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DEFTECH SCAN

September 2020

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

Dear Reader,

If the world general focus is still about health issues, military developments and achievements are still going strong, breaking new grounds month after month.

To keep physical distance, simulation and training in a virtual environment are getting a lot of attention and progress. We are going in that direction as well with the development of our "Technology Wargaming Platform – https://deftech.ch/wargaming - and it seems we'll have exciting times ahead !

As you will discover, the period considered was rich in tests and announcements, including the publication of really interesting documents on China and North Korea by the USA.

We wish you a passionate reading, discovering how a lot of efforts are dedicated to bring science-fiction to science-facts.

Truly Yours,

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Introduction and Summary

This DEFTECH SCAN reports on and assesses key developments in military technology and capability development taking place from late July through mid-September. It includes developments from the United States—which saw an especially active reporting period—Russia, China, the United Kingdom, Germany, the Netherlands, and India among other countries involved in the discussion around the ethics and safety of defence and security applications of artificial intelligence.

Breakthroughs: The reporting period included at least three especially significant defence technology breakthroughs in the United States: 1) the shock announcement of the flying in the real world of a digitally designed sixth generation fighter jet; 2) the victory of an artificial intelligence algorithm over a human pilot in a virtual dogfight; and 3) the interception of a manoeuvrable cruise missile by a hypervelocity projective fired from a howitzer. Individually and collectively, these developments reflect the pace with which technological innovation is taking place with implications not just for the largest militaries in the world. Each of these breakthroughs has real and present implications for

Convergence: One of the key objectives of several of the innovations and developments covered in this report is to use technology to cohere and assess the increasing number of intelligence, surveillance, and reconnaissance inputs to which military personnel and decision-makers have access. Building a persistent, real-time, and more complete situational awareness has become a priority outcome for technology and operational concept development across both small and large militaries.

Artificial Intelligence: A key theme of this report is that for both small and large militaries artificial intelligence is now a critical enabling technology across a wide range of capability categories and applications. However, as these technologies are integrated into novel systems, militaries are struggling with questions of how to ensure AI is developed and applied in safe, ethical, and responsible ways.

International collaboration on these issues of safe and ethical development has many benefits, including facilitating interoperability between like-minded states and partners that may be required to operate together to meet various military and security threats and challenge

Reports: While not covered in the main text of this report, the U.S. Department of Defense released two reports of general interest. The annual "Military and Security Developments Involving the People's Republic of China 2020: Annual Report to Congress" was published in September. The report is a useful and matter-of-fact accounting of how the Pentagon views China's military modernization. This year's effort focuses on China's modernization of its nuclear capability and the fact that China has surpassed the United States as the world's largest Navy. It also details how and why China seeks to building a world-class military by 2049. In addition, the U.S. Army's 332-page "North Korean Tactics" report details and assesses North Korea's development of electronic warfare capabilities.

Energy, Power, and Propulsion

Key Insights:

- Developments in academia and commercial aerospace / space are driving possible new capabilities that could enhance efficiency, survivability, and flexibility of military platforms and systems in material ways for both small and large militaries around the world.
- For example, a breakthrough in small satellite thrusters in 2020 is driving considerable interest from both commercial aerospace companies and defense / security communities for the ability to place maneuverable (and therefore more survivable) cube satellites (CubeSats) in space. Similarly, an academic institution tested a prototype of a blended wing / V-wing concept that will greatly enhance energy efficiency and can be leveraged by militaries.
- The collision of energy, propulsion, and design challenges and priorities for large and small militaries and the commercial / civilian sector is generating cross-domain interest in new forms of air mobility, especially those that allow for freer movement in congested urban environments or hard to access locations. Electronic vertical take-off and landing and hybrid engines as well as novel design concepts such as cyclocopters are shaping this fast-moving area of technological and operational concept innovation.

Small Satellite Thruster Attracting Investment: German company Morpheus Space has developed electric thrusters that allow tiny cube-satellites to manoeuvre. The company's unique capability has attracted interest from investors in defence and intelligence communities as well as the commercial and civil space and aerospace markets, including investment from In-Q-Tel, the investment arm of the Central Intelligence Agency (CIA) in the United States and Airbus Ventures, according to an article published in *Defense One* during the reporting period.[1]

Six Morpheus thrusters are currently operating aboard two satellites in space. In June 2020, these thrusters manoeuvred a 10-centimeter CubeSat out of the path of a disabled Iridium satellite, marking the first time a CubeSat had manoeuvred to avoid a collision. According to Istvan Lorincz, Morpheus' chief business officer, "This is the first CubeSat that actually had an electric propulsion system on board and could successfully operate the propulsion system."

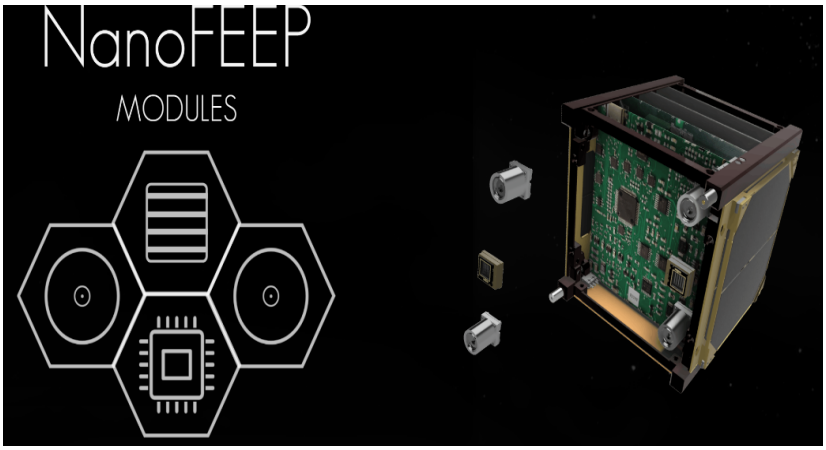

Figure 1: An image of Morpheus Space's NanoFEEP that highlights the modular design of its thruster system. Source: Morpheus Space's website, https://morpheus-space.com/

The thrusters are described as varying in size from "about the size of a fingertip" to "about the size of a rubix cube." They also incorporate a modular design in order to be used on satellites as light as 1 kg all the way up to satellites weighing more than one ton.

The value of these thrusters to defence and intelligence communities is not difficult to ascertain, given the growing interest and activity in space and the enhanced focus on the development of constellations of small

[1] Marcus Weisgerber, "CIA's In-Q-Tel Among Backers of German Satellite-Thruster Startup", *Defense One,* August 26, 2020, https://www.defenseone.com/business/2020/08/cias-q-tel-among-backers-german-satellite-thruster-startup/167984/

satellites for a range of intelligence, surveillance, and reconnaissance (ISR) and communications tasks. The ability to manoeuvre these assets in the increasingly crowded environment of space will not just enhance the survivability, but also the mission flexibility, of small satellites.

