State of AI

Artificial intelligence, the military and increasingly autonomous weapons

PAX

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Engaging the private sector

This report is part of the PAX project aimed at dissuading the private sector from contributing to the development of lethal autonomous weapons. These weapons pose a serious threat to international peace and security, and would violate fundamental legal and ethical principles.

PAX aims to engage with the private sector to help prevent lethal autonomous weapons from becoming a reality.

In a series of four reports we look into which actors could potentially be involved in the development of these weapons. Each report will look at a different group of actors, namely states, the tech sector, universities & research institutes, and arms producers. This project is aimed at creating awareness in the private sector about the concerns related to lethal autonomous weapons, and at working with private sector actors to develop guidelines and regulations to ensure their work does not contribute to the development of these weapons.

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About PAX

PAX works with committed citizens and partners to protect civilians against acts of war, to end armed violence and to build peace. PAX operates independently of political interests.

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1. Introduction

In September 2017, President Putin stated in a speech on national TV that "Artificial intelligence is not only the future of Russia, it is the future of all mankind. [...] The one who becomes the leader in this sphere will be the lord of the world".[1] In September 2018, the Pentagon pledged to make the largest investment to date in artificial intelligence (AI) systems for US weaponry, committing to spend USD 2 billion over the next five years through its Defense Advanced Research Projects Agency (DARPA), to "develop [the] next wave of AI technologies".[2] It is not only the United States and Russia that are investing in the military application of AI; other countries also have specific programmes looking at how to best apply these new technologies to warfare.

So are we at the dawn of an AI arms race? Or is this arms race already underway? A fully-fledged AI arms race will have negative economic, political and societal impacts and will severely endanger international peace and security. The huge amounts of money invested in military technologies could alternatively be used for education, healthcare and other socio-economic purposes.

Furthermore, an AI arms race would push states to develop autonomous systems as rapidly as possible to keep ahead of adversaries, with little time for appropriate reflection on the long-term effects of the introduction of such new technologies. So states should not be asking 'How can we *win* the AI arms race?' but rather 'How can we *prevent* an AI arms race?'

WHAT ARE LETHAL AUTONOMOUS WEAPON SYSTEMS?

Lethal autonomous weapon systems are weapons that can select and attack individual targets without meaningful human control.[3] This means the decision on whether a weapon should deploy lethal force is delegated to a machine. This development would have an enormous effect on the way war is conducted and has been called the third revolution in warfare, after gunpowder and the atomic bomb. The function of autonomously selecting and attacking targets could be applied to various platforms, for instance a battle tank, a fighter jet or a ship.

Lethal autonomous weapons raise many legal, ethical and security concerns. It would be deeply unethical to delegate the decision over life and death to a machine or algorithms. These weapons are also unlikely to comply with International Humanitarian Law (IHL, also known as the law of war), as it is unlikely that they will be able to properly distinguish between civilians and combatants, or to make a proportionality assessment. Lethal autonomous weapons also create an accountability vacuum in terms of who responsibility can be attributed to in the case of an unlawful act. The deployment of lethal autonomous weapons could lead to accidental wars and rapid escalation of conflicts, as well as other unintended but dangerous consequences. It is unclear how lethal autonomous weapons designed and deployed by opposing forces would react and interact with each other.

This report

This report analyses developments in seven key countries: the United States, China, Russia, the United Kingdom, France, Israel and South Korea. These states are among those most heavily involved in AI development, particularly with regard to its military applications. Each chapter focuses on one country and spells out, if applicable, their national AI policies and military AI strategies/policies. It then looks at AI-related military projects, including cooperation with the private sector and academia. The research is based on information available in the public domain. This report is not intended to be an exhaustive overview; instead, it focuses on the most relevant aspects.

States mostly commission companies and research institutes to develop increasingly autonomous weapons. Whereas in the past this was naturally the domain of the arms industry, with the emergence of the digital era, the tech sector and tech departments at universities have become increasingly involved. Thus, this report shows the linkages between the public and private sectors in the area of military technology with increasingly autonomous capabilities.

Since lethal autonomous weapons are being developed within a continuum, with levels of technology varying from simple automation to full autonomy, and in different functionalities of weapon systems, we see a slippery slope where the human role is gradually diminishing in the decision-making loop regarding the use of force. Therefore PAX believes that it is imperative that states draw a clear line, guaranteeing meaningful human control over decisions on the use of force. Hoping to contribute to that discussion, this paper illustrates some developments in this area that are currently operational or under development, with varying levels of (proclaimed) autonomy or use of AI. As not all technical information is publicly available, PAX does not draw conclusions from these perceived levels of autonomy and human control.

This report is the first in a series of four. The following three will focus on three different sectors potentially working on artificial intelligence and increasingly autonomous weapon systems: the tech sector, universities & research institutes, and the arms industry. While we believe states should lead developments towards a pre-emptive ban on lethal autonomous weapons without meaningful human control, we also believe that scientists and companies working on these and related technologies have an interest and indeed a role to play in preventing such weapons from becoming reality.[4]

2. United States of America

State of artificial intelligence in the US

The United States is currently seen as the world leader in artificial intelligence due to the large number of leading tech companies (Google, Microsoft, Amazon, Facebook and Apple) based in the US. It is also the leading player in academic AI research.[5] The heart of research and development (R&D) in AI and related technologies is in California's Silicon Valley. Despite that leadership, the US has no official national AI *strategy*, and in that sense it is lagging behind the 18 countries that to date have outlined such a strategy.[6] But both the government and the military are eager to encourage innovation and maintain American leadership in this area.

In October 2016, the Obama administration issued the report 'Preparing for the Future of Artificial Intelligence' and a strategic plan.[7] It discusses how AI can be used to "advance social good and improve government operations", how to adapt regulations in a way that "encourages innovation while protecting the public", how to ensure that AI applications are "fair, safe, and governable", and how to develop a skilled AI workforce.

Some two years later, in July 2018, the administration released a memo highlighting national R&D priorities, with computing, AI and autonomous systems mentioned prominently, both in a general context and in a military context:

> *"As adversaries leverage emerging technologies to threaten the nation, it is imperative that we invest in R&D to maintain military superiority and keep the American people safe. This requires prioritized investment in AI, autonomous systems, hypersonics, a modernized nuclear deterrent, and advanced microelectronics, computing, and cyber capabilities."*[8]

President Trump signed an executive order in February 2019, affirming that AI leadership is of importance to "maintaining the economic and national security of the United States and to shaping the global evolution of AI in a manner consistent with [the] Nation's values, policies, and priorities".[9] This executive order establishes the American AI Initiative, guided by five principles:

- Drive technological breakthroughs in AI across the federal government, industry and academia to promote scientific discovery, economic competitiveness and national security;
- Drive development of technical standards and reduce barriers to the safe testing and deployment of AI technologies;

- Train American workers to develop and apply AI technologies;
- Foster public trust and confidence in AI technologies and protect civil liberties, privacy and American values;
- Promote an international environment that supports American AI research and innovation and opens markets for American AI industries, while protecting technological advantage in AI and protecting critical AI technologies from acquisition by strategic competitors and adversarial nations.

While the initiative will redirect funding towards AI research, the "program includes no new funding for AI development, and is thin on details".[10] A more detailed AI plan is expected to be released mid-2019.

THE US POSITION ON LETHAL AUTONOMOUS WEAPONS AT THE UN

In April 2018, the US underlined the need to develop "a shared understanding of the risk and benefits of this technology before deciding on a specific policy response. We remain convinced that it is premature to embark on negotiating any particular legal or political instrument in 2019".[11] The country stated that "[t]here remains a lack of common understanding on various issues related to LAWS, including their characteristics and elements. We recognize that these are complex issues, and we need to continue to educate ourselves and deepen our collective understanding".[12] "The United States also continues to believe that advances in autonomy and machine learning can facilitate and enhance the implementation of IHL, including the principles of distinction and proportionality. One of our goals is to understand more fully how this technology can continue to be used to reduce the risk to civilians and friendly forces in armed conflict".[13]

AI in the military

THE PENTAGON'S AI POLICY

AI technologies have been on the US Department of Defense (DoD) radar for decades. Moreover, separate branches of the military (army, navy and air force) have each published on the use of AI in their respective domains. This report will focus on the general DoD strategy.

