



Statement of

**Kelley M. Sayler**

Analyst in Advanced Technology and Global Security

Before

United States Commission on Security and Cooperation in Europe

Hearing on

**“AI, UAVS, Hypersonics, and Autonomous  
Systems: Emerging Technologies and Euro-  
Atlantic Security”**

January 22, 2020

**Congressional Research Service**

7-5700

[www.crs.gov](http://www.crs.gov)

<Product Code>

Thank you Representative Veasey and the U.S. Commission on Security and Cooperation in Europe for the opportunity to provide an overview of emerging military technologies and their potential implications for international security. My name is Kelley Saylor, and I am an analyst in advanced technology and global security with the Congressional Research Service.

As noted by the 2018 National Defense Strategy, U.S. national security will likely be “affected by rapid technological advancements and the changing character of war...New technologies include advanced computing, ‘big data’ analytics, artificial intelligence, autonomy, robotics, directed energy, hypersonics, and biotechnology—the very technologies that ensure we will be able to fight and win the wars of the future.”<sup>1</sup> While the United States is the leader in developing many of these technologies, China and Russia—our key strategic competitors—are also making steady progress in developing advanced military technologies. As these technologies are integrated into military forces and deployed, they could hold significant implications for the future of international security.

## **Artificial Intelligence**

Although the U.S. government has no official definition of artificial intelligence (AI), AI generally refers to a computer system capable of human-level cognition. AI is further divided into two categories: narrow AI and general AI. Narrow AI systems can perform only the specific task that they were trained to perform, while general AI systems would be capable of performing a broad range of tasks, including those for which they were not specifically trained. General AI systems do not yet—and may never—exist.

Narrow AI is currently being incorporated into a number of military applications by both the United States and U.S. competitors, including but not limited to intelligence, surveillance, and reconnaissance; logistics; cyber operations; command and control; and semi-autonomous and autonomous vehicles. These technologies are intended to either augment or replace human operators, freeing the operators for more complex and cognitively demanding work. In addition, AI-enabled systems could both react significantly faster than systems that rely upon operator input and cope with an exponential increase in the amount of data available for analysis. AI could also enable new concepts of operations, such as swarming (i.e., cooperative behavior in which unmanned vehicles autonomously coordinate to achieve a task) that could confer a warfighting advantage by overwhelming adversary defensive systems.

Finally, recent news reports and analyses have highlighted the role of AI in enabling increasingly realistic photo, audio, and video digital forgeries, popularly known as “deep fakes.” Adversaries could potentially deploy this AI capability as part of their information operations in a “gray zone” conflict.<sup>2</sup> Deep fake technology could be used against the United States and its allies to generate false news reports, influence public discourse, erode public trust, and attempt to blackmail diplomats. Some have suggested that AI could be used to create full digital “patterns-of-life,” in which an individual’s digital footprint is mapped against other personal information, such as spending habits and job history, to create comprehensive behavioral profiles of servicemembers, suspected intelligence officers, government officials, and private citizens. Similar to deep fakes, this information could be used for targeted influence operations or blackmail.

## ***United States***

The Department of Defense’s (DOD) unclassified investments in AI have grown from just over \$600 million in FY2016 to \$927 million in FY2020, with the Department reportedly maintaining over 600

---

<sup>1</sup> Department of Defense, “Summary of the 2018 National Defense Strategy of The United States of America,” 2018, p. 3, <https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf>.

<sup>2</sup> “Gray zone” conflicts are those that occur below the threshold of formally-declared war.

active AI projects.<sup>3</sup> Pursuant to the FY2019 NDAA, DOD established the Joint Artificial Intelligence Center (JAIC, pronounced “jake”) to coordinate DOD projects of over \$15 million.<sup>4</sup> The JAIC has identified its priority national mission initiatives for AI as predictive maintenance,<sup>5</sup> humanitarian aid and disaster relief, cyberspace, and automation. The FY2019 NDAA additionally directed DOD to publish a strategic roadmap for AI development and fielding, as well as guidance on “appropriate ethical, legal, and other policies for the Department governing the development and use of artificial intelligence enabled systems and technologies in operational situations.”<sup>6</sup>

The FY2019 NDAA also established a National Security Commission on Artificial Intelligence to conduct a comprehensive assessment of militarily relevant AI technologies and provide recommendations for strengthening U.S. competitiveness.<sup>7</sup> The commission’s interim report to Congress identifies five key lines of effort for U.S. AI competitiveness: (1) investing in research and development, (2) applying AI to national security missions, (3) training and recruiting AI talent, (4) protecting and building upon U.S. technology advantages, and (5) marshalling global AI cooperation. The commission’s final report, which is to provide recommendations for implementing these lines of effort, is to be available in October 2020.

## *Russia*

Russian president Vladimir Putin has stated that “whoever becomes the leader in [AI] will become the ruler of the world.”<sup>8</sup> At present, however, Russian AI development lags significantly behind that of the United States and China. As part of Russia’s effort to close this gap, Russia has released a national strategy that outlines 5- and 10-year benchmarks for improving the country’s AI expertise, educational programs, datasets, infrastructure, and legal regulatory system.<sup>9</sup> Russia has also indicated it will continue to pursue its 2008 defense modernization agenda, with the aim of robotizing 30% of its military equipment by 2025.<sup>10</sup>

---

<sup>3</sup> Office of the Under Secretary of Defense (Comptroller)/Chief Financial Officer, Defense Budget Overview: United States Department of Defense Fiscal Year 2020 Budget Request, March 2019, p. 9; and Brendan McCord, “Eye on AI,” August 28, 2019, transcript available at <https://static1.squarespace.com/static/5b75ac0285ede1b470f58ae2/t/5d6aa8edb91b0c0001c7a05f/1567>.

