mission Y-20: The Chief Designer of China's indigenously designed Y-20 strategic transport plane confirmed in March 2019 that the platform will be modified to accommodate several variants, potentially beginning in 2019, according to the *Global Times*. Tang Changhong, a Chinese political advisor and chief designer of the aircraft said at a press conference on 11 March 2019 that "the Y-20 can serve as a general platform from which a variety of variants can be derived." He continued by saying that the Y-20 is now "playing its role as a [variant – spawning] platform as planned."[45]

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[41] Gady, Franz-Stefan, "Russia's First 'Poseidon' Underwater Drone-Carrying Submarine to Be Launched in 2019", *The Diplomat,* 20 February 2019, https://thediplomat.com/2019/02/russias-first-poseidon-underwater-drone-carrying-submarine-to-be-launched-in-2019/
[42] Gady, Franz-Stefan, "US Intelligence: Russia's Nuclear-Capable 'Poseidon' Underwater Drone Ready for Service by 2027", *The Diplomat,* 26 March 2019, https://thediplomat.com/2019/03/us-intelligence-russias-nuclear-capable-poseidon-underwater-drone-ready-for-service-by-2027/
[43] Gady, Franz-Stefan, "Russia's First 'Poseidon' Underwater Drone-Carrying Submarine to Be Launched in 2019", *The Diplomat,* 20 February 2019, https://thediplomat.com/2019/02/russias-first-poseidon-underwater-drone-carrying-submarine-to-be-launched-in-2019/
[44] Gady, Franz-Stefan, "Russia's First 'Poseidon' Underwater Drone-Carrying Submarine to Be Launched in 2019", *The Diplomat,* 20 February 2019, https://thediplomat.com/2019/02/russias-first-poseidon-underwater-drone-carrying-submarine-to-be-launched-in-2019/
[45] Xuanzun, Liu, "China's Y-20 large transport plane to spawn several variants: chief designer", *Global Times,* 12 March 2019, http://www.globaltimes.cn/content/1141794.shtml

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Speculation about specific mission variants for the Y-20 has centred for over years on aerial refuelling and early warning, given the platform's weight of 200 tons and its capacity to carry more fuel than other Chinese-built aircraft. Some observers also believe the Y-20 could be repurposed for electronic warfare missions.[46]

Developing modular or multi-mission manned platforms such as the Y-20 (or, in the United States, the Littoral Combat Ship) has become an increasing priority for militaries around the world as they seek to balance a growing spectrum of threats and domains of conflict with cost constraints, even in the most well-funded militaries. As militaries attempt to carry out more missions, the ability to leverage in service platforms for multiple missions can offer important cost and performance efficiencies.

Undersea Focus in the Indo-Pacific: The United States Navy released its 2020 budget request in March 2019. The plan included several important trade-offs between new ship builds and developing and procuring advanced weapons. Notably, though, the plan had a strong focus on developing more nuclear-powered attack submarines (SSNs) to arrest a worrying anticipated decline in the U.S. SSN fleet out to the mid-2030s. The Navy's plans include developing three new Virginia-Class submarines per year into the early 2020s[47] and, according to commentary in *The National Interest* on 28 March 2019, a total of 32 new nuclear attack subs over the next 15 years.[48]

The undersea domain is an area of particularly important competition in the Indo-Pacific region. Undetectable undersea assets can more easily hold competitor or adversary assets at risk while the current and anticipated proliferation of unmanned underwater vehicles creates an enhanced reconnaissance and anti-submarine warfare challenge.

The new Virginia – Class submarines will incorporate new technology-enabled capabilities, such as improved undersea navigation and detection technology made possible by the combination of new sonar, increased computer automation and AI. The Virginia-class is engineered with Fly-by-Wire capabilities that allow the boat to "quietly linger in shallow waters without having to surface or have each small move controlled by a human operator." With this technology, ships can be driven "primarily through software code and electronics, thus freeing up time and energy for an operator who does not need to manually control each small manoeuvre." The Virginia-Class Block III variants will also include other novel technologies, such as quieting coating materials for the hull and a large aperture bow conformal array sonar system while Block V variants will include Virginia Payload Modules that will greatly enhance the firepower of the platform, increasing the Tomahawk missile firepower from 12 to 40.[49]

Also, during the reporting period, the Japan Maritime Self-Defense Force (JMSDF) commissioned its second *Asahi*-class guided missile destroyer (*JS Shivani)* on 27 February 2019. The ship will enter service largely as an anti-submarine warfare platform designed to better cope with the proliferation of diesel-electric and nuclear submarines throughout the region, especially Chinese submarines and unmanned underwater vehicles.[50]