The key point of reference is the 2014 'Third Offset Strategy', which seeks to outmanoeuvre advantages made by top adversaries through technology. As the then Deputy Secretary of Defence Bob Work put it in 2016: "We believe quite strongly that the technological sauce of the Third Offset is going to be advances in Artificial Intelligence (AI) and autonomy".[14] According to him the Third Offset's aim "is to exploit all advances in artificial intelligence and autonomy and insert them into DoD's battle networks to achieve a step increase in performance that the department believes will strengthen conventional deterrence".[15]

The abovementioned 2016 report 'Preparing for the Future of Artificial Intelligence' also refers to the weaponisation of AI:

> *"Given advances in military technology and artificial intelligence more broadly, scientists, strategists, and military experts all agree that the future of LAWS is difficult to predict and the pace of change is rapid. Many new capabilities may soon be possible, and quickly able to be developed and operationalized. The Administration is engaged in active, ongoing interagency discussions to work toward a government-wide policy on autonomous weapons consistent with shared human values, national security interests, and international and domestic obligations."*[16]

In August 2018, a Pentagon strategy report noted that the "technologies underpinning unmanned systems would make it possible to develop and deploy autonomous systems that could independently select and attack targets with lethal force" but that commanders were reluctant to surrender control to such systems, in part due to lack of confidence in the machine-learning system.[17] That is why one of the numerous AI programmes that **DARPA** is working on is the Explainable AI programme, which aims to create machine-learning techniques that produce more explainable models "while maintaining a high level of learning performance", and enable human users "to understand, appropriately trust, and effectively manage the emerging generation of artificially intelligent partners".[18]

A day after the White House's American AI Initiative, the DoD released its AI strategy, which calls for the rapid deployment of "resilient, robust, reliable, and secure" AI-enabled technologies to "address key missions" across the DoD".[19] This strategy puts the Joint Artificial Intelligence Centre (**JAIC**) at the forefront of efforts, focusing on collaborations with the private sector and academia. Again, this AI strategy is unclear about how its implementation will be funded.[20]

POLICY ON LETHAL AUTONOMOUS WEAPON SYSTEMS

The US is one of the very few states to have a policy specifically on lethal autonomous weapon systems. In its 2012 3000.09 Directive, the DoD states that "semi-autonomous weapon systems that are onboard or integrated with unmanned platforms must be designed such that, in the event of degraded or lost communications, the system does not autonomously select and engage individual targets or specific target groups that have not been previously selected by an authorized human operator".[21] The regulation refers to "human-supervised autonomous weapons systems" that are limited to military purposes, prohibits the "selecting of humans as targets" and allows for computer-controlled non-lethal systems.

General Paul Selva, the second-highest-ranking military officer in the US, said in 2016 that the US would have the technology within a decade to build an autonomous system that could decide on its own who and when to kill, but added that the US has no intention of building one. That same year, then Deputy Secretary of Defense Bob Work also confirmed that when it comes to decisions over life and death, "there will always be a man in the loop".[22]

However, there is a loophole in the Directive: any use of autonomous or semi-autonomous systems that falls outside its scope must be approved by three top Pentagon officials. But what they consider as "appropriate levels of human judgment in the use of force" is left undefined.[23] Also the term 'human in the loop' does not appear anywhere in the directive. "The Directive does not use the phrase 'human in the loop,' so we recommend not indicating that DoD has established requirements using that term," according to a DoD spokesperson.[24]

MILITARY PROGRAMMES AND INITIATIVES

There are many different DoD programmes and initiatives looking at military applications of AI, as

well as more specifically at autonomous weapon systems. According to DARPA itself, it "has played a leading role in the creation and advancement of artificial intelligence (AI) technologies that have produced game-changing capabilities for the Department of Defense" over the past 60 years.[25]

To stay ahead of others, especially China, the US military has increased its commitment. In September 2018, the Pentagon pledged to make the largest investment to date in AI systems for US weaponry, committing to spend USD 2 billion over the next five years through DARPA to "develop [the] next wave of AI technologies".[26]

One example is DARPA's Collaborative Operations in Denied Environment (**CODE**) programme. DARPA points out that most current unmanned aerial systems require "continuous control by a dedicated pilot and sensor operator supported by numerous telemetry-linked analysts". Hence, the CODE programme aims to develop new algorithms or software "for existing unmanned aircraft that would extend mission capabilities and improve U.S. forces' ability to conduct operations in denied or contested airspace". In addition, "using collaborative autonomy, CODE-enabled unmanned aircraft would find targets and engage them as appropriate under established rules of engagement, leverage nearby CODE-equipped systems with minimal supervision, and adapt to dynamic situations such as attrition of friendly forces or the emergence of unanticipated threats".[27] Testing was undertaken by arms producers Lockheed Martin and Raytheon.[28]

It was reported in March 2019 that a Pentagon project may lead to the world's "first large-scale armed unmanned warship". The **Overlord** programme "will develop core autonomy" and field prototype unmanned surface vessels "capable of being seamlessly operable with the fleet".[29]

Another example is the army's Advanced Targeting and Lethality Automated System (**ATLAS**), which "will use artificial intelligence and machine learning to give ground-combat vehicles autonomous target capabilities" that will allow weapons to "acquire, identify, and engage targets at least 3X faster than the current manual process".[30] Still, it appears that a human makes the final decision to attack a target.[31]

Cooperation with the private sector

The United States DoD recognises that expertise in artificial intelligence lies with the private sector, and specifically tech companies and research institutes. In this section we look at the initiatives the Pentagon has undertaken to stimulate cooperation, the challenges involved in that cooperation, and examples of cooperation with the private sector.

INITIATIVES TO FACILITATE COOPERATION

Acknowledging the innovative power of the private sector, the DoD is keen to have better connections with the engineers in Silicon Valley. Indeed, recent initiatives demonstrate that public-private partnership is a US military AI priority. One such initiative is the Defense Innovation Unit Experimental (**DIUx**), set up in 2015 and "meant to serve as a liaison between the Defence Department and the tech world".[32] The DIUx contracts companies "offering solutions in a variety of areas—from autonomy and AI to human systems, IT, and space—to solve a host of defence problems".[33] The DIUx was set up initially as an experiment, but in August 2018 the DoD announced that it would be renamed the Defense Innovation Unit (**DIU**) "to convey a sense of permanence to the agency".[34]

CHALLENGES IN COOPERATING WITH THE TECH SECTOR

Establishing collaboration with private companies can be challenging as well, as the widely publicised case of Google and **Project Maven** has shown. Launched in April 2017, the objective of Project Maven is to "turn the enormous volume of data available to the DoD into actionable intelligence and insights at speed".[35] To do so, "the project aims to develop and integrate 'computer-vision algorithms needed to help the military and civilian analysts encumbered by the sheer volume of full-motion video data that DoD collects every day in support of counterinsurgency and counterterrorism operations,' according to the Pentagon".[36] The project was known for its collaboration with Google. However, following protests from Google employees, Google stated that it would not renew its contract.[37] Nevertheless, other tech companies such as Clarifai, Amazon and Microsoft still collaborate with the Pentagon on this project.[38]

The Project Maven controversy deepened the gap between the AI community and the Pentagon. To bridge it, two new initiatives have been developed.[39] One is the creation of the aforementioned JAIC with the goal of "accelerating the delivery of AI-enabled capabilities, scaling the Department-wide impact of AI, and synchronizing DoD AI activities to expand Joint Force advantages", by "collaborating within DoD, across government, and with industry, academia, and US allies to strengthen partnerships, highlight critical needs, solve problems of urgent operational significance, and adapt AI technologies for DoD missions".[40]

As a result of this controversy, the DoD is working on a new review of AI ethics through the Defense Innovation Board (DIB). It aims to develop principles for the use of AI by the military, "particularly while the adoption of this technology is at a nascent stage".[41] According to the DIB, "these AI Principles should demonstrate DoD's commitment to deter war and use AI responsibly to ensure civil liberties and the rule of law are protected".[42]

CONTINUING COOPERATION WITH THE PRIVATE SECTOR

At the same time, there is a long history of tech sector cooperation through DARPA programmes. One recent example is the **OFFSET** programme (OFFensive Swarm-Enabled Tactics), with the aim of "using swarms compromising upwards of 250 unmanned aircraft systems (UASs) and/or unmanned ground systems (UGSs) to accomplish diverse missions in complex urban environments".[43] This programme is being undertaken in collaboration with Carnegie Mellon University, Cornell University, Michigan Technological University and others, as well as with start-ups such as Corenova Technologies, Inc.[44]

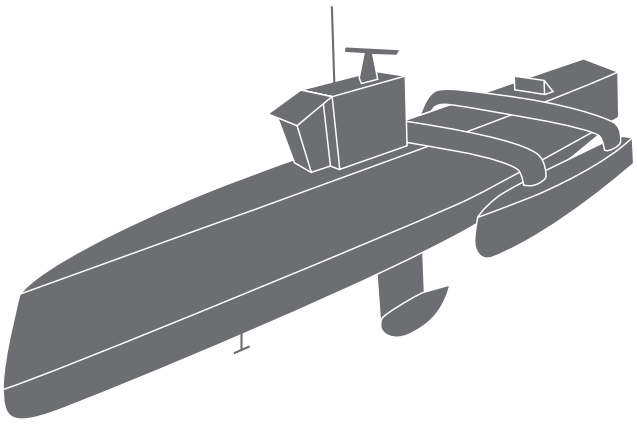
Another programme is the **Squad X Experimentation Programme**,[45] which is exploring four key technical areas: precision engagement, non-kinetic engagement, squad sensing and squad autonomy.[46] The aim of the programme is for human fighters to "have a greater sense of confidence in their autonomous partners, as well as a better understanding of how the autonomous systems would likely act on the battlefield",[47] as well as to "extend and enhance the situational awareness of small, dismounted units".[48] In this programme, Lockheed Martin Missiles is working on approaches to "provide unique capabilities to enhance ground infantries".[49]

