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# DEFTECH SCAN

## August 2019



<https://deftech.ch/scans>



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Dear Reader,

Same but different!

As you might have noticed already, this version has a new refreshing layout. This is quite welcome after this very warm summer. Considering the different inputs we got from you (or at least some of you), we've tried to modify the way we present the information by adding some "key insights" boxes at the beginning of every category listed below:

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

The name also changed from "Update" to "Scan". We believe it does better reflect the intent of creating such document, being to provide a global and general overview of the new and evolving military capabilities as a consequence of new technologies, systems, processes, inventions and innovations.

Last, but not least, we suggested and were allowed to make this document accessible to everybody. The content being mostly Open Source, we are happy about it, and hope it will stimulate some interesting discussions. We do our really best to present objective research. If some elements presented as facts could be challenged, or if you know a better or different source of information out there, we would be more than happy to learn about it!

We hope you will find this "DEFTECH SCAN" insightful and we look forward to any feedback for continuous improvement.

We wish you a very good reading and do not hesitate to connect!



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## Introduction and Summary

The August 2019 volume of the DEFTECH report incorporates indicative examples across the six categories of capability areas from a wide range of defence communities: The United States, United Kingdom, Russia, Iran, France, the European Defence Agency, Estonia, and the private sector.

Five themes emerged from across the six capability categories

**Flexibility, Versatility, Modularity:** The profiled stories reflect a particularly strong demand for the design and development of platforms able to carry out multiple missions, operate in multiple contexts, and carry multiple payloads.

**Conspicuous Convergence of Commercial and Military Requirements and Technology:** A common theme of DEFTECH reports has been the intersection of the sorts of requirements and capabilities of interests to militaries and commercial entities. Discussion in this volume of the convergence of military, applied research, and commercial interest in hydrogen fuel cells, optionally manned aircraft, even defence against threats to space assets all demonstrate the

**Competition Driving Innovation in Technologies and Concepts:** Domain area competition in space and cyber are at the root of several of the developments featured in this report. For example, the French Ministry of Defence's announcement of a more robust "Space Force" and plans to place laser weapons on satellites for active defence is in response to an increasingly challenging counter-space environment in which countries are demonstrating a wider array of means of disrupting space-based assets and communications.

Similarly, the report highlights the intensifying competition between the development of drones and the recent proliferation of counter-drone weapon development and deployment. The combination of the increasing investment in small and large militaries in unmanned systems and their suddenly more pronounced vulnerability will drive technological innovation, to be sure. It will also likely develop innovation in new ways of thinking about balancing concerns over unmanned system survivability with an acceptance of risk and tolerance for attrition of these relatively low-cost assets.

**Long-Talked About Capabilities Being Fielded:** The reporting period was particularly notable for the integration, deployment, and actual operational use of novel capabilities that have long-been talked about or in development. The UK's use of the F-35B fifth generation fighter in combat operations in Syria is a prominent first as is the J-20 being integrated into a People's Liberation Army Air Force combat unit. The age of dispersion of fifth generation fighters in service beyond the United States has begun and is likely to have an effect on air power and air defence assumptions of both small and large militaries. The period also saw an escalating cyber conflict between Iran and the United States as well as other Gulf States and the use of directed energy counter-drone weapons, again offering an early snapshot into a technology area that is receiving considerable investment.

**Lateral Thinking:** The report also stresses the importance of creative and lateral thinking for militaries of all sizes as they seek to better understand and manage the threats and challenges of a modern security environment characterized by the development and diffusion of advanced technologies and the capabilities they enable.

France's Defence Innovation Agency's announcement of the establishment of a red team comprised of science fiction writers as a creative measure and indicative of the type of dynamic thinking that is required to prepare militaries for disruptive threats while a U.S. Army initiative to incorporate techniques used by high-performance athletes seeks to use best – practice from analogous domains to drive even incremental improvements in performance that could be the difference between mission success and failure. Russia's effort to incorporate successful tactics and capabilities incorporated by Daesh in the Syria conflict is another example of the ways in which militaries of all sizes can develop relevant and effective capabilities.

## Energy, Power, and Propulsion

### Key Insights:

- Interest and investment in **hydrogen fuel cells** has been a frequent topic covered in DEFTECH reports. As the technology matures, both militaries and commercial organisations have seen increasing **evidence of the environmental, operational, and cost benefits hydrogen fuel cells provide.**
- For both small militaries and large and exceptionally well-resourced ones, **this proliferation and overlapping interest creates new (and in some cases unconventional) avenues for mutually beneficial innovation and collaboration** with private industry—particularly the automotive and unmanned systems industries— and academia / applied research.
- The nexus of novel materials and technologies, new manufacturing techniques, and *design ingenuity* are also driving opportunities for new capabilities, efficiencies, and performance parameters.
- While most small militaries are not in a position to fund programs such as, for example, active flow control aircraft, **they can look to these programs to better understand how design principals and materials can be applied to better meet their current and emerging requirements**

**Hydrogen-Powered Fuel Cells:** Washington State University’s School of Mechanical and Materials Engineering announced during the reporting period that it had received a \$1.8 million grant from the United States Army to demonstrate a liquid hydrogen -powered unmanned aerial vehicle and refuelling system. The grant was part of a total award of \$7.2 million award to a team that also includes researchers from Mississippi State University, Insitu, and Navmar Applied Sciences Corporation.<sup>1</sup>

Hydrogen fuel cell-powered aircraft can fly longer and farther than aircraft running on batteries and typically require less maintenance than gasoline-powered aircraft, reducing the total costs associated with owning and operating platforms. They also are quieter than conventionally powered aircraft, an important quality for the Army, which deploys drones in a range of crowded and contested environments in which adversaries may be able to detect unmanned systems via sight or sound.