<sup>4</sup> P.L. 115-232, Section 2, Division A, Title II, §1051.

<sup>5</sup> Predictive maintenance uses AI “to predict the failure of critical parts, automate diagnostics, and plan maintenance based on data and equipment condition.” Department of Defense, “Summary of the 2018 Department of Defense Artificial Intelligence Strategy,” February 12, 2019, p. 11, <https://media.defense.gov/2019/Feb/12/2002088963/-1/-1/1/SUMMARY-OF-DOD-AI-STRATEGY.PDF>.

<sup>6</sup> P.L. 115-232, Section 2, Division A, Title II, §238. In support of this mandate, the Defense Innovation Board, an independent federal advisory committee to the Secretary of Defense, has drafted recommendations for the ethical use of artificial intelligence. See Defense Innovation Board, “AI Principles: Recommendations on the Ethical Use of Artificial Intelligence by the Department of Defense,” October 31, 2019, [https://media.defense.gov/2019/Oct/31/2002204458/-1/-1/0/DIB\\_AI\\_PRINCIPLES\\_PRIMARY\\_DOCUMENT.PDF](https://media.defense.gov/2019/Oct/31/2002204458/-1/-1/0/DIB_AI_PRINCIPLES_PRIMARY_DOCUMENT.PDF).

<sup>7</sup> P.L. 115-232, Section 2, Division A, Title X, §1051. The Commission’s Interim Report, which assesses the challenges and opportunities of militarily relevant AI technologies, is available at <https://drive.google.com/file/d/153OrxnuGEjsUvIvXWsfYauslwNeCEkvUb/view>.

<sup>8</sup> “Whoever leads in AI will rule the world’: Putin to Russian children on Knowledge Day,” *RT.com*, September 1, 2017, <https://www.rt.com/news/401731-ai-rule-world-putin/>.

<sup>9</sup> Office of the President of the Russian Federation, “Decree of the President of the Russian Federation on the Development of Artificial Intelligence in the Russian Federation” (Center for Security and Emerging Technology, Trans.), October 10, 2019, <https://cset.georgetown.edu/wp-content/uploads/Decree-of-the-President-of-the-Russian-Federation-on-the-Development-of-Artificial-Intelligence-in-the-Russian-Federation-.pdf>.

<sup>10</sup> Tom Simonite, “For Superpowers, Artificial Intelligence Fuels New Global Arms Race,” *Wired*, August 8, 2017.

The Russian military has been researching a number of AI applications, with a heavy emphasis on semiautonomous and autonomous military vehicles. Russia has also reportedly built a combat module for unmanned ground vehicles that is capable of autonomous target identification—and, potentially, target engagement—and plans to develop a suite of AI-enabled autonomous systems.<sup>11</sup> In addition, the Russian military plans to incorporate AI into unmanned aerial, naval, and undersea vehicles and is currently developing swarming capabilities.<sup>12</sup> These technologies could reduce both cost and manpower requirements. Russia is also exploring innovative uses of AI for remoting sensing and electronic warfare, which could in turn reduce an adversary’s ability to effectively communicate and navigate on the battlefield.<sup>13</sup> Finally, Russia has made extensive use of AI technologies for domestic propaganda and surveillance, as well as for information operations directed against the United States and U.S. allies.<sup>14</sup>

Despite Russia’s aspirations, analysts argue that it may be difficult for Russia to make significant progress in AI development. In 2017, Russian military spending dropped by 20% in constant dollars, with subsequent cuts in 2018.<sup>15</sup> In addition, many analysts note that Russian academics have produced few research papers on AI and that the Russian technology industry has yet to produce AI applications that are on par with those produced by the United States and China.<sup>16</sup> Others analysts counter that such factors may be irrelevant, arguing that while Russia has never been a leader in internet technology, it has still managed to become a notably disruptive force in cyberspace.<sup>17</sup>

## China

China is the United States’ most ambitious competitor in the international AI market. China’s 2017 “Next Generation AI Development Plan” describes AI as a “strategic technology” that has become a “focus of international competition.”<sup>18</sup> Recent Chinese achievements in the field demonstrate China’s potential to realize its goals for AI development. In particular, China has pursued language and facial recognition technologies—many of which it plans to integrate into the country’s domestic surveillance network and social credit system. This system aims to monitor and “grade” every Chinese citizen by 2021 based on social behavior.<sup>19</sup> China is also developing various types of air, land, sea, and undersea autonomous

---

<sup>11</sup> Tristan Greene, “Russia is Developing AI Missiles to Dominate the New Arms Race,” *The Next Web*, July 27, 2017, <https://thenextweb.com/artificial-intelligence/2017/07/27/russia-is-developing-ai-missiles-to-dominate-the-new-arms-race/>; and Kyle Mizokami, “Kalashnikov Will Make an A.I.-Powered Killer Robot,” *Popular Mechanics*, July 19, 2017, <https://www.popularmechanics.com/military/weapons/news/a27393/kalashnikov-to-make-ai-directed-machine-guns/>.

<sup>12</sup> Samuel Bendett, “Red Robots Rising: Behind the Rapid Development of Russian Unmanned Military Systems,” *The Strategy Bridge*, December 12, 2017.

<sup>13</sup> Jill Dougherty and Molly Jay, “Russia Tries to Get Smart about Artificial Intelligence”; *The Wilson Quarterly*, Spring 2018; and Margarita Konaev and Samuel Bendett, “Russian AI-Enabled Combat: Coming to a City Near You?,” *War on the Rocks*, July 31, 2019, <https://warontherocks.com/2019/07/russian-ai-enabled-combat-coming-to-a-city-near-you/>.