[46] Xuanzun, Liu, "China's Y-20 large transport plane to spawn several variants: chief designer", *Global Times,* 12 March 2019, http://www.globaltimes.cn/content/1141794.shtml

[47] Eckstein, Megan, "FY2020 Budget: Navy Cuts Ship, Aircraft Procurement; Vows High-End Weapons Procurement", 12 March 2019, https://news.usni.org/2019/03/12/fy-2020-budget-navy-cuts-ship-aircraft-procurement-vows-high-end-weapons-procurement

[48] Osborn, Kris, "The U.S. Navy Wants 32 More Nuclear Attack Submarines in the Next 15 Years", *The National Interest,* 28 March 2019, https://nationalinterest.org/blog/buzz/us-navy-wants-32-more-nuclear-attack-submarines-next-15-years-49442

[49] Osborn, Kris, "The U.S. Navy Wants 32 More Nuclear Attack Submarines in the Next 15 Years", *The National Interest,* 28 March 2019, https://nationalinterest.org/blog/buzz/us-navy-wants-32-more-nuclear-attack-submarines-next-15-years-49442

[50] Gady, Franz-Stefan, "Japan Commissions New Anti-Submarine Warfare Destroyer", *The Diplomat*, 6 March 2019, https://thediplomat.com/2019/03/japan-commissions-new-anti-submarine-warfare-destroyer/

Missile Systems and Munitions

Perhaps the most important development during the reporting period was India's demonstration of an anti-satellite missile capability on 27 March 2019. This testing has catalysed renewed focus on space – counter-space competition and the types of capabilities that will be required to protect space assets from more sophisticated counter-space capabilities and the space debris that capabilities like India's ASAT weapons create. The report period also revealed growing focus on weapons systems discussed in previous reports, such as hypersonic glide vehicles, and counter-drone weapons.

India's ASAT Test: On 27 March 2019, India's Defense Research and Development Organization revealed that it had successfully tested a direct-ascent ASAT weapon by shooting an ageing satellite out of low earth orbit (LEO) about 300 km above earth. The Indian government celebrated the test, known as "Mission Shakti" as a great national success indicative of India's growing military and geopolitical strength. During a televised statement, Prime Minister Narendra Modi stated that the test "shows the remarkable dexterity of India's outstanding scientists and the success of our space programme,"[51] Modi also claimed that with the test, "India registered its name as a space power."[52]

Reaction within the international community was considerably less enthusiastic, and observers focused on two main concerns. First, criticism has centred on the test's most urgent strategic consequence: space debris. While the amount of space debris created was contained by the way the test was designed and relatively low altitude of the satellite and is considerably less than that created by China's 2007 ASAT weapons test, the test did create 400 pieces of space debris.[53] Space debris poses a direct threat to satellites on orbit in space.

Mr. Jim Bridenstine, Director of the U.S. National Aeronautics and Space Administration (NASA) in the United States effectively captured the strong response of the international space community in comments made during a NASA town hall the day after the test was revealed. Mr. Bridenstine called the space debris generated by the test a "terrible, terrible thing" and noted that space debris threatened the International Space Station. He also suspended cooperation between NASA and the Indian Space Research Organisation (ISRO), saying that "that kind of activity is not compatible with the future of human spaceflight that we need to see have happen."[54] Mr. Bridenstine revealed in a letter on 7 April, 2019 that the suspension of cooperation had been lifted and NASA would continue collaboration with ISRO after receiving "guidance received from the White House."[55]

Second, the test further highlighted the competition in and growing militarization of space, especially among and by states in the Indo-Pacific. The Nikkei Asian Review outlined the current state of space-based and space-related military capabilities among actors in the region:[56]

> "India's ASAT test is a reminder that the Asia-Pacific region is the hub of the growing space-war capabilities. The United States and Russia field extensive missile defence systems and boast a diverse range of ground-launched and directed-energy ASAT capabilities. China's ASAT weaponry is becoming more sophisticated, even as it aggressively seeks theatre ballistic missile defences.