Of course, these benefits—extended duration, reliability, quietness, and reduced costs—are not only of interest to military communities. In fact, the June edition of this report highlighted the development of a hydrogen-fuel cell-powered electronic vertical take-off and landing (eVTOL) unmanned taxi by commercial company Alaka’i Technologies.

Further proof of the dual-use nature of hydrogen fuel cell technology and development programs was seen in an announcement from Ballard Unmanned Systems, Inc. of the launch of the FCair fuel cell product line. The FCair is described as a “complete long duration fuel cell power solution for commercial Unmanned Aerial Vehicles (UAVs).” FCair features a hydrogen fuel cell power system and advertises benefits such as “3x the

<sup>1</sup> Vodnala, Siddharth, “U.S. Army grant supports development of hydrogen-powered Unmanned Aerial Vehicle”, *Washington State University*, 18 July 2019, <https://news.wsu.edu/2019/07/18/us-army-grant-supports-development-hydrogen-powered-unmanned-aerial-vehicle/>

flight duration of batteries; 5x the reliability and a fraction of the noise of small internal combustion engines; and significantly reduced operational expenses.”<sup>2</sup>

The global commercial and applied research development of hydrogen fuel cells is likely to intensify and intersect with growing military and security community interest in the benefits these technologies provide. For small militaries, this intersection creates new pathways for development and innovation, if engagement and procurement models can be aligned to partner non-traditional defence suppliers.

## Human Performance Enhancement

### Key Insights:

- Efforts to enhance soldier survivability and performance are **calling upon a diverse set of technologies to create step-change increases in capability** by the middle of the next decade.
- Enhancing the performance of individual military personnel in a dynamic technology development environment is **not solely about the integration of new technologies**. It also involves the adaption of *approaches and creative mindsets from non-military disciplines*, such as high-performance athletics and science fiction writing
- **Red teams are critical for small and large militaries to maximizing human performance in a complex, uncertain, and dynamic environment in which technology development and diffusion are shaping difficult to anticipate threats.** By seeking to understand how adversaries and potential adversaries might use novel technologies, defence communities can mitigate risks of disruption innovation and critically, better focus training on dealing with new tactical and operational challenges.

**21<sup>st</sup> Century Survivability: From Ratnik to Sotnik and the Potential of Living Camouflage:** On June 26, Russian media outlet TASS reported that Russia’s Central Research Institute of Precision Machine – Building will begin work on the Sotnik next-generation soldier system in 2020. The system, previously known as Ratnik – 3 and profiled in the April volume of this report, will include several ‘breakthrough’ components:

- Anti-mine boots
- Anti-thermal clothing to hide the soldier from infrared sensors
- Anti-radiation suit
- Integration of micro-drones linked with tactical – level automated command and control
- The system’s weight is expected to be reduced by 20% to 20kg

Sotnik is expected to replace the currently in-use Ratnik starting in 2025<sup>3</sup>.

<sup>2</sup> “Ballard Offers Turnkey Fuel Cell Solutions to Power Commercial UAV”, *Inside Unmanned Systems*, 26 July 2019, <https://insideunmannedsystems.com/ballard-offers-turnkey-fuel-cell-solutions-to-power-commercial-uav/>

<sup>3</sup> “Russia to start replacing Ratnik combat gear with next-generation outfit from 2020”, *TASS*, 26 June 2019, <https://tass.com/defense/1065726>

Also during the reporting period, the U.S. Army Research Lab announced that synthetic biology was one of its 10 biggest research priorities. The U.S. Army seeks to use synthetic biology technologies to help deliver its next generation living camouflage, among other novel capabilities designed to make soldiers more survivable in contested environments. According to Dimitra Stratis-Cullum, who is overseeing the Army's synthetic biology research: "We're talking about trying to make the soldier look like nature, like natural environments . . . We want our soldiers to be able to move and not be detected on the battlefield. We don't want their infrared signature to be detected."<sup>4</sup>



Figure 1: A model of the former Ratnik – 3 soldier system (Source: TASS)

Individually and collectively these two research and development efforts highlight a preoccupation across large and small militaries with leveraging the Fourth Industrial Revolution to greatly enhance soldier survivability and performance. Even if smaller militaries are unable to develop synthetic biology living camouflage—though some certainly will—the capabilities will be developed and will be part of future conflict, probably within the next five to 10 years. Developing means to acquire this technology—or highly-advanced soldier systems—or to determine whether it needs to be countered and if so, how are questions all militaries should consider.

**Soldiers and Athletes:** Innovation in technology is only element of generating improved performance, and must be accompanied by other innovations that enable the transition from invention of a new technology to the deployment of improved capabilities.

