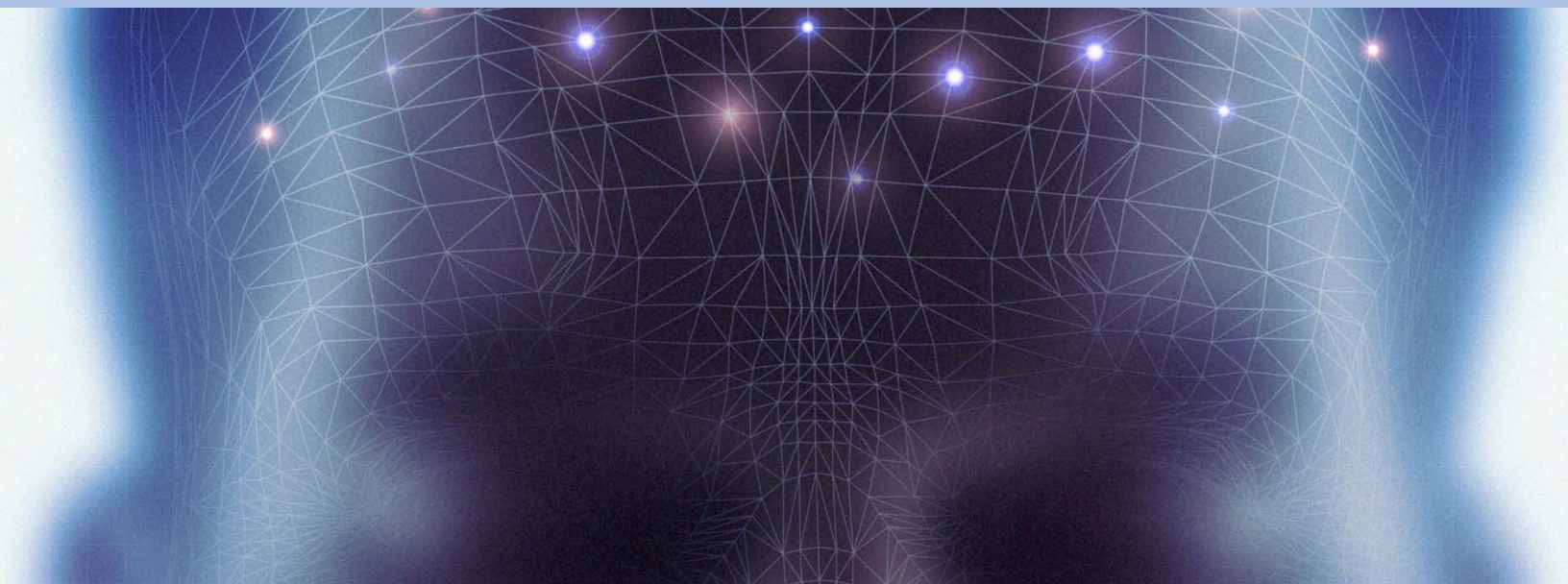




Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
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Federal Department of Defence,
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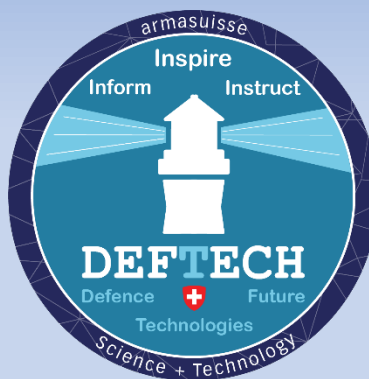
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DEFTECH Update

Enabling Military Capabilities

December 2018



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

Dear Reader,

As promised in the last Update, I'm happy to present you the new type of document we will release every two months as part of the DEFTECH alpha-concept. Another type of document will also be released every 3 months, with a different cycle, in complement to this one.

I am therefore really proud to welcome OTH Intelligence Group with whom we'll be interacting in the generation of this *Military Capabilities* report. This report provides insight on design, development, deployment, and use of novel military capabilities around the world. It includes both reporting on events, announcements, exhibitions, and advancements of new capabilities and analysis of what these capabilities mean for defense and security communities, future requirements, and military competitions and operations.

If it is important to understand how technologies and innovation can impact security and defense, it is also equally important and complementary to grasp what the different actors worldwide are trying to achieve. In order to structure this approach, each iteration of the report will center on six broad categories of military capability areas listed below.

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

Each Update is **not** a comprehensive accounting of capabilities displayed, demonstrated, or discussed within each of these categories. Rather, it will draw attention to indicative or especially relevant capabilities and developments that incorporate novel technologies, including those associated with the 4th Industrial Revolution, among others. It will also emphasize, where appropriate, adjacent, non-technological innovations in operational concepts, organizational structure, and innovation and procurement models that facilitate design, procurement, and deployment of new capabilities.

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



Dr. Quentin Ladetto
armasuisse S+T
Research director – Technology Foresight
quentin.ladetto@armasuisse.ch

Introduction and Summary

The reporting period for this inaugural report was bookended by two high-profile defence exhibitions, during which several capabilities of interest were demonstrated and announcements made.

The Association of the U.S. Army (AUSA) exhibition was held in Washington, DC from 8 – 10 October – marking the start of the reporting period—while the China International Aviation and Aerospace Exhibition (also known as the Zhuhai Air Show) was held from 6 – 11 November in Zhuhai, China. Asia-Pacific-focused media outlet *The Diplomat* described the Zhuhai Airshow 2018 as “the most impressive (iteration of the Zhuhai) event in recent memory by a significant margin”¹, and several of the outputs of this ‘impressive’ show are included in this report. The reporting period also saw developments of interest from European and Russian providers, important announcements about future capabilities, and the release of analytical reports outlining development pathways for advanced capabilities.



Sgt. 1st Class Joshua Tygret, left, and Sgt. Austin Murphy, assigned to 744th Ordnance Disposal Company, 52nd Explosive Ordnance Group, navigate the TALON (source: military.com & U.S. Army/Staff Sgt. Lance Pounds)

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

Capability Development and Organizational Models: Defence and security communities are designing and implementing new models of development and incorporation of novel technologies and new military capabilities that stress engagement of high-tech industry and applied research centers as well as of allied and partner defense communities. The U.S. Army's Capabilities Development and Integration Directorate, for example, partnered with the National Advanced Mobility Consortium to conduct an outcome-based innovation

¹ Joe, Rick, “China’s Air Force on the Rise: Zhuhai Air Show 2018”, *The Diplomat*, 13 November 2018, <https://thediplomat.com/2018/11/chinas-air-force-on-the-rise-zhuhai-airshow-2018/>

workshop -- an approach to challenges that has been "proven in the commercial industry sector but never potentially used in a partnership with the military to get after some of the military's problems."² Other examples include efforts by Central European states to jointly develop new WMD sensors and training centers, China's decision to jointly manufacture Wing Loong II unmanned aerial vehicles, and the increasing use of biomimicry to support military drone development.