[51] Foust, Jeff, "India Tests Anti-Satellite Weapons", *Space News*, 27 March 2019, https://spacenews.com/india-tests-anti-satellite-weapon/
[52] "India celebrates as country's newest space weapon passes 'hit-to-kill' test", *ABC News (Australia),* 27 March 2019, https://www.abc.net.au/news/2019-03-28/india-space-weapon-missile-shoots-satellite-down/10947246
[53] Foust, Jeff, "NASA warns Indian anti-satellite test increased debris risk to ISS", *Space News*, 2 April 2019, https://spacenews.com/nasa-warns-indian-anti-satellite-test-increased-debris-risk-to-iss/
[54] Schultz, Kai, "NASA Says Debris From India's Antisatellite Test Puts Space Station at Risk", *The New York Times,* 2 April 2019, https://www.nytimes.com/2019/04/02/world/asia/nasa-india-space-debris.html
[55] "Cooperation with Isro remains intact: Nasa", *Times of India,* 5 April 2019, https://timesofindia.indiatimes.com/india/cooperation-with-isro-remains-intact-nasa/articleshow/68742588.cms
[56] Chellaney, Brahma, "The Looming Spectre of Asian Space Wars", *Nikkei Asian Review,* 29 March 2019, https://asia.nikkei.com/Opinion/The-looming-specter-of-Asian-space-wars?utm_campaign=RN%20Subscriber%20newsletter&utm_medium=one%20time%20newsletter&utm_source=NAR%20Newsletter&utm_content=article%20link

Japan and South Korea are working with the U.S. separately to create missile defence systems. Although aimed at thwarting regional threats, these systems are interoperable with American missile defences. Australia, for its part, participates in trilateral missile-defence consultations with the U.S. and Japan."

The growing threats to space infrastructure was further demonstrated during the reporting period by an announcement from the U.S. Air Force that it was seeking to develop satellites able to manoeuvre to avoid threats. In a Mitchell Institute event on 21 February, Mr. Michael Dickey, the head of the Enterprise and Strategy and Architectures Office at Air Force Space Command, suggested the United States is seeking to develop manoeuvrable satellites that have the capability to avoid inbound threats. According to Mr. Dickey, "[The United States] have to give our mission systems an opportunity to participate in their own defence, give them a fighting chance."[57]

His comments came ten days after the U.S. Defense Intelligence Agency (DIA) released a report entitled "Challenges to Security in Space", which details DIA's analysis of Russia's and China's improving counter-space capabilities. A spokesman for DIA articulated one of the report's key assessments that both China and Russia "have developed robust and capable space services, and these capabilities provide their militaries with the ability to command and control their forces worldwide, and with enhanced situational awareness enabling them to monitor, track and target U.S. and allied forces."[58]

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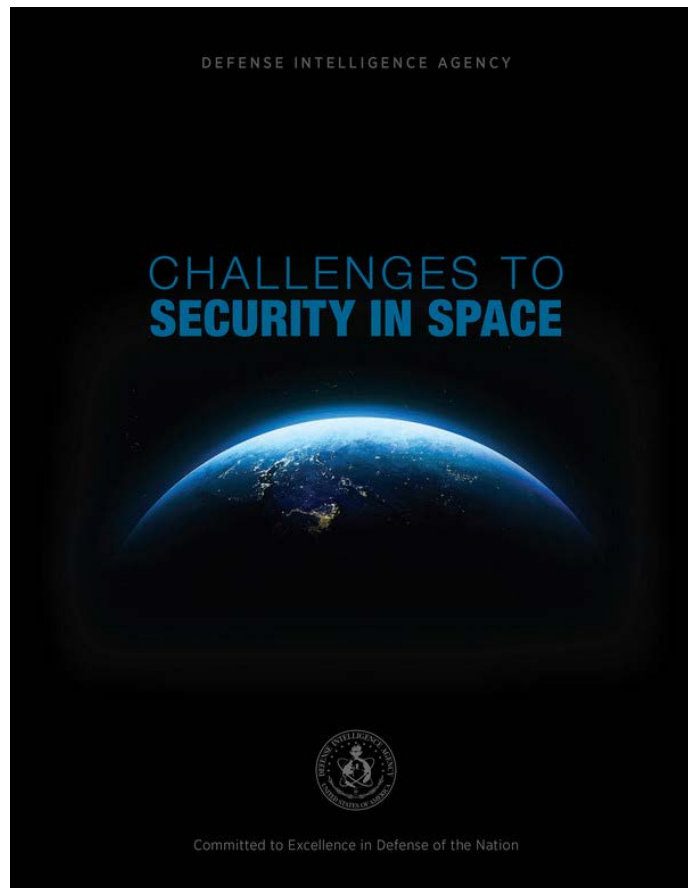
[57] Tucker, Patrick, "Pentagon Wants Satellites That Can Dodge Incoming Fire", *Defense One,* 25 February 2019, https://www.defenseone.com/technology/2019/02/pentagon-wants-satellites-can-dodge-incoming-fire/155088/
[58] "DIA Report Details Threats to America's Space-Based World", Department of Defense, 11 February 2019, https://dod.defense.gov/News/Article/Article/1754509/dia-report-details-threats-to-americas-space-based-world/