One of the most publicised programmes is the Joint Enterprise Defense Infrastructure (**JEDI**), aiming to use "commercial cloud services to transform how DoD captures, processes, understands, and harnesses its data to deliver advanced capabilities, enable real-time decision-making, and support joint force operations".[50] It has been reported that "the real force driving Jedi is the desire

to weaponize AI—what the defence department has been calling 'algorithmic warfare'. By pooling the military's data into a modern cloud platform, and using the machine-learning services that such platforms provide to analyse the data, JEDI will help the Pentagon realize its AI ambitions".[51] The JEDI contract is reportedly worth USD 10 billion,[52] and many big tech companies have submitted bids, including Microsoft, Oracle and IBM.[53] Amazon is believed to be the main contender.[54]

DARPA also has the **Gremlins programme**. The programme "envisions launching groups of UASs from existing large aircraft such as bombers or transport aircraft [...] while those planes are out of range of adversary defences". The rationale is that being able to send larger numbers of UASs "with coordinated, distributed capabilities" could provide the US with better operational flexibility at a much lower cost.[55] In May 2018, it was announced that the Phase III contract had been awarded to Dynetics.[56]

In February 2019, it was announced that the DoD is launching the US Army's **Artificial Intelligence Task Force** in collaboration with Carnegie Mellon University (CMU). The location of this task force will allow the army to work closely with CMU as well as other universities and companies in the Pittsburgh region.[57] The DoD is investing USD 72 million in the five-year effort. "Tackling difficult science and technology challenges is rarely done alone and there is no greater challenge or opportunity facing the Army than Artificial Intelligence," said the director of the army's corporate laboratory.[58]



3. China

State of artificial intelligence in China

"China is poised to enter a 'golden age' for AI development based on government support for this research, growing public and commercial entity participation, and global partnerships that leverage the expertise of US companies", according to a 2016 report by the US-China Economic and Security Review Commission of the US Congress.[59] Indeed, China gives AI a high priority as a key aspect of national and military power.[60] Chinese tech companies such as Baidu, Alibaba, Tencent and Huawei have grown to become world players.

In July 2017, China released the 'New Generation Artificial Intelligence Development Plan' (AI Plan).[61] This plan outlines China's strategic goals in three steps. The first step, to be completed by 2020, "is to keep up the overall technology and application of artificial intelligence with the advanced level of the world".[62] The second step is for China to achieve major breakthroughs in terms of basic AI theory by 2025. The third step is that by 2030, China "shall make artificial intelligence theory, technology and application achieve the world's leading level to be the major artificial intelligence innovation centre of the world, intelligent economy, intelligent society achieve remarkable results, and lay an important foundation for China's entry into the forefront of the innovative countries and economic powers".[63] Within these steps, AI will notably be applied to "national defence construction, security assessment and control capabilities".[64] All this has been noted as an "extraordinary commitment from the government" to push for AI development, as well as a "very strong signal to everyone that things will happen".[65]

Few doubt that China possesses the elements needed for such advancements in AI, such as "bold, disruption-friendly management styles including actively putting AI high on the agenda, encouraging rapid development and piloting, and fostering cross-functional, agile R&D", as well as a large base of scientists and engineers.[66]

China is also becoming a leader in AI funding. In 2017, "48 per cent of total equity funding of AI start-ups globally came from China, compared to 38 per cent funded by the US, and 13 per cent by the rest of the world".[67] Moreover, China's main tech companies are investing heavily in hiring AI experts, "building new research centres, and investing in data centres".[68]

In December 2017, the country's Ministry of Industry and Information Technology published a document on how to foster the development of AI from 2018 to 2020.[69] This is seen as the Chinese leadership's "vision for a new Chinese economy in the age of AI".[70] According to the head of this Ministry, "accelerating industrialization and application is the key point for the development of artificial intelligence".[71]

In December 2018, China launched the Zhongguancun (Shougang) AI Industrial Park, which will become the world's largest industrial park for AI innovations and applications.[72] It was reported that this park will house up to 400 enterprises and have an annual output worth an estimated EUR 6.6 billion.[73]

THE POSITION OF CHINA ON LETHAL AUTONOMOUS WEAPONS AT THE UN

In April 2018, China demonstrated the "desire to negotiate and conclude" a new protocol for the Convention on Certain Conventional Weapons (CCW) "to ban the use of fully autonomous lethal weapons systems". However, the delegation stressed that the ban would only be for the use of such weapons, and not their development.[74] This differentiation between development and use has raised questions about the exact position of China in relation to lethal autonomous weapons. At the November 2018 CCW Meeting of the High Contracting Parties, China stated that lethal autonomous weapons system raise many problems and that it was necessary to work on legal implementation. It was in favour of continuing discussions the following year that achieve a positive result.[75]

AI in the military

In January 2019, an article in the military's newspaper explained that warfare innovation must aim at intelligent operations and focus on new types of combat forces, including artificial intelligence and unmanned combat systems. The article emphasised that research on operational applications of AI must be strengthened, demonstrating that AI is seen as an important area of development for the military.[76]

At the same time, Chinese officials have expressed concerns relating to a possible arms race associated with AI, as well as the potential need for arms control. This appears reflected in China's ambiguous positioning on lethal autonomous weapons at UN meetings, demonstrating a desire to ban the use of such weapons but not the underlying development.

In September 2018, a white paper published by the China Academy of Information and Communications Technology,[77] part of the powerful Ministry of Industry and Information Technology, called upon the Chinese government to avoid AI arms races. The sentiment is echoed in the private sector, where the chairman of Alibaba has said that new technology, including machine learning and artificial intelligence, could lead to a World War III.[78]

Despite these concerns, China's leadership continues pursuing the use of AI for military purposes. Military officials refer increasingly to "intelligentized" warfare as the future of warfare, and the Chinese military intends to capitalise upon this transformation.[79] Given that much of the military's AI strategy revolves around cooperation with the private sector, other initiatives are explained below.

Cooperation with the private sector

One of the AI Plan's key tasks is to "strengthen AI in the field of military-civilian integration", which means, among other things, to "promote the formation of multi-element, multi-field, highly efficient AI integration of military and civilian pattern" and to "strengthen a new generation of AI technology in command-and-decision, military deduction, defence equipment, strong support, and guide AI in the field of defence technology to civilian applications".[80]

"To advance military innovation, [President] Xi Jinping has called for China to follow 'the road of military-civil fusion-style innovation', such that military innovation is integrated into China's national innovation system".[81] This fusion has been elevated to the level of a national strategy, guided by the **Central Commission for Integrated Military and Civilian Development,** which was established in January 2017 and is headed by Xi Jinping. The Commission is described as "an institutional arrangement to strengthen the Party Central Committee's centralised and unified leadership over major tasks involving the party and the state".[82] Furthermore, the Central Military Commission (CMC)'s **Military Scientific Research Guidance Commission** was created "to exercise high-level leadership on technical innovation, while also seeking to facilitate military-civil fusion in science and technology".[83] These developments show willingness on the part of the Chinese government to strengthen reform as well as promote implementation.[84]

Other initiatives to promote civil-military cooperation include the **Defence and Technology Innovation Rapid Response Group,** launched in March 2018 by the CMC Science and Technology Commission. The aim of this group is to further promote the "integration of military and civilian developments in the domain of science and technology, and to use advanced commercial technologies to serve the military", where "priority fields highlighted [...] include artificial intelligence".[85] The national strategy as well as these initiatives have led to the boundaries between civil and military research and development becoming more and more blurred, which also means that the Chinese military is "often closely associated with cutting-edge research in AI".[86]

The People's Liberation Army (PLA) relies heavily on tech firms and innovative start-ups. The larger AI research organisations in China can be found within the private sector. For instance, SenseTime has around 600 full-time research staff.[87] The army "intends to take advantage of the private sector's most exciting advances in AI to extract military applications".[88]

The government has also increased its influence in tech companies by setting up Communist Party committees "reviewing everything from operations to compliance with national goals". There have also been discussions about taking a 1% stake in some big tech companies like Alibaba and Tencent, along with a seat on the board.[89]

There are a growing number of collaborations between defence and academic institutions in China. There is no sign that moral or ethical considerations will constrain Chinese academics "in the pursuit of military applications of artificial intelligence".[90] For instance, Tsinghua University launched the **Military-Civil Fusion National Defence Peak Technologies Laboratory** to create "a platform for the pursuit of dual-use applications of emerging technologies, particularly artificial intelligence".[91]

However, some Chinese scholars have argued that the development of artificial intelligence should not be without limits. Indeed, Xu Nengwu and Ge Hongchang of China's National University of Defence Technology state that "the international community maintains that the control of autonomous lethal weapons systems is difficult, but necessary" and recommend a framework that emphasises both transparency and legal principles.[92] Furthermore, some Chinese researchers in the private sector (including researchers for Tencent and Baidu) have signed the Future of Life pledge, agreeing that the decision to take a human life should never be delegated to a machine.[93]