Competition: A strong competitive dynamics is shaping capability investment, development, and procurement priorities within and across capability category areas as military and security communities seek to either meet or counter-act capabilities developed by potential adversaries or geopolitical competitors. By way of example, the U.S. Air Force's award of nearly \$200 million in contracts to companies to develop counter-laser glasses for pilots, largely in response to suspected Chinese efforts to use directed energy to disrupt U.S. Air Force operations. Similarly, the development of advanced exo-atmospheric interceptors and radar capable of detecting hypersonic threats stands as a strong response to a growing ballistic and hypersonic missile threat.

Diffusion and New Actors: The increasing availability of novel technologies and diffusion and acquisition of the know-how to utilize these technologies is both introducing new actors and accelerating the maturation of defence industrial bases in emerging markets. In short, more actors are capable of creating disruptive capabilities, and typically along timelines quicker than previously imagined. Ukrainian defence enterprise Antonov's announcement of the concept for a strategic intelligence and strike platform and the more immediate procurement of an armed tactical unmanned system fill a gap for Ukraine and potential drive new competitive dynamics on the global export market. Demonstration of a prototype of the J-10 equipped with a thrust vector control (TVC) nozzle and a prototype quantum radar highlight China's defence industrial base's progress in both overcoming long-standing technological challenges (aero-engines) and mastering of critical emerging technologies (quantum, as well as solar energy and others).

² Cox, Matthew, "Army Wants to Use Robots to Help Conduct Precision Strikes on the Enemy", *Military.com*, 22 October 2018, https://www.military.com/defensetech/2018/10/22/army-wants-use-robots-help-conduct-precision-strikes-enemy.html?utm_source=Sailthru&utm_medium=email&utm_campaign=ebb%2010/23/18&utm_term=Editorial%20-%20Early%20Bird%20Brief

Energy, Power, and Propulsion

Defence and security communities are increasingly developing novel means of increasing the range, endurance, efficiency, and mission effectiveness of platforms and systems (as well as humans). Various stages of successful development of high-efficiency power sources, such as lithium-ion batteries and hydrogen fuel cells, were demonstrated during the reporting period as were examples of the incorporation of renewable energies into military platforms.

Lithium – Ion Battery Powered Submarine: Mitsubishi Heavy Industries (MHI) launched the *Oryu* on 5 October, the 11th vessel in Japan’s *Soryu* diesel-electric submarine class. The 84 meter, 2,950 ton vessel *Oryu*’s launch is notable largely because it is the first ship in the class to replace lead-acid batteries with lithium ion ones.³ Lithium-ion batteries allow operators to shut down the primary diesel – electric engines—which create undesirable acoustics while underwater—and switch to a battery source that will enable quieter maneuverability and long-endurance propulsion, making the *Oryu* more difficult to detect, allowing it to stay underwater for longer periods of time, and extending its range.⁴ The *Oryu* is expected to be delivered to the Japanese Maritime Self-Defense Force in March of 2020.⁵

Fuel Cell Technologies: On 8 October the U.S. Department of Energy’s Office of Energy Efficiency and Renewable Energy Fuel Cell Technologies Office (EERE-FCO) and the U.S. Army’s Tank Automotive Research Development and Engineering Center (TARDEC) announced the signing of a memorandum of understanding (MoU) outlining a partnership to develop cell and hydrogen infrastructure-related technologies. According to the MoU, initial efforts will “focus upon identification and evaluation of hydrogen production, storage, transportation, and dispensing in support of future military operations and nation-wide hydrogen demand scenarios.”⁶ Hydrogen fuel cells can offer military platforms enhanced range, endurance, and operational efficiency.

TARDEC has already developed at least one fuel-cell prototype. According to Jane’s.com, TARDEC has trialed General Motors’ (GM) Colorado ZH2 hydrogen fuel cell-powered electric truck over the past two years to with the objective of demonstrating that “hydrogen fuel cell technology in ground vehicles would be stable enough for possible military use.” According to *Jane’s*, the truck’s hydrogen fuel storage tank was shot with 7.62 mm standard, incendiary, and armour-piercing rounds. It was penetrated with a rocket-propelled grenade round but did not explode.⁷

GM rolled out its next generation ZH2—based on a Chevrolet Silverado pick-up truck chassis—during AUSA 2018. The ZH2 Silverado—which is still set to undergo testing by TARDEC—can output up to 10kW of power and host much heavier payloads than its predecessor, the ZH2 Colorado, according to Charlie Freese, executive director of GM’s Global Fuel Cell Business.⁸

³ Asada, Kenji, “Japan’s silent submarines extend range with new batteries”, *Nikkei*, 5 October,

<https://asia.nikkei.com/Economy/Trade-War/Japan-s-silent-submarines-extend-range-with-new-batteries>

⁴ Panda, Ankit, “Japan Launches First Lithium-Ion Equipped *Soryu* – class Submarine”, *The Diplomat*, 5 October 2018,

<https://thediplomat.com/2018/10/japan-launches-first-lithium-ion-equipped-soryu-class-submarine/>

⁵ Asada, Kenji, “Japan’s silent submarines extend range with new batteries”, *Nikkei*, 5 October,

<https://asia.nikkei.com/Economy/Trade-War/Japan-s-silent-submarines-extend-range-with-new-batteries>

⁶ Wasserbly, Daniel, “AUSA 2018: GM develops next-generation ZH2 hydrogen fuel cell-powered truck”, *Janes.com*, 10 October 2018,

https://www.janes.com/article/83683/ausa-2018-gm-develops-next-generation-zh2-hydrogen-fuel-cell-powered-truck?from_rss=1

⁷ Wasserbly, Daniel, “AUSA 2018: GM develops next-generation ZH2 hydrogen fuel cell-powered truck”, *Janes.com*, 10 October 2018,