Flying V-Plane Scaled Prototype Test: A team from Delft University of Technology (TU Delft) in the Netherlands successfully tested a scaled prototype of a flying V-wing aircraft in which the fuselage and wing are integrated into one body.[2] The design is estimated to consume approximately 20% less fuel than a traditional aircraft design.[3]

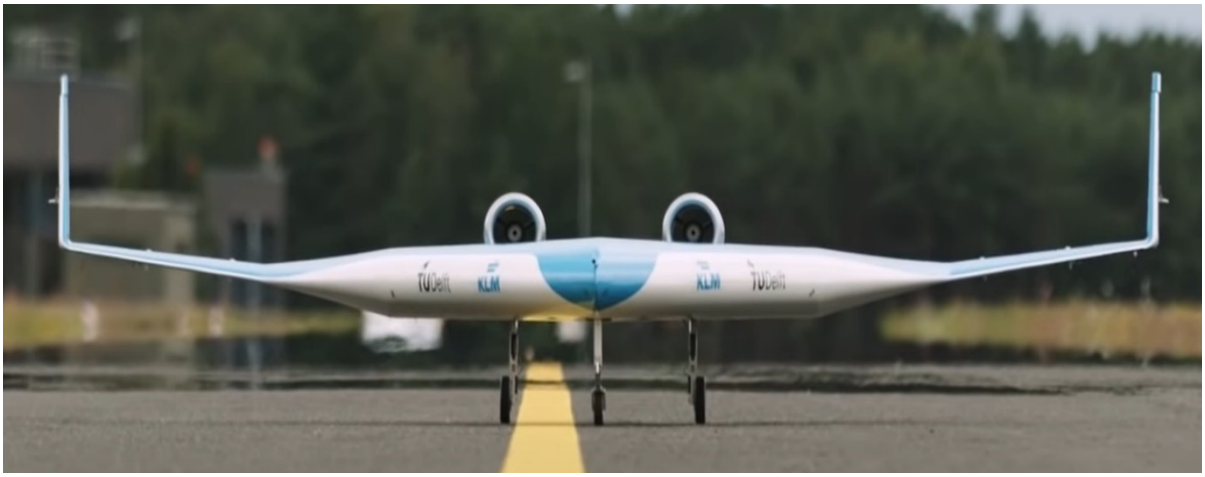

Figure 2: An image of the scaled prototype of TU Delft's flying V-wing plane before take-off. Source: YouTube, "Flying-V scale model maiden flight", https://www.youtube.com/watch?v=XHFcLfSfJWQ

The remotely – piloted, scaled model weighed 22.5 kg and has a 3-meter wingspan. The test flight is an important milestone in a program that began in February of 2019 and is expected to serve as catalyst for refining the design by creating an aerodynamic model that can be programmed into a flight simulator. Among the most pressing technical challenges is developing a sustainable propulsion source. The team believes the design is best suited for liquid hydrogen.[4]

As with the Morpheus Space thrusters, the development of this novel approach has attracted the attention of a range of prominent companies. The TU Delft team is partnered with Dutch airline KLM. Airbus was described as both a partner and "an explicit supporter for the first flight."[5] Notably, in February 2020, Airbus revealed its Maveric blended wing scaled body design aircraft.[6]

While reporting did not indicate an immediate interest on the part of specific militaries, the ability to increase fuel efficiency will be of interest to militaries looking to save money associated with operations and maintenance and in many cases to reduce emissions.

Innovations in Urban Mobility: BAE Systems is designing a new class of flight-control and energy-management systems for the hybrid and all-electric aircraft segments, according to reporting from *Flight Global* during the reporting period.[7]

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[2] "Flying-V - Scale model maiden flight", TU Delft YouTube Channel, 1 September 2020, https://www.youtube.com/watch?v=XHFcLfSfJWQ

[3] "Successful maiden flight for TU Delft flying-V", TU Delft website, 1 September 2020, https://www.tudelft.nl/en/2020/tu-delft/successful-maiden-flight-for-the-tu-delft-flying-v/

[4] Ibid.

[5] Ibid.

[6] "Airbus reveals its blended-wing concept demonstrator", Airbus website, 11 February 2020, https://www.airbus.com/newsroom/press-releases/en/2020/02/airbus-reveals-its-blended-wing-aircraft-demonstrator.html

[7] Jon Hemmerdinger, "BAE prepares to roll out new flight-control and energy-manegement systems", *Flight Global*, 24 August 2020, https://www.flightglobal.com/airframers/bae-prepares-to-roll-out-new-flight-control-and-energy-management-systems/139866.article

The company seeks to move fast to capitalize on growing interest in the small urban air mobility market that is building around air taxis and other electric vertical take-off and landing (eVTOL) aircraft. Mark Dreschler, director of business development for controls and avionics, estimates that BAE Systems will have "demos for the energy management and controls in 18 – 24 months."[8]

BAE Systems is already partnered with all-electric developers including Jaunt Air Mobility and Wright Electric and expects to test prototypes from these partnerships "later this year and early next year."[9]

Air taxis are another capability that sit at the junction of commercial and military markets. In the commercial and civil space, air taxis offer a novel way of transporting people and goods across dense and expansive urban environments, a role that is also relevant for militaries that are increasingly being asked to operate in urban environments that are notoriously crowded, contested, and complex.

Solutions to the challenges of air mobility in these settings also include novel designs. Among the systems displayed at the Army 2020 forum in Moscow from 23 – 29 August was a flight demonstrator of Russia's first cyclocopter—called "Cyclone". The demonstrator was produced by the Advanced Research Fund Russia, which anticipates acceptance trials for the 60 kg prototype in February 2021 at which point the main thrust of the programme will shift to developing a full-sized vehicle capable of carrying up to six people by 2024. According to *TASS,* "Russian specialists are developing the cyclocopter for its operation in urban conditions and hard-to-access mountainous terrain." It is also being designed to carry bombs or machine guns for strike operations.[10]