Regarding the application of artificial intelligence to weapons, China is currently developing "next generation stealth drones",[94] including for instance Ziyan's **Blowfish A2** model, which, according

to the company, "autonomously performs more complex combat missions, including fixed-point timing detection, fixed-range reconnaissance, and targeted precision strikes".[95] Saudi Arabia and Pakistan are reportedly considering acquiring the Chinese helicopter drone.[96] Another example is the highly advanced CH-7 stealth drone currently being developed by China Aerospace Science and Technology Corp. (CASC). While its design resembles the US X-47B development, its chief designer insists the technology is original.[97]

In the area of land systems, Norinco is leading the way in increasingly autonomous unmanned ground vehicles (UGVs), such as the Cavalry. According to a company spokesman, "some of the major difficulties in putting autonomous unmanned ground vehicles in the field have been the limitations on machine vision and intelligent behaviour", requiring vast amounts of computing power to process information.[98]

4. Russia

State of artificial intelligence in Russia

It is expected that Russia's artificial intelligence market will increase exponentially over the next couple of years, but the amounts involved are still only a fraction of the US market, or even just what the US military spends on this.[99] But AI is clearly a Russian priority. In September 2017, President Putin made a speech on national TV in which he stated that "artificial intelligence is not only the future of Russia, it is the future of all mankind. [...] The one who becomes the leader in this sphere will be the lord of the world".[100]

In March 2018, during the presidential address to the Federal Assembly, he stated that "as soon as possible, we need to develop a progressive legal framework and eliminate all barriers for the development and wide use of robotic equipment, artificial intelligence, unmanned vehicles, e-commerce and Big Data processing technology".[101] Despite this prioritisation, Russia's drive for the development and use of AI currently revolves primarily around its military.[102]

At the time of writing, Russia has no national AI plan or strategy. However, it was announced by Russian private-sector groups that a roadmap for AI development is expected to be released by mid-2019.[103] Reportedly, this roadmap would provide a list of projects that "will help identify and remove barriers to the development of end-to-end technologies, as well as forecast the demand for artificial intelligence technologies in economic sectors".[104] This roadmap will form a cornerstone for the larger national Digital Technologies programme.[105]

A separate initiative is a national strategy on the research and development of AI. In January 2019, Putin ordered his government "to create a national strategy for research into and development of artificial intelligence, according to state media".[106] This strategy will align "government, military, academic, and private resources to speed the country's development of artificial intelligence".[107]

AI in the military

While Russia does not have a military-only AI strategy yet, it is clearly working towards integrating AI more comprehensively. In March 2018, the Ministry of Defence (MoD), together with the Ministry of Education and Science and the Russian Academy of Sciences, held a first conference on artificial intelligence. There, Defence Minister Sergei Shoigu pushed for increasing cooperation between military and civilian scientists in developing AI technology, which he stated was crucial for countering "possible threats to the technological and economic security of Russia".[108] Following this conference, officials released a 10-point plan, including references to holding AI war games and AI proposals in domestic military forums.[109]

The **Foundation for Advanced Research Projects** (the Foundation) was established in 2012 to overcome stagnation in the area of military technology. It "promotes research and development in the interest of national defence and state security",[110] and can be seen as the Russian equivalent of

THE POSITION OF RUSSIA ON LETHAL AUTONOMOUS WEAPONS AT THE UN

Russia has not been the most constructive partner in the UN discussions on autonomous weapons. At a UN meeting in November 2018, Russia actively worked to prevent the 2019 meetings from lasting ten days, suggesting five days instead. Russia argued that previous meetings finished earlier, so more time was not needed, in part in light of the financial situation at the UN's Convention on Certain Conventional Weapons (CCW). After long deliberations, it was agreed to meet for seven days in 2019. At the meeting in March 2019, Russia again insisted on limiting the time for certain discussions.

Ahead of the March 2019 meeting, Russia released a working paper in which it defined LAWS as "unmanned technical means other than ordnance that are intended for carrying out combat and support missions without any involvement of the operator".[111] Furthermore, Russia underlined that "potential LAWs can be more efficient than a human operator in addressing the tasks by minimising the error rate. In particular, such systems are capable of considerably reducing the negative consequences of the use of weapons related to operator's errors, mental and physiological state, as well as ethical, religious or moral stance in the IHL context".[112]

the United States' DARPA. In 2015, the Foundation opened the National Centre for the Development of Technology and Basic Elements of Robotics.[113] In 2018, it announced proposals for the MoD "to standardise artificial intelligence development along four lines of efforts: image recognition, speech recognition, control of autonomous military systems, and information support for weapons' life-cycle".[114]

A recent video from the Foundation shows its Marker unmanned ground vehicles and drone swarms.[115] "The evolution of combat robots is on the path of increasing the ability to perform tasks in autonomous mode with a gradual reduction in the role of the operator", states the agency.[116] The Marker is being developed in conjunction with a company called Android Technology.[117]

In January 2019, reports emerged that Russia was developing an autonomous drone, apparently the Sukhoi '**Okhotnik**' ('Hunter') heavy strike drone, which has been under development since 2011.[118] It "will be able to take off, accomplish its mission, and land without human interference. Weapons use will require human approval, maintaining a 'man in the loop' who can critically analyze a combat situation and if necessary abort an attack. Okhotnik will pioneer the development of a combat artificial intelligence system [...]", as a tech website describes it.[119]

Cooperation with universities and the private sector

Many Russian MoD initiatives for furthering AI research and applications involve partnerships with universities and the industry. Or, as a member of the American Foreign Policy Council noted, the Russian MoD "is trying to install the American-style culture of flexibility to certain military innovations and developments".[120] In recent years there have been several initiatives to increase civil-military cooperation regarding AI developments.

Indeed, increasing collaboration can be observed between Russian universities and defence. It was reported that scientists may come to the aid of the MoD on artificial intelligence,[121] while one Russian academic warned that "[t]here are high risks in the development of artificial intelligence systems, especially in relation to military tasks".[122]

The Russian MoD has made education a priority, including for example the development of educational standards for "Robotics for Military and Special Purposes".[123] What is more, a new city named Era devoted entirely to military innovation is currently under construction.[124] According to the Kremlin, the "main goal of the research and development planned for the technopolis is the creation of military artificial intelligence systems and supporting technologies".[125] In August 2018, the first university graduates arrived to start learning military robotics and AI applications.[126] A month later, Russia held a national competition called **Aquarobotics 2018**. "Universities from across Russia sent a total of 13 student teams with designs for autonomous and tethered underwater robots to compete for the prize of forming scientific units at the ERA Technopolis in Anapa".[127] As a journalist notes: "It will likely take some time for designs to move from student competition to military refinement to deployment in theater, but with the pipeline in place it's reasonable to expect Russia to keep iterating on its robot submarines. And there's a good chance existing designs are already seeing military use".[128]

Interestingly, in Russia it tends to be the state that leads R&D in key information technology concepts, and not the civilian sector.[129] For instance, in July 2018 Russian state corporation Rostec, a conglomerate incorporating Russia's main arms-producing companies, launched Kryptonite, a research and production company that "will create civilian IT products based on military developments in the field of information security, including blockchain".[130] The main areas of this activity will include machine learning and big data. The aim of this company is the "commercialisation of military technology".[131]

THE ARMS INDUSTRY

At the IDEX arms fair in Abu Dhabi (United Arab Emirates) in February 2019, Russia's largest gun manufacturer Kalashnikov unveiled a kind of kamikaze drone known as KUB. Kalashnikov says the loitering missile, with a payload of three kilograms and a flight time of 30 minutes at 80 to 130 kilometres per hour, is silent and covertly launched, attacking a target whether it is "concealed or not, both at low and high altitudes. […] It is [an] extremely accurate and efficient weapon, […] very hard to combat by traditional air defense systems".[132] In addition, the missile is reported to strike "on the coordinates of the target, which are set manually or in the image from the target load of guidance".[133] "If true, this suggests that operators could pick an image of, for example, an American M-ATV vehicle and the drone would seek out similar-looking vehicles on the battlefield. That sort of target-recognition system is increasingly common in anti-tank missiles".[134]

In 2017, Kalashnikov announced that it had developed a fully automated combat module based on neural-network technologies that enable it to identify targets and make decisions. Director for Communications Sofiya Ivanova stated: "In the imminent future, the Group will unveil a range of products based on neural networks. A fully automated combat module featuring this technology is planned to be demonstrated at the Army-2017 forum".[135] To date, a combat module using a neural network does not appear to be on the market.

5. United Kingdom

State of artificial intelligence in the UK

The UK's national policy appears to focus mainly on making the UK as innovative as possible when it comes to AI.