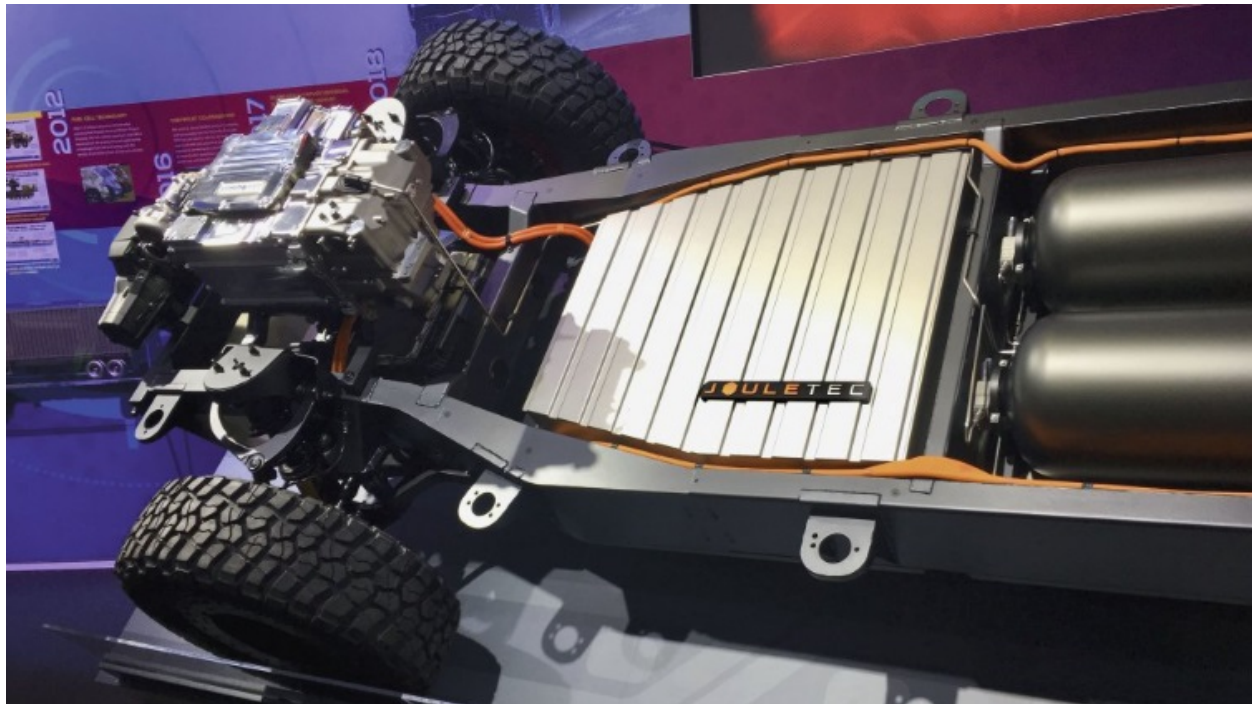
https://www.janes.com/article/83683/ausa-2018-gm-develops-next-generation-zh2-hydrogen-fuel-cell-powered-truck?from_rss=1

⁸ Wasserbly, Daniel, “AUSA 2018: GM develops next-generation ZH2 hydrogen fuel cell-powered truck”, *Janes.com*, 10 October 2018,

https://www.janes.com/article/83683/ausa-2018-gm-develops-next-generation-zh2-hydrogen-fuel-cell-powered-truck?from_rss=1

Solar-Powered, High-Altitude Long Endurance Unmanned System: The Aviation Industry Corporation of China (AVIC) announced on 26 October that it had successfully conducted the maiden flight of the Qi Mingxing (Venus) solar-electric long-endurance unmanned aerial vehicle (UAV) technology demonstrator. The Venus has a 20 m wingspan and was flown at a cruising altitude of over 20,000 m (65,616 ft). AVIC’s announcement highlighted the engineering experience and flight data gathered through the technology demonstrator program and its ability to further “master the key design, manufacturing, testing, and flight technologies of large -scale solar powered UAVs.”⁹

The development of innovative unmanned systems is a long-standing priority for China’s defence science and technology community and defence industrial base. Unmanned systems as a category was listed as one of six development priorities by the Ministry of Science and Technology (MOST) and Central Commission on Civil-Military Integration in August of 2017.¹⁰ In addition, development of alternative energies to power high-altitude-long endurance UAVs is also a priority, as evidenced by similar programs being developed by Chinese defense space such as China Aerospace Science & Industry Corporation and China Aerospace Science and Technology Corporation, according to the *South China Morning Post*.¹¹ China also has a robust domestic solar energy industry and is considered a global leader in the development of solar energy for civil / commercial purposes.¹²



GM's Silverado ZH2's chassis is shown with the company's next-generation hydrogen fuel cell powered engine at the front.
 Source: IHS Markit/Daniel Wasserbly

⁹ Wong, Kelvin, “China’s AVIC trials Venus solar-electric UAV”, *Janes.com*, 29 October 2018, <https://www.janes.com/article/84114/china-s-avic-trials-venus-solar-electric-uav>

¹⁰ Grevatt, Jon, “China Releases Civil-Military Integration Plan,” *Jane’s Defense Industry*, August 25, 2017 <http://www.janes.com/article/73364/china-releases-civil-military-integration-plan>.

¹¹ Zhen, Liu, “China solar powered drone Morning Star spreads its wings in successful test flight”, 31 October 2018, <https://www.scmp.com/news/china/military/article/2171081/chinese-solar-powered-drone-spreads-its-wings-successful-test>

¹² Slezak, Michael, “China cementing global dominance of renewable energy and technology”, *The Guardian*, 6 January 2017, <https://www.theguardian.com/environment/2017/jan/06/china-cementing-global-dominance-of-renewable-energy-and-technology>

Human Performance Enhancement

The introduction of novel technologies has created three linked imperatives for defence and security communities and the industry that supports them related to human performance enhancement: 1) to leverage these technologies to enhance human endurance, speed, strength, cognition, lethality; 2) to defend or insulate humans in combat from the use of emerging technologies—such as directed energy or acoustic weapons—in a material way; 3) to keep up with adversaries and competitors in the science and application of human performance enhancement.