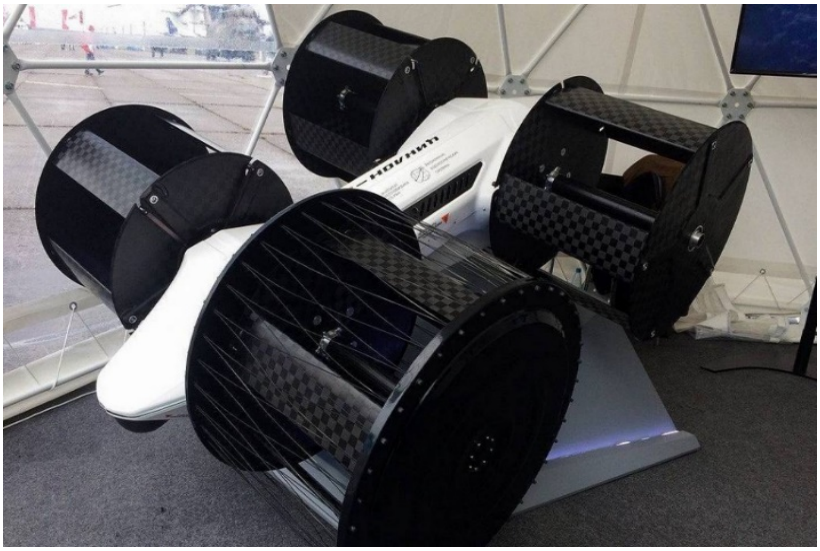

Figure 3: The Advanced Research Fund Project Cyclone prototype on display at Army 2020, Source: https://tass.com/defense/1194821

Cycloidal rotors provide some advantages over traditional helicopter and quadcopter designs in these settings, according to Cyclone Project Head Grigory Makeich. Most notably, they are "compact and [have] a low level of noise." They are also "highly manoeuvrable."[11]

[8] Ibid.
[9] Ibid.
[10] "Russian tech firm to develop army flying vehicle for airborne operations", *TASS,* 28 August 2020, https://tass.com/defense/1194821
[11] Ibid.

Human Performance Enhancement and Protection

Key Insights:

- Interest from militaries of all sizes in synthetic training is both expanding and evolving as militaries seek ways to leverage advances in various supporting technologies. The United Kingdom's recently announced effort to develop a comprehensive synthetic training solution that enables training of all functions across several distinct platforms is indicative of the types of efficiencies in time, cost, and flexibility that synthetic training can provide to large and small militaries.
- Human – machine interface technologies and, critically, related operational concepts are increasingly being incorporated as a means of ensuring soldier protection and survivability. These systems rely on a range of emerging technologies that enable humans to overcome the limitations of human physiology, such as the limits of human sight. A combined effort between researchers at the University of California, San Diego and the U.S. Army has successfully tested technologies that enable robots to detect even subtle changes in a given tactical environment and communicate those changes to a human partner through augmented reality goggles. This process should greatly enhance the capacity of the human to identify threats that the human eye may not be able to.

"Comprehensive" Synthetic Training: On 8 September, the UK Ministry of Defence (MoD) issued an invitation to tender (ITT) for a Ground Manoeuvre Synthetic Trainer (GMST) that will serve as a "comprehensive simulator system to satisfy individual (driver, gunner, commander) and crew training" for the Boxer infantry fighting vehicle, the Warrior IFV, and the Challenger 2 main battle tank. The contract is expected to be worth £70-90 million and will run from March 2022 through March 2027.[12]

The programme, known as Project Vulcan, is notable for providing a single pan-platform solution to "replace planned single platform simulation solutions."[13] Giles Ebbutt of *Janes* notes that "this is the first time the British Army has adopted a comprehensive and holistic approach to providing a simulation capability for its armoured fighting vehicle training."[14]

The tender is part of a broader effort within the UK MoD and, especially with the MoD's Defence Science and Technology Lab (Dstl) to take advantage of the "substantial advances over the last ten years in the quality of the synthetic environment." Of particular concern for Dstl has been the ability to link different training devices and applications that have been procured for specific purposes thereby enabling MoD to "achieve the full potential of the training."[15]

"This is the first time the British Army has adopted a comprehensive and holistic approach to providing a simulation capability for its armoured fighting vehicle training."—Giles Ebbut, Janes

Project Vulcan appears to address this challenge—which is shared by most small and medium sized militaries—by requiring an "open systems architecture and templated hardware profiles" that will "support rapid reconfiguration and future exploitation will enable the core software to be re-used in crew training for other platforms."[16]

[12] "Project Vulcan—Ground Maneouvre Synthetic Trainer", Bidstats, http://bidstats.uk/tenders/2020/W37/734527598
[13] Ibid.
[14] Giles Ebbut, "UK MoD Seeks bids for new Ground Manoeuvre Synthetic Trainer", *Janes International Defence Review,* 14 September 2020, https://customer.janes.com/Janes/Display/FG_3721113-IDR
[15] "Dstl: developing synthetic and next-generation training", MoD Defence Contracts website, https://www.contracts.mod.uk/blog/dstl-developing-synthetic-and-next-generation-training/
[16] Ibid.

3-D Threat Detection and Tracking: In a paper published in July 2020, researchers from the U.S. Army and the University of California, San Diego revealed that they had demonstrated in a real-world environment the first human – robot team in which an autonomous robot performs point cloud-based change detection to facilitate information-gathering tasks and provides enhanced situational awareness. The robotic system communicates detected changes via augmented reality goggles to a human teammate for evaluation.[17]

The end result, according to the study's lead Dr. Christopher Reardon, is to enhance soldier survivability by letting robots "inform their Soldier teammate of changes in the environment that might be overlooked by or not perceptible to the Soldier, giving them increased situational awareness and offset from potential adversaries."[18]

The test described in the paper paired a small autonomous mobile ground robot equipped with light detection and ranging (LIDAR), which build a virtual representation of the tactical environment. The robot was accompanied by a human wearing augmented reality glasses. The robot compared current and previous readings to detect changes and would then instantly displays these changes in the human's eyewear to be interpreted and responded to. The next step in this promising area of research is to find ways for the robot to determine if the environmental changes are made by an adversary, are natural occurring, or are a false positive.[19]

Figure 4: The IVAS System. Source: The United States Army, as found on https://taskandpurpose.com/military-tech/army-ivas-schedule-coronavirus#:~:text=The%20Integrated%20Visual%20Augmentation%20System%20%28IVAS%29%20is%20one,the%20individual%20soldier%2C%22%20as%20Army%20Times%20put%20it.

The Army believes that this technology can be incorporated into its Integrated Visual Augmentation System (IVAS), which has been described as providing "fighter pilot-like situational awareness to the individual soldier."[20]

IVAS is a soldier-worn combat goggle that can help dismounted soldiers overcome limitations of human vision while quickly organizing and processes sensor data. During a September event at the U.S. think tank Foundation for the Defense of Democracies, General Joseph Martin, the Vice Chief of Staff of the Army, explained one value of IVAS to enhancing soldier situational awareness: "We take all soldiers who have IVAS and turn them into a sensor collecting data to share with a greater network. The screen can

[17] Reardon C., Gregory J., Nieto-Granda C., Rogers J.G. (2020) Enabling Situational Awareness via Augmented Reality of Autonomous Robot-Based Environmental Change Detection. In: Chen J., Fragomeni G. (eds) Virtual, Augmented and Mixed Reality. Design and Interaction. HCII 2020. Lecture Notes in Computer Science, vol 12190. Springer, Cham. https://doi.org/10.1007/978-3-030-49695-1_41

[18] U.S. Army CCDC Army Research Laboratory Public Affairs, "Army robo-teammate can detect, share 3-D changes in real time", The United States Army, 24 August 2020, https://www.army.mil/article/238420/army_robo_teammate_can_detect_share_3_d_changes_in_real_time#:~:text=Army%20researchers%20demonstrated%20in%20a,and%20decide%20follow%2Don%20action.