In April 2018, the UK launched its AI Sector Deal,[136] the underlying idea of which is to be the world's most innovative economy. Key commitments in the deal include "government action to support AI", "industry action to support AI" and "investments in the UK from AI powerhouses". It "is the first commitment from government and industry to realise this [AI] technology's potential, outlining a package of up to £0.95 billion [EUR 1.11 billion] of support for the sector",[137] with the aim of supporting research and education, as well as enhancing the UK's data infrastructure.[138] The AI Sector Deal follows recommendations made in October 2017.[139] The Deal encourages the government to partner with academia, "the broader research community, industry and end users" to integrate AI into future industry challenges and to "support tech businesses to provide the government with innovative solutions for more efficient public services and stimulate the UK's growing GovTech sector".[140]

It appears that investment in education, particularly developing, attracting and retaining talent, is one of the UK's priorities. Indeed, the UK has a 'skills gap' in terms of AI and therefore the AI Sector Deal also tackles the issue of education. It provides key commitments for the government to work with "schools, universities and industry to ensure a highly-skilled workforce".[141] As of October 2019, industry-funded AI and Machine Learning Master's courses will be offered, as a result of which an additional 200 AI/Machine Learning students will graduate per year as of 2020.[142] In October 2018, the government announced an additional investment of GBP 50 million, building on the Sector Deal, to "help the UK get the top AI talent from across the world".[143] This additional funding will go into Turing AI fellowships to bring the best AI researchers to the UK.[144]

AI in the military

In December 2018, a UK Ministry of Defence (MoD) report pledged greater use of AI in order to repel military threats. It states that the character of warfare is changing fundamentally and "areas such as artificial intelligence, autonomy [...] provide new challenges and opportunities".[145] The report also underlines that the MoD is pursuing modernisation "in areas like artificial intelligence, machine-learning, man-machine teaming and automation to deliver the disruptive effects we need in this regard".[146] The MoD has various programmes and projects that relate to artificial intelligence and autonomy. One of these is the **Autonomy programme**.[147] This programme performs research into technologies "that can be used within all environments and that will provide

THE UK POSITION ON LETHAL AUTONOMOUS WEAPONS AT THE UN

The UK has quite a futuristic definition of autonomous weapons. It believes that an "autonomous system is capable of understanding higher level intent and direction. From this understanding and its perception of the environment, such a system is able to take appropriate action to bring about a desired state. It is capable of deciding a course of action, from a number of alternatives, without depending on human oversight or control, although these still may be present". On automation, the UK suggested that autonomy "confers significant advantages and has existed in weapons systems for decades" and that "evolving human/machine interfaces will allow us to carry out military functions with greater precision and efficiency". It also stated that "the application of lethal force must be directed by a human, and that a human will always be accountable for the decision".

The UK is of the view that banning an "undefined concept [...] seems counterintuitive and impractical".[148] In March 2019, the UK added that "the current lack of consensus on key themes counts against any legal prohibition". Adding a legal instrument prohibiting LAWS "would not have any practical effect".[149]

the most significant military impact over current capabilities".[150] Activities in this programme include algorithm development, artificial intelligence, machine learning, "developing underpinning technologies to enable next generation autonomous military systems" and optimisation of human autonomy teaming. To this end, the programme seeks to collaborate with academia, industry and international partners, with the aim of drawing on "external civil and military scientific and technological developments and capabilities".[151] To help this programme, a framework entitled Defence Capability for Autonomous and Novel Technologies (**DECANT**) was established and is scheduled to launch officially in spring 2019. DECANT aims to build a "robust supplier network for innovated and cutting-edge underpinning autonomous systems technologies".[152]

The Defence Science and Technology Laboratory (**Dstl**) is the MoD's research arm, which aims to ensure "that innovative science and technology contribute to the defence and security of the UK".[153] Based at Dstl is the **AI Lab,** launched in May 2018 as a flagship for AI, machine learning and data science. "AI Lab will enhance and accelerate the UK's world-class capability in the application of AI-related technologies to defence and security challenges".[154] It was stated that, around that time, Dstl had delivered more than GBP 20 million of AI-related research, and that this was forecast to grow significantly.

In terms of weaponry, the best-known example of autonomous technology currently under development is the top-secret **Taranis** armed drone, the "most technologically advanced demonstration aircraft ever built in the UK" according to the MoD.[155] It is flown by a specially trained 'pilot' who can manually control the craft from a remote location. However, in autonomous flight mode it is trusted to "self-navigate within a boundary of set constraints", according to its lead flight engineer. "It does have limitations on what we give it in the mission plan—it can only fly in certain areas—but it does think for itself, it will navigate, and it will search for targets."[156] It has been reported that the development is progressing on the basis that an autonomous strike capability could be required in the future.[157] Also, in November and December 2018, **Autonomous Warrior** was "the first ever land-based exercise by the British Army dedicated solely to the testing

of robotic and autonomous systems", including demonstrations of "robotic long-range and precision targeting".[158] The British Army currently has five robotics and autonomous systems initiatives that aim to identify how the service can exploit developments in these technologies in the short to medium term (five to 15 years).

Public-private military collaboration

As the UK has an integrated AI strategy, private-sector cooperation was touched upon in the previous paragraphs. On military-private cooperation, the MoD states that "we need to work with industry to ensure key skills are more available, especially in artificial intelligence [...] and other new technology areas".[159]

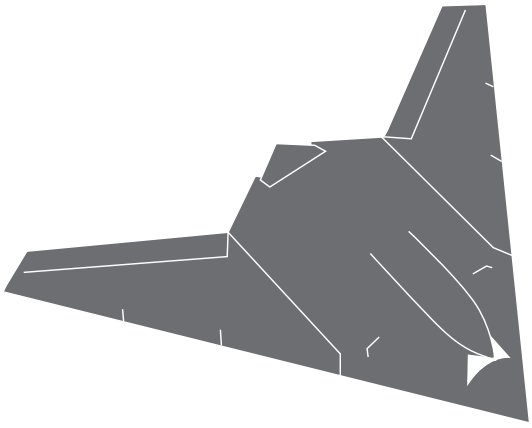
Often such initiatives start with exploring uncontroversial security applications, which may later serve as a stepping stone for broader military uses.[160] An apparent example of this is the **drone swarming 'hackathon'** that Dstl and the US Air Force Research Laboratory (AFRL) organised in March 2019, "to develop new and innovative ways to use unmanned aerial systems (UAS) to assist emergency services to deal with wildfires. [...] Dstl and AFRL are using this innovative approach to find the best Artificial Intelligence or Machine Learning algorithms that embody efficiency and resilience", according to a press release.[161] "We are reaching out to industry, academia, tech start-ups, coders, anyone with new ideas and an interest in drones, artificial intelligence or autonomy to help us find and develop new concepts of controlling drones in the most efficient and effective ways to give as much assistance to the emergency services as possible". Winning teams will be recognised at the AUVSI XPONENTIAL 2019, the largest unmanned and autonomous systems trade show, with all relevant arms producers in this field present.[162]

The UK MoD also has a cross-government organisation called the Defence and Security Accelerator (**DASA**), launched in December 2016. DASA "finds and funds exploitable innovation to support UK defence and security quickly and effectively, and support UK property".[163] DASA is composed of people with backgrounds ranging from defence and security to the private sector and academia, with a hub based at Imperial College. In 2018 it "worked in partnership with MOD Information Systems and Services (ISS) to run an artificial intelligence hackathon which attracted 30 suppliers to work on several defence challenges", where participants were invited to develop their ideas into proposals in order to receive Defence Innovation Fund support via DASA.[164]

In March 2019, as part of the **Many Drones Make Light Work** project, DASA awarded its largest single contract to date, worth GBP 2.5 million (nearly EUR 3 million).[165] Commenting on being awarded the contract, the director of Blue Bear Systems said: "The ability to deploy a swarm of low cost autonomous systems delivers a new paradigm for battlefield operations. During this project we will deploy next generation autonomy, machine learning, and AI to reduce the number of operators required, the time it takes to train them, and the cognitive burden on any operator during active operations. This allows very complex swarm-based missions to be performed simultaneously against single or multiple targets in a time sensitive and highly effective manner".[166] The UK Armed Forces are actively seeking robotic solutions to provide a 'force-multiplier' effect whereby a greater military capability is delivered by fewer people and less equipment. "The future project phase will seek to establish a more 'self-sufficient' UAS swarm, providing the military with the ability to operate in increasingly complex and contested environments. Effective Human Machine Teaming will remain at the core of this research to ensure that the human remains firmly in control of the system", according to the government's press release.[167]

A recent report by civil society organisation Drone Wars UK details how the MoD is funding research into autonomous weapons through collaborations between defence, universities and the private sector, including BAE Systems, Thales and QinetiQ. It states that "universities appear usually to undertake applied research of this nature in collaboration with private sector contractors, often as part of a broad industry-academia consortium involving several partners from each sector, with projects specifically focused on defined outputs".[168] One example mentioned is the Dstl-funded Autonomous Systems Underpinning Research (**ASUR**) programme, led by BAE Systems with support from e.g. Cranfield and Loughborough universities. ASUR supports the development of technologies for unmanned systems, including with regard to "engineering autonomous systems", "operator-system decision-making partnership" and "reasoning about metadata in a distributed autonomous environment in order to exploit, prioritise and adapt".[169]

The **Alan Turing Institute** is the UK's national institute for data science and artificial intelligence. Some of their work also relates to autonomy in weaponry. Their research programmes include AI and Defence and Security, which has three goals: to deliver world-leading research, to deliver impact in real-world scenarios and to develop the next generation of data science leaders. For instance, one of their projects is entitled Flexible Autonomy for Swarm Robotics, where they are "developing the fundamental elements needed for research into the design of large-scale swarm coordination systems that can be flexibly controlled by human operators".[170] Nevertheless, the work in this project focuses on disaster responses, according to the Turing Institute.