<sup>14</sup> Alina Polyakova, “Weapons of the Weak: Russia and AI-driven Asymmetric Warfare,” Brookings Institution, November 15, 2018, <https://www.brookings.edu/research/weapons-of-the-weak-russia-and-ai-driven-asymmetric-warfare/>; and Chris Meserole and Alina Polyakova, “Disinformation Wars,” *Foreign Policy*, May 25, 2018, <https://foreignpolicy.com/2018/05/25/disinformation-wars/>.

<sup>15</sup> “Military expenditure by country, in constant (2017) US\$ m., 1988-2018,” Stockholm International Peace Research Institute, <https://www.sipri.org/sites/default/files/Data%20for%20all%20countries%20from%201988%E2%80%932018%20in%20constant%202017%29%20USD%20%28pdf%29.pdf>.

<sup>16</sup> Leon Bershidsky, “Take Elon Musk Seriously on the Russian AI Threat,” *Bloomberg*, September 5, 2017, <https://www.bloomberg.com/view/articles/2017-09-05/take-elon-musk-seriously-on-the-russian-ai-threat>; and Polyakova, “Weapons of the Weak.”

<sup>17</sup> Gregory C. Allen, “Putin and Musk Are Right: Whoever Masters AI Will Run the World,” *CNN*, September 5, 2017.

<sup>18</sup> China State Council, “A Next Generation Artificial Intelligence Development Plan,” p. 2.

<sup>19</sup> “Beijing to Judge Every Resident Based on Behavior by End of 2020,” *Bloomberg*, November 21, 2018, <https://www.bloomberg.com/news/articles/2018-11-21/beijing-to-judge-every-resident-based-on-behavior-by-end-of-2020>. It should be noted that Chinese technology companies such as ZTE Corp are working with other authoritarian regimes to develop

military vehicles and is actively pursuing swarm technologies, which could be used to overwhelm adversary missile defense interceptors. In addition, open-source publications indicate that the Chinese are developing a suite of AI tools for cyber operations.<sup>20</sup>

China's management of its AI ecosystem stands in stark contrast to that of the United States.<sup>21</sup> In general, few boundaries exist among Chinese commercial companies, university research laboratories, the military, and the central government; China's National Intelligence Law requires companies and individuals to "support, assist, and cooperate with national intelligence work."<sup>22</sup> As a result, the Chinese government has a direct means of guiding military AI development priorities and accessing technology that was ostensibly developed for civilian purposes.

### *International Institutions*

A number of international institutions have examined issues surrounding AI, including the Group of Seven (G7), the Asia-Pacific Economic Cooperation (APEC), and the Organisation for Economic Co-operation and Development (OECD), which developed the first intergovernmental set of principles for AI. These principles are intended to "promote AI that is innovative and trustworthy and that respects human rights and democratic values."<sup>23</sup> The United States is one of 42 countries—including the OECD's 36 member countries, Argentina, Brazil, Colombia, Costa Rica, Peru, and Romania—to have adopted the OECD AI Principles. These principles serve as the foundation for the Group of Twenty (G20)'s June 2019 Ministerial Statement on human-centered AI.<sup>24</sup> In addition, the OECD established the AI Policy Observatory in 2019 to develop policy options that will "help countries encourage, nurture, and monitor the responsible development of trustworthy AI systems for the benefit of society."

### **Lethal Autonomous Weapon Systems**

Although there is no internationally agreed upon definition of Lethal Autonomous Weapon Systems (LAWS), the U.S. Department of Defense has defined LAWS as a class of weapon systems that is capable of independently identifying a target and employing an onboard weapon system to engage and destroy the target without manual human control. LAWS require computer algorithms and sensor suites to classify an object as hostile, make an engagement decision, and guide a weapon to the target. This capability would enable the system to operate in communications-degraded or -denied environments where traditional systems may not be able to operate. Some analysts have noted that LAWS could additionally "allow weapons to strike military objectives more accurately and with less risk of collateral damage" or civilian casualties.<sup>25</sup> Others, including approximately 25 countries and 100 nongovernmental organizations, have

---

similar social-control systems. See, for example, Angus Berwick, "How ZTE helps Venezuela create China-style social control," *Reuters*, November 14, 2018, <https://www.reuters.com/investigates/special-report/venezuela-zte/>.

<sup>20</sup> Elsa Kania, *Battlefield Singularity: Artificial Intelligence, Military Revolution, and China's Future Military Power*, Center for a New American Security, November 28, 2017, p. 27.

<sup>21</sup> *Ibid.*, p. 6.

<sup>22</sup> Arjun Kharpal, "Huawei says it would never hand data to China's government. Experts say it wouldn't have a choice," *CNBC*, March 5, 2019.

<sup>23</sup> Organisation for Economic Co-operation and Development, "OECD Principles on AI," June 2019, <https://www.oecd.org/going-digital/ai/principles/>.

<sup>24</sup> "G20 Ministerial Statement on Trade and Digital Economy," June 9, 2019, available at <https://www.mofa.go.jp/files/000486596.pdf>.

<sup>25</sup> U.S. Government, "Humanitarian Benefits of Emerging Technologies in the Area of Lethal Autonomous Weapons," March 28, 2018, [https://www.unog.ch/80256EDD006B8954/\(httpAssets\)/7C177AE5BC10B588C125825F004B06BE/\\$file/CCW\\_GGE.1\\_2018\\_WP.4.pdf](https://www.unog.ch/80256EDD006B8954/(httpAssets)/7C177AE5BC10B588C125825F004B06BE/$file/CCW_GGE.1_2018_WP.4.pdf).

called for a preemptive ban on LAWS due to ethical concerns such as a perceived lack of accountability for use and a perceived inability to comply with the proportionality and distinction requirements of the laws of war. Although LAWS generally do not yet exist, some analysts have classified Israel's Harpy anti-radar loitering munition as a LAWS.<sup>26</sup>

### *United States*

The United States is not known to be currently developing LAWS. However, Department of Defense Directive (DODD) 3000.09 establishes department guidelines for the development and fielding of LAWS to ensure that they comply with "the law of war, applicable treaties, weapon system safety rules, and applicable rules of engagement."

