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Federal Department of Defence, Civil Protection and Sports DDPS **armasuisse** Science and Technology S+T



DEFTECH SCAN

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Dear Reader,

First of all and most important thing, we would like to wish you a wonderful 2020! It is definitely a nice number and we hope it will bring you luck, health and prosperity in all your activities.

The end of 2019 was rich in announcements and news in many different topics that we try to summarise here. I would also take the opportunity to congratulate Tate on the nice piece of work that together with Mr. Stephen Rodriguez, he released for the <u>Atlantic Council</u>. It provides a lot insights and food for thoughts about Artificial Intelligence in the security environment.



Part of this scan was inspired by this report, but we kept the general 2019 structure to ensure some continuity.

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,

Tate

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

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:

Global Scope and Relevance: This report contains mentions of developments, activities, and entities in 14 countries / regions. The breadth of countries referenced is both intentional and indicative; that is, it is designed to demonstrate at least three levels of impact of technology and capability development, diffusion, and deployment beyond large militaries such as those in the United States, China, and Russia.

First, more small and mid-sized militaries are taking advantage of technology diffusion and new requirements to develop advanced technology-enabled capabilities. Saudi Arabian Military Industry's decision in January to develop a national counter-drone program is a useful example. So, too, is the recent incorporation of facial recognition software into Turkey's KARGUS drone. This dynamic is unlikely to slow.

Second, the implications of new technology-enabled capabilities and the military and geopolitical competitions they create or amplify are broad and frequently unpredictable. The C4ISTAR section of this report details use of tools and technologies in support of layered Russian disinformation campaigns that affected entities in countries as diverse as the United Kingdom, Lithuania, and Switzerland. Similarly, the emphasis on uses of technologies such as artificial intelligence and bio and neuro-technologies has already generated important questions about ethics and norms of use that are of interest to militaries of all sizes.

Third, as new technology-driven capabilities are actually deployed the need for small and mid-sized militaries to prioritize capabilities critical to complementing the new capabilities of allies and partners or counter ingthose of potential competitors or adversaries becomes more urgent.

"Intelligentization" of Warfare: A series of in-depth reports addressing the importance and implications of AI techniques and technologies for defence and security communities around the world were published during the reporting period. Collectively, this publishing flurry is reflective of a broader preoccupation among many militaries and security communities with the digitization and

"intelligentization" of military and security operations and the expansive military and security applications of AI-enabled capabilities (see Figure 1).

Several examples of development and deployment of AI-enabled capabilities in these categories are highlighted throughout this report. The Gripen E's "fighter intelligence" system, for example, has the capacity to "work autonomously" and "provide the pilot with suggestions."



Figure 1: Source: A Candle in the Dark: US National Security Strategy for AI (Atlantic Council, Nurkin and Rodriguez)

The importance of AI for the future of military capabilities and competition is a global conversation and concern. While much of the discussion centres on the United States, Russia, and China, a December 2019 report from the European Council on Foreign Relations (ECFR) argues that "AI will play an important role for Europe's defence capabilities, and its funding and development decisions will influence the future of military AI." Moreover, the report concludes that "there is currently too little European thinking about what artificial intelligence means for the military" beyond a small group of notable outliers, particularly France.¹

¹ Ulrike Esther Franke, "Not Smart Enough: The Poverty of European Military Thinking on Artificial Intelligence", European Council on Foreign Relations, December 2019,

https://www.ecfr.eu/publications/summary/not smart enough poverty european military thinking artificial intelligence



Energy, Power, and Propulsion

Key Insights:

- Many of the novel solutions for extending battery life of platforms and people under consideration are being developed at the seam of commercial, civil government, and military / security sectors. Previous DEFTECH Scans have focused on development of fuel cells in the automotive and applied research sectors while this volume describes development of methanol-based fuel cells used on dual-use aircraft.
- Soldiers are carrying more electronic equipment into operational environments—and, indeed, much of this equipment is essential to military personnel effectively operating in contested environments. The "digitization" / "intelligentization" of the battlefield is increasing the urgency of efforts of small and large militaries to develop creative, efficient, and renewable means of power for soldier use.

'Game-changing' drone batteries: Chinese scientists at the Dalian Institute of Chemical Physics have developed a "game – changing" methanol – powered fuel system that reportedly greatly extended the persistence of a Chinese-developed unmanned aerial vehicle.² The technology was developed for the FY-36, an approximately 15 kilogram (33 pounds), small unmanned aerial vehicle (UAV) designed to carry out dual – use tasks such as power line inspection, search and rescue missions, geological mapping and, of



Figure 2: The Lange Research Aircraft Antares E2 (top) and the methane - powered fuel cell (bottom). Source: Sustainableskies.org

course, military intelligence gathering.

The methanol fuel cell reportedly extended the FY-36's persistence to 12 hours from an estimated half-an-hour for similarly sized drones using a lithium-ion battery pack. In theory, methanol can store "70 times more energy than lithium-ion."³ As methanol flows through a battery cell, "its molecules are broken apart by a catalyst into carbon dioxide and water, a process that releases a huge amount of electrons." ⁴

Dalian Institute scientists have worked on the technology for more than two years, coping with a range of technical and weather challenges that have hampered overall efficiency and effectiveness. However, as of December 2019, the battery had been successfully tested in the FY-36 on 15 test flights.