Building the Super Soldier: A Center for a New American Security report released in October—the sixth in the organization’s *Super Soldier* series—highlights the urgency and complexity of the challenge while also emphasizing the opportunity availability to savvy defence communities that can sustain “cross-disciplinary dialogue” about human performance technologies and their applications in military settings. The report’s recommendations—primarily focused on the U.S. Army, but applicability to nearly any military examining the future of human performance enhancement—focused on enhancing physical fitness, nutrition, sleep patterns and incorporating pharmaceuticals for cognitive improvement all within a sound ethical framework that ensures all humans involved in human performance enhancement activities do so voluntarily.¹³



Concern over “Integration of Human and Machines”: The United States, of course, is not the only state pursuing efforts to improve the physical and mental health of soldiers and even the integration of human and machine intelligence. On 10 October at the AUSA Exhibition, Lieutenant General Robert Ashley, the Director of the U.S. Defense Intelligence Agency suggested that China’s efforts to use neural nets to teach machines to think is part of a process that will inevitably include “the integration of human and machines”.¹⁴ China’s government is already funding academic research in this area. Elsa Kania, an expert on China’s technology development for military and security purposes, commented to *Defense One* that “The PLA’s Academy of

¹³ Scharre, Paul and Fish, Lauren, “Human Performance Enhancement”, Center for a New American Security, 7 November 2018, <https://www.cnas.org/publications/reports/human-performance-enhancement-1>

¹⁴ Tucker, Patrick, “Defense Intel Chief Worried About Chinese Integration of Human and Machines”, *Defense One*, 10 October 2018, <https://www.defenseone.com/technology/2018/10/defense-intel-chief-worried-about-chinese-integration-human-and-machines/151904/>

Military Science has focused on advancing civil-military fusion in brain science research”. China is also attempting to develop a “battle brain”, a network of individual human brains working on a collective task.¹⁵

Dealing with Directed Energy: On September 28, 2018, The United States Air Force awarded contracts totaling a ceiling of nearly \$200 million to Gentex Corp and Teledyne Scientific & Imaging LLC to develop laser eye protection solutions. Each company received a multi-award indefinite delivery / indefinite quantity contract with a ceiling of \$98.3 million to develop, manufacture, and deliver different variants or form factors of laser eye protection to be used for the purpose of protecting aircrew against emerging laser threats.¹⁶

The award comes only months after the USAF issued a Notice to Airmen in April and May 2018 that warned pilots operating aircraft near the Chinese military base in Djibouti to use caution due to reported use of directed energy lasers to blind pilots. The Pentagon reports that there had been 10 similar laser attacks on U.S. personnel working at Camp Lemonnier prior to the spring attacks. The U.S. military has accused China of carrying out the attacks from its base, which is located near the U.S. base.¹⁷ In addition, U.S. military pilots flying aircraft over the East China Sea have been targeted by blinding laser attacks more than 20 times over the last 10 months, according to U.S. officials.¹⁸ China denies all U.S. accusations. However, China has an active directed energy development program featuring both high-powered microwaves (e.g., the WB-1) and lasers (e.g., Silent Hunter), meaning that the U.S. investment in counter-laser glasses must be seen as part of a broader effort to meet an emerging threat stemming from the diffusion and weaponization of various forms of directed energy.

¹⁵ Kime, Patricia, “Engineering Supersoldiers: Boost in lethality may come from within”, *Association of the US Army*, 24 October 2018, <https://www.ausa.org/articles/engineering-supersoldiers-boost-lethality-may-come-within>

¹⁶ U.S. Department of Defense Contracts for September 28, 2018, Air Force, <https://dod.defense.gov/News/Contracts/Contract-View/Article/1648706/>

¹⁷ Kube, Courtney and Slezmasko, Corky, “Pentagon accuses Chinese of blinding Djibouti-based U.S. pilots with lasers”, NBC News, 3 May 2018, <https://www.nbcnews.com/news/africa/pentagon-accuses-chinese-blinding-djibouti-based-u-s-pilots-lasers-n871096>

¹⁸ Johnson, Jesse, “U.S. military pilots in East China Sea targeted in laser attacks”, *Japan Times*, 22 June 2018, <https://www.japantimes.co.jp/news/2018/06/22/asia-pacific/u-s-military-pilots-east-china-sea-targeted-laser-attacks/#.W-7tnvZFxZc>

Cyber and C4ISTAR

Many of the most popular and powerful new technologies are already driving game-changing enhancements in perception, processing, cognition, and decision-making—effects that are likely to be even more pronounced as several of the capabilities introduced during this reporting period (quantum radar, for example) mature. But activity in the information domain is not solely driven by exotic technologies. It is also driven by new applications of existing technologies—such as jamming counter-drone guns—and new models of development that leverage not just multi-disciplinary inputs from non-traditional defense industry, but also multi-national approaches that pool limited resources to meet an expanding range of common threats.

Artificial Intelligence Border Guards: On 29 October 2018, the European Union published an article raising awareness for the Intelligent Border Control initiative (iBorderCtrl), which will imminently deploy artificially intelligent border guards at travel checkpoints in three trial countries—Latvia, Hungary, and Greece.¹⁹ The system’s most prominent feature is an avatar that asks a traveler from outside the EU a series of questions. According to *Defense One*, the AI software looks for subtle symptoms of stress as the interviewee answers. If enough indicators are present, the system will refer the traveler to a human border guard for secondary screening.²⁰

The system is most immediately and directly a response to concerns about the expanding and intensifying range of border security challenges in Europe—from terrorism, to smuggling, to migration. As project coordinator George Bouladakis of European Dynamics in Luxembourg, noted “The global maritime and border security market is growing fast in light of the alarming terror threats and increasing terror attacks taking place on European Union soil, and the migration crisis.”²¹

The iBorderCtrl program represents the promise of emerging AI-technologies to help combat a range of complicated and difficult to detect threats for security and defence communities. However, similarly designed capabilities can clearly have a range of other less salutary applications. For example, many of the technologies buttressing the iBorderCtrl program—deep learning supporting language, facial, and emotion recognition stand out—are all also central to emerging AI-driven efforts at information warfare as highlighted in a Brookings Institution paper entitled *Weapons of the Weak: Russia and AI-driven asymmetric warfare* published on 15 November. The paper singles out three critical “threat vectors” related to the use of some of the components (and other AI applications) in deception, influence, and information operations, including:

- Advances in deep learning “are making synthetic media content quick, cheap, and easy to produce”, especially when combined with advances in facial and emotion recognition and mapping
- The ability to use computing power and natural language processing “to manipulate human emotions and extract sensitive information”. As the paper points out, “as AI gains access to more personal data, it will become increasingly customized and personalized to appeal to and manipulate specific users.”
- Advances in content distribution networks will mean that “deep fakes and emotionally manipulative content will be able to reach the intended audience with a high degree of precision.”²²