### *Russia*

Russia has not publicly stated that it is developing LAWS; however, Russian weapons manufacturer Kalashnikov has reportedly built a combat module for unmanned ground vehicles that is capable of autonomous target identification and, potentially, target engagement.<sup>27</sup>

### *China*

According to U.S. Secretary of Defense Mark Esper, Chinese weapons manufacturers, such as Ziyang, have advertised LAWS.<sup>28</sup> In addition, some reports indicate that China has exported—or is in negotiations to export—systems that are capable of autonomous target selection and engagement to the United Arab Emirates, Saudi Arabia, and Pakistan.<sup>29</sup>

### *International Institutions*

Since 2014, the United States has participated in international discussions of LAWS under the auspices of the United Nations Convention on Certain Conventional Weapons (UN CCW). The UN CCW has considered proposals by states parties to issue political declarations about LAWS, as well as proposals to regulate or ban them. At the UN CCW, the United States and Russia have opposed a preemptive ban on LAWS, while China has supported a ban on the use—but not development—of LAWS, which it defines as weapon systems that are inherently indiscriminate and thus in violation of the law of war.

## **Hypersonic Weapons**

Hypersonic weapons—which fly at speeds of at least Mach 5—are in development in a number of countries, including the United States, Russia, and China. There are two categories of hypersonic weapons:

- **Hypersonic glide vehicles** are launched from a rocket before gliding to a target.
- **Hypersonic cruise missiles** are powered by high-speed engines throughout the duration of their flight.

---

<sup>26</sup> Defense Innovation Board, "AI Principles: Recommendations on the Ethical Use of Artificial Intelligence by the Department of Defense, Supporting Documents," p. 12.

<sup>27</sup> Kyle Mizokami, "Kalashnikov Will Make an A.I.-Powered Killer Robot," *Popular Mechanics*, July 19, 2017.

<sup>28</sup> Patrick Tucker, "SecDef: China is Exporting Killer Robots to the Mideast," *Defense One*, November 5, 2019.

<sup>29</sup> Gregory C. Allen, *Understanding China's AI Strategy: Clues to Chinese Strategic Thinking on Artificial Intelligence and National Security*, Center for a New American Security, February 2019, p. 6.

In contrast to ballistic missiles, hypersonic weapons do not follow a ballistic trajectory and can maneuver en route to their destination, making defense against them difficult.<sup>30</sup> Currently, no such defense against hypersonic weapons exists, and experts disagree on the affordability, technological feasibility, and utility of hypersonic missile defense options. These options could include interceptor missiles, hypervelocity projectiles, laser guns, and electronic attack systems.

### *United States*

The Pentagon's FY2020 budget request for all hypersonic-related research is \$2.6 billion, including \$157.4 million for hypersonic defense programs. The Department of Defense (DOD) is currently developing hypersonic weapons under the Navy's Conventional Prompt Strike program, which is intended to provide the U.S. military with the ability to strike hardened or time-sensitive targets with conventional warheads, as well as through several Air Force, Army, and DARPA programs.<sup>31</sup> Analysts who support these development efforts argue that hypersonic weapons could enhance deterrence, as well as provide the U.S. military with an ability to defeat capabilities such as advanced air and missile defense systems that form the foundation of U.S. competitors' anti-access/area denial strategies.<sup>32</sup> Others have argued that hypersonic weapons confer little to no additional warfighting advantage.

The United States is unlikely to field an operational hypersonic weapons before 2022; however, in contrast to Russia and China, the United States is not currently developing hypersonic weapons for potential use with a nuclear warhead. As a result, U.S. hypersonic weapons will likely require greater accuracy and will be more technically challenging to develop than nuclear-armed Russian and Chinese systems.

### *Russia*

Although Russia has conducted research on hypersonic weapons technology since the 1980s, it accelerated its efforts in response to U.S. missile defense deployments in both the United States and Europe, and in response to the U.S. withdrawal from the Anti-Ballistic Missile Treaty in 2001.<sup>33</sup> Detailing Russia's concerns, President Putin stated that "the US is permitting constant, uncontrolled growth of the number of anti-ballistic missiles, improving their quality, and creating new missile launching areas. If we do not do something, eventually this will result in the complete devaluation of Russia's nuclear potential. Meaning that all of our missiles could simply be intercepted."<sup>34</sup> Russia thus seeks hypersonic weapons, which can maneuver as they approach their targets, as an assured means of penetrating U.S. missile defenses and restoring its sense of strategic stability.<sup>35</sup>

---

<sup>30</sup> While ballistic missiles do travel at hypersonic speeds, they are not classified as "hypersonic weapons," which both fly at hypersonic speeds and can maneuver throughout their course of flight.

<sup>31</sup> For a full history of U.S. hypersonic weapons programs, see CRS Report R41464, *Conventional Prompt Global Strike and Long-Range Ballistic Missiles: Background and Issues*, by Amy F. Woolf.

<sup>32</sup> Roger Zakheim and Tom Karako, "China's Hypersonic Missile Advances and U.S. Defense Responses," Remarks at the Hudson Institute, March 19, 2019. See also Department of Defense Fiscal Year (FY) 2020 Budget Estimates, Army Justification Book of Research, Development, Test and Evaluation, Volume II, Budget Activity 4, p. 580.