The Dalian Institute is not the only group pursuing this technology. German company Lange Research Aircraft has built a 1.5 – ton methanol-powered plane known as the Antares E2. A mock-up of the aircraft first appeared at the AeroExpo in April 2018 in Friedrichshafen,

Germany. The aircraft includes an integrated methanol reformer system Lange claims to be "superior to

⁴ Stephen, Chen, "Chinese scientists create 'game changer' methanol powered battery that keeps drone in the air for 12 hours", *South China Morning Post,* 20 December 2019, <u>https://www.scmp.com/news/china/science/article/3042818/chinese-scientists-create-game-changer-methanol-battery-keeps</u>



² Stephen, Chen, "Chinese scientists create 'game changer' methanol powered battery that keeps drone in the air for 12 hours", *South China Morning Post,* 20 December 2019, <u>https://www.scmp.com/news/china/science/article/3042818/chinese-scientists-create-game-changer-methanol-battery-keeps</u>

³ Stephen, Chen, "Chinese scientists create 'game changer' methanol powered battery that keeps drone in the air for 12 hours", *South China Morning Post,* 20 December 2019, <u>https://www.scmp.com/news/china/science/article/3042818/chinese-scientists-create-game-changer-methanol-battery-keeps</u>





other forms of energy supply, especially when there is a long-term and constant need for energy. This is because the reformer allows the extraction of much higher energy than standard burner motors."⁵ The glider-type aircraft has not yet flown, but was described by Lange CEO Alex Lange as "a flying sensor platform for research purposes, which can remain in the air with fuel cell drive about 40 hours in the air," with the support of its methanol fuel cell.⁶

Creative Means for Harnessing Soldier Power: Russian engineering troops are the first Russian forces to receive solar panel-powered portable electric power sources, according to a 31 December 2019 announcement from the Russian Ministry of Defence.⁷ According to the ministry's press office, "The system is a mobile compact solar charger with a photovoltaic device in the form of a folding solar panel." ⁸ Russian troops have received 30, 50, and 100-watt autonomous electric power sources.

The use of solar panel powered electric power sources is one more creative means militaries around the

world are pursuing as part of efforts to develop and deploy scalable means of enhancing the battery life of the growing amount of electrical equipment soldiers carry.

A December 2019 article from the U.S. *Army Times* provided insight into additional novel means of using soldier "Soldiers are carrying more electronic gear than ever before, and those radios, tablets, sensors and other devices need to charged. And its hard to find a wall socket on the battlefield." – Army Times, "How the Army wants to use your boots to generate juice"

movement to drive increased energy production. Notably, over the past year, the U.S. Army's C5ISR Center has developed a patent for a shoe insole that can generate electricity with each step: "As the soldier's heel pushes down into the insole, the force hits a miniature rotational level mechanism, turning a small generator, which creates an electric charge." ⁹ The C5ISR Center has also previously developed concepts for a rucksack that converts the energy created when the pack moves into an electrical charge and a "kinetic knee harvester" that uses the motion of a soldier's legs to build electrical current as the soldier marches as well as "wearable, flexible solar panels."¹⁰

⁵ ⁵ Dean Sigler, "Lange Research Shows Six-Motor, Fuel-Cell Driven E2 at Aero Expo", *Sustainable Skies* blog, 5 May 2018, http://sustainableskies.org/lange-research-shows-six-motor-fuel-cell-driven-e2-at-aero-expo/

⁶ Dean Sigler, "Lange Research Shows Six-Motor, Fuel-Cell Driven E2 at Aero Expo", *Sustainable Skies* blog, 5 May 2018, <u>http://sustainableskies.org/lange-research-shows-six-motor-fuel-cell-driven-e2-at-aero-expo/</u>

⁷ "Russian troops to use solar panels to power their equipment", *Tass*, 31 December 2019, <u>https://tass.com/defense/1105137</u> ⁸ Russian troops to use solar panels to power their equipment", *Tass*, 31 December 2019, <u>https://tass.com/defense/1105137</u>

 ⁹ South, Todd, "How the Army wants to use your boots to generate juice (and keep tabs on you)", *Army Times*, 19 December 2019, <u>https://www.armytimes.com/news/your-army/2019/12/19/how-the-army-wants-to-use-your-boots-to-generate-juice-and-keep-tabs-on-you/</u>

¹⁰ South, Todd, "How the Army wants to use your boots to generate juice (and keep tabs on you)", *Army Times*, 19 December 2019, <u>https://www.armytimes.com/news/your-army/2019/12/19/how-the-army-wants-to-use-your-boots-to-generate-juice-and-keep-tabs-on-you/</u>





Human Performance Enhancement

- Fourth Industrial Revolution (4IR) technologies are shaping efforts of militaries around the world to better prepare personnel for operations as well as efforts to protect them and enhance their performance in contested operational environments
- Augmented reality, machine learning, and cloud computing are among the technologies that are transforming simulation and training activities for militaries of all sizes by reducing cost, speeding up training timelines, better replicating complex environments, and offering more opportunities for individuals to train
- The combination of artificial intelligence and neuro and biotechnologies are creating opportunities for the incorporation of "direct neural enhancement of the human brain for two-way data transfer." According to a U.S. Department of Defense report, the effects in military capabilities would be "revolutionary."
- There are important implications for militaries of all sizes as 4IR technologies change approaches to simulation and training and human performance enhancement. First, diffusion of these technologies, many of which are being developed in the commercial sector, are likely to lead to proliferation over a relatively short period of time of new capabilities to more militaries. Second, all militaries will need to develop ethical and legal frameworks for whether, how, and when to incorporate human performance enhancement technologies.

Flying with Augmented Reality: On 18 November 2019, the United States Air Force successfully conducted a test of an augmented reality pilot training system from Red6 Aerospace known as the Airborne Tactical Augmented Reality System (A-TARS). The A-TARS system uses augmented reality to create virtual air assets for pilots to train with or against during live training exercises. According to reporting from *Signal* magazine, the A-TARS technology "puts a virtual aircraft into a pilot's helmet display. The current system has 105-degrees field of view and is integrated into a standard HDU 55 helmet system. It is also daylight capable."¹¹



Figure 3: The pilot's view of digitally created air assets created by the A-TARS augmented reality training system. Source: Red 6 through AINonline, <u>https://www.ainonline.com/aviation-news/defense/2019-12-24/flying-augmented-skies-red-6</u>

The November test simulated an air-to-air refuelling sortie. According to Red6 cofounder and CEO Daniel Robinson, RAF (ret.), it was "the world's first-ever multiplayer augmented reality air-to-air refuelling tanking sortie in a real airplane and augmented reality. Our proof of concept was a tanker training sortie, but it could have been anything, including a manoeuvring J-20."