¹⁹ “Smart lie-detection system to tighten EU’s busy borders”, European Commission website, 24 October 2018, http://ec.europa.eu/research/infocentre/article_en.cfm?artid=49726

²⁰ Tucker, Patrick, “European Countries to Test AI Border Guards”, *Defense One*, 1 November 2018, <https://www.defenseone.com/technology/2018/11/european-countries-test-ai-border-guards/152511/>

²¹ “Smart lie-detection system to tighten EU’s busy borders”, European Commission website, 24 October 2018, http://ec.europa.eu/research/infocentre/article_en.cfm?artid=49726

²² Polyakova, Alina, “Weapons of the weak” Russia and AI-driven asymmetric warfare”, Brookings Institution, 15 November 2018, <https://www.brookings.edu/research/weapons-of-the-weak-russia-and-ai-driven-asymmetric-warfare/>

Quantum Radar: China Electronics Technology Group Corporation's (CETC) 14th Institute displayed a prototype of a quantum radar at the Zhuhai Airshow during a limited press conference for Chinese journalists on 5 November. According to a CETC brochure distributed at the Airshow, the quantum radar “is expected to solve the traditional bottleneck (of) detection of low observable target detection, survival under electronic warfare conditions, platform load limitations, etc.”²³

While the radar system is still in early stages of development, it gives further credence to the conspicuous successes China has achieved in quantum encryption and computing. A representative sample list of recent successes in this field include: the launch of a “quantum satellite”, Quantum Experiments at Space Scale (QUESS), in August 2016²⁴; the September 2017 quantum-encrypted teleconference between Chinese scientists and the president of the Austrian Academy of Sciences in Vienna; and the development of an “unhackable computer network” connecting Beijing and Shanghai in August 2017.²⁵

Russia's Electronic Warfare Capabilities: The Russian military jammed Global Positioning System (GPS) signals between 16 October and 7 November during NATO's Trident Juncture in Norway, according to NATO. The exercise also involved personnel from non-NATO members Finland and Sweden.²⁶

The jamming episode is another example of Russia's growing focus on and capabilities in electronic warfare (EW), an assessment supported by additional developments during the reporting period. First, on 6 November, Russia's Ministry of Defence announced that it had extended the range of its drone-carried jammer system (known as Leer-3) to 100 km / 60 miles.²⁷ The Leer-3 system includes a two or three – vehicle pod with a ground station, and, according to Samuel Bendett, a research analyst for the Center for Naval Analysis, has already been deployed to Ukraine and potentially Syria²⁸. The latter theatre has proven a particularly active and effective one for Russia to trial and develop its EW capabilities. In an April 2018 speech at the U.S. Geospatial Intelligence Foundation's 2018 GEOINT Symposium, General Raymond Thomas, commander of U.S. Special Operations Command, noted that the conflict at Syria had become “the most aggressive EW environment on the planet”, implicating Russia while not explicitly mentioning it.²⁹

Second, Russia has demonstrated and trained with a variety of counter-drone weapons that jam global navigation satellite system (such as GPS, GLONASS, GALILEO, and Beidou) signals to and from the drone. The PISHAL and REX-1 counter-drone rifles were exhibited at the International Military-Technological Forum in Moscow in August 2018. Kalashnikov Concern's REX-1 was also used during Russia's September 2018 Vostok military exercise in a counter-drone mission.³⁰ Unconfirmed reports from November 2018 indicate that

²³ Trimble, Steve, “China Shows Off First Quantum Radar Prototype”, *Aviation Week*, 5 November 2018,

<http://aviationweek.com/defense/china-shows-first-quantum-radar-prototype>

²⁴ Fei, Yu and Haitao, Xu, “Feature: A life of quantum entanglement,” *Xinhua*, 10 July 2017.

http://news.xinhuanet.com/english/2017-07/10/c_136432026.htm.

²⁵ Ward, Tom, “China has unveiled the world's first ‘unhackable computer network’,” *World Economic Forum*, 14 August 2017.

<https://www.weforum.org/agenda/2017/08/why-china-is-leading-the-world-in-developing-quantum-communication-networks>.

²⁶ Browne, Ryan, “Russia jammed GPS during major NATO military exercise with US troops”, *CNN*, 14 November 2018,

<https://www.cnn.com/2018/11/14/politics/russia-nato-jamming/index.html>

²⁷ Atherton, Kelsey, “Russian phones can jam cellphones 60 miles away”, *C4ISRNet*, 16 November 2018,

<https://www.c4isrnet.com/newsletters/unmanned-systems/2018/11/16/russian-drones-can-jam-cell-phones-60-miles-away>

²⁸ Atherton, Kelsey, “Russian phones can jam cellphones 60 miles away”, *C4ISRNet*, 16 November 2018,

<https://www.c4isrnet.com/newsletters/unmanned-systems/2018/11/16/russian-drones-can-jam-cell-phones-60-miles-away>

²⁹ Varfolomeeva, Anna, “Signaling Strength: Russia's real Syria success is electronic warfare against the United States”, *The Defense Post*, 1 May 2018, <https://thedefensepost.com/2018/05/01/russia-syria-electronic-warfare/>

³⁰ Galer, Andrew, “Russian REX-1 counter-UAV system breaks cover on exercise”, *Janes.com*, 14 September 2018,

<https://www.janes.com/article/82990/russian-rex-1-counter-uav-system-breaks-cover-on-exercise>

“Russian soldiers will receive electronic warfare REX-1 gun to fight drones”, suggesting broader distribution of the weapon.³¹

WMD Detection Network: Austria, Croatia, Hungary, Slovenia, Slovakia, and the Czech Republic have agreed to work together to develop a new sensor network to detect weapons of mass destruction. The group is jointly developing a “pioneering software sensor network to detect any biological, chemical, nuclear, or radiological threat.”³² The capability includes placing “sensors on unmanned ground vehicles and aerial drones that can be deployed in danger zones and beyond line of sight. Any information gathered will be transmitted and collected by software in real time” and then shared among the partners. A prototype of the network is planned for the end of 2020 with the potential for funding from the European Defence Fund that could enable production and eventually even export.³³