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"Regardless of how much we modernize, or new technology we bring into the Army it is always going to come down to the human dimension and performance of our individual soldiers" – Brigadier General Antonio Munera

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One low-cost and low-technology area of innovation being pursued by the U.S. Army is in improving soldier efficiency and effectiveness through the use of performance psychologists, a measure frequently employed by high-performance athletes and sports teams. The U.S. Army is embedding 55 "Master Resilience

Trainers-Performance Experts" with Reserve Officer Training Corps (ROTC) cadets during summer training exercises in Fort Knox, Kentucky.<sup>5</sup>

Brigadier General Antonio Munera, the Deputy Commanding General for the U.S. Army Cadet Command summed up the key implication for both the U.S. Army and for militaries around the world: "Regardless of how much we modernize, or new technology we bring into the Army it is always going to come down to the human dimension and performance of our individual soldiers The bottom line for me is that we have [to

<sup>4</sup> Tucker, Patrick, "The US Army is Making Synthetic Biology a Priority", *Defense One*, 1 July 2019, <https://www.defenseone.com/technology/2019/07/us-army-making-synthetic-biology-priority/158129/>

<sup>5</sup> Rico Antonieta, "Resilience experts aim to boost performance at ROTC camp", *U.S. Army*, 12 July 2019, [https://www.army.mil/article/224468/resilience\\_experts\\_aim\\_to\\_boost\\_performance\\_at\\_rotc\\_camp](https://www.army.mil/article/224468/resilience_experts_aim_to_boost_performance_at_rotc_camp)

treat] our Soldiers just like professional athletes and [give] them the same access to the same capabilities that professional athletes have.”<sup>6</sup>

**No Failures of Imagination:** The French Defence Innovation Agency’s (DIA) annual report was released on 20 July 2019. It included a commitment to establish a ‘red team’ of science fiction writers that will “propose scenarios of disruption” that military strategists may not think of.<sup>7</sup> The team will include four to five futurists and writers who will provide an outside and highly creative perspective on how terrorist organizations and foreign adversaries could apply emerging technologies to harm French citizens, military personnel and assets, and national security interests.<sup>8</sup>

Red teaming is a powerful methodology through which organizations seek to expand their analytical filters, avoid failures of imagination, and mitigate against the challenges associated with mirror imaging—that is, assuming that your adversaries and competitors think, behave, act, prioritize, and decide just as you do.

They have become particularly important (and still under-utilized) in the current strategic and operational environment marked in part by rapid technological innovation and diffusion. Understanding what capabilities one’s adversaries possess is a critical intelligence challenge. Just as important, though, is understanding how adversaries might use these capabilities in unexpected and disruptive ways—think of the disruptive effect of the improvised explosive device on the Iraq conflict or, more recently, Russia’s weaponization of social media to influence elections in the West, both of which took their intended targets by surprise. It is these types of questions that Red Teams can help military planners in small and large militaries address and, as a result, to better train military personnel to identify and respond to novel threats.<sup>9</sup>

## Cyber and C4ISTAR

### Key Insights:

- The report highlights developments in three critical competitions that are equally relevant for small and large militaries: **competition in the cyber domain, space versus counter-space capabilities, and between camouflage and detection**
- Militaries and security organisations **are turning to the cyber domain to hold at risk or damage adversary or competitor** military capabilities, critical infrastructure, or economic and political systems while still **avoiding escalation** of a given crisis to a kinetic conflict.
- Competition in space is also intensifying as **defense communities small and large struggle with a sense of vulnerability of military and dual-use space infrastructure**
- New concepts and technologies are being developed **to meet an evolving counter-space challenge**, many of these new technologies will be available to small militaries while counter-space weapons could affect access to space-based C4ISTAR capabilities in the future
- As militaries develop technology – driven means of enhancing concealment, **the need for innovative means of detection has become more urgent.**

<sup>6</sup> Rico Antonieta, “Resilience experts aim to boost performance at ROTC camp”, *U.S. Army*, 12 July 2019, [https://www.army.mil/article/224468/resilience\\_experts\\_aim\\_to\\_boost\\_performance\\_at\\_rotc\\_camp](https://www.army.mil/article/224468/resilience_experts_aim_to_boost_performance_at_rotc_camp)

<sup>7</sup> “French sci-fi team called on to predict future threats”, *BBC*, 19 July 2019, <https://www.bbc.com/news/world-europe-49044892>

<sup>8</sup> “French sci-fi team called on to predict future threats”, *BBC*, 19 July 2019, <https://www.bbc.com/news/world-europe-49044892>

<sup>9</sup> Nurkin, Tate, “Red Teaming and Disruptive Innovation”, *HDLAC Journal*, Vol 4, Issue 3-1, [https://www.hdiac.org/wp-content/uploads/2018/04/Red\\_Teaming\\_and\\_Disruptive\\_Innovation\\_Volume\\_4\\_Issue\\_3-1.pdf](https://www.hdiac.org/wp-content/uploads/2018/04/Red_Teaming_and_Disruptive_Innovation_Volume_4_Issue_3-1.pdf)

**Cyber activity increasing:** The reporting period saw a series of notable developments reflecting the growing importance of the cyber domain and the increasing sense among modern militaries—as well as economic, commercial, and political leaders—that their critical infrastructure, assets, personnel, and systems are vulnerable to difficult to detect and sophisticated state-sponsored cyber-attacks.