The successful testing of the A-TARS system as part of live training reflects a broader trend in simulation and training efforts of small and large militaries to increased incorporation of virtual and augmented reality, artificial intelligence and machine learning, cloud computing, and

other increasingly available advanced technologies in order to:

1) Accelerate the training process, especially for pilots of which there is a general shortage across many militaries

¹¹ Kimberly Underwood, "Flying with Augmented Reality", *Signal*, 18 November 2019, <u>https://www.afcea.org/content/flying-augmented-reality</u>





- 2) **Increase efficiency and safety** of live exercises by providing lower cost and frequently virtual "reps and steps" training that enable trainees to gain experience before they are placed in more expensive training environments
- 3) **Replicate** the increasingly complex operational and tactical multi-domain environment military personnel face in ways that are difficult to do in live training
- 4) Ensure remote training via cloud-based technologies

The World of "Hyper-Enabled" Operators: In December 2019, the U.S. Army released a report from the Biotechnologies for Health and Human Performance Council study group entitled "Cyber Soldier 2050" Human/Machine Fusion and the Implications for the future of the DoD". The report examined a range of emerging technologies and their applications for the enhancement of military personnel as well as the legal, moral, and societal implications of next generation human performance enhancement technology.

The report identified the below areas as having the potential to "incrementally enhance performance beyond the normal human baseline" for military operators:

- Ocular enhancements to imaging, sight, and situational awareness
- Restoration and programmed muscular control through an optogenetic bodysuit sensor web
- Auditory enhancement for communication and protection

However, a main thrust of the report was that "the development of direct neural enhancements of the human brain for two-way data transfer would create a revolutionary advancement in future military capabilities. . . the potential for direct data exchange between human neural networks and micro-electric systems could revolutionize tactical warfighter communications, speed the transfer of knowledge throughout the chain of command, and ultimately dispel the 'fog' of war."¹²

In addition to studying the technical aspects of soldier enhancement technologies, the DoD team also stressed the societal, perception, and ethical challenges associated with the development and, particularly, integration of these technologies. Indeed, the four recommendations featured in the report's executive summary are largely focus on socializing the use of these technologies and developing ethical and legal frameworks to discern appropriate applications from inappropriate ones.¹³

Early attempts to use bio- and other advanced and emerging technologies such as smart sensors, artificial intelligence, and human/machine interfaces to at least reduce this 'fog of war' were on display in December 2019 at the U.S. Special Operations Command during *Defense One's* Genius Machines event in Tampa, FL.

One particularly interesting and indicative human/machine interface technology tested in December by SOCOM's SOFWERX prototyping and innovation initiative was a "physiological analysis tool" designed to help troops understand in real time, "how foreigners are receiving or interpreting their messaging, information, and psychological operations." The technology uses sensors and data processing equipment to detect and decipher heart rate variability, body temperature, and voice modulation to provide soldiers a sense of how a message being communicated by an individual soldier is being received by individuals or groups.¹⁴

¹² U.S. Army, Biotechnologies for Health and Human Performance Council Study Group, "Cyber Soldier 2050: Human / Machine Fusion and the Implications for the Future of the DoD", *November 2019*, <u>https://community.apan.org/wg/tradoc-g2/mad-scientist/m/articles-of-interest/300458</u>

¹³ U.S. Army, Biotechnologies for Health and Human Performance Council Study Group, "Cyber Soldier 2050: Human / Machine Fusion and the Implications for the Future of the DoD", *November 2019*, <u>https://community.apan.org/wg/tradoc-g2/mad-scientist/m/articles-of-interest/300458</u>

¹⁴ Patrick Tucker, "Special Operations Command Made a Mind-Reading Kit For Elite Troops", *Defense One*, 11 December 2019, https://www.defenseone.com/technology/2019/12/specops-lab-made-mind-reading-kit-elite-troops/161830/





Efforts such as those demonstrated in Tampa reflect a broader focus of militaries around the world, including small militaries, on leveraging novel technologies to support improved soldier persistence, performance, and protection in a complex and contested environment. In short, to create what U.S. SOCOM calls hyper-enabled operators.¹⁵

Cyber and C4ISTAR

Key Insights:

- AI enabled military capabilities go well-beyond autonomous weapons systems and "killer robots" and will affect the future of intelligence processing, simulation and training, logistics and maintenance, electronic warfare, cyber-security, surveillance, and human performance enhancement.
- In addition to traditional military capabilities, AI-enabled tools are now being deployed as part of disinformation and influence operations designed to affect domestic political debates in targeted countries.
- Even absent the use of AI-enabled tools, disinformation and influence operations are playing an increasingly prominent role in shaping the strategic context in which geopolitical and military competition is playing out. Frequently, these disinformation campaigns are aimed at or cleverly draw in smaller countries, meaning that detecting and mitigating the risks of technology-driven disinformation campaigns should be a priority even for security communities that may feel an urgent adversarial threat.

AI, Weaponization of Media, and Disinformation Campaigns: A series of in-depth reports addressing the importance and implications of AI technologies for defence and security communities were published during the reporting period. A prominent theme across many of them was the exceptionally disruptive effects AI-enabled tools will have on government institutions, economies, and societies when deployed as part of disinformation campaigns.