<sup>33</sup> United Nations Office of Disarmament Affairs, *Hypersonic Weapons: A Challenge and Opportunity for Strategic Arms Control*, February 2019, <https://www.un.org/disarmament/publications/more/hypersonic-weapons-a-challenge-and-opportunity-for-strategic-arms-control/>.

<sup>34</sup> Vladimir Putin, "Presidential Address to the Federal Assembly," March 1, 2018, <http://en.kremlin.ru/events/president/news/56957>.

<sup>35</sup> In this instance, "strategic stability" refers to a "bilateral nuclear relationship of mutual vulnerability." See Tong Zhao, "Conventional Challenges to Strategic Stability: Chinese Perceptions of Hypersonic Technology and the Security Dilemma," Carnegie-Tsinghua Center for Global Policy, July 23, 2018, <https://carnegietsinghua.org/2018/07/23/conventional-challenges-to>

Russia is pursuing two nuclear-capable hypersonic weapons—the Avangard and the 3M22 Tsirkon (or Zircon). Avangard is a hypersonic glide vehicle launched from an intercontinental ballistic missile (ICBM), giving it “effectively ‘unlimited’ range.”<sup>36</sup> Russia claims that Avangard became operational on December 27, 2019; however, this claim has not been verified by U.S. intelligence reports and has been met with skepticism by some U.S. officials.<sup>37</sup> Tsirkon, a ship-launched hypersonic cruise missile, may become operational as early as 2023.<sup>38</sup>

## China

According to Tong Zhao, a fellow at the Carnegie-Tsinghua Center for Global Policy, “most experts argue that the most important reason to prioritize hypersonic technology development [in China] is the necessity to counter specific security threats from increasingly sophisticated U.S. military technology, including [hypersonic weapons].”<sup>39</sup> In particular, China’s pursuit of hypersonic weapons, like Russia’s, reflects a concern that U.S. hypersonic weapons could enable the United States to conduct a preemptive, decapitating strike on China’s nuclear arsenal and supporting infrastructure. U.S. missile defense deployments could then limit China’s ability to conduct a retaliatory strike against the United States.<sup>40</sup>

China has tested the DF-ZF hypersonic glide vehicle at least nine times since 2014. U.S. defense officials have reportedly identified the range of the DF-ZF as approximately 1,200 miles and have stated that the missile may be capable of performing “extreme maneuvers” during flight.<sup>41</sup> Although unconfirmed by intelligence agencies, some analysts project the DF-ZF will be operational as early as 2020.<sup>42</sup> China also successfully tested Starry Sky-2, a nuclear-capable hypersonic vehicle prototype, in August 2018.<sup>43</sup> Some reports indicate that the Starry Sky-2 could be operational by 2025.<sup>44</sup> U.S. officials have declined to comment on the program.<sup>45</sup>

---

strategic-stability-chinese-perceptions-of-hypersonic-technology-and-security-dilemma-pub-76894.

<sup>36</sup> Steve Trimble, “A Hypersonic Sputnik?,” *Aviation Week*, January 14-27, 2019, p. 20.

<sup>37</sup> Amanda Macias, “US intelligence reports: Russia’s new hypersonic weapon will likely be ready for war by 2020,” *CNBC*, May 15, 2018.

<sup>38</sup> “Russian Navy to accept latest Tsirkon hypersonic missile for service in 2023—source,” *TASS*, March 20, 2019.

<sup>39</sup> Tong Zhao, “Conventional Challenges to Strategic Stability: Chinese Perceptions of Hypersonic Technology and the Security Dilemma.”

<sup>40</sup> Tong Zhao, “Conventional Challenges to Strategic Stability”; and Lora Saalman, “China’s Calculus on Hypersonic Glide,” August 15, 2017, Stockholm International Peace Research Institute, <https://www.sipri.org/commentary/topical-backgroundunder/2017/chinas-calculus-hypersonic-glide>.

<sup>41</sup> “Gliding missiles that fly faster than Mach 5 are coming,” *The Economist*, April 6, 2019, <https://www.economist.com/science-and-technology/2019/04/06/gliding-missiles-that-fly-faster-than-mach-5-are-coming>; and Franz-Stefan Gady, “China Tests New Weapon Capable of Breaching US Missile Defense Systems,” *The Diplomat*, April 28, 2016, <https://thediplomat.com/2016/04/china-tests-new-weapon-capable-of-breaching-u-s-missile-defense-systems/>.

<sup>42</sup> *U.S.-China Economic and Security Review Commission 2015 Annual Report*, p. 20, [https://www.uscc.gov/sites/default/files/annual\\_reports/2015%20Annual%20Report%20to%20Congress.PDF](https://www.uscc.gov/sites/default/files/annual_reports/2015%20Annual%20Report%20to%20Congress.PDF).

<sup>43</sup> Jessie Yeung, “China claims to have successfully tested its first hypersonic aircraft,” *CNN*, August 7, 2018, <https://www.cnn.com/2018/08/07/china/china-hypersonic-aircraft-intl/index.html>. See also *U.S.-China Economic and Security Review Commission 2018 Annual Report*, p. 220, [https://www.uscc.gov/sites/default/files/annual\\_reports/2018%20Annual%20Report%20to%20Congress.pdf](https://www.uscc.gov/sites/default/files/annual_reports/2018%20Annual%20Report%20to%20Congress.pdf).

<sup>44</sup> *U.S.-China Economic and Security Review Commission Report 2015*, p. 20.

<sup>45</sup> Bill Gertz, “China Reveals Test of New Hypersonic Missile,” *The Washington Free Beacon*, August 10, 2018, <https://freebeacon.com/national-security/chinas-reveals-test-new-hypersonic-missile/>.