On 19 June 2019, Anil Kashyap, a member of the Bank of England’s financial policy committee, issued a warning that banks would struggle to defend themselves against a state-sponsored cyber-attack that corrupted bank records over a period of months. Corrupted data cyber- attacks are especially concerning for commercial, civil, and military stakeholder because they can be difficult to detect and also to determine the full scale of damage that has been done by a successful attack.<sup>10</sup>

The warning occurred only weeks before a flurry of reporting on an on-going cyber conflict between the United States and Iran during heightened tensions between the two states in the Arabian Gulf in late June and early July. On 3 July, the United States Cyber Command (USCYBERCOM) tweeted that the command had discovered “active malicious use” of a known bug in Microsoft Outlook named CVE-2017-117. While the Malware Alert did not identify who was responsible for launching the bug, cybersecurity company FireEye reported that a hacking group known as APT 33—thought to be working at the behest of the Iranian government—had previously used the same vulnerability in Microsoft Outlook. In a June blog post, FireEye asserted that APT 33 was part of a coordinated campaign against “U.S. federal government agencies and financial, retail, media, and education sectors.”<sup>11</sup>

In late June, *The New York Times* reported that USCYBERCOM had launched a cyber-attack against “an Iranian intelligence organization that American officials believe helped plan the attacks against oil tankers” earlier that month. In August 2019, the *Wall Street Journal* reported that Bahrain’s National Security Agency had been hacked, purportedly by Iran.<sup>12</sup> For both the United States and Iran, the conflict in the information domain was viewed as a means of signalling, and demonstrating capability and intent without explicitly escalating tensions to a kinetic conflict that would be far more difficult to slow or stop.<sup>13</sup>

And the war in the information domain is not solely about cyber-attacks and cleverly designed and deployed malware. The threat of disinformation and influence operations—the weaponization of the internet—is also of concern to many small and large Western militaries, in particular. So worried is the UK Ministry of Defence about the threat that it established 6 Division (6 Div), a new special cyber operations unit designed to focus on “information warfare” generally, and Russia’s disinformation and influence operations in particular. According to Philip Ingram, an independent defence analyst in the UK, “this is the first step in the British Army recognizing and countering how the information sphere can be and is weaponized.”<sup>14</sup>

**Lasers in Space:** French Minister of Defence Florence Parly announced in August plans to develop and deploy an active defence system for its space assets and infrastructure to include satellites equipped with cameras, lasers and “maybe even guns” by 2030. The announcement follows closely French President Emmanuel Macron’s announcement during Bastille Day celebrations in July 2019 of a new “Space Command” that improves upon

<sup>10</sup> “BoE issues cyber attack warning”, *Finextra*, 19 June 2019, <https://www.finextra.com/newsarticle/34000/boe-issues-cyber-attack-warning>

<sup>11</sup> Tucker, Patrick, “Suspected Iranian Cyber Attacks Show No Sign of Slowing”, *Defense One*, 3 July 2019, <https://www.defenseone.com/technology/2019/07/suspected-iranian-cyber-attacks-show-no-sign-slowing/158213/>

<sup>12</sup> Hope, Bradley, Strobel, Warren P., and Volz, Dustin, “High-Level Cyber Intrusions Hit Bahrain Amid Tensions with Iran”, *The Wall Street Journal*, 7 August 2019, <https://www.wsj.com/articles/high-level-cyber-intrusions-hit-bahrain-amid-tensions-with-iran-11565202488>

<sup>13</sup> Barnes, Julian E. and Gibbons-Neff, Thomas, “U.S. Carried Out Cyberattacks on Iran”, *The New York Times*, 22 June 2019, <https://www.nytimes.com/2019/06/22/us/politics/us-iran-cyber-attacks.html>

<sup>14</sup> Doffman, Zak, “Cyber Warfare: Army Deploys ‘Social Media Warfare’ Division to Fight Russia”, *Forbes*, 1 August 2019, <https://www.forbes.com/sites/zakdoffman/2019/08/01/social-media-warfare-new-military-cyber-unit-will-fight-russias-dark-arts/>

the French “Joint Space Command” concept established in 2010.<sup>15</sup> Together these announcements offer valuable insight into the military and security competition unfolding in space.

Of particular concern is the vulnerability of military, commercial, and dual-use space infrastructure that has become critical not just to military C4ISTAR capabilities but also civilian and commercial communications that rely on space-based assets. Development *and deployment* in the last decade of a growing range of counter-space capabilities—from direct ascent anti-satellite weapons, to ground-based directed energy, to co-orbital satellites capable of using robotic arms to damage satellites, to the use of cyber-attacks—is shaping the need for new concepts and capabilities to ensure the resilience of space-based communications.