While the technology behind the capability is certainly of interest, the innovative nature of the development partnership—known as the Central European Defence Cooperation—is notable, too. Cross-nation development of capabilities offer nations with smaller defence profiles and budgets and less mature defence industrial bases an opportunity to build capability and to more efficiently meet an expanding range of persistent threats and mission sets in a scalable and resilient way. And this approach among Central European states in particular is not unique to WMD sensor development. On 4 November, Hungary, Croatia, Bulgaria, and Slovenia signed a Memorandum of Understanding on 4 October 2018 to create a new centre to be located in Croatia to train aircrews supporting Special Operations Forces.³⁴



With new cell phone jammers, these drones can interference with communications over a 135 miles away from where they're launched (Vadim Savitsky, Ministry of Defence of the Russian Federation)

³¹ “Russian soldiers will receive electronic warfare REX-1 gun to fight drones”, *armyrecognition.com*, 18 November 2018, <https://www.armyrecognition.com/weapons-defence-industry-military-technology-uk/russian-soldiers-will-receive-electronic-warfare-rex-1-gun-to-fight-drones.html>

³² Braw, Elizabeth, “Here’s a 6-Country Defense-Development Effort That Just Might Work”, *Defense One*, 15 October, 2018, https://www.defenseone.com/ideas/2018/10/heres-6-country-defense-cooperation-effort-just-might-work/152016/?oref=defenseone_today_nl

³³ Braw, Elizabeth, “Here’s a 6-Country Defense-Development Effort That Just Might Work”, *Defense One*, 15 October, 2018, https://www.defenseone.com/ideas/2018/10/heres-6-country-defense-cooperation-effort-just-might-work/152016/?oref=defenseone_today_nl

³⁴ Tigner, Brooks, “Various NATO allies pool SOF helicopter crew training and co-operate on unmanned maritime systems”, *Jane’s360*, <https://www.janes.com/article/83560/various-nato-allies-pool-sof-helicopter-crew-training-and-co-operate-on-unmanned-maritime-systems>

Manned Platforms

Defence and security communities designed, demonstrated, developed, and procured a wide-range of manned platforms during the reporting period, incorporating an equally wide-range of novel technologies. Of particular interest to this report, however, was a growing focus on the survivability of these platforms (and the humans that man them) and the ability of these platforms to effectively deploy and interact with large numbers of unmanned systems. Indicative examples of these trends include:

Active Protection System Tested: The proliferation and growing sophistication of anti-tank weapons has driven a requirement for several means of enhancing vehicle survivability, including fielding active protection systems (APS).

In October, Israel Military Industries' (IMI) Iron Fist Light Configuration (IF-LC) active protection system began taking part in tests for the Israel Defense Forces (IDF) ground vehicles, including the Eitan wheeled armoured personnel carrier (APC), bulldozers, and trucks.³⁵ The Iron Fist Lightweight Configuration variant (IF-LC) is an 'all in one' system where radars, EO sensors, processor and countermeasures launcher are all mounted on a single pedestal protecting the vehicle over 360 degrees. IMI has refined the Iron Fist system seeking to introduce a more capable and modular system that can be incorporated by more vehicle types in part in response to the commercial success of its chief competitor, Rafael's Trophy system, which has secured contracts to supply up to 1,000 Trophy APS equipped Merkava Mk3, Mk4 and Namer combat vehicles IDF.³⁶

Next Generation Fighter Design and 'Mother Ships' France and Germany announced on 20 November that both countries will launch demonstrator design studies for a jointly developed next-generation combat aircraft. The announcement from French Minister of Defence Florence Parly stated that the studies of architecture and design and the "launch of demonstrators (aircraft and engine) by mid-2019". The Next Generation Fighter (NGF) is envisioned as a manned aircraft that will operate in conjunction with a swarm of unmanned 'wingmen'.³⁷

This manned-unmanned teaming requirement as well as the development of 'mother ships' are becoming a more relevant feature of future platform (both manned and unmanned) designs as technology enables increased use of small drones (land, air, sea, and undersea). An example of the concept of an unmanned mother ship was unveiled during Euronaval in October. French robotics, automation, and industrial group ECA unveil the Inspector 120 unmanned surface vehicle (USV), developed to provide a platform with increased capacity and better seakeeping for the operation of autonomous underwater system payloads. The company adds that it has worked with BE Mauric to optimize the design according to the characteristics and constraints of a range of different mother ship platforms.³⁸

³⁵ Lappin, Yaakov, "IDF to test Iron Fist APS", *Janes.com*, 10 October 2018, https://www.janes.com/article/83690/idf-to-test-iron-fist-aps?from_rss=1

³⁶ Eshel, Tamir, "IDF Evaluates Active Protection for Light Vehicles", *Defense Update Defense Innovation Review*, 10 October 2018, https://defense-update.com/20181010_ironfist_light.html

³⁷ Jennings, Gareth, "France and Germany agree next-gen fighter design studies", *Janes.com*, 21 November 2018, <https://www.janes.com/article/84738/france-and-germany-agree-next-gen-fighter-design-studies>

³⁸ Scott, Richard, "ECA lifts the veil on Inspector 120 USV", *Janes.com*, 4 October 2018, https://www.janes.com/article/83559/eca-lifts-the-veil-on-inspector-120-usv?from_rss=1

Missile Systems and Munitions

The missile versus missile defence competition is one of the most impactful and active shaping the future of warfare. It is being driven largely by technologies that increase the speed, maneuverability, lethality, and versatility of missile systems to strike various types of targets effectively and technologies that enable air and missile defense systems to better meet these rapidly evolving threats. The development of maneuverable ballistic and hypersonic threats stand out during this reporting period as do significant advancements in the radars and kill vehicles being tested in response.

Short-Range Anti-Ship Ballistic Missiles: China Aerospace Science and Industry Corporation (CASIC) demonstrated two launch platforms for a new short-range supersonic anti-ship ballistic missile (SRASBM) known as the CM-401 at the Zhuhai Airshow. One platform was an 8x8 truck mounted type with two missiles inside self-contained launch canisters while the other appeared to be a deck launcher for ships, indicating that the system was designed to be both land and ship-launched.³⁹ Reporting from *The Global Times*, a mouthpiece for the Central Communist Party regime, indicated the missile could achieve hypersonic speeds up to Mach 6,⁴⁰ though other reporting on the system indicated it was a “supersonic” missile.