## *International Institutions*

There is currently no international regime dedicated to overseeing the development of hypersonic weapons. Although the New START Treaty, a strategic offensive arms treaty between the United States and Russia, does not specifically cover hypersonic weapons, it does cover intercontinental ballistic missiles, which could be used to launch hypersonic glide vehicles.<sup>46</sup> Furthermore, Article V of the treaty states that “when a Party believes that a new kind of strategic offensive arm is emerging, that Party shall have the right to raise the question of such a strategic offensive arm for consideration in the Bilateral Consultative Commission (BCC).” Accordingly, some legal experts hold that it would be possible to negotiate to include hypersonic weapons in the New START limits.<sup>47</sup> However, because New START is due to expire in 2021, unless extended through 2026, this solution may be temporary.<sup>48</sup> In addition, it would not cover hypersonic weapons developed in countries other than the United States and Russia.

## **Directed-Energy Weapons**

DOD defines directed-energy (DE) weapons as those using concentrated electromagnetic energy, rather than kinetic energy, to “incapacitate, damage, disable, or destroy enemy equipment, facilities, and/or personnel.” DE weapons—often colloquially referred to as “lasers”—could be used by ground forces in counter rocket, artillery, and mortar (C-RAM) or short-range air defense (SHORAD) missions. They could offer low costs per shot and nearly limitless magazines that, in contrast to existing conventional systems, could enable an efficient and effective means of defending against missile salvos and swarms of unmanned vehicles. Theoretically, DE weapons could also provide options for boost-phase missile intercept, given their speed-of-light travel time; however, as in the case of hypersonic missile defense, experts disagree on the affordability, technological feasibility, and utility of this application.

High-powered microwave weapons, a subset of DE weapons, could be used as a nonkinetic means of disabling electronics, communications systems, and improvised explosive devices in the event of a conflict, or as a nonlethal “heat ray” system for crowd control.

## *United States*

In 2014, the U.S. Navy fielded the first—and, to date, only—operational DE weapon, the Laser Weapon System (LaWS), aboard the USS Ponce. LaWS was a 30-kilowatt laser prototype that “was capable of blinding enemy forces as a warning, shooting down drones, disabling boats, or damaging helicopters.”<sup>49</sup> The Navy plans to deploy its 60-kilowatt laser, HELIOS, aboard the USS Preble in 2021. The U.S. military has previously developed the Active Denial System, a high-powered microwave weapon used for crowd control; however, the system was recalled—likely due to ethical and operational considerations.

The Army, Navy, Air Force, and DARPA each have DE development programs underway, with the Pentagon requesting \$235 million for directed-energy weapons and directed-energy defensive capabilities

---

<sup>46</sup> For example, Russia’s Avangard hypersonic glide vehicle is reportedly launched by an intercontinental ballistic missile. See Rachel S. Cohen, “Hypersonic Weapons: Strategic Asset or Tactical Tool?”

<sup>47</sup> James Acton notes: “during [New START] negotiations, Russia argued that boost-glide weapons might constitute ‘a new kind of strategic offensive arm,’ in which case they would trigger bilateral discussions about whether and how they would be regulated by the treaty—a position [then] rejected by the United States.” James M. Acton, *Silver Bullet?: Asking the Right Questions about Conventional Prompt Global Strike*, Carnegie Endowment for International Peace, 2013, p. 139, <https://carnegieendowment.org/files/cpgs.pdf>.

<sup>48</sup> CRS Report R41219, *The New START Treaty: Central Limits and Key Provisions*, by Amy F. Woolf.

<sup>49</sup> Kyle Mizokami, “The U.S. Army Plans To Field the Most Powerful Laser Weapon Yet,” *Popular Mechanics*, August 7, 2019.

in FY 2020. These programs are intended to scale up power levels from around 150 kilowatts, as is currently feasible, to around 300 kilowatts, a level at which cruise missiles could be intercepted.<sup>50</sup>

### ***Russia***

Russia claims to have fielded the Peresvet ground-based DE weapon system in December 2018. Although little is publicly known about Peresvet, including its power level, the weapon can reportedly disrupt Global Positioning System (GPS) and communications signals and may be able to perform an anti-satellite mission.<sup>51</sup>

### ***China***

China has reportedly developed a 30 kilowatt road-mobile DE system, LW-30, designed to engage unmanned aerial vehicles and precision-guided weapons.<sup>52</sup> China claims the system is comparable to Russia's Peresvet. Reports indicate that China is also developing an airborne DE weapon pod.<sup>53</sup>

According to the Defense Intelligence Agency, China is additionally pursuing DE weapons

to disrupt, degrade, or damage satellites and their sensors and possibly already has a limited capability to employ laser systems against satellite sensors. China likely will field a ground-based laser weapon that can counter low-orbit space-based sensors by 2020, and by the mid-to-late 2020s, it may field higher power systems that extend the threat to the structures of non-optical satellites.<sup>54</sup>

### ***International Institutions***

As a discussion paper for the UN Convention on Certain Conventional Weapons notes, DE weapons, “are not authoritatively defined under international law, nor are they currently on the agenda of any existing multilateral mechanism.”<sup>55</sup> Certain applications of DE weapons are, however, prohibited. For example, Protocol IV of the CCW “Protocol on Blinding Lasers,” prohibits “excessively injurious” applications of DE weapons, including the use of DE weapons to permanently blind enemy combatants.