Attacks against satellites can be very targeted, but they can also have wide-ranging implications for nearly all militaries and the global economy. Disrupting global navigation satellite systems (GPS, GALILEO, GLONASS, BEIDOU) as a means of degrading military targeting and navigation systems will have considerable repercussions for other militaries that leverage these systems as well as potentially for civilian and commercial applications of these systems—for example car or cell-phone navigation systems. Similarly, the destruction of a satellite in space will create space – debris that could threaten a much broader spectrum of space architecture as successful direct ascent anti-satellite missile tests by China in 2007 and India in 2019 have both done.<sup>16</sup>

## Manned Platforms

### Key Insights:

- **Fifth generation fighters are becoming more deeply integrated in air forces around the world**—beyond the United States. China’s state-owned media released pictures of a J-20 fifth generation fighter with the serial number of a known combat unit of the PLAAF while the UK deployed F-35s to Syria and Iraq in support of combat missions
- Manned platforms—especially air platforms—are being designed to **prioritize the flexibility and versatility** to carry out an array of different types of missions
- **Concern over maintenance costs and availability of aircraft** is leading to new design concepts, technologies, and solutions that can be applied and leveraged by both small and large militaries

**F-35 and Fifth Generation Fighters:** The reporting period saw further integration and operational activity of fifth generation fighters in militaries around the world.

The reporting period saw mixed activity related to the F-35. Most notably, Britain successfully deployed the F-35B over the skies of Iraq as part of “the on-going fight against Daesh” in late June, according to the UK Ministry of Defence. The aircraft flew alongside Typhoon aircraft as Operation Shade, which is the UK contribution to the Global Coalition’s fight against Daesh in Syria and Iraq. The deployment follows “Exercise Lightning Dawn” during which the F-35s were deployed to Cyprus for a training exercise.<sup>17</sup>

<sup>15</sup> Mahlandt, Taylor, “France is Getting Serious About Its ‘Space Command’”, *Slate*, 1 August 2019, <https://slate.com/technology/2019/08/france-space-command-plan-satellites-lasers.html>

<sup>16</sup> Nurkin, Tate et. al, “China’s Advanced Weapons Systems”, *U.S.-China Economic and Security Review Commission*, 17 May 2019, [https://www.uscc.gov/sites/default/files/Research/Jane%27s%20by%20IHS%20Markit\\_China%27s%20Advanced%20Weapons%20Systems.pdf](https://www.uscc.gov/sites/default/files/Research/Jane%27s%20by%20IHS%20Markit_China%27s%20Advanced%20Weapons%20Systems.pdf)

<sup>17</sup> “UK F-35s join fight against Daesh”, UK Ministry of Defence, *desider*, Issue 132, July 2019

Only weeks after the F-35 crossed this mission threshold for the UK, then U.S. Army Secretary Mark Esper (now confirmed as the U.S. Secretary of Defense) revealed that the F-35 is not expected to meet the Pentagon's previously established objective of an 80% mission-capable rate by the end of the fiscal year due to "supply shortages" of transparency canopies. The assessment was delivered as part of written responses Esper delivered on 16 July to questions from the Senate Armed Services Committee.<sup>18</sup>



Figure 2: Chinese state-owned media have for the first time released an image of a J-20 fighter bearing the serial number of a known combat unit of the PLAAF. Source: Jane's, via cctv.com

There was also news about China's most developed fifth generation fighter, the J-20, during the reporting period. For the first time, Chinese state-owned media released an image of a Chengdu Aircraft Industry Group J-20 bearing the serial number of a known combat unit of the People's Liberation Army Air Force (PLAAF), suggesting that the aircraft is now ready for front-line service.<sup>19</sup>

**Optionally Manned Aircraft:** In July 2019, Northrop Grumman revealed that it had two commercial customers for its Firebird optionally-manned medium – altitude, long-endurance (MALE) surveillance aircraft: Grand Sky and Tenax Aerospace. Northrop Grumman has previously secured unnamed government contracts for the Firebird.<sup>20</sup> The platform is regarded as a potential disruptor of the military ISR market as well as the commercial surveying and monitoring market due its unique optionally – manned design, payload flexibility, and low procurement and operating cost. The aircraft's payload-carrying capability is modular in nature. It already can carry a selection of approximately two dozen sensors, communications systems, and electronic intelligence gathering payloads.<sup>21</sup>

In a Northrop Grumman press release, Thomas Stower Jr., President of Grand Sky, the company is "excited to bring Firebird to Grand Sky and to utilize its long-endurance and variable payload capabilities for commercial customers. Our goal is to support energy infrastructure monitoring and humanitarian and disaster relief operations by leveraging Firebird's range, altitude and endurance." Tenax Aerospace similarly highlighted Firebird's "adaptability



Figure 3: The Firebird optionally-manned MALE aircraft

<sup>18</sup> Hudson, Lee, "F-35 Will Not Meet 80% Mission Capable Goal", *Aviation Week*, 16 July 2019, <https://aviationweek.com/defense/f-35-will-not-meet-80-mission-capable-goal>

<sup>19</sup> Rupprecht, Andrea, "Image Confirms J-20 fighter assigned to PLAAF combat unit at Wuhu", *Jane's*, 1 August 2019, <https://www.janes.com/article/90225/image-confirms-j-20-fighter-assigned-to-plaaf-combat-unit-at-wuhu>

<sup>20</sup> Rogway, Tyler, "Northrop Grumman's Optionally Manned Firebird Aircraft Has Its First Official Customers", *The Drive*, 17 July 2019, <https://www.thedrive.com/the-war-zone/29040/northrop-grummans-optionally-manned-firebird-aircraft-has-its-first-official-customers>

<sup>21</sup> Rogway, Tyler, "Northrop Grumman's Optionally Manned Firebird Aircraft Has Its First Official Customers", *The Drive*, 17 July 2019, <https://www.thedrive.com/the-war-zone/29040/northrop-grummans-optionally-manned-firebird-aircraft-has-its-first-official-customers>

and flexibility in data collection at an extremely affordable price point . . . Firebird provides a unique flexibility and responsiveness.”<sup>22</sup>

Momentum for Firebird in the military and commercial space provides further confirmation of the appeal of modular, highly flexible platforms that can perform many missions depending on payload. It also demonstrates the conspicuous convergence of capabilities in demand by commercial and military entities, offering new pathways of proliferation to both state and non-state actors of similarly dual use manned and optionally manned aircraft.