For example, the November 2019 Interim Report from the U.S. National Security Commission on Artificial Intelligence (NSCAI), a Congressionally established organisation chaired by former Google CEO Eric Schmidt and vice-chaired by former Deputy Secretary of Defense Robert Work, concluded that diffusion of AI "will accelerate the already severe threat of cyber enabled disinformation campaigns, including false flag efforts."¹⁶ Similarly, a 10 December 2019 report from the Atlantic Council agreed: "AI technologies will be used—*already are being used*—to exploit the vulnerabilities of the digital age and pose difficult to detect and deter threats to the stability and efficacy of US and allied societies and polities."¹⁷

In December 2019, the Atlantic Council's Digital Forensics Lab in conjunction with Graphika released a report that indicates the threshold of AI-enabled disinformation campaigns may have already been crossed. The joint report entitled Operation FFS: Fake Face Swarm chronicles Facebook's efforts to shut down "over 900 pages, groups, and accounts on its own platform and on Instagram" all closely associated with the Beauty of Life organisation, widely reported to be linked to the Falun Gong movement and the Epoch Times media outlet. The group established networks to originate and disseminate media in support of conservative political candidates in the United States, especially President Donald J. Trump. Among tactics

¹⁵ Patrick Tucker, "Special Operations Command Made a Mind-Reading Kit For Elite Troops", *Defense One*, 11 December 2019, <u>https://www.defenseone.com/technology/2019/12/specops-lab-made-mind-reading-kit-elite-troops/161830/</u>

¹⁶ National Security Commission on Artificial Intelligence, "Interim Report", November 2019, <u>https://www.epic.org/foia/epic-v-ai-commission/AI-Commission-Interim-Report-Nov-2019.pdf</u>

¹⁷ Tate Nurkin and Stephen Rodriguez, "A Candle in the Dark: US National Security Strategy for Artificial Intelligence", Atlantic Council, 10 December 2019, <u>https://www.atlanticcouncil.org/uncategorized/a-candle-in-the-dark-us-national-security-strategy-for-artificial-intelligence/</u>





employed was the use of AI-built photos to add authenticity to fake profiles. According to the report, the tactic constituted "the first large-scale deployment of fake faces known to the authors of [the] report." ¹⁸

This specific use of AI-created fake photos was largely designed to influence U.S. domestic politics and U.S. – China policy. These technologies along with tools such as deepfakes—are growing more advanced and are proliferating, creating potentially difficult new threats for both large and small militaries. As Graham Brookie, the director of the Atlantic Council's Digital Forensic Research Lab, noted in the wake of the report, this example portends "an eerie, tech-enabled future of disinformation."¹⁹.

Of course, AI-enabled tools are not required for the creation and execution of effective technologydriven disinformation campaigns. In-depth



Figure 4: An image of an administrator of one of the groups identified in the Graphika / Atlantic Council report. The image was deemed by experts to be generated through the use of generative adversarial networks (GANs), an AItechnique. Asymmetries in the glasses offer evidence of the inauthenticity of the image. Source: #Operation FFS: Fake Face Swarm

reporting from *The Atlantic* and *Defense One* in December 2019 demonstrate the sophisticated tactics Russia is using to undermine public support for key government positions in both Lithuania and the United Kingdom. In Lithuanian, on-going Russian weaponization of social media is designed to undermine popular support for the NATO deployment there and has included hacking Lithuanian news service kasvyksta.lt and planting inflammatory stories. One fabricated story stated that the United States was moving nuclear weapons to Lithuania from Turkey. Another story falsely reported that German NATO troops had desecrated Jewish gravestones in the city of Kaunus.²⁰

Reporting from *The Atlantic* during the period revealed a multi-dimensional and massive Russian disinformation campaign to discredit the UK government's official view that the Russian government was responsible for the March 2018 poisoning of former Russian spy Sergei Skripal and his daughter in Salisbury, UK. The main objective of this campaign was not to create a single alternative narrative to challenge the UK's version of events, but rather to flood international and British media with *so many different narratives* that it would become impossible for individuals and organizations to definitively determine which was correct. In other words, the objective was not to convince, but to confuse.

The article cites a March 2019 report from King's College London that found that Russian-government funded news outlets RT and Sputnik alone were responsible for an impressive 138 separate and often contradictory narratives in the four weeks following the poisoning.²¹ The effort purportedly also involved a spear-phishing attack against the Swiss Federal Office for Civil Protection laboratory based in Spiez, demonstrating the comprehensiveness of Russia's effort and willingness to target even indirectly connected actors. The lab was responsible for performing independent tests of the poison used against the Skripals.²²

China's Space Launch and Testbed Satellite: On December 27, 2019, China successfully launched the Long March – 5 Y3 heavy lift rocket, marking an important milestone in the country's space program and long-term capacity to enhance its space-based commercial communications and military C4ISR networks.

²⁰ Patrick Tucker, "Russian Trolls Hammering Away at NATO Presence in Lithuania", *Defense One*, 3 December 2019, <u>https://www.defenseone.com/technology/2019/12/russian-trolls-are-hammering-away-natos-presence-lithuania/161654/</u>

²¹ Gordon Ramsey and Sam Robenshaw, "Weaponizing News: RT, Sputnik, & Targeted Disinformation", King's College London, 1 March 2019, <u>https://www.kcl.ac.uk/news/how-russian-state-media-weaponises-news</u>

²² Tom McTague, "Britain's Secret War with Russia", *The Atlantic*, 3 December 2019,

¹⁸ Ben Nimmo et al., "#Operation FFS: Fake Face Swarm", Atlantic Council Digital Forensics Lab and Graphika, December 2019, <u>https://graphika.com/uploads/Graphika%20Report%20-%20OperationFFS_Fake_Face_Storm.pdf</u>

¹⁹ Davey Alba, "Facebook Discovers Fakes that Show Evolution of Disinformation", *The New York Times*, 20 December 2019, https://www.nytimes.com/2019/12/20/business/facebook-ai-generated-profiles.html

https://www.theatlantic.com/international/archive/2019/12/britain-russia-nato-disinformation/602836/





This was the first launch of the Long March 5 since a first-stage booster failure in 2017 destroyed the vehicle's cargo—the Shijian -18 satellite.