6. France

State of artificial intelligence in France

The French national artificial intelligence policy is detailed in the March 2018 'Villani Report', the result of a mission led by MP Cédric Villani and assigned by Prime Minister Édouard Philippe.[171] At the presentation of the report, President Emmanuel Macron emphasised the need for a policy of open data and stressed that France has to "think on the subject from a political and ethical point of view [...] to come up with a common understanding and rules".[172] Macron also announced that the government will invest EUR 1.5 billion in AI research up to the end of his term in 2022.[173] The EUR 1.5 billion investment aims to support research, "encourage startups and collect data that can be used, and shared, by engineers".[174] Other plans include attracting talent and developing an ethical framework.[175] The Villani Report calls for a focus on four sectors—health, transport, environment and defence & security—as strong state action is required in these fields in order to generate momentum.[176] Education features prominently. The French Institute for Research in Computer Science and Automation (INRIA) will create a national AI research programme with four or five partners. "The goal is quite simple—Macron said that there should be twice as many people studying and researching AI projects in France".[177] It will also be made easier to work for a private company during PhD studies.[178]

As Macron stated, France's AI strategy emphasises the moral and ethical impacts of AI. According to him, the EU's General Data Protection Regulation (GDPR) "was a step in the right direction".[179] He said on Twitter that "with the GDPR we are building a European sovereignty on data. We have to do the same for the cloud, for AI, for innovation at large".[180] Macron also affirmed that "turning the country into an AI leader would allow it to use AI for the public good and ensure that a 'Promethean' promise doesn't become a 'dystopia'".[181] Previously, he criticised the Chinese model for not doing enough to protect privacy and human rights, as well as US regulation on tech that, in his opinion, is not doing enough when it comes to taxes and labour.[182]

The Villani Report asserts the need to develop the transparency of algorithms by developing capacities to observe, understand and audit their functioning.[183]

In November 2018, a national strategy for AI research, derived from the Villani Report, was launched with a budget of EUR 665 million up to 2022.[184] The double objective of the strategy is to establish France in the top five countries with expertise in AI and to establish France as a European leader in AI research.[185]

AI in the military

On defence and security, the Villani Report states that the use of AI will be a necessity in the future to ensure security missions, to maintain power over potential opponents and to maintain France's position relative to its allies.[186] The report emphasises that, given for example the risks linked to mass surveillance and the diminution of civil liberties, the development of AI in the defence and security sectors cannot be done in the same way as in other sectors, though it also

THE POSITION OF FRANCE ON LETHAL AUTONOMOUS WEAPONS AT THE UN

France has a rather futuristic definition of LAWS. It understands the autonomy of LAWS as total, meaning that there would be no form of human supervision from the moment of activation and no subordination to a chain of command. In the 2018 UN meetings on autonomous weapons, France stated that it did not consider that a legally binding instrument on the issues of LAWS would be appropriate, given that it is neither realistic nor desirable. However, France did propose a political declaration, which would reaffirm fundamental principles that have been agreed upon and "would underline the need to maintain human control over the ultimate decision of the use of lethal force". France believes that such a proposal will allow the work to advance while taking into account the current divergence in views.[187]

says that in combat, AI would support decision-making and serve the forces locally in the context of collaborative combat.[188] The Villani Report references autonomous weapon systems, stating that "the increasing use of AI in some sensitive areas such as [...] in Defence (with the question of autonomous weapons) raises a real society-wide debate and implies an analysis of the issue of human responsibility".[189] It also raises the question of whether there are areas where "human judgement, fallible though it is, must not be replaced by a machine".[190] In fact, on whether machines can be trusted to make decisions over life and death without human intervention, Macron believes that "you always need responsibility and assertion of responsibility".[191] The French Minister for the Armed Forces Florence Parly has echoed this, stating recently that "giving a machine the choice to fire or the decision over life and death is out of the question".[192]

The report refers to DARPA (see US chapter) as a model, though not with the aim of replicating it. "Financial capacity, methods, culture and mentalities are not the same on the other side of the Atlantic. In addition, DARPA's success has much to do with a historical context of major integration of the military-industrial complex, which has no real equivalent in France or Europe. Some of the Agency's methods and the spirit in which they are implemented should inspire us nonetheless. In particular as regards the President of the Republic's wish to set up a European Agency for Disruptive Innovation, enabling funding of emerging technologies and sciences, including AI".[193] The Villani Report emphasises a need for collaboration between the public and private sectors, "in order to bring out 'quality ecosystems'; in other words, building synergies around civil and military innovation in AI".[194] The goal is to build a "civil-military complex of technological innovation, focused on digital technology and more specifically on artificial intelligence" and this will require the exchange of data between the public and private sectors.[195]

Cooperation with the private sector

In September 2018, the Defence Innovation Agency (**DIA**) was created as part of the Direction Générale de l'Armement (**DGA**, the arms procurement and technology agency). According to Parly, the new agency "will bring together all the actors of the ministry and all the programs that contribute to defence innovation. [...] It will allow experimentation, in short loop with the operational users".[196] The DIA has a budget that will increase to EUR 1 billion euros per annum by 2022. It is indeed presented as a French DARPA, "a super-agency of innovation operating in open organization".[197] The DIA is

headed by Emmanuel Chiva, a specialist in artificial intelligence.[198] The DIA "will seek to coordinate attempts to apply new technology to military applications".[199] Parly has said that the DIA is "largely open to the civilian sphere".[200] As a showcase, the DIA launched a three-day **defence innovation forum** in Paris in November 2018 to "stimulate the defence ecosystem and foster the acceleration of innovative projects for deployment to the forces or integration into weapons operations".[201] The forum showcased 160 innovations with defence and civil applications, including applications from start-up Earth Cube using "the latest advances in medical imagery and artificial intelligence and appl[ying] them to automatically classify objects, detect changes and analyze scenes. The objective is to offload the drudge work for image analysts by only offering images which feature whatever it is the analyst is looking for: tanks, combat aircraft, a new building, for example".[202]

The procurement and technology agency DGA has various programmes relating to autonomy and robotics. For instance, it launched a **Man-Machine Teaming** (MMT) study in March 2018. The MMT study "will look at the feasibility of flying fighter jets and drones together to evade air defence systems" and will be run by Thales and Dassault, in collaboration with various start-ups.[203]

In September 2018, DGA launched three studies to prepare new capabilities in the Scorpion modernisation programme, including the integration of unmanned ground and aerial vehicles into the Scorpion combat system, and to enable "the best use of sensors deployed on the battlefield, supported by artificial intelligence and huge data processing, offering soldiers solutions for reacting more quickly".[204]

One of the most advanced projects currently underway is the **nEUROn** unmanned combat air system, developed by French arms producer Dassault on behalf of DGA, which can fly autonomously for over three hours.[205] Over the years the project has expanded to include other European companies: the Spanish branch of Airbus, Leonardo (Italy), Saab (Sweden), Hellenic Aerospace Industries (Greece) and RUAG (Switzerland).[206] Like the UK's Taranis (see above), this is a demonstrator project aimed at creating new technological capabilities.

Contributing to the discussion about autonomous weapons, Patrice Caine, CEO of Thales, one of France's largest arms producers, stated in January 2019 that there is one application of AI that Thales will never pursue: "autonomous killing machines".[207] He also stated that Thales is working on a charter of ethics relating to AI, "which will focus on trust, vigilance and governance, and clear 'red lines' for what kinds of technologies should remain out of bounds".[208]

Private-sector cooperation is an integral part of the French national AI policy, which can be seen in the various initiatives developed by the national government as well as the Ministry of Defence.