**Future Combat Air System:** *Jane's* reported on 1 August 2019 that the manned New Generation Fighter component of the Future Combat Air System (FCAS) being jointly developed by Dassault Aviation and Airbus will be optimised for carrier operations from the design phase. The development program will follow a similar to path as the Dassault Rafale fighter program, which included three variants of the Rafale: The Etendard, Super Etendard, and Rafale.<sup>23</sup>

By developing a carrier capable variant from the start, the program will enable platform versatility and flexibility in carrying out a range of missions. Critically, it will also ensure efficiency in coping with some of the unique design and operational challenges that accompany operating off of the decks of an aircraft carrier, namely mitigating the shocks and impact loads on airframes stemming from landings on the decks of carriers. By building the strength required for carrier operations into the initial airframe, the FCAS manned aircraft will hope to avoid later structural enhancements that will add weight to the aircraft.

## Missile Systems and Munitions

### Key Insights:

- **Hypersonic weapons programs are no longer the purview solely of the United States, China, and Russia.** More countries are showing interest in developing air-launched, air-breathing hypersonic missiles that ensure the viability of fourth generation fighters in an operational environment dominated by advanced air and missile defence systems.
- **The “democratization” of hypersonic weapons poses opportunities and challenges for small militaries.**
- Development of hypersonic weapons is leading the U.S. to develop hypersonic interceptors and to engineer existing systems to better meet the hypersonic weapons challenge.
- **Several military drones were downed during the reporting period**, including by a directed energy counter-drone weapons and by more traditional surface-to-air missiles.
- Even as these early iterations of counter-drone weapons enter into service, **several countries are now developing directed energy and radio frequency weapons expected to come on line in the early 2020s** to cope with the threat from drones and especially drone swarms.

<sup>22</sup> Rogway, Tyler, “Northrop Grumman’s Optionally Manned Firebird Aircraft Has Its First Official Customers”, *The Drive*, 17 July 2019, <https://www.thedrive.com/the-war-zone/29040/northrop-grummans-optionally-manned-firebird-aircraft-has-its-first-official-customers>

<sup>23</sup> Grolleau, Henri-Pierre, “European FCAS fighter to be optimized carrier ops”, *Jane's*, 1 August 2019, <https://www.janes.com/article/90221/european-fcas-fighter-to-be-optimised-for-carrier-ops>

**Hypersonic Weapons Programs Expanding:** On 17 July 2019, the UK's Royal Air Force announced it would explore the feasibility of a locally designed hypersonic weapon within four years.<sup>24</sup>

The announcement indicated that the UK is seeking to develop an air-launched, air-breathing hypersonic weapon, which would extend the operational range and effectiveness of fourth generation aircraft in a future operating environment marked by more sophisticated air defence systems. According to Air Vice Marshal Simon Rochelle, Chief of Staff-Capability for the Royal Air Force, "imagine if all those aircraft on Day 1, Day 2 and 3 [of a conflict] are firing thousands of an affordable Mach 5 weapon back into the fight. It makes sure those [fourth generation] aircraft stay leading-edge, and not waiting for Day 7 of combat" to be deployed.<sup>25</sup> While the UK has no history of developing hypersonic air-breathing weapons, some observers believe the process could be accelerated by leveraging the UK's experience developing the Mach 4 Meteor missile.<sup>26</sup>

The UK announcement adds one more nation to the list of countries actively pursuing hypersonic weapons. While the United States, China, and Russia have hypersonic glide vehicle programs, the list of countries seeking air-launched, air-breathing weapons includes Japan, France, and now the United Kingdom and is likely to grow longer over the next five years. The implication is that hypersonic weapons are no longer only a component of "great power competition".

In order to respond to the development and diffusion of hypersonic missile technologies—to include boost-glide and air-breathing technologies—the U.S. Missile Defense Agency (MDA) announced it is drafting requirements for a hypersonic defence architecture that encompasses new interceptors, sensors, and

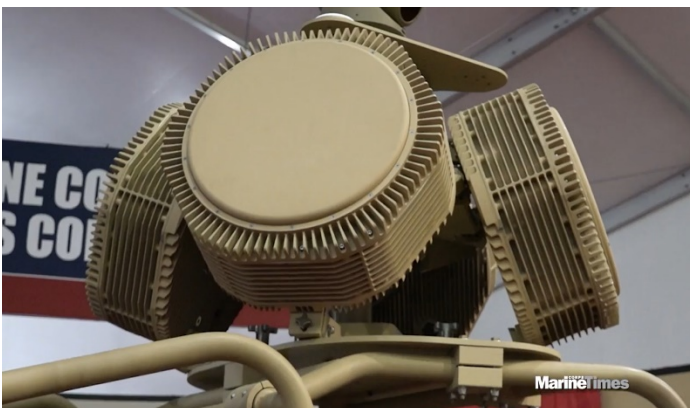


Figure 4: A 2018 photo of the MRZR LMADIS mounted on top of a military vehicle. A version of this weapon was deployed aboard the USS Boxer and used to down Iranian drones in the Arabian Gulf (source: Marine Corps Times)

command-and-control systems. It is also modifying existing equipment to better respond to the perceived growing threat from hypersonic weapons.<sup>27</sup>