[19] Ibid.

[20] Todd South, "The Army wants to buy 40,000 'mixed reality' goggles", *Army Times,* 11 February 2020, https://www.armytimes.com/news/your-army/2020/02/11/the-army-wants-to-buy-40000-mixed-reality-goggles/

chart a path and tell you where a reported adversary is. You can see through heat and augment existing light."[21] The Army hopes to field over 40,000 IVAS goggles by late FY2021.[22]

Cyber and C4ISTAR

Key Insights:

- A key theme of this report is that for both small and large militaries artificial intelligence is now a critical enabling technology across a wide range of capability categories and applications. However, as these technologies are integrated into novel systems, militaries are struggling with questions of how to ensure AI is developed and applied in safe, ethical, and responsible ways.
- International collaboration on these issues of safe and ethical development has many benefits, including facilitating interoperability between like-minded states and partners that may be required to operate together to meet various military and security threats and challenges.
- Electronic attack and electronic warfare capabilities are a key priority for militaries as they seek to compete in the congested and highly contested electromagnetic spectrum. New EW-capable radars are being developed or refined to help upgrade, for example, fourth generation aircraft like the UK's Eurofighter Typhoon to maintain relevance while the sixth generation Tempest is being developed.
- The push for increased persistent situational awareness in and across all domains is leading to the deployment of more sensors by most militaries around the world especially in difficult to access and operate in environments such as the undersea environment. The demand for these sensors are creating new technical and operational challenges and opportunities.
- The advancement of DARPA's 'Ocean of All Things' program to gain near ubiquitous maritime situational awareness offers an extreme example of the growing demand for technologically advanced and connected sensors—many of which are available in the commercial sector. There are more modest and accessible efforts being pursued that reflect innovative new technologies that can provide this type of persistent situational awareness.

A Multinational Forum for Safe and Reliable AI Development: The initial meeting of the "AI Partnership for Defense" took place on 15-16 September, bringing together representatives from 13 countries: Australia, Canada, Denmark, Estonia, Finland, France, Israel, Japan, Norway, Republic of Korea, Sweden, The United Kingdom, and the United States.

The event was hosted by the Joint Artificial Intelligence Center (JAIC) of the U.S. Department of Defense (DoD).

The two days of discussion covered several topics—including exchanges of best practice on AI development. But he primary objective of the event was to establish a multilateral forum for likeminded nations to "provide values-based global leadership in defense for policies and approaches in adopting" safe and reliable AI.[23]

This is an area of growing concern among many states seeking to develop and apply AI in ways that are consistent with ethical and legal constraints and norms and reduce the risks of implicit or explicit bias, including, of course, in areas central to the future of C4ISTAR and cyber operations.

[21] Kris Osborn, "Soldier Targeting Goggles "Augment" Human 3-D Vision Tracking", *Fox News,* 9 September 2020, https://www.foxnews.com/tech/soldier-targeting-goggles-augment-human-3-d-vision-tracking
[22] Todd South, "The Army wants to buy 40,000 'mixed reality' goggles", *Army Times,* 11 February 2020, https://www.armytimes.com/news/your-army/2020/02/11/the-army-wants-to-buy-40000-mixed-reality-goggles/
[23] AI Partnership for Defense Joint Statement", Joint Artificial Intelligence Center, U.S. Department of Defense, https://www.ai.mil/docs/AI_PfD_Joint_Statement_09_16_20.pdf

A September 2020 white paper published on DefenceIQ entitled *The Current State of AI in Defence and Security: Insights into AI and its Applications in the Context of Cyber Threat Intelligence* stressed the importance of and challenges associated with developing and deploying safe and ethical AI, particularly as it relates to the use of machine learning for cyber threat intelligence processing.

The paper underscores the nuance associated with ethical and safe AI: "ethical judgments about given applications should be taken in context, with specific attention devoted to assessing how a specific application was developed, how it is to be used, by whom and to what intended end." Such an approach, the article asserts, "may create room for relativism—one country's salutary application may well be unacceptable to others."[24] Specifically, small and large militaries in democratic states are likely to have different norms and perspectives on the use of AI than states governed by authoritarian regimes, a disconnect that reinforces the need for organizations to establish a common set of standards for the use of AI in defence and security.[25]

Another objective of the Partnership that is also particularly important for militaries of all sizes is to improve interoperability between partner nations. The May 2020 DEFTECH SCAN highlighted the inefficiencies that could result from various militaries developing AI independent from one another and provided examples of bilateral efforts to bridge this gap in standards and technological priorities. Stephanie Culberson, the JAIC's chief of international affairs, believes the Partnership discussion on safety and responsibility will "lay the foundation for interoperability in lots of different ways."[26]

New Typhoon Radar Meeting Electronic Warfare Challenge: On 3 September, the UK Minister of Defence Jeremy Quinn announced a £317 million investment in a next generation radar for the Typhoon fighter jet program.[27]

BAE Systems and Leonardo will produce the European Common Radar System (ECRS) Mk2 to equip the RAF's Typhoon Tranche 3 with a multi-function active electronically scanned array (AESA) radar that can provide advanced electronic-warfare and electronic-attack capabilities in addition to more traditional functions such as detection and tracking. Quinn's announcement is reflective of a longer – term UK MoD program to develop AESA radar. The effort could be included in the Tempest sixth-generation combat jet and marks a separation between the UK and its Typhoon national partners Germany and Spain. Both Germany and Spain have recently revealed they were focused on the development and manufacture of the ECRS Mk1[28].