Hypersonic Contract Award: The U.S. Defense Advanced Research Projects Agency (DARPA) awarded a $63.3 million contract with Raytheon on 5 March 2019 to support development of a hypersonic tactical boost glide weapon. The contract is part of an Air Force effort to create an effective hypersonic glide vehicle that will use a rocket to get launch a payload to achieve hypersonic speeds at which point the payload will separate and glide to its target on a manoeuvrable trajectory.[59]

Developments in hypersonic weapons have featured in both previous volumes of this report as the competition in hypersonic weaponry between Russia, China, and the United States in particular has speed up. February's volume detailed progress in Russia's Avangard hypersonic glide vehicle program and announcements from China that it was capable of using a glide vehicle payload on a DF-17 ballistic missile.

Counter-Drone Shotgun Drone: Russia showed off another component of its counter-drone arsenal during the reporting period. In March 2019, a video surfaced on the internet of a drone with a shotgun mounted on the airframe and designed to serve in a counter-drone function.[60] The project reportedly began in 2016 while the recent video demonstrates that the development team appear to have devised a means of managing the negative effects of the recoil from firing a shotgun from a drone. Almaz-Antey was awarded the patent for the design and is assumed to have created the prototype in the video.[61]

The drone is armed with a Russian-made Vepr-12 shotgun. An operator using a visor can control the drone from the ground. It takes off vertically and can fly for approximately 40 minutes. The video shows the system attacking a balloon target and a remote-controlled plane. Previous footage of the drone demonstrates that it can also be land-based and serve in a fixed-based defence role.[62]

As noted in the December volume of this report, Russia has demonstrated and trained with a variety of counter-drone weapons, including the PISHAL and REX-1 counter-drone rifles, which largely rely on directed energy and jamming techniques to disable drones.

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[59] Larter, David B., "DARPA inks a contract for hypersonic weapon research", *C4ISRNet,* 5 March 2019, https://www.c4isrnet.com/it-networks/2019/03/05/darpa-signs-raytheon-up-for-work-on-hypersonics/
[60] "Russian Shotgun Drone Shoots Down RC Plane", Military.com, 26 March 2019, https://www.military.com/video/russian-shotgun-drone-shoots-down-rc-plane
[61] Liptak, Andrew, "Russia's shotgun-firing drone is designed to shoot down enemy drones", *The Verge*, 30 March 2019, https://www.theverge.com/2019/3/30/18287487/russia-shotgun-drone-counter-uav-syria
[62] Liptak, Andrew, "Russia's shotgun-firing drone is designed to shoot down enemy drones", *The Verge*, 30 March 2019, https://www.theverge.com/2019/3/30/18287487/russia-shotgun-drone-counter-uav-syria

Robotics and Unmanned Systems

Activity in robotics and unmanned systems development are reaching an inflection point as militaries consider the pathways for and implications of development of autonomous unmanned weapons systems; implications such as new operational concepts, means of manned-unmanned teaming, and means of talking about these new capabilities that will encourage rather than repel support of both traditional and non-traditional defence industries.

Loyal Wingman and Valkyrie: Low-Cost, Attritable, Versatile Unmanned Systems: In March 2019, Boeing revealed the concept for the Skyborg UAV, what Boeing hopes will be the foundation of the "loyal wingman" concept that incorporates the Skyborg drone to help manned aircraft operate in contested airspace. Air Force Research Labs Aerospace Systems Directorate engineer Matt Duquette described the concept as "a vessel for AI technologies that could range from rather simple algorithms to fly the aircraft and control the in airspace to the introduction of more complicated levels of AI to accomplish certain tasks or subtasks of the mission." The system is envisioned as a low-cost, attritable (but not expendable) unmanned combat aerial vehicle that can "bring mass to the fight" when addressing near-peer engagements in the future.[63]

A week after the revelation of the 'loyal wingman' concept, the U.S. Air Force Research Lab announced the XQ-58A Valkyrie had made its first flight. A U.S. Air Force press release described the Valkyrie demonstrator as "a long-range, high subsonic, unmanned air vehicle." Valkyrie is part of the Low Cost Attritable Aircraft Technology (LCAAT) portfolio, "which has the objective to break the escalating cost trajectory of tactically relevant aircraft." The aircraft is manufactured by Kratos Defense.[64]