### **Biotechnology**

Biotechnology leverages life sciences for technological applications. A number of developments in biotechnology hold potential implications for international security. As a 2018 Government Accountability Office report notes, the Departments of Defense, State, and Homeland Security, and the Office of the Director of National Intelligence, all assess that biotechnologies, such as the low-cost gene-editing tool CRISPR, have the potential to “alter genes or create DNA to modify plants, animals, and humans. Such biotechnologies could be used to enhance [or degrade] the performance of military personnel. The proliferation of synthetic biology—used to create genetic code that does not exist in nature—may increase the number of actors that can create chemical and biological weapons.” In addition,

---

<sup>50</sup> Sydney J. Freedberg Jr., “Lasers to Kill Cruise Missiles Sought by Navy, Air Force, Army,” *Breaking Defense*, October 29, 2019.

<sup>51</sup> Defense Intelligence Agency, *Challenges to Security in Space*, February 2019, p. 23, [https://www.dia.mil/Portals/27/Documents/News/Military%20Power%20Publications/Space\\_Threat\\_V14\\_020119\\_sm.pdf](https://www.dia.mil/Portals/27/Documents/News/Military%20Power%20Publications/Space_Threat_V14_020119_sm.pdf).

<sup>52</sup> Nikolai Novichkov, “Airshow China 2018: CASIC’s LW-30 laser weapon system breaks cover,” *Jane’s Defence Weekly*, November 9, 2018.

<sup>53</sup> Andrew Tate, “China aiming to procure airborne laser-based weapon pod,” *Jane’s Defence Weekly*, January 8, 2020.

<sup>54</sup> Defense Intelligence Agency, *Challenges to Security in Space*, p. 20.

<sup>55</sup> “Directed Energy Weapons: Discussion paper for the Convention on Certain Conventional Weapons (CCW),” Article 36, November 2017.

biotechnology could be used to create adaptive camouflage, cloaking devices, or lighter and stronger body armor.<sup>56</sup> U.S. competitors may be less restrained in both researching and applying biotechnology, particularly as it relates to human performance modification and biological weapons.<sup>57</sup>

### ***United States***

There is no coordinating body for biotechnology research within the U.S. government, nor is there a DOD-specific biotechnology research strategy.<sup>58</sup> However, pursuant to Section 1086 of the FY 2017 NDAA,<sup>59</sup> the Trump Administration released the *National Biodefense Strategy*, which outlines “how the United States Government will manage its activities more effectively to assess, prevent, detect, prepare for, respond to, and recover from biological threats, coordinating its biodefense efforts with those of international partners, industry, academia, non-governmental entities, and the private sector.”<sup>60</sup>

U.S. biotechnology programs with national security applications are primarily centered on improving military “readiness, resilience, and recovery.” DARPA, for example, has a number of biotechnology programs devoted to battlefield medicine, diagnostics, and prognostics. It is also exploring options for mitigating the effects of traumatic brain injury, treating neuropsychiatric illnesses such as depression and post-traumatic stress, and protecting against infectious diseases and bio-engineered threats to the U.S. food supply. In addition, DARPA’s Safe Genes program seeks “to [protect] servicemembers from accidental or intentional misuse of genome editing technologies.”<sup>61</sup> Biotechnology research also continues at the service laboratories, which recently completed a \$45 million, three-year joint research initiative in synthetic biology.<sup>62</sup> Overall U.S. government spending on biotechnology is difficult to track; however, a report prepared for the U.S.-China Economic and Security Review Commission notes that “the largest contributors to life science spending were the Department of Health and Human Services (HHS) (\$25.1 billion), US Department of Agriculture (USDA) (\$1.8 billion), Department of Defense (\$0.8 billion), and National Science Foundation (NSF) (\$0.7 billion).”<sup>63</sup>

### ***Russia***

The Russian biotechnology sector lags behind that of the United States and China. According to one recent study, Russia imports more than 80 percent of its biotechnology products.<sup>64</sup> In recognition of this deficiency, Russia released BIO2020, the country’s whole-of-government strategy for developing a

---

<sup>56</sup> Patrick Tucker, “The US Army Is Making Synthetic Biology a Priority,” *Defense One*, July 1, 2019.

<sup>57</sup> Daniel R. Coats, Director of National Intelligence, “Statement for the Record: Worldwide Threat Assessment of the US Intelligence Community,” U.S. Senate Committee on Armed Services, March 6, 2018.

<sup>58</sup> Diane Dieuliis, “Biotechnology for the Battlefield: In Need of a Strategy,” *War on the Rocks*, November 27, 2018. There is, however, a coordinated framework for biotechnology regulation. See “Modernizing the Regulatory System for Biotechnology Products: Final Version of the 2017 Update to the Coordinated Framework for the Regulation of Biotechnology,” January 2017, [https://www.epa.gov/sites/production/files/2017-01/documents/2017\\_coordinated\\_framework\\_update.pdf](https://www.epa.gov/sites/production/files/2017-01/documents/2017_coordinated_framework_update.pdf).

<sup>59</sup> P.L. 114-328, Section 2, Division A, Title X, §1086.

<sup>60</sup> The White House, *National Biodefense Strategy*, 2018, <https://www.whitehouse.gov/wp-content/uploads/2018/09/National-Biodefense-Strategy.pdf>.

<sup>61</sup> See Defense Advanced Research Projects Agency, “Our Research: Biological Technologies Office,” <https://www.darpa.mil/our-research?Filter=&oFilter=1>.

<sup>62</sup> Marisa Alia-Novobilski, “Tri-Service effort leverages synthetic biology expertise to address future warfighter needs,” Wright-Patterson AFB, September 27, 2017.

<sup>63</sup> “China’s Biotechnology Development: The Role of US and Other Foreign Engagement,” Prepared for the U.S.-China Economic and Security Review Commission, February 14, 2019, p. 42.