The assumed range of the missile based on CASIC’s displays was from nine to 180 miles. Graphics associated with the CM-401 indicated it has a skip-glide trajectory that involves the warhead abruptly pulling up at least once as it begins the terminal stage of its flight. This approach can extend the range of the missile, but also gives the missile a more irregular flight path, which can make it more difficult for missile defense systems to engage. “The system is intended for rapid and precision strikes against medium-size ships, naval task forces, and offshore facilities,” according to a CASIC representative.⁴¹

CASIC was not the only Chinese company demonstrating novel anti-ship weapons during Zhuhai. China Aerospace and Technology Company (CASC) demonstrated the A/MGG-20B short-range anti-ship ballistic missile at the show while Guangdong Hongda Mining Company showed a model of its HD-1 ramjet powered high-supersonic anti-ship cruise missile at the show—dubbed, as with the DF-21D, the “carrier killer”.⁴²

The PLA’s interest in ASBMs is not new. China’s arsenal currently includes medium (DF-21D) and intermediate (DF-26) range ASBMs, which are critical components of China’s anti-access / area denial (A2/AD or ‘counter-intervention’) military modernization effort. While the reconnaissance – strike complex associated with these systems are still being improved, the general perception of China’s ASBM weapons is that they are viable, yet currently vulnerable. The CM-401—especially if it is indeed able to achieve hypersonic speeds—offers an additional layer to China’s A2/AD effort, which will be especially relevant in a conflict or crisis that emerges in highly-trafficked area (for example, the South China Sea) in the first island chain in the Western Pacific in which potential adversary ships already have achieved access.

³⁹ Novichkov, Nikolu, “Airshow China 2018: CASIC unveils CM-401 anti-ship missile system”, *Janes.com*, 8 November 2018, <https://www.janes.com/article/84372/airshow-china-2018-casic-unveils-cm-401-anti-ship-missile-system>

⁴⁰ Xuanzun, Liu, “CASIC unveils new anti-ship ballistic missile providing greater deterrence against aircraft carrier attacks”, *Global Times*, 16 November 2018, <http://www.globaltimes.cn/content/1126120.shtml>

⁴¹ Novichkov, Nikolu, “Airshow China 2018: CASIC unveils CM-401 anti-ship missile system”, *Janes.com*, 8 November 2018, <https://www.janes.com/article/84372/airshow-china-2018-casic-unveils-cm-401-anti-ship-missile-system>

⁴² Trevithick, Joseph, “China Reveals Short-Range Anti-Ship Ballistic Missile Designed To Dodge Enemy Defenses”, *The Drive*, 5 November 2018, <http://www.thedrive.com/the-war-zone/24699/china-reveals-short-range-anti-ship-ballistic-missile-designed-to-dodge-enemy-defenses>

Hypersonic Detection Radar: Saab announced during Euronaval 2018 in October that it is introducing a capability for detecting and tracking targets travelling at hypersonic speeds on its Sea Giraffe naval radars. The Hypersonic Detection Mode (HDM) is optimized for the Sea Giraffe 4A Fixed Face.⁴³

The capability is a response to a growing threat from hypersonic weapons, which can travel at Mach 5 or higher. Currently, the United States, Russia, and China each have sophisticated hypersonic glide vehicle (HGV) programs—weapons that use a ballistic missile to reach the seam in the earth’s atmosphere before gliding to their targets at exceptionally high speeds along maneuverable flight paths. Modern missile defence systems currently lack the capacity to first detect and then successfully engage threats moving at hypersonic speeds, especially if they are maneuverable. As U.S. Air Force General John Hyten, commander of the U.S. Strategic Command told a Senate Armed Services Committee in March of 2018: “We don’t have any defense that could deny the employment of such a weapon (HGV) against us.”⁴⁴ This air and missile defence challenge is amplified when dealing with short-range hypersonic threats, such as hypersonic cruise missiles or short-range anti-ship ballistic missiles, including (potentially) the CM-401 system discussed above.

Exo-Atmospheric Kill: On 16 October 2018, the U.S. Navy and Missile Defense Agency completed the second successful intercept of a ballistic missile target by Raytheon’s next generation Standard Missile-3 Block IIA (SM-3 Block IIA).⁴⁵ The missile is designed to defeat missile threats outside of the earth’s atmosphere, especially medium- and intermediate-range ballistic missiles or in-theatre and shorter-range missiles, including missiles such as the CM-401. “It would not be the weapon we’d use against an ICBM fired at the continental United States”, according to Joint Staff Director Marine Corps Lieutenant General Kenneth McKenzie.⁴⁶ The IIA variant has large rocket motors and a bigger kinetic warhead, raising its effectiveness against a range of evolving ballistic missile threats. According to Raytheon, it is the only hit-to-kill interceptor at present that can launched at sea (as part of AEGIS systems) and on land (as part of AEGIS Ashore).



A mockup of the CM-401 missile in its launcher canister

⁴³ “Saab Launches Hypersonic Mode for Naval Radars”, Saab press-release, 23 October 2018, <https://saabgroup.com/media/news-press/news/2018-10/saab-launches-hypersonic-mode-for-naval-radars/>

⁴⁴ Macias, Amanda, “Russia and China are ‘aggressively developing’ hypersonic weapons — here’s what they are and why the US can’t defend against them”, CNBC, 21 March 2018, <https://www.cnbc.com/2018/03/21/hypersonic-weapons-what-they-are-and-why-us-cant-defend-against-them.html>

⁴⁵ “Standard Missile – 3 Block IIA Obliterates Target in Latest Intercept Test”, Raytheon press release, 26 October 2018, <http://raytheon.mediaroom.com/2018-10-26-Standard-Missile-3-Block-IIA-obliterates-target-in-latest-intercept-test>

⁴⁶ Werner, Ben, “Pentagon Confirms SM-3 Block IIA Missile Missed its Target in Test This Week”, *USNI News*, 1 February 2018, <https://news.usni.org/2018/02/01/pentagon-confirms-sm-3-block-ia-missile-test-did-not-meet-objective>

Robotics and Unmanned Systems

Robotics and unmanned systems was the most active capability category over the reporting period with significant advancements in concepts, design, and technologies. Developments in the reporting period also revealed the changing nature of the unmanned systems market with new suppliers and new business models. Ukrainian aerospace company Antonov unveiled the concept for the country's first long-range unmanned aerial vehicle for both surveillance and strike in October⁴⁷ and also unveiled a new tactical drone named the Gorlytsa in early November⁴⁸. In addition, Chengdu Aircraft Corp (CAC), a unit of AVIC, and Pakistan Aeronautical Complex (PAC) Karma have agreed to co-manufacture 48 of CAC's advanced Wing Loong II UAVs.⁴⁹ Particularly relevant applications of novel technologies include:

Drone Swarms: The China North Industries Corporation (Norinco) presented a concept for the use of strike-capable, multi-rotor unmanned aerial vehicles (UAVs) flying in a swarm at Zhuhai Airshow. The concept involves the use of several MR40-series (equipped with four rotors) and MR150-series (six rotors) UAVs fitted with search and targeting radars and reconnaissance subsystems and armed with an array of weapons, including guided missiles and fragmentation bombs, as well as parachute-retarded and rocket-propelled munitions. The UAV swarm can be used to engage an array of targets, including soft-skin and a number of armoured vehicles, artillery systems, radars, military and storage facilities, communication hubs, aircraft shelters, and logistics support lines.⁵⁰

Norinco's drone swarm concept is reflective of wide-spread interest in military-focused drone swarms across China's defence industrial base. In June of 2017, CETC successfully tested a swarm of 119 drones, the largest drone swarm ever tested, breaking a record previously held by the U.S. Air Force. In May 2018, Yunzhou Intelligence Technology (Yunzhou Tech), a Zhuhai-based company specializing in designing and manufacturing unmanned surface vessels (USVs), performed a swarming USV demonstration comprising 56 autonomous USVs.

Other countries also have an acute interest in swarming technologies and concepts and are moving fast to make progress in these areas, including the United States. On 12 October, the United States Defense Advanced Research Projects Agency released a call for proposal for the third sprint associated with its OFFensive Swarm Enabled Tactics (OFFSET) program. The OFFSET program is designed to develop solutions for small military units operating in urban environments to work closely with swarms of up to 250 drones. In order to keep up with what program manager Timothy Chung calls "the ever-changing pace of technology", DARPA holds "sprints" in which organizations are able to demonstrate new technologies and solutions.⁵¹

According to Chung, "for the third swarm sprint, DARPA is seeking to design, develop, and demonstrate novel interaction modalities and interface technologies for enhanced human-swarm teaming." These technologies "may offer new interaction frameworks and interface modalities such as 'pan and touch', 'gestures', or even 'speech' for intuitively conveying commander's intent through swarm tactics."⁵²

⁴⁷ Tucker, Patrick, "Ukraine armed-drone makers sprint ahead as Russian efforts hits snag", *Defense One*, 12 October 2018, <https://www.defenseone.com/technology/2018/10/ukrainian-armed-drone-makers-sprint-ahead-russian-effort-hits-snag/151983/>

⁴⁸ Tucker, Patrick, "Ukraine Fields an Armed Drone for Use Against Pro-Russian Forces", *Defense One*, 17 November, 2018, <https://www.defenseone.com/technology/2017/11/ukraine-fields-armed-drone-use-against-russia/142651/>

⁴⁹ Liu Zhen, "China, Pakistan sign deal to build 48 strike-capable Wing Loong II drones", *South China Morning Post*, 10 October 2018, <https://www.scmp.com/news/china/military/article/2167857/china-pakistan-sign-deal-build-48-strike-capable-wing-loong-ii>

⁵⁰ Novichkov, Nikolai, "Air Show China 2018: Norinco presents UAV swarm concept", *Janes.com*, 9 November, <https://www.janes.com/article/84438/airshow-china-2018-norinco-presents-uav-swarm-concept>

⁵¹ DARPA OFFset Program Calls for Third Swarm Sprint, *DARPA At YouTube*, <https://www.youtube.com/watch?v=2S3gmLZoYBQ>

⁵² DARPA OFFset Program Calls for Third Swarm Sprint, *DARPA At YouTube*, <https://www.youtube.com/watch?v=2S3gmLZoYBQ>

Drone Biomimicry: Russia demonstrated a new drone designed to resemble the snowy owl on 29 October 2018. The drone was designed by Zhokovsky / Gagarin Air Force Academy—an institution that previously developed a drone that looked like a falcon—and includes an electric motor for quiet flight and carries a laser targeter to illuminate targets. It will mainly be used to track tanks, vehicles and other heavy equipment and directing fire while avoiding detection, essentially “hiding in plain sight”.⁵³

Biomimicry is of increasing interest to some unmanned systems development communities not only to enhance camouflage – as with the owl drone—but also in an effort to use the refined and efficient movement of animals in nature to drive enhanced performance and mission execution. The United States has developed several unmanned underwater vehicles, including the WANDA, GhostSwimmer, and BIOSwimmer with propulsion systems to extend range and energy efficiency or to maintain position while performing inspections or mine-counter measure operations. In July of 2018, *Quartz* reported that “European scientists” created an autonomous swarm of 30 drones based on the movement of “a school of fish and a flock of birds to help figure out how to make the drones fly together without colliding.”⁵⁴

The Terminator 1000 : Chinese scientists say they have developed a type of robot powered by liquid metal inspired by T-1000, the self-repairing, shape-shifting killer android from one of the Terminator films. The palm-sized robot is made up of a plastic wheel, a small lithium battery and drops of liquid metal. The robot’s wheel rolls when the liquid metal changes the centre of gravity, which is controlled by altering the voltage through the embedded battery.

The team began work on the project six years ago, when materials scientists discovered the unique properties of liquid metal alloys – high electrical conductivity, controllable surface tension and extreme flexibility. Li Xiangpeng, a robotics professor at Soochow University in Suzhou, China, led the team that designed the liquid metal robot prototype noted, “we think liquid metal alloys could help with the development of self-reconfiguring robots that can change their own shape.”⁵⁵ Li listed several potential applications of the shape-shifting robot, including for military purposes or, significantly, espionage.

⁵³ Atherton, Kelsey, “New Russian owl drone will hunt tanks in northern warfare”, *C4ISRNet*, 29 October 2018, <https://www.c4isrnet.com/unmanned/2018/10/29/new-russian-owl-drone-will-hunt-tanks-in-northern-warfare/>

⁵⁴ Kabash, Madis, “Scientists have invented an autonomous flock of drones that think collectively”, *Quartz*, 24 July 2018, <https://qz.com/1333190/scientists-have-invented-a-group-of-self-flying-drones-that-think-collectively/>

⁵⁵ Shen, Alice, “Chinese scientists develop shape-shifting robot inspired by T-1000 from Terminator”, *South China Morning Post*, 25 October 2018, <https://www.scmp.com/news/china/science/article/2169960/chinese-scientists-develop-shape-shifting-robot-inspired-t-1000>