The Mk2 radar is expected to maintain the operational relevance of the Typhoon by, as a joint BAE – Leonardo statement assessed, offering "significantly more transmit-receive elements than other radars" as well as incorporating "simultaneous operation of its wide-band electronic warfare functionality."[29]

'Ocean of All Things': The U.S. Defense Advanced Research Programs Agency (DARPA) awarded a contract at the end of July for the next phase of the development of the Ocean of Things (OoT) project

[24] Giorgos Georgopoulos and Tate Nurkin, "The Current State of AI in Defence and Security: Insights into AI and its applications in the context of Cyber Threat Intelligence", *DefenceIQ,* September 2020, file:///C:/Users/taten/Downloads/elemendar-ai-white-paper-finalgXzJoE4FIYMBW1d1xYqyQXBTYtmyaydDHg6oaHoG.pdf
[25] Ibid.
[26] Patrick Tucker, "France, Israel, S. Korea, Japan, Others Joint Pentagon's AI Partnership", *DefenseOne,* 16 September 2020, https://www.defenseone.com/technology/2020/09/france-israel-s-korea-japan-others-join-pentagons-ai-partnership/168533/
[27] "Counter-drone tech and state-of-the-art radar for the RAF", UK Ministry of Defence, 3 September, 2020, https://www.gov.uk/government/news/counter-drone-tech-and-state-of-the-art-radar-for-the-raf
[28] Andrew Chuter, "Britain moves forward with its own Typhoon radar primed for electronic warfare", *Defense News,* 3 September 2020, https://www.defensenews.com/global/europe/2020/09/03/britain-moves-forward-with-its-own-typhoon-radar-primed-for-electronic-warfare/
[29] Ibid.

to "seed the seas with thousands of floating sensors, monitoring everything that passes from aircraft to submarines."[30]

The project involves the use of thousands of floating sensors (or 'floats'), that can remain at sea for extended periods of time. Each of the DARPA floats will contain a suite of *commercially available* sensors such as cameras, software designed radios, AIS receivers, microphones, and hydrophones.[31] These sensors will then collect environmental data as well as activity data about military and commercial vessels, aircraft, and even maritime mammals moving through the area. The floats transmit data periodically via satellite to a cloud network for storage and real-time analysis.[32] The objective is to be able to combine data from multiple floats, offering a broader perspective on what is happening over, on, and beneath the sea.

The contract was awarded to PARC, a technology company whose 18 kg solar-powered glass float design was selected over two others. DARPA has identified two technical challenges for the program—float technology and data analytics.[33]

DARPA plans to carry out tests with thousand-float arrays later this year. Initially, they will be placed in arrays of one float every three square kilometers, though over time program director John Waterson believes separation of floats in much larger arrays can increase to one float per twenty square kilometers while still maintaining coverage.[34]

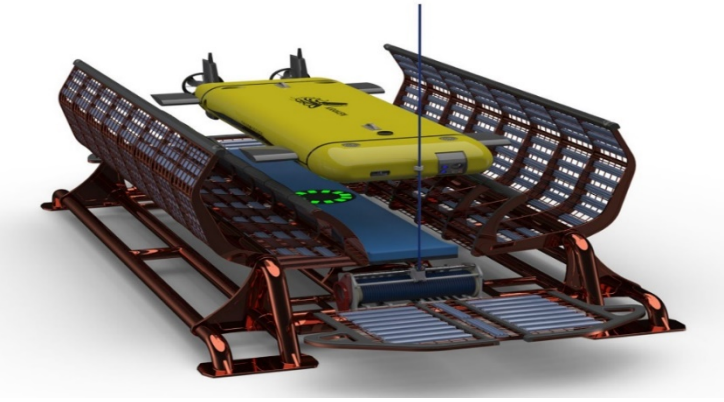

Figure 5: The Kraken ThunderFish XL will use an underwater docking station to recharge its batteries, transfer data, or be stored. Source: https://www.janes.com/defence-news/news-detail/kraken-robotics-announces-thunderfish-xl-auv-development

The "Ocean of Things" effort will rely on floats operating on the surface of the sea. Industry and other militaries around the world are also developing novel technological solutions to enhance situational awareness in the underwater environment.

For example, Canada's Kraken Robotics announced in late August it is developing the new seabed resident ThunderFish XL autonomous underwater vehicle to carry out a range of C4ISTAR missions in the underwater domain. The ThunderFish XL will measure 4.5 meters in length, 1.4 meters in width. It will have a dry weight of 2,000 to 2,500 kg with a modular frame. The autonomous vehicle will use an underwater docking station to recharge its batteries, transfer and download mission data, or be stored. The modular frame adds to the platform's mission flexibility by allowing it to carry one of several payload modules, including synthetic aperture sonar, 3-D laser profiler, rim-driven thrusters and pressure tolerant batteries, among other customized mission systems.[35]

[30] David Hambling, "DARPA Progress With 'Ocean of Things' All-Seeing Eye On The High Seas", *Forbes,* 13 August 2020, https://www.forbes.com/sites/davidhambling/2020/08/13/darpas-ocean-of-things-is-an-all-seeing-eye-on-the-high-seas/#35226caaf270

[31] Ibid.

[32] John Waterson, "Ocean of Things", DARPA, https://www.darpa.mil/program/ocean-of-things

[33] Ibid.

[34] Ibid.

[35] Kelvin Wong, "Kraken Robotics announces ThunderFIsh XL AUV development", *Janes,* 2 September 2020, https://www.janes.com/defence-news/news-detail/kraken-robotics-announces-thunderfish-xl-auv-development

Manned Platforms

Key Insights:

- Arguably the most important development during reporting period was the U.S. Air Force's shock announcement that it had developed and flown a new fighter jet within a year using digital design and development techniques. While digital design has been used on smaller aircraft such as combat trainers in the past, it had yet to be used to design an aircraft as sophisticated as a modern sixth generation fighter jet.
- Benefits of digital development can be reaped by nearly all militaries as the technology becomes more entrenched and proven. Most notably, digital development can reduce development timelines and cost and increase industry competitiveness.
- The Army 2020 Forum was held in Moscow from 23 – 29 August. It was one of the few global defense exhibitions that has been held in person during 2020 due to the coronavirus. Several weapons systems and platforms were displayed and demonstrated. One of those demonstrations involved a notably high rate of misses by several Russian tanks, which was reported on by several international media outlets and defence-related blogs.

Digital Design Effort Produces Shock Announcement: On 15 September, the United States Air Force disclosed that it has secretly built and flown a prototype fighter jet within one year using a novel approach that could fundamentally alter how large and small militaries engage industry and develop advanced platforms and systems.

Will Roper, the head of Air Force acquisition, made the shock announcement during the Air Force Association's Virtual Air, Space and Cyber Conference,. The previously undisclosed jet was part of the Air Force's Next Generation Air Dominance (NGAD) project.

According to Roper, the aircraft was designed and developed digitally, greatly reducing cost and development timelines: "Digital engineering is lowering overhead for production and assembly [so] you do not have to have huge facilities, huge workforces [and] expensive tooling."[36]. By designing and developing an aircraft in a virtual format means designers can modify and test the plane's systems with various configurations over the course of its design, again lowering costs of prototype development.

And the benefits go beyond both time and expense—and beyond large militaries, too, given the proliferation of digital development capabilities. Digital technologies expand the number of companies able to build high-end platforms, such as military aircraft, potentially driving new efficiencies. Roper did not divulge which company (or companies) had developed and built the aircraft. However, he did embrace the potential for having more companies being able to bid on future Air Force platform contracts as "super exciting", highlighting that a company could develop an aircraft in "hangar-like facilities with small, but of engineers and mechanics."[37]

> *"The announcement isn't that we just built an 'e-plane', and have flown it a lot of times in our virtual world, which we've done, but that we have built a full-scale flight demonstrator and flown it in the real world." – Will Roper*

[36] Marcus Weisgerber, "Revealed: US Air Force Has Secretly Built and Flown a New Fighter Jet", *Defense One*, 15 September 2020, https://www.defenseone.com/technology/2020/09/usaf-jet/168479/
[37] Ibid.