**Counter-Drone Weapons on Display:** The reporting period saw considerable activity in the development and use in combat of counter-drone weapons, reflecting the intensification of a competition between increasingly prevalent drones of all sizes and systems designed to meet the threat drones present.

The UK's Ministry of Defence announced an investment of £130 million to test several types of directed energy weapons starting in

2023. Tests will involve both Royal Navy ships and British Army vehicles. Among the most prominent uses for directed energy weapons is to provide a **deep magazine, low cost capability** to defend fixed

<sup>24</sup>

<sup>25</sup> Trimble, Steve, "RAF Embarks on Hypersonics Push", *Aviation Week*, 17 July 2019, <https://aviationweek.com/defense/raf-embarks-hypersonics-push>

<sup>26</sup> Trimble, Steve, "RAF Embarks on Hypersonics Push", *Aviation Week*, 17 July 2019, <https://aviationweek.com/defense/raf-embarks-hypersonics-push>

<sup>27</sup> Trimble, Steve and Norris, Guy, "First Pieces of USAF Hypersonic Interceptor Enter Development", *Aviation Week*, 7 August 2019, <https://aviationweek.com/defense/first-pieces-usaf-hypersonic-interceptor-enter-development>

installations and platforms from drones without having to expend exceptionally expensive air defence munitions.<sup>28</sup>

A variety of counter-drone capabilities were actually used during the reporting period as tensions between the United States and Iran unfolded in the Arabian Gulf in June and July. On 21 July 2019, the U.S. Department of Defense announced that Navy ship operating in the Arabian Gulf used a directed energy weapon to destroy an Iranian drone that come within a thousand yards. Reporting on the event indicates that Marines aboard the USS Boxer used the MRZR LMADIS—Light Marine Air Defense Integrated System. According to *USNI News* the incident is the “first known kill be a new generation of electronic warfare and directed energy weapons” by the United States.<sup>29</sup> Iran claimed it shot down a U.S. drone in the area on 20 June and Houthi rebels in Yemen also downed an MQ-9 drone using surface-to-air missiles.<sup>30</sup>

Also during the reporting period, the U.S. Air Force unveiled a new microwave weapon known as the Tactical High-Power Microwave Operational Responder (THOR) designed to protect fixed installations from drone swarms. The system fires short bursts of high-powered microwaves to disable drones at short ranges. A second system known as the Counter-Electronic High-Power Microwave Extended Range Air Base Air Defense (CHIMERA) is designed to counter drones at longer ranges and is expected to be delivered in 2020.<sup>31</sup>

The proliferation of directed energy and counter-drone weapons systems presents opportunities and challenges for military planners. Certainly, they provide enhanced, low cost capabilities to meet the emerging threat from drones and drone swarms. However, planners in small and large militaries will also have to contemplate how the proliferation of these weapons will affect their own calculations about the use of unmanned systems in a growing number of missions (see below). Instincts toward investing large sums of money in technologies to ensure unmanned survivability will likely need to be balanced by an appreciation of the cost of these upgrades and of an acceptance of the risks of attrition of (relatively inexpensive) unmanned aircraft in highly contested environments.

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<sup>28</sup> Dormehl, Luke, “U.K. military is getting serious about lasers and other energy weapons”, *Digital Trends*, 10 July 2019, <https://www.digitaltrends.com/cool-tech/mod-laser-directed-energy-weapons/>

<sup>29</sup> Lagrone, Sam, “Marines took out Iranian drone for the cost of a tank of gas”, *USNI News*, 19 July 2019, <https://news.usni.org/2019/07/19/marines-took-out-iranian-drone-for-the-cost-of-a-tank-of-gas>

<sup>30</sup> Cooper, Helene, “American drone shot down over Yemen”, *The New York Times*, 21 August 2019, <https://www.nytimes.com/2019/08/21/us/politics/american-drone-yemen.html>

<sup>31</sup> Liptak, Andrew, “The US Air Force has a new weapon called THOR that can take out swarms of drones”, *The Verge*, 21 June 2019, <https://www.theverge.com/2019/6/21/18701267/us-air-force-thor-new-weapon-drone-swarms>

## Robotics and Unmanned Systems

### Key Insights:

- **New collaborative development models** are being explored to take advantage of demand for regional and global demand for unmanned systems. **These models offer an opportunity for small militaries to gain access to new technologies and capabilities.**
- **Unmanned systems and robots are being used in more diverse ways and as part of a growing range of missions**, including the use of humanoid robots in support of manned space flight.
- New variations of unmanned systems—including **small and mini-UAVs**—are being incorporated into militaries.
- Some of these new capabilities reflect **the effectiveness of unmanned systems use by non-state actors such as Daesh against modern military forces**
- Russia's focus on unmanned systems has led to **an advancing industry that is churning out an impressive diversity of unmanned systems**, including a stealth combat drone, which underwent trials and testing during the reporting period