The vehicle carried the experimental Shijian-20 satellite, reportedly expected to test a laser communications payload for future missions. The satellite will also test the adaptability of the DFH-5 satellite platform, designed to address the need of high-capacity satellites for high orbit communications, microwave remote sensing, optical remote sensing, space scientific exploration, in-orbit service and other purposes in the next 20 years.²³

The DFH-5 program seeks to build on the momentum of the DFH-3 and DFH-4 development—there are currently 20 communications satellites running on the DFH-4 platform.²⁴ According to Hao Yanyan, the product assurance manager of the Shihian-20 program with China Aerospace and Science Technology Corporation (CAST), "with the government's consistent support for the communications satellite industry in the past decades, we have developed the DFH-3 and DFH-4 satellite platforms, making China one of the few countries in the world that can independently develop large communications satellites and provide in-orbit commercial services."²⁵ China's government-run space program is led by the People's Liberation Army and China National Space Agency (CNSA) and is largely dual-use in nature, meaning that technologies developed with ostensibly commercial purposes are also available to China's military and security community.

Manned Platforms

Key Insights:

- China has commissioned its first indigenously designed and built aircraft carrier. The *Shandong* is an advancement in capability from China's first aircraft carrier, the *Liaoning*, which was procured from Ukraine. However, the technological complexity of developing even more advanced aircraft carriers has slowed the program and reportedly reduced the overall number of aircraft carriers China is seeking to develop in the next four years
- Russia's Su-57 and the international F-35 programs both reached milestones during the reporting period, despite recent setbacks including the crash of an Su-57 prototype in December 2019. Su-57s have reportedly been deployed to Syria, like much of Russia's advanced military equipment. The conflict has served as a useful testbed for new military capabilities
- Development of advanced fourth generation fighters also continues, including the incorporation of artificial intelligence technologies to relieve pilot burden and enhance pilot performance

China Commissions Aircraft Carrier: China's People's Liberation Army Navy (PLAN) commissioned its second aircraft carrier—and first indigenously designed and built-on 17 December. The *Shandong* is a 50,000-ton vessel that includes a "ski jump" short take-off but arrested recovery system (STOVAR) for launch and recovery. The ship is the first of four planned indigenously designed and built aircraft carriers. Future iterations are likely to have a different design in order to accommodate electromagnetic launch

²³ "China launchers heaviest satellite to test key technologies", *Xinhua Net*, 27 December 2019, <u>http://www.xinhuanet.com/english/2019-12/27/c_138662080.htm</u>

²⁴ "China launchers heaviest satellite to test key technologies", *Xinhua Net*, 27 December 2019, http://www.xinhuanet.com/english/2019-12/27/c_138662080.htm

²⁵ "China launchers heaviest satellite to test key technologies", *Xinhua Net*, 27 December 2019, http://www.xinhuanet.com/english/2019-12/27/c_138662080.htm





capability.²⁶ The Shandong is powered by a conventional oil-fuelled steam turbine power plant, rather than the nuclear propulsion used by the United States aircraft carriers.



Figure 5: An image of the newly commissioned Shandong. Source: Center for Strategic and International Studies

The *Shandong* was originally launched on 26 April 2017 and went through nine rounds of sea trials over a span of 18 months before being commissioned. It was designated as the Type 002. It is based on the southern island province of Hainan, which sits in the South China Sea.²⁷ The commissioning represents a significant achievement for China's naval ship-building industry and also constitutes an advancement in capability over the PLAN's first aircraft carrier, the *Liaoning*, which was refitted after being acquired from Ukraine and was commissioned in 2014.

China's domestically – built aircraft carrier efforts have been a central component of its increasingly maritime – focused military modernization effort and growing efforts to develop capabilities not only to press China's claims in the Asia-Pacific region, but also to protect China's growing global interests and presence. However, there are indications that the PLAN will have to slow some elements of its ambitious carrier building plans. The PLAN had previously stated that it was planning to build five domestically-built carriers, for a total fleet of six, though reporting in November 2019 indicated that these plans had been scaled back due to challenges related to the complexity and cost of building advanced aircraft carriers.²⁸

The *South China Morning Post* reports that work on two additional aircraft carriers will continue. These carriers will be equipped with electromagnetic catapults for launch and recovery, but like the *Shandong* will be conventionally powered. However, plans for an additional two aircraft carriers, including the potential for a nuclear-powered carrier, have been put on hold due to technical challenges related to developing nuclear propulsion systems for aircraft carrier, integrating advanced carrier-based fighters, and systems integration concerns. According to a Chinese military source, "Aircraft carrier-building is the world's most complicated and costly project employing many sophisticated technologies. It is a new era for Chinese shipbuilders and engineers and really needs time to catch up with other countries."²⁹

²⁶ Minnie Chan, "Chinese navy set to build fourth aircraft carrier, but plans for a more advanced ship are put on hold", *South China Morning Post*, 28 November 2019, <u>https://www.scmp.com/news/china/military/article/3039653/chinese-navy-set-build-fourth-aircraft-carrier-plans-more</u>

²⁷ "China commissions aircraft carrier", The Associated Press, *Navy Times*, 18 December 2019, https://www.navytimes.com/news/your-navy/2019/12/19/china-commissions-aircraft-carrier/

²⁸ Minnie Chan, "Chinese navy set to build fourth aircraft carrier, but plans for a more advanced ship are put on hold", *South China Morning Post*, 28 November 2019, <u>https://www.scmp.com/news/china/military/article/3039653/chinese-navy-set-build-fourth-aircraft-carrier-plans-more</u>

²⁹ Minnie Chan, "Chinese navy set to build fourth aircraft carrier, but plans for a more advanced ship are put on hold", *South China Morning Post,* 28 November 2019, <u>https://www.scmp.com/news/china/military/article/3039653/chinese-navy-set-build-fourth-aircraft-carrier-plans-more</u>





Advanced Fighter Jets Passing Milestones: The reporting period included several notable developments related to the *deployment* of advanced manned fighter jets.