Boeing and SAAB have previously partnered to fully design and test the T-7 trainer on computers before they were physically built. Still, there remained a prevailing view among industry observers that these methods could not be used for a more sophisticated aircraft until the reveal of the still classified NGAD aircraft.

Army 2020 Expo: The sixth International Military and Technical Forum Army 2020 was held in person outside of Moscow from 23 – 29 August. Over 1,500 Russian and foreign companies showcased over 28,000 pieces of military hardware and weaponry, according to Russian state news agency *TASS.*[38]

Among the notable events during the exposition was the failure of multiple Russian main battle tanks to hit targets in a live demonstration on 24 August. Out of 16 shots using the 9K119M Refleks-M anti-tank guided munition (ATGM) against static mock-ups on a testing range only eight actually hit their intended target:

- T-90A tanks hit on only one of three shots
- T-80U MBTs hit one of three shots
- T-80UE-1 tanks hit two out of three shots
- T-72B3 MBTs hit four of four shots
- T-80BVM tanks missed on all three shots

The result is difficult to understand or justify, given the importance of the Army 2020 show for Russia's defense industry. *Shepherd Media* assessed that the performance, which "borders on the disastrous", could be attributed to low crew proficiency, defective missiles, or both.[39]

Figure 6: An image of the MBT tank demonstration at Army 2020. Source: https://defence-blog.com/news/army/russian-new-t-80bvm-tanks-couldnt-hit-targets-during-the-army-2020-forum.html

[38] "Sixth international military forum Army-2020 begins near Moscow on Sunday", *TASS*, 23 August 2020, https://tass.com/defense/1192733#:~:text=The%20sixth%20International%20Military%20and,open%20for%20the%20general%20public.

[39] "Russian tank firing demonstration results in fiasco", *Shephard Media,* 26 August 2020, https://www.shephardmedia.com/news/landwarfareintl/russian-tank-firing-demonstration-results-fiasco/#:~:text=Russian%20MBTs%20underperformed%20badly%20when,during%20the%20Army%202020%20event.

Missile Systems and Munitions

Key Insights:

- Counter-drone systems continue to be a priority for defence and security communities around the world as development of buttressing technologies advance and new systems achieve initial operational capability. Some novel systems are now incorporating AI to help better scan the RF spectrum and enhance detection of drones.
- AI was also central to an important breakthrough in cruise missile defence that occurred in the reporting period. The U.S. Air Force successfully hit a maneuverable cruise missile with a smart hypervelocity projectile (HVP) fired from a howitzer during an extensive test held in late August. The test offers multiple implications for militaries around the world, many of which are concerned about the proliferation of advanced cruise missiles.
- The successful use of an HVP in a missile defense role could be significant for future concepts of hypersonic missile defence, an area that is also receiving increased interest as more countries seek to develop scramjet – powered air and sea-launched hypersonic weapons. India's successful test of a hypersonic missile demonstrator further reinforces the growing perception that while hypersonic glide vehicle weapons may be the purview of large and sophisticated militaries, shorter-range scramjet-powered missiles will by the middle of the decade be in service in several militaries throughout the world.

Counter-Drone Technology Progresses: Leonardo's ORCUS counter-drone capability achieved initial operating capability (IOC) in September marking an important milestone in the UK Royal Air Force's counter-drone program. Leonardo has delivered four systems to the RAF.[40]

The modular ORCUS is a key part of an on-going research and testing effort designed to evaluate a range of capabilities such as advanced radar, electro-optic and radio frequency sensors, and electronic attack countermeasures and determine the most effective ways of meeting the threat of hostile drones.[41]

Figure 7: A depiction of the ORCUS system. Source: UK Ministry of Defence, https://www.gov.uk/government/news/counter-drone-tech-and-state-of-the-art-radar-for-the-raf

A UK Ministry of Defence announcement on the milestone highlighted the supporting role Leonardo's counter unmanned aerial systems (C-UAS) technology played in Force Protection 2018 and 2019 in response to disruptive drone incidents at both Gatwick and Heathrow airports.[42]

Development of C-UAS systems is moving quickly and increasingly incorporating novel technology areas such as AI.

In late July, C-UAS company DroneShield revealed that its recent contract award with the U.S. Air Force was driven by its use of AI, particularly in its DroneSentry system. The System includes a passive radio frequency direction-finding sensor and DroneCannon soft-kill countermeasure system. According to

[40] "Counter-drone tech and state-of-the-art radar for the RAF", UK Ministry of Defence, 3 September 2020, https://www.gov.uk/government/news/counter-drone-tech-and-state-of-the-art-radar-for-the-raf
[41] Ibid.
[42] Ibid.

DroneShield CEO Oleg Vornik, AI provides "a smart way of analysing the RF spectrum"[43] to enhance detection of drones, even those that may be hovering. In addition, DroneShield's description of the "autonomous drone detection and countermeasure" capability of DroneSentry also stresses the incorporation of DroneOpt (camera) sensors that "can take advantage of DroneOptID which offers the latest in computer vision technology to detect, verify and track drones in real time."[44]

Breakthrough in Cruise Missile Defence: In late August, a U.S. M109 Paladin 155 mm Howitzer shot down a fast-moving manoeuvring cruise missile with a hypervelocity projectile (HPV) traveling at speeds up to between Mach 3 and Mach 5.[45]

The shoot down of a "surrogate" Russian missile featured the Air Force's Advanced Battle Management System (ABMS). The program seeks to bring together networks of otherwise disconnected sensor nodes in a given tactical or operational environment, which are likely to be characterized by a surplus of information.[46]

The successful test incorporated a "smart HPV" that used AI-enabled data analytics to gather, organize, and assess data coming from these networked sensors nearly instantaneously. Will Roper, the Assistant Secretary of the Air Force for Acquisition, Technology, and Logistics, explained how central AI is to this breakthrough capability: "You're not supposed to be able to shoot down a cruise missile with a tank. But, yes, you can, if the bullet is smart enough, and the bullet we use for that system is exceptionally smart."

The milestone occurred during the ABMS Onramp #2 test, which took place in various locations across the United States from 31 August through 3 September. The exercise also included an MQ-9 Reaper and an F-16 shooting down cruise missiles.[47] None of these capabilities are currently or imminently operational. However they do constitute impressive progress in incorporating new technology-driven capabilities to meet the expanding range of cruise missile threats facing both small and large militaries throughout the world.