As with the Skyborg platform, the Valkyrie is designed to be operated independently, as a cooperative swarm, or as part of the loyal wingman concept of operations in which a group of Q-58s would work under the command of a nearby manned combat aircraft.[65]

UK Drone Swarm Investment: The United Kingdom's (UK) Ministry of Defence (MoD) announced on 28 March 2019 that it will invest £2.5 million ($3.3 million) to develop drone swarm technology through a contract awarded to a consortium led by Blue Bear Systems Research Ltd.[66]

The contract is part of the 'Many Drones Make Light Work' project and the swarms are planned to operate alongside Britain's F-35 and Typhoon combat aircraft. Funding comes from the Defense and Security Accelerator, designed to improve engagement between the MoD and commercial industry. According to the MoD, "the funding will steer the project for around 20 unmanned aircraft systems (UAS) into the final stage of development, which will ultimately be managed by the Defence Science and Technology Laboratory (Dstl)," the MoD said.[67]

The announcement comes only weeks after the UK Minister of Defence, Gavin Williamson, made the ambitious claim that the UK would deploy "swarm squadrons" of drones by the end of 2019.[68]

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[63] Jennings, Gareth, "USAF reveal Skyborg 'loyal wingman' concept", 27 March 2019, *Jane's Defence Weekly,* https://www.janes.com/article/87512/usaf-reveals-skyborg-loyal-wingman-concept

[64] Trevithick, Joseph and Rogoway, Tyler, "Air Force's Secretive QX-58A Valkyrie Experimental Combat Drone Emerges After First Flight", *The Drive*, 9 March 2019, https://www.thedrive.com/the-war-zone/26825/air-forces-secretive-xq-58a-valkyrie-experimental-combat-drone-emerges-after-first-flight

[65] Trevithick, Joseph and Rogoway, Tyler, "Air Force's Secretive QX-58A Valkyrie Experimental Combat Drone Emerges After First Flight", *The Drive*, 9 March 2019, https://www.thedrive.com/the-war-zone/26825/air-forces-secretive-xq-58a-valkyrie-experimental-combat-drone-emerges-after-first-flight

[66] 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

[67] 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

[68] Jenkins, Simon, "British 'lethality'?: Gavin Williamson's brain has gone absent without leave, *The Guardian,* 11 February 2019, https://www.theguardian.com/commentisfree/2019/feb/11/gavin-williamson-defence-policy-uk

Eurodrone: The European Commission announced it will allocate €525 million to fund defence industrial and research projects in 2019 and 2020. A key component of this funding includes €100 million for the development of the Eurodrone, a Medium-Altitude Long-Endurance Remotely Piloted Aircraft System (MALE RPAS) programme.[69]

The project will be managed by the Organisation for Joint Armament Co-operation (OCCAR) and seeks to produce a twin-turboprop aircraft in two configurations: an intelligence, surveillance and reconnaissance version, and another which will be armed. France, Germany, Italy and Spain are participants in the project. Belgium holds observer status. Prime contractor Airbus along with Dassault and Leonardo revealed a full-scale model at the Berlin Air Show in April 2018, and the system passed its preliminary design review in November.

The program is another example of European collaboration on defence issues, both EU-driven and bilateral. For example, France and Germany are jointly seeking to develop a sixth-generation fighter concept that features a similar mother ship / loyal wingman concept to the one discussed above.

ATLAS Adjustment: The U.S. Army faced backlash to a request for information (RFI) to industry to support its new Advanced Targeting and Lethality Automated System (ATLAS) program, which seeks to give ground combat vehicles the ability to "acquire, identify, and engage targets at least 3X faster than the current manual process."[70]

Concern emerged that the Army was seeking to develop a fully autonomous weapons system capable of identifying and acting against targets absent human intervention. As a result, a second RFI was released that included U.S. DoD recommended language that emphasises human control of lethal robots.[71]

The change—as well as the controversies related to Google and Microsoft's support of DoD mentioned above---reflects enduring public concern about on-going efforts of militaries around the world to integrate AI into unmanned systems. Michael C. Horowitz, a senior adjunct fellow at the Center for New American Security, noted that "the controversy over ATLAS demonstrates that there are continuing technological and ethical issues surrounding the integration of autonomy into weapons systems."[72]

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[69] Kelly, Fergus, "EU allocates €525 million for defense projects, including Eurodrone", *Defense Post,* 19 March 2019, https://thedefensepost.com/2019/03/19/eu-funding-defense-projects-eurodrone-525-million/
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