On 27 December 2019, *The Diplomat* reported that the Russian Air Force is still expected to receive the first batch of serial – produced Sukhoi Su-57 fighter aircraft in 2020. The Su-57 is Russia's first indigenously designed and produced fifth generation stealthy fighter jet. The news comes only days after

an Su-57 crashed on 24 December. The Russian Air Force is currently testing 10 Su-57 prototypes, including four that reportedly flew combat missions in Syria.³⁰ The Syria conflict has served as a useful testbed for many emerging and advanced Russian capabilities, including the Uran-9 autonomous unmanned ground combat vehicle. Russia's United Aircraft Corporation has also developed an export variant of the Su-57 (the Su-57E), which has been offered to the People's Republic of China. Iran, Turkey, Algeria, and Pakistan have also inquired about the aircraft.



Figure 6: The Su-57. Source: Moscow Times

On 17 December 2019, the Republic of Korea Air Force (ROKAF) declared initial operational capability for its fleet of F-35A Lightning II fifth generation stealthy fighters. The announcement indicates that the fleet is now cleared to carry out some combat missions such as interdiction, close air support, and limited suppression of enemy air defences. A total of 13 F-35As are thought to have been delivered to the ROKAF while up to 26 F-35As are set to be delivered by the end of the year with a total of 40 aircraft being delivered by the end of 2022.³¹

In Sweden, the first series of production for the Gripen E made its initial flight.³² The advanced fourth generation fighter was developed "to counter and defeat advanced future threats" especially for "customers with more pronounced threats or wider territories to secure."³³ Technological upgrades to the fighter include: a new and more powerful engine, improved range performance, the ability to carry greater payloads, a new AESA-radar, an InfraRed Search and Track system, highly advanced electronic warfare and communication systems, and "superior situational awareness." Significantly, the Gripen E's "fighter intelligence has the capability to work autonomously on several areas simultaneously and provides the pilot with suggestions" ranging from anything between weapon selection and full manoeuvring of the fighter.³⁴

³⁰ Franz-Stefan Gady, "Despite Su-57 Crash, Russia Plans for Mass Delivery of New Fighter Jet in 2020", *The Diplomat*, 27 December 2019, <u>https://thediplomat.com/2019/12/despite-su-57-crash-russia-plans-for-mass-delivery-of-new-fighter-jet-in-2020/</u>

³¹ Franz-Stefan Gady, "F-35A Stealthy Fighter Formally Enters Service in South Korea", *The Diplomat*, 19 December 2019, https://thediplomat.com/2019/12/f-35a-stealth-fighter-formally-enters-service-in-south-korea/

³² David Donald, "First Gripen E for Sweden Flies", *AINonline*, 6 December 2019, <u>https://www.ainonline.com/aviation-news/defense/2019-12-06/first-gripen-e-sweden-flies</u>

³³ SAAB website, "Gripen E: Forever Forward", <u>https://saab.com/gripen/our-fighters/gripen-fighter-system/gripen-e-</u> series/gripen-e/

³⁴ SAAB website, "Gripen E: Forever Forward", <u>https://saab.com/gripen/our-fighters/gripen-fighter-system/gripen-e-series/gripen-e/</u>





Missile Systems and Munitions

Key Insights:

- The counter-drone market is growing as more military and security communities of all sizes seek to develop and / or procure both soft and hard kill solutions to the threat posed by the diffusion and clever use by state and non-state actors of small or low-flying drones
- However, there is a growing sense that counter-drone technologies still require development in order to be effectively deployed and used. Enduring challenges for counter-drone weapons include discernment of adversarial drones from friendly ones; jamming of autonomous systems; and detection of low-altitude threats. Small and large militaries will need to understand the full nature of these challenges and incorporate lessons learned from early applications of counter-drone weapons into future procurement and development programs
- China has launched an effort to develop an airborne laser weapons pod designed to intercept missiles and serve as self-protection for fighters and other air platforms. This is the latest effort of predominantly large militaries around the world to develop directed energy weapons for uses by individual platforms. The U.S. Army has investigated placing laser weapons on vehicles, among other efforts.
- China's announcement further indicates the importance of directed energy for a growing range of applications and missions for small and large militaries.

Counter-Drone Weapons: On 12 December 2019 the Spanish Ministry of Defence awarded Aeronautica SDLE a contract for two portable counter-drone systems that will be used by the Spanish Guardia Civil, a Spanish law enforcement agency. ³⁵

The rifle-shaped system jams communications between drones and their controllers and is designed to be

used against an unlimited number of drones simultaneously. Other reported benefits of the Aeronautica system include its capacity to be fitted with omnidirectional antennas in order to protect against sudden undetected threats and its ability to be customized to be deployed on moving vehicles or fixed locations.³⁶

Demand for counter-drone systems is on the rise in large and small military, security, and law-enforcement communities as the diffusion of



Figure 7: Aeronautica SDLE's counter-drone system. Source: Aeronautica SDLE

unmanned aerial, especially small and potentially even commercially available systems, has accelerated. And the market is set to become more crowded as both established and emerging defence industry organisations seek to capitalize on growing interest and demand.