7. İsrael

State of artificial intelligence in İsrael

Israel is known as a tech-savvy nation, with a very innovative and burgeoning start-up scene. As it currently lacks a national artificial intelligence policy, the Israel Innovation Authority, in charge of setting Israel's tech policies, has urged the government to help boost the development of AI.[209] In their '2018-2019 Innovation Report', the Authority stated that "we must acknowledge the fact that we are already falling behind in the race for AI-based technological dominance. [...] If appropriate resources are not allocated, and if we do not develop suitable tools to advance Israeli leadership in AI-based technologies, we risk lagging behind. Accordingly, we are calling for the consolidation of all sectors—government, academia, and industry—to establish a vision and a strategy on AI for the Israeli economy".[210] The Authority also proposes augmenting "human resources capable of staffing Israel's expanding artificial intelligence industry" and reinforcing research infrastructure in academia.[211] Furthermore, it notes the strong role that the Israeli government has played promoting various technologies in the past, and suggests that it should do the same when it comes to boosting the development of AI technologies.[212] The Innovation Report estimates that Israel has a strong chance of becoming a technological leader "in the era of AI", as the country possesses academic talent, skilled human capital and daring entrepreneurs, as well as a "mature and sophisticated" innovation ecosystem.[213] Indeed, when it comes to AI, like other technological fields such as cyberscience, "national security reasons have led Israel to the forefront of technology".[214]

A national plan is reportedly under development, with the objective of positioning Israel among the top five leaders in AI.[215] The National Security Council and the Directorate of Defence R&D in the Israeli Ministry of Defence play key roles in this. There is hope that Israel will emerge as a major player in the use of AI in everyday life, as has been the case in the past, "especially with regard to the field of cyber".[216] The Global Competitive Index ranked Israel third in the world for innovation,[217] and its start-up ecosystem is one of the largest in the world, reportedly second only to Silicon Valley.[218] It has been estimated that Israeli AI start-ups raised up to USD 2 billion in 2017, an increase of 70% compared to 2016. Over the past five years, an average of 140 start-ups have been created every year, and more than 950 active Israeli start-ups were working on AI as at September 2018.[219] Moreover, over the past five years, the exit average for AI start-ups was USD 121 million per deal.[220] Israeli entrepreneurs usually have more hands-on experience working with AI and related technologies than entrepreneurs in other countries due to their strong military background.[221]

Aİ in the military

It is expected that Israeli use of AI tools in the military will increase rapidly in the near future. One example is a small Israel Defence Forces (IDF) unit called **C4i**, which is the IDF's technical unit and the engine behind most of the army's AI developments.[222] Indeed, "the main activity of the C4i directorate is to provide commanders in the field with the technology that they need in order to manage a combat situation in the best possible way".[223] According to one

ISRAEL'S POSITION ON LETHAL AUTONOMOUS WEAPONS AT THE UN

At UN meetings in April 2018, İsrael stated that the "development of rigid standards or imposing prohibitions to something that is so speculative at this early stage, would be imprudent and may yield an uninformed, misguided result" and that it does not support a pre-emptive ban on LAWS.[224] İn August 2018, İsrael underlined that "[w]e should also be aware of the military and humanitarian advantages that may be associated with LAWS, both from operational as well legal and ethical aspects. These may include better precision of targeting which would minimise collateral damage and reduce risks to combatants and non-combatants".[225] İt in fact argued that potential benefits should be discussed at upcoming UN meetings.[226]

source, they are racing to "apply machine learning to such functions as self-driving cars [...] and cybersecurity—or to fight Israel's next war more intelligently".[227] Within the C4i directorate, there is the **Sigma** branch, whose "purpose is to develop, research, and implement the latest in artificial intelligence and advanced software research in order to keep the IDF up to date. [...] The branch is focusing on developing artificial intelligence capabilities like machine learning, deep learning, video analysis, and smart chatbots for military applications".[228] Among other things, C4i developed the face identification system used at security crossings in the Central Command. "This system was designed to streamline security checks, shorten lines, and protect soldiers. Workers are currently working on a new system to operate in the field of observation. This machine will be able to analyse videos and warn of potential problems".[229]

However, the message coming out of the October 2018 conference on 'Creating Insights into the Flood of Data' that was organised by Elta Systems, part of Israel Aerospace Industries (IAI), is that AI technology "is still in its infancy, and it will be a long time before it will be able to be completely safely deployed for critical missions".[230]

Nevertheless, the Israeli military deploys weapons with a considerable degree of autonomy. One of the most relevant examples is the IAI's **Harpy** loitering munition, also known as a kamikaze drone: an unmanned aerial vehicle that can fly around for a significant length of time to engage ground targets with an explosive warhead. A 2014 IAI video explains that "Harpy operates autonomously, detecting, engaging and destroying emitting enemy radars".[231] Another example is the **SkyStriker**, another loitering munition produced by Elbit Systems. It is a "fully autonomous UAS [Unmanned Aerial System] that can locate, acquire and strike operator-designated targets with a 5kg warhead installed inside the fuselage, enabling high-precision performance".[232] Israel was also one of the first countries to "reveal that it has deployed fully automated robots: self-driving military vehicles to patrol the border with the Palestinian-governed Gaza Strip".[233] In fact the Israeli-Palestinian conflict has been a major driver for Israel's military innovations.[234]

Cooperation with the private sector

Innovation in Israel often involves public-private partnerships, with several government initiatives aimed at kick-starting such innovation. One example is the **Yozma** programme, established in 1993, which became the catalyst for Israel's venture capital industry.[235]

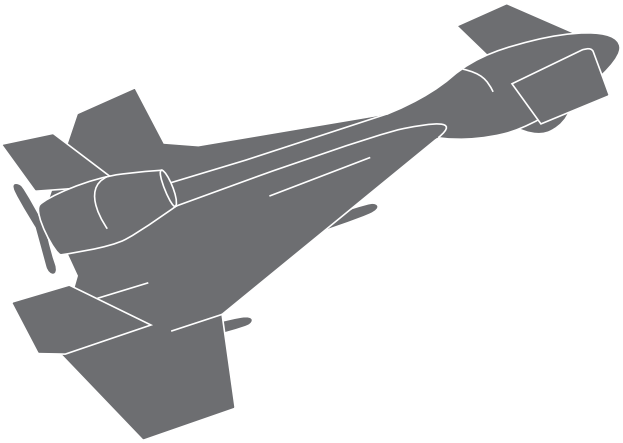
Public-private partnerships are common in the development of Israel's military technology. There is a "close connection between the Israeli military and the digital sector", which is said to be one of the reasons for the country's AI leadership.[236] Indeed, the Israeli defence establishment has invested substantial resources in cooperation with industry and academia to provide technological units with basic AI capabilities.[237]

Israel Aerospace Industries, one of Israel's largest arms companies, says that whatever technology it cannot develop in-house, it plans to get via cooperation with start-ups, especially Israeli ones.[238] IAI itself has long been developing increasingly autonomous weapons, including the abovementioned Harpy. Following from its existing loitering munitions, it recently unveiled the Mini Harpy, which "loiters [in] the sky until the threat is detected. Upon detection the system locks in on the threat and attacks it for a quick, lethal closure. The system was designed to provide operators with control up to the last moment, including cessation of attack at any stage", according to a company statement.[239] An IAI representative stated: "Rather than relying on a precise reference point, the system we developed loiters in the air waiting for the target to appear and then attacks and destroys the hostile threat within seconds".[240] The Mini Harpy can be launched from land, sea and air platforms, and has a range of 100 kilometres and an endurance of 120 minutes. IAI subsidiary Elta Systems has developed new artificial intelligence systems and is integrating them with radars to upgrade image recognition and classification. According to the company "AI and visual intelligence have jumped forward by a generation".[241]

IAI is also active in the area of ground robots and is looking at the next generation: flocks or swarms of robotic systems that communicate and collaborate with each other to accomplish their mission. According to one of its vice-presidents, a retired IDF major general and former Israeli defence attaché in the US, IAI's robot systems can "either be remotely controlled by human operators or switch into a fully autonomous mode where they make decisions based on what their sensors see and what instructions the humans gave them before the mission". With such robotic technologies likely to be implemented on a "massive" scale, he said, "it opens operational opportunities that are now considered a wild dream".[242]

The Israeli company Rafael is "working to create a network of manned and unmanned armored vehicles, with one acting as a mothership to coordinate the use of their weapon systems against targets. With such a suite of armored vehicles, an operator could manage drones and a variety of weapons systems".[243] The "ultra-modern combat system" can simultaneously acquire and neutralise multiple targets. When asked how quickly armies would want to move in this direction, the head of Rafael's innovation programme centre, a former IDF brigadier general, stated "I believe many of the forces that will start this program will go in several steps and will not go straight to the complete autonomous capabilities". But he said, "We understood in the most complicated scenario when it is engaging four targets and different angles, it is the point where the two human crew members need to step back and let the computer do the job, and that is where we are going, part of a bigger discussion of what is the role of ground maneuver, do you still need to have boots on the ground or robots. The level of autonomacy and how to bring it

to the customer depends on operational perspectives. The far vision is everyone sees complete autonomous units. So the question is if we go in three steps, or straight to the future." According to him, the Israeli military is looking at Rafael's system.[244]



8. South Korea

State of artificial intelligence in South Korea

South Korea, known worldwide for its leadership in industrial robotics,[245] aims to become a world leader in artificial intelligence by 2022.[246] In 2014 it was the third largest producer of AI patents, behind the US and Japan, with 16%. The number of patents held in South Korea in 2014 was nearly five times that of the number of patents in 2004, the biggest increase among the top inventor regions.[247]

In February 2016, the Korean Ministry of Science, ICT and Future Planning (MSIP) released the national artificial intelligence development strategy, which encapsulated four main elements:

- Foster an intelligent information society on the basis of public-private partnership;
- Develop a policy regime that encompasses technology, industry and society, to create a more humane society;
- Secure access to intelligent IT to ensure competitiveness;
- Expand the social security net on the basis of social consensuses.[248]

The report also refers to establishing ethics for AI, preventing technological trends that may involve negative impacts from emerging technologies.[249]