<sup>64</sup> Anna Grebenyuk and Nikolai Ravin, “The long-term development of Russian biotech sector,” *Emerald Insight*, September 11, 2017.

biotechnology sector worth approximately 1% of gross domestic product (GDP) by 2020 and for “creating the conditions” for a sector worth at least 3% of GDP by 2030.<sup>65</sup> BIO2020 identifies Russia’s priority areas for biotechnology research as biopharmaceutics and biomedicine, industrial biotechnology and bioenergetics, agricultural and food biotechnology, forest biotechnology, environmental protection biotechnology, and marine biotechnology. Little information is publicly available with regard to how Russia might employ such technologies within a military or national security context. However, the accusation that the country recently attempted to assassinate a former double agent for the United Kingdom using a Novichok nerve agent—in violation of the 1992 Chemical Weapons Convention—suggests that it may be similarly unrestrained with regard to the use of biological agents.<sup>66</sup> Furthermore, the Soviet Union is known to have maintained an extensive, long-standing biological weapons program, Biopreparat, in violation of the 1972 Biological Weapons Convention.<sup>67</sup>

## *China*

Motivated by an aging population and growing health care needs, China has been particularly interested in conducting biotechnology research. Biotechnology is cited as a key strategic priority within China’s Made in China 2025 initiative and is additionally highlighted within China’s current five-year development plan. This plan “stipulates that the biotechnology sector should exceed 4% of gross domestic product by 2020 and that there should be 10 to 20 life-science parks for biomedicine with an output surpassing 10 billion yuan (US\$1.5 billion).”<sup>68</sup> Some reports suggest that the Chinese government may be spending as much as \$600 million annually on biotechnology research; however, China’s biotechnology market remains less than a tenth of the size of the U.S. market.<sup>69</sup>

In particular, China is aggressively pursuing biotechnologies for genetic testing and precision medicine. In 2016, Chinese scientists became the first to use the CRISPR gene-editing tool on humans. In 2018, a Chinese scientist produced—perhaps with the approval of the Chinese government—the first “gene-edited babies,” although amidst international outcry China later sentenced the scientist to three years in jail and termed his work “extremely abominable in nature.”<sup>70</sup> China additionally maintains one of the world’s largest repositories of genetic information, the National Genebank, which includes U.S. genetic data. Such information could be used to develop personalized disease treatment plans or, potentially, precision bioweapons.<sup>71</sup>

## *International Institutions*

Only the weaponization of biotechnology is prohibited under international law.<sup>72</sup> Some international institutions have demonstrated interest in considering the implications of biotechnology. For example, since 1983, ASEAN has maintained a sub-committee on biotechnology, which facilitates coordination on

---

<sup>65</sup> Russian Federation, “BIO2020: Summary of the State Coordination Program for the Development of Biotechnology in the Russian Federation,” 2012, [http://bio-economy.ru/upload/BIO2020%20\(eng\)%20-%20short.pdf](http://bio-economy.ru/upload/BIO2020%20(eng)%20-%20short.pdf).

<sup>66</sup> Mark Urban, “Salisbury attack ‘evidence’ of Russian weapon stockpile,” *BBC*, March 4, 2019.

<sup>67</sup> Lukas Trakimavičius “Is Russia Violating the Biological Weapons Convention?,” Atlantic Council, May 23, 2018, <https://www.atlanticcouncil.org/blogs/new-atlanticist/is-russia-violating-the-biological-weapons-convention/>.

<sup>68</sup> Shannon Ellis, “Biotech Booms in China,” *Nature*, January 17, 2018.

<sup>69</sup> “China’s Biotechnology Development: The Role of US and Other Foreign Engagement.”

<sup>70</sup> Michael Standaert, “‘Extremely abominable’: Chinese gene-editing scientist faces law,” *Al Jazeera*, November 26, 2018. See also, Elsa Kania, “Weaponizing Biotech: How China’s Military Is Preparing for a ‘New Domain of Warfare,’” *Defense One*, August 14, 2019.

<sup>71</sup> David J. Lynch, “Biotechnology: the US-China dispute over genetic data,” *Financial Times*, July 31, 2017.

<sup>72</sup> The United States, China, and Russia have ratified the 1972 Biological Weapons Convention, which is a legally binding treaty that bans the development and production of biological weapons.

regional biotechnology projects. Similarly, since 1993, the OECD has maintained an Internal Coordination Group for Biotechnology, which monitors developments in biotechnology and facilitates coordination among various sectors involved in biotechnology research (e.g., agriculture, science and technology, environment, industry).

In addition, the 1972 Biological Weapons Convention requires review conferences, which assess both the implementation of the treaty and ongoing developments in biotechnology, every five years. Annual meetings are held between review conferences to informally consider these topics as well as to address national bilateral and multilateral efforts to enhance biosecurity.

### **Potential Implications of Emerging Technologies for International Security**

The implications of emerging technologies for international security and strategic stability are difficult—if not impossible—to predict, as they will be a function of many factors, including the rate of technological advancement in both the United States and competitor nations, the manner in which emerging technologies are integrated into existing military forces, the interactions between emerging technologies, and the extent to which national policies and international law enable or inhibit their development, integration, and use.

Nonetheless, many emerging technologies exhibit characteristics that could potentially impact the future character of war. For example, developments in technologies such as artificial intelligence, Big Data analytics, and lethal autonomous weapons could diminish or remove the need for a human operator. This could, in turn, increase combat efficiency and accelerate the pace of combat—potentially with destabilizing consequences.

Emerging technologies could also potentially shift the offense-defense balance. For example, some analysts have suggested that swarms of coordinated, unmanned vehicles could overwhelm defensive systems, providing a greater advantage to the attacker, while directed-energy weapons that provide a low-cost means of neutralizing such attacks, could favor the defender.