³⁵ "The Spanish Guardia Civil to use the Anti-drone Manufactured by Aeronautica SDLE", *Armada International*, 24 December 2019, <u>https://armadainternational.com/2019/12/the-spanish-guardia-civil-to-use-the-anti-drone-manufactured-by-aeronautica-sdle/</u>

³⁶ Mike Reiss, "Spanish Ministry of Defence Selects Portable Anti-Drone System", Unmanned Systems Technology, 12 December 2019, <u>https://www.unmannedsystemstechnology.com/2019/12/spanish-ministry-of-defense-selects-portable-counter-drone-systems/</u>





For example, on 8 January 2020, the Saudi Arabian Military Industries (SAMI) announced it is developing a new national counter-drone system to address the uptick in asymmetric threats to the country and to protect critical infrastructure and domestic bases. According to SAMI CECO Andreas Schwer, "This

A December 2019 study from the Center for the Study of the Drone outlines the dramatic growth in the counterdrone market over the last year:

The report lists 537 systems developed by 227 companies in 38 countries, up from 235 products listed in the Center's February 2018 report. system will have the 'soft kill' option and various 'hard kill' options to counter all types of drones from very small ones the kind of Phantom IV type of threats up to the professional militarized threats."³⁷ The Saudi Arabian requirement for a counter-drone system became considerably more urgent after a 14 September 2019 in which drones and low-altitude cruise missiles attacked the Abqaiq and Khurais oil facilities in Saudi

Arabia, defeating previously installed air defence systems.

While counter-drone system demand is increasing, these weapons systems should not yet be seen as insulating military and security communities against drone threats, asymmetric or otherwise. A December 2019 report from the Center for the Study of the Drone at Bard College in New York provides in-depth analysis of some of the technical and operational challenges that continue to hinder the development of counter-drone technologies. According to the report, which cited both publicly available information as well as interviews with military and law enforcement personnel, challenges related to the actual deployment of counter-drone systems include not only the technical challenges associated with threat identification and mitigation, but also "complex questions around safety, practicality, policy, and legality". Key technical challenges identified in the report include:³⁸

- Detection of low-altitude threats
- Discerning between legitimate threats and benign activities, such as commercial use of a drone or the flight of bird, especially in low visibility environments
- Electromagnetic interference, especially in crowded urban areas where many of these systems are likely to be deployed, can degrade the detection performance of radio-frequency sensors
- Jamming will not work against autonomous drones that are not communicating back to a ground station or human controller

A New Airborne Laser Effort: The People's Liberation Army posted an announcement of a procurement competition for a laser "attack pod" on 6 January 2020. The reference to an "attack pod" rather than a laser guidance pod indicates that the objective of the procurement may be to field a weapon that can be used by air assets for self-defence; that is, to shoot down missiles and potentially other aircraft in a tactical environment, according to the *Global Times*, a nationalist media outlet that frequently incorporates narratives of the Chinese Communist Party.³⁹

Military observers in China have noted that China has already developed a prototype for an airborne laser weapon, citing a paper entitled "Study on Energy Storage and Power Supply of Airborne Laser Weapon". The academic thesis was produced jointly by state-owned defence enterprise Aviation Corporation of China (AVIC) and the Military Resident Representative Bureau of Special Equipment of the PLA Rocket

 ³⁷ Agnes Helou, "Saudi Arabia is developing a new counter-drone system", *Defense News*, 8 January 2019, https://www.defensenews.com/unmanned/2020/01/08/saudi-arabia-is-developing-a-new-counter-drone-system/
³⁸ Arthur Holland Michel, "Counter-Drone Systems", Second Edition, Center for the Study of the Drone, December 2019, https://dronecenter.bard.edu/files/2019/12/CSD-CUAS-2nd-Edition-Web.pdf

³⁹ Liu Xuanzun, "Military developing airborne laser attack pod, says report", *Global Times*, 7 January 2019, https://www.globaltimes.cn/content/1175931.shtml





Force. The paper reportedly confirmed the existence of a working prototype of a power supply for a 100-kilowatt laser weapon that could be used as an airborne weapon.⁴⁰

High-energy lasers are a particularly attractive weapon for missile defence and platform protection, given that they travel at the speed of light, faster than even hypersonic missiles. They also are considered a "low cost / deep magazine" capability, meaning that the overall cost of a high-energy laser is considerably less than an interceptor missile and there are few constraints on the number of "rounds" an laser system can fire. Technical challenges do remain, though. Firing high-energy lasers requires a considerable amount of power. Power supplies capable of generating this power could affect other performance parameters of highly engineered fighter aircraft.

Robotics and Unmanned Systems

Key Insights:

- As unmanned systems technologies advance, militaries around the world are seeking to simultaneously develop operational concepts for their efficient and effective use, especially against other robots and unmanned systems. Currently, even militaries at the leading edge of unmanned ground vehicle development and deployment, like Russia, are constrained by "the virtual absence of a unified concept for the use of military robotics by the Russian armed forces."
- Increased autonomy of unmanned systems is creating new capabilities, but also creating new ethical challenges for many militaries. The incorporation of facial recognition software on a Turkish loitering munition has created the potential for the system to autonomously determine a target based on AI-enabled software that may or may not be trustworthy, safe, or reliable.
- Some international observers are expressing concern about the growing number of countries and companies developing autonomous unmanned systems, especially in absence of established norms for the use of autonomous unmanned systems

Russia Exploring New Operational Concepts: Russia continues to be at the forefront of the development of military unmanned ground vehicles, including combat UGVs such as the Uran-9. While the Uran-9s deployment to Syria was widely viewed as a disappointment as "practically all of the Uran-9s major systems have failed", Russia has learned from that failure and has continued to move forward with development of new families of UGVs such as the Marker and Kungas.⁴¹