India's Hypersonic Missile Test: India test fired its first hypersonic missile demonstrator on 7 September. The indigenously developed Hypersonic Technology Demonstrator Vehicle (HSTDV) is designed to demonstrate the viability of technologies such as:[48]

- Aerodynamic configuration for hypersonic manoeuvring
- Scramjet propulsion
- Thermo-structural characterisation of high temperature materials
- Separation mechanisms at hypersonic velocities that will be incorporated into next generation weapons.

The Indian demonstrator reached Mach 6 for 20 seconds, constituting a successful test, though a viable missile will need to maintain hypersonic speeds for at least 100 seconds.[49] The first test of the HSTDV in June 2019 reportedly failed to meet mission parameters.

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[43] Gerrard Cowan, "DroneShield readies AI-driven C-UAS system for USAF", *Jane's International Defence Review,* 27 July 2020, https://www.janes.com/defence-news/news-detail/droneshield-readies-ai-driven-c-uas-systems-for-usaf
[44] DroneSentry product description, DroneShield website, https://www.droneshield.com/sentry
[4545] Kris Osborn, "Massive Breakthrough: 155 Howitzer Artillery Destroys Attacking Cruise Missile", *Defense Maven,* 12 September 2020, https://defensemaven.io/warriormaven/land/massive-breakthrough-155-howitzer-artillery-destroys-attacking-cruise-missile-aXVnb3nljUCRAboVGAXd5g
[46] Ibid.
[47] Joseph Trevithick, "MQ-9 Reaper, Howitzer, Rocket-Toting F-16 All Shoot Down Mock Cruise Missiles in Huge Test", *The Drive,* 11 September 2020, https://www.thedrive.com/the-war-zone/36345/mq-9-reaper-howitzer-rocket-toting-f-16-all-shoot-down-mock-cruise-missiles-in-huge-test
[48] Rahul Singh, "India takes first step towards developing hypersonic missiles", *Hindustan Times,* 7 September 2020, https://www.hindustantimes.com/india-news/india-takes-first-step-towards-developing-hypersonic-missiles/story-lwpdbN7LhNkgyd4it2KjeN.html
[49] Ibid.

A statement from the Indian government focused on the performance of the scramjet engine, relaying that "critical events like fuel injection and auto ignition of scramjet demonstrated technological maturity. The scramjet engine performed in a textbook manner."[50]

According to Defense Research Develop Organization (DRDO) Chief G Satheesh Reddy, the test "marks a technological breakthrough for the country", and will help India develop a hypersonic missile within approximately four years.[51] Naval analyst HI Sutton assessed that the development of "hypersonic missiles could massively increase the potency of Indian Navy warships in a future conflict" and also constitutes an important step in countering China's People's Liberation Army Navy (PLAN) increasing investment in anti-ship missiles.[52]

The United States, China, and Russia continue to develop hypersonic glide vehicles (HGV) launched on ballistic missiles. However, as evidenced by India's test, several countries are currently actively and openly progressing development of air and ship-launched hypersonic missiles that use scramjet engines to reach hypersonic speeds with aspirations to have these weapons in service by the middle of the 2020s..

Robotics and Unmanned Systems

Key Insights:

- An AI algorithm defeated a human fighter pilot in a virtual dogfight, again demonstrating the potential of AI to both support and eventually potentially replace humans in an increasing range of tasks for small and large militaries throughout the world.
- China's unmanned systems programs continue to produce a variety of unmanned systems at an impressive velocity. The importance of China's unmanned systems development both to the People's Liberation Army (PLA) modernization effort and to defence export strategies is driving more state-owned enterprises into development and manufacturing UAVs
- The world's leading small drone manufacturer has made deep staff cuts in response to intensifying efforts to ban its products in the United States as a result of the on-going U.S.-China geopolitical competition.

AI Wins Virtual Dogfight: An AI algorithm defeated a human fighter pilot in a virtual dogfight in August as part of the U.S. DoD's AlphaDogFight challenge.

The contest was actually the second phase in a DARPA effort that began in August of 2019 with the organization selecting eight teams to develop AI that would compete against one another in a series of trials. The winning team among those eight was Heron Systems, which then participated in the 20 August final against a human fighter pilot using a virtual reality helmet in a simulator. The Heron AI defeated the human pilot in all five rounds, though the human operator was able to adapt his tactics and last longer in the later rounds.[53]

The Heron AI heavily leveraged an AI technique known as deep reinforcement learning in which AI algorithms repeatedly experience a task in a virtual environment until they develop more human-like instincts and more robust and contextual understanding of the environment—for example, the AI can use this technique to learn not to crash the plane into the ground. As the AI experiences an environment over and over it will learn that there is a "cost to every error but those costs aren't equal." The algorithm

[50] Ibid.
[51] Ibid.
[52] HI Sutton, "India Goes Hypersonic: New Missile Technology May Be Answer to China's Navy", *Forbes,* 8 September 2020, https://www.forbes.com/sites/hisutton/2020/09/08/india-goes-hypersonic-new-missile-technology-may-be-answer-to-chinas-navy/#380097d2d937
[53] Patrick Tucker, "An AI Just Beat a Human F-16 Pilot in a Dogfight—Again", *Defense One,* 20 August 2020, https://www.defenseone.com/technology/2020/08/ai-just-beat-human-f-16-pilot-dogfight-again/167872/

will then begin to assign weights to each manoeuvre and reassign those weights as it goes through the simulation subsequent times.[54]

Heron's victory over a human pilot does not portend a sudden shift toward the replacement of human pilots with AI. Clearly, the technology will require further development and testing, and DoD along with many other small and large militaries around the world are not comfortable with removing human judgment entirely from the decision-making process of flying combat aircraft. Rather, DARPA views the test as advancing human – machine teaming in combat by expanding the range of tasks that can be automated.[55]

Volume and Velocity: China Reveals More About Its High-End UAVs: China revealed images of two indigenously developed, medium / high altitude long endurance (MALE/HALE)-class gas turbine-powered unmanned aerial vehicles (UAVs), further demonstrating the velocity and volume of innovation on-going in China's unmanned systems industry—and, as a result, the growing number of companies participating in this industry.

In mid-August, a previously unseen image of a new indigenously developed, medium / high-altitude long endurance (MALE/HALE)-class gas turbine powered unmanned aerial vehicle (UAV) began circulating on Chinese social media. According to *Jane's International Defence Review,* the image strongly resembles the WJ-700 MALE / HALE armed reconnaissance UAV concept model previously unveiled by China Aerospace Science and Industry Corporation (CASIC) at the 2018 Airshow China in Zhuhai.[56]

The WJ-700 is a multi-role platform and has been described as the largest and most capable multirole platform to date with a large payload capacity and a high-level of autonomy, including automatic take-off and landing and airborne patrol. It is expected to carry out land and maritime ISR, airborne early warning, signals intelligence, electronic warfare, and strike.[57]

CASIC's previous UAVs –the WJ-500, WJ-600, and WJ-600A/D—were vehicle launched with a "cruise missile-like form factor."[58] The WJ-700, however, has a more standard monoplane design. CASIC has traditionally been a centrepiece of China's missile, rockets, space, and munitions industry and has developed only a small number of unmanned systems in the past. That it has established the Hiwing General Aviation Equipment and the UAV Technology Institute in 2012 indicates the importance of UAVs for China's military modernization as well as for its defence exports ambitions.