**Estonia Leads UGV Development Program:** The Estonian Centre for Defence Investment (ECDI) signed an agreement with representatives from Belgium, Spain, Latvia, France, Germany, and Finland for the development of the Modular Unmanned Ground System (MUGS). Estonia will lead the project. The Ministry of Defence released a statement saying that the program's goal is "no less than the development of the F-16 of unmanned ground systems", suggesting broad international diffusion of the system and a degree of flexibility.<sup>32</sup>

The seven participating countries received a total of €30.6 million in funds from the European Defence Fund, to which countries co-funding will be added. The system first prototype is expected to be revealed in 2021.

**Robots in Space:** On 22 August, Russia became the first country to send a humanoid robot into space when FEDOR (Final Experimental Demonstration Object Research) launched as part of the crew aboard the Soyuz MS-14 spacecraft headed for International Space Station.<sup>33</sup>



Figure 5: A Milrem Modular Unmanned Ground System (MUGS) being tested by Estonian troops in Mali. Source: mil.ee

<sup>32</sup> "Estonia to lead six countries in developing next unmanned ground system", ERR News, 25 August 2019, <https://news.err.ee/973635/estonia-to-lead-six-countries-in-developing-next-unmanned-ground-system>

<sup>33</sup> "Sending FEDOR to ISS to be first step in space research by humanoid robots—Roscosmos", TASS, 20 July 2019, <https://tass.com/science/1069935>

The FEDOR android robot was created by Android Technics and the Russian Foundation for Advanced Research Projects (FPI). It was scheduled to spend two weeks running tests on board the space station with expedition commander Alexy Ovchinin before returning home in early September. The tests are designed to demonstrate how humanoid robots can assist humans in space, especially in carrying out dangerous missions, “including future manipulations outside space stations.”<sup>34</sup> While the Russian spacecraft was unable to dock with the International Space Station as planned on 24 August, a redocking attempt was made on 26 August.

**More Russian Unmanned System Development:** The launch of FEDOR was not the only notable Russian unmanned systems development during the reporting period. The last two months have been active for Russia’s unmanned system industry and indicate that despite challenges in some parts of its defence industrial base, Russia’s unmanned system development has made impressive strides in a relatively short period of time. According to Mathieu Boulegue, a Russia expert at British think tank Chatham House, Russia has “been able to turn things around and create an industrial base for drones. Its been quite impressive”, especially given that Russia’s drone development effort is only approximately 10 – 15 years old.<sup>35</sup>

On 8 August, Russia’s Ministry of Defence published a short video of its new Okhotnik (“Hunter”) stealthy combat drone. This report has previously covered the development of the Okhotnik, but this was the first time that the Ministry of Defence had published information on the new system. The video lasted approximately 20 minutes and included footage of the Okhotnik taking off, manoeuvring in the air, and landing.<sup>36</sup>



Figure 6: The Russian Okhotnik stealth drone in footage released by the Russian Ministry of Defence

On 2 July, the Russian Defence Ministry told news site *Izvestia* that the Russian military is seeking to deploy small multi-rotor drones armed with explosives—tactical bomb drones. “It is planned that the new flight vehicles will perform not only reconnaissance missions, but also strike targets with miniature bombs”, according to *Izvestia*. The development is notable largely because it reflects the impact of Russia’s operational experience in Syria fighting against a range of militant groups, including Daesh, which used small quad-copter drones armed with grenades to strike targets.<sup>37</sup> In addition, reporting on the announcement also focused on Russia’s conspicuous interest in and adoption of unmanned systems. Russia military expert Samuel Bendett told *Defense One* that “many developers have in fact built, tested and showcased quadric and multi-rotor copters” in hopes of Ministry of Defence contracts.<sup>38</sup>

<sup>34</sup> “Sending FEDOR to ISS to be first step in space research by humanoid robots—Roscosmos”, TASS, 20 July 2019, <https://tass.com/science/1069935>

<sup>35</sup> Guy, Jack, “Russia has released footage of its new ‘Hunter’ stealth attack drone”, *CNN*, 8 August 2019, <https://www.cnn.com/2019/08/08/europe/russia-hunter-drone-scli-intl/index.html>

<sup>36</sup> Guy, Jack, “Russia has released footage of its new ‘Hunter’ stealth attack drone”, *CNN*, 8 August 2019, <https://www.cnn.com/2019/08/08/europe/russia-hunter-drone-scli-intl/index.html>

<sup>37</sup> Tucker, Patrick, “Russian Troops Will Be Getting Tactical Bomb Drones”, *Defense One*, 2 July 2019, <https://www.defenseone.com/technology/2019/07/russian-troops-will-be-getting-tactical-bomb-drones/158179/>

<sup>38</sup> Tucker, Patrick, “Russian Troops Will Be Getting Tactical Bomb Drones”, *Defense One*, 2 July 2019, <https://www.defenseone.com/technology/2019/07/russian-troops-will-be-getting-tactical-bomb-drones/158179/>



<https://deftech.ch>