As it continues to advance unmanned technologies, the Russian Ministry of Defence is also seeking to develop new operational concepts that will fill what the Russian Ministry of Defence referred to in a November call for proposals as "the virtual absence of a unified concept for the use of military robotics by the Russian armed forces."⁴²

⁴⁰ Liu Zhen, "Chinese military hints at plans for airborne laser attack weapon", *South China Morning Post*, 7 January 2019, https://www.scmp.com/news/china/military/article/3045066/chinese-military-hints-plans-airborne-laser-attack-weapon
⁴¹ Samuel Bendett, "Russia's Military Is Writing an Armed-Robot Playbook", *Defense One*, 26 November 2019, https://www.defenseone.com/ideas/2019/11/russias-military-writing-armed-robot-playbook/161549/
⁴² Samuel Bendett, "Russia's Military Is Writing an Armed-Robot Playbook", *Defense One*, 26 November 2019, https://www.defenseone.com/ideas/2019/11/russias-military-writing-armed-robot-playbook/161549/





Tests of some operational concepts are already being planned. According to *C4ISRNET*, Russia is expected to test robot swarms, guided by humans, and armed, as a means of dealing with adversary armed unmanned systems at some point in the first half of 2020. The anticipated tests will revolve around the Market robot



Figure 8: The Marker armed UGV, which was designed to serve as a testbed for new technologies and operational concepts. Source: Foundation for Advanced Studies

but will include unmanned ground vehicles from the Kungas family, operating in swarms of five vehicles. The Marker UGV was unveiled in video footage that emerged in February 2019. It is considered an experimental platform that was developed to help Russian special forces to test and mature emerging technologies and operational concepts.⁴³

Samuel Bendett, a Russian military expert and advisor at the Center for Naval Analysis, noted that there was a possibility that the Marker could be armed with "a grenade launcher and / or 120 mm

mortars"⁴⁴. Currently, the Marker is armed with a Kalashnikov machine gun (MG) as its primary weapon with sensors and optics fitted to the front and top of the turret structure, with two anti-tank guided missiles (ATGMs) mounted opposite the machine gun.⁴⁵ Adding an option for 120 mm mortars could, in Bendett's view, create a "significant mission multiplier for the ground forces, assuming proper mechanism is worked out for coordinating unmanned and manned formations." Bendett expects these systems will feature "after 2025."⁴⁶

Turkish Kamikaze Drones Upgraded with AI: In

September 2019, Turkish defence contractor Defence Technologies and Engineering and Trade Inc (STM) announced that 30 upgraded KARGU autonomous tactical multi-rotor kamikaze drones / loitering munitions will be added to the Turkish Armed Forces' inventory in 2020. The upgraded systems will support operations taking place in Eastern Turkey and in Syria.⁴⁷

The upgraded systems will have an enhanced ammunition capacity and improved accuracy, but perhaps the most notable improvement is the incorporation of AI and facial recognition systems



Figure 9: The KARGU autonomous rotary wing loitering munition weighs less than 70 kilograms, has a range of 15 kilometers, and can stay in the air for 30 minutes with explosives, according to manufacturer STM General Director Murat Ikinci.¹ Source: STM YouTube

that will enable the KARGUS systems to autonomously recognize and attack targets.⁴⁸ Clearly the capability to use facial recognition to identify individuals to be attacked raises a wide range of important questions about the ethics of autonomous weapons, safe and trustworthy AI, and algorithm bias.

⁴⁶ Kelsey D. Atherton, "Russia will test swarms for anti-robot combat in 2020", *C4ISRNET*, 13 December 2019, https://www.c4isrnet.com/unmanned/2019/12/13/russia-will-test-swarms-for-anti-robot-combat-in-2020/

⁴⁷ "Turkey to start operating kamikaze drones near Syrian border", *Ehamedya*, 12 September 2019, <u>http://ehamedya.com/turkey-to-start-operating-kamikaze-drones-near-syrian-border-in-2020_28626.html</u>

⁴⁸ "Slippery Slope: The Arms Industry and Increasingly Autonomous Weapons", PAX, November 2019, <u>https://www.paxcforpeace.nl/publications/all-publications/slippery-slope</u>

⁴³ Melanie Rovery, "Russia's FPI unveils Marker armed UGV", *Jane's International Defence Review*, 6 March 2019, <u>https://www.janes.com/article/87031/russia-s-fpi-unveils-marker-armed-ugv</u>

 ⁴⁴ Kelsey D. Atherton, "Russia will test swarms for anti-robot combat in 2020", *C4ISRNET*, 13 December 2019, https://www.c4isrnet.com/unmanned/2019/12/13/russia-will-test-swarms-for-anti-robot-combat-in-2020/
⁴⁵ Melanie Rovery, "Russia's FPI unveils Marker armed UGV", *Jane's International Defence Review*, 6 March 2019, https://www.janes.com/article/87031/russia-sfpi-unveils-marker-armed-ugy





The KARGU was used as a compelling example of loitering munitions featured in a November 2019 report released by Pax, a Netherlands – based not-for-profit, entitled *Slippery Slope: The Arms Industry and Increasingly Autonomous Weapons.* The report notes that the KARGU "has been called one of the first systems to be deployed that can 'find, track, and kill people without human intervention". More broadly, the Pax report assess a prevailing industry trend of "increasing autonomy in weapons systems", noting that the last decade has seen a significant increase in the number of "countries and companies" working on these technologies.⁴⁹

⁴⁹ "Slippery Slope: The Arms Industry and Increasingly Autonomous Weapons", PAX, November 2019, <u>https://www.paxforpeace.nl/publications/all-publications/slippery-slope</u>



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