The aircraft represents "a small but growing range of gas turbine-powered armed reconnaissance UAVs being offered by Chinese aerospace firms for the domestic and international markets."[59] Another in this group is the Cloud Shadow UAV, produced by the Aviation Industry Corporation of China (AVIC), which is the export variant of the secretive Wind Shadow MALE / HALE UAV. The Wind Shadow gained attention on 3 August when state broadcaster CCTV released images of the UAV being operated by the China Meteorological Administration (CMA).[60]

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[54] Ibid.
[55] Ibid.
[56] Kelvin Wong, "Image of new Chinese MALE/HALE UAV emerges, likely CASIC WJ-700 prototype, *Janes International Defence Review,* 18 August 2020, https://www.janes.com/defence-news/news-detail/image-of-new-chinese-malehale-uav-emerges-likely-casic-wj-700-prototype
[57] Ibid.
[58] Ibid.
[59] Ibid.
[60] Kelvin Wong, "China reveals rare glimpse of Wind Shadow UAV", *Janes,* 4 August 2020, https://www.janes.com/defence-news/news-detail/china-reveals-rare-glimpse-of-wind-shadow-uav

The "rare display"[61] of the Wind Shadow did reveal some design differences between the two platforms, according to *Jane's International Defence Review*. The Wind Shadow is powered by two indigenously developed Wo Shan-500 (WS-500/Turbofan-500) small turbofan engines while the Cloud Shadow is powered by a single WP11C turbojet engine. Also, "unlike the exposed exhaust nozzle of the Cloud Shadow's WP-11C turbojet, the Wind Shadow's twin WS-500 turbofan exhaust nozzles are recessed deep within the airframe's 'platypus' tail structure" in order to reduce its radar signature.[62]

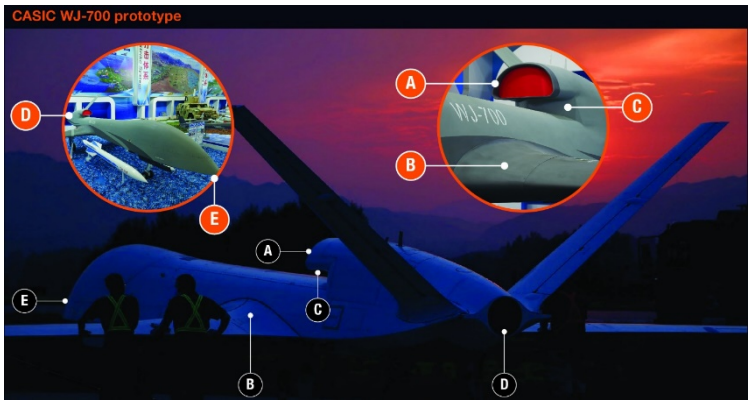

Figure 8: An image from Jane's demonstrating the similarities between the unmanned system in the previously unseen photo and the previously displayed at WJ-700 displayed in August 2018. Source: https://www.janes.com/defence-news/news-detail/image-of-new-chinese-malehale-uav-emerges-likely-casic-wj-700-

DJI Takes a Hit: These developments offer glimpses into China's vibrant military UAV development activities. However, the reporting period also saw a stalwart of China's commercial drone industry take aggressive steps to reduce its exposure to growing geopolitical and market risks.

DJI, the dominant force in the hobbyist and commercial drone market with approximately 70% in market share[63], made large cuts to its sales and marketing team in order to control costs in response to a coronavirus – related downturn and growing pushback against Chinese technology companies especially in the United States. *Reuters* reported in mid-August that the company had reduced its corporate sales and marketing team from 180 to 60 at its Shenzhen headquarters "with similar cuts on the consumer side." The company's global video production team has in recent months shrunk from 40-50 people to "around three." A DJI spokesman confirmed the cuts, saying that "We had to make some difficult decisions to realign talent so that we can continue to achieve our business goals during challenging times."[64]

Under President Donald Trump, the U.S. government had previously banned the procurement of DJI drones due to concerns over how and where the data the drones collected would be stored, creating constraints in the market that have only intensified as the U.S.-China geopolitical competition has done the same.

One indicative example of how different components of the U.S. government have targeted DJI and small Chinese hobbyist drones was seen in August. The U.S. DoD's Defense Innovation Unit (DIU), announced that it had approved five companies following a months long review designed to end DoD's military reliance on emerging technology made in China. DIU Director Mike Brown announced the five companies, which fall under DIU's "Blue sUAS" program, adding that the U.S. DoD needs "an alternative to Chinese-made small drones." The named companies were Altavian, Parrot, Skydio, Teal, and Vantage Robotics.[65]

The U.S. Army had previously banned commercial off the shelf procurement of Chinese drones in August 2017 while the DoD more broadly did the same in 2018.

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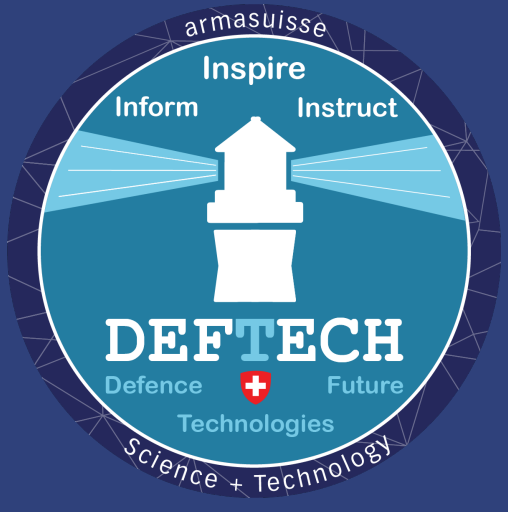
[61] Ibid.
[62] Ibid.
[63] David Kirton, "Chinese dronemaker DJI makes sweeping cuts in 'Long March' reforms", *Reuters,* 17 August 2020, https://www.reuters.com/article/us-china-tech-dji-focus-idUSKCN25D0HF
[64] Ibid.
[65] Oriana Pawlyk, "After Initial Ban, Pentagon Approves 5 Small Commercial Drones for Troops", *Military.com*, 27 August, https://www.military.com/daily-news/2020/08/27/after-initial-ban-pentagon-approves-5-small-commercial-drones-troops.html



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