In order to guide the course of the digital revolution, South Korea launched the Presidential Committee on the Fourth Industrial Revolution (PCFIR) in October 2017.[250] In May 2018, the South Korean government released a memorandum that included the five-year AI R&D strategy for 2018-2022. There, the government pledged to invest USD 2 billion by 2020 to increase and strengthen its R&D capability in order to kick-start its AI industry,[251] its aim being to "secure world-class artificial intelligence technology".[252] In addition, the memorandum unveiled plans to establish six new artificial intelligence research institutes. The R&D strategy also envisages funding AI projects related to areas such as public safety, medicine and national defence, as well as helping to develop emerging AI businesses and providing funding "for the creation of AI semiconductors by 2029".[253] The plans also feature an "R&D challenge similar to those developed by DARPA".[254]

AI in the military

In December 2018, the South Korean Army announced the launch of a research institute focusing on artificial intelligence, entitled the AI Research and Development Centre. The aim is to capitalise on cutting-edge technologies for future combat operations and "turn it into the military's next-generation combat control tower".[255] It is supposed to employ 20 to 30 military AI experts who will "focus on drawing AI-driven combat strategies to be in line with the rapid military paradigm shift".[256] The institute will seek collaborations with universities and research entities.[257]

SOUTH KOREA'S POSITION ON LETHAL AUTONOMOUS WEAPONS AT THE UN

South Korea did not make any statements at the 2018 Group of Governmental Experts (GGE) meetings in April and August, and it did not attend the CCW meeting of the High Contracting Parties in November 2018.

However, South Korea did make statements in previous years. In April 2015, South Korea stated that "the discussions on LAWS should not be carried out in a way that can hamper research and development of robotic technology for civilian use", but that it is "wary of fully autonomous weapons systems that remove meaningful human control from the operation loop, due to the risk of malfunctioning, potential accountability gap and ethical concerns".[258] In 2018, South Korea raised concerns about limiting civilian applications as well as the positive defence uses of autonomous weapons. South Korea has repeatedly opposed any form of regulation of LAWS.

A separate fourth industrial revolution plan is also being pursued by the Korean Air Force, which in May 2018 announced a Smart Air Power project to integrate various technologies and boost "future warfighting requirements".[259] In collaboration with local industry, the Air Force is pursuing several development projects in the next few years, including advanced sensors and AI-based control systems for UAVs.

Such initiatives run in parallel with the development of new warfighting units. One example is the **Dronebot Jeontudan** ('Warrior') unit that embodies the Korean Army's aim to develop and deploy unmanned platforms that incorporate advanced autonomy and cutting-edge capabilities.[260] First announced in late 2017, it will not be fully staffed until 2019. It is expected to operate new types of surveillance and strike-capable mini to tactical-class UAVs. One such example is the **Striker Drone** quadcopter manufactured by NES&TEC, which has a maximum take-off weight of 9kg and can carry a 2.5kg payload.[261] The unit will also be tasked with integrating unmanned and robotic systems into wider Korean Army operations, as well as providing direct support to other units during wartime. The service plans to expand the number of such specialised units by 2030, as well as to set up a division-sized organisation at army headquarters level that will advance operational doctrine, technology development and training for these units.

In terms of deployed systems featuring high levels of autonomy, South Korea is known to have used the armed **SGR-A1** sentry robot[262], which has operated in the demilitarised zone separating South and North Korea. The weapon has a 5.56mm machine gun and a 40mm grenade launcher, and detects human beings via infrared sensors. The robot has both a supervised mode and an unsupervised mode. In the unsupervised mode "the SGR-A1 identifies and tracks intruders [...], eventually firing at them without any further intervention by human operators".[263] The SGR-A1 has also been used in Afghanistan and Iraq.[264]

Cooperation with the private sector

Public-private cooperation is an integral part of the military strategy: the plan for the **AI Research and Development Centre** is "to build a network of collaboration with local universities and research entities such as the KAIST [Korea Advanced Institute for Science and Technology] and the Agency for Defence Development".[265] For example, it is possible for an engineer to serve 2.5 years of their military service at a tech start-up, following two months of training.[266]

In September 2018, South Korea's **Defence Acquisition Programme Administration** (DAPA) launched a new strategy to develop its national military-industrial base, with an emphasis on boosting 'Industry 4.0 technologies', such as artificial intelligence, big data analytics and robotics.[267] DAPA is the governmental agency linking industry and the military.[268] The new industry plan has three main elements: expanding investment in research and development and promoting innovation; supporting greater collaboration between civilian and military industries and agencies; and promoting entrepreneurship in the defence industry. The plan will be supported by the tentatively named Defence Industry Promotion Act and the Defence Science and Technology Innovation Promotion Act.[269]

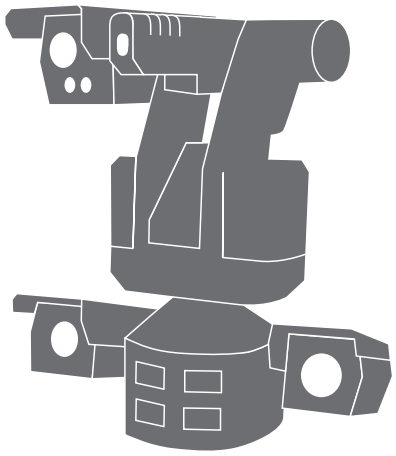
Earlier in 2018 there was a controversy after research university KAIST launched a joint research centre[270] with Hanwha to co-develop AI technologies to be applied to weapon systems. Over 50 AI professors called for a boycott of the university over concerns that its research would lead to killer robots.[271] They called off their boycott after KAIST responded that it "does not have any intention of engaging in the development of lethal autonomous weapons systems and killer robots". KAIST subsequently ended its collaboration with Hanwha and launched an ethics subcommittee "to study artificial intelligence in a bid to cope with a series of challenging ethical questions being posed by AI-powered systems worldwide".[272]

KAIST planned to work on four areas of research: "AI-based command and decision systems, composite navigation algorithms for mega-scale unmanned undersea vehicles, AI-based smart aircraft training systems, and AI-based smart object tracking and recognition technology."[273]
At the opening of the centre in February 2018, KAIST president Sung-Chul Shin said: "KAIST is equipped with 60 professors in the AI field, hence it has the ability to carry out research on artificial intelligence on a global scale. The establishment of this research center will provide a strong foundation for developing national defense technology".[274]

South Korean companies are financially incentivised to develop these new technologies and Hanwha has been one of the leading enterprises in this regard. It is developing 'smart' defence factories that leverage automation, robotics, machine learning and big data analytics.[275]
The head of robotics at subsidiary Hanwha Techwin told *Jane's* that its aerospace and defence business is focusing on strengthening manufacturing competitiveness by pursuing initiatives in AI and analytics, including "developing deep- and reinforcement-learning-enabled intelligent robots".[276]

Another semi-autonomous Korean border control system is the **Super aEgis II**, an automated turret that can be mounted with a 12.7mm machine gun, automatic 40mm grenade launcher or portable surface-to-air missile.[277] Produced by DoDAAM Systems, it was introduced in 2010 as "a new breed of automated weapon, able to identify, track and destroy a moving target from a great distance, theoretically without human intervention." But while the tracking and targeting takes

place autonomously, the Super aEgis II will not fire without first receiving an OK from a human. The human operator must first enter a password into the computer system to unlock the turret's firing ability. Then they must enter the manual input that permits the turret to shoot. "It wasn't initially designed this way," explained a senior research engineer for DoDAAM to the BBC: "Our original version had an auto-firing system," he said. "But all of our customers asked for safeguards to be implemented. Technologically it wasn't a problem for us. But they were concerned the gun might make a mistake."[278] It is used at various facilities in the Middle East and has been tested in the Korean Demilitarized Zone.



9. Conclusions and recommendations

This report gives an overview of the developments in policy and practice related to the military application of artificial intelligence in seven countries: the US, China, Russia, the UK, France, Israel and South Korea. Overall, the US is ahead in terms of AI development and investments, but China is catching up quickly and other states aim to follow suit. Indeed, the report shows that all these states aim to become a leader in AI (or to maintain leadership in the case of the US).

AI arms race

The analysis shows clear signs of the start of an AI arms race. First of all, the research shows states are implementing national policies and programmes with the aim of developing the military application of AI. The majority of states in this report are implementing specific research programmes to look at how to use AI in the military, as well as programmes to stimulate cooperation with tech companies and universities to make use of their expertise. Secondly the report demonstrates states are increasing their investments into the military application of AI, most notably the US with the decision to invest USD 2 billion.[279] Thirdly there is an increase in rhetoric around the need to invest in military AI in order to not fall behind adversaries. As former US Deputy Secretary of Defense Robert Work put it: "If we wait for the Sputnik moment, we will be too far behind."[280] The French Villani report notes that the use of artificial intelligence will be a necessity to ensure maintaining power over potential adversaries. Also Chinese Maj. Gen. Ding Xiangrong of the Central Military Commission, is reported to have stated that China wants to narrow the gap between the Chinese military and global advanced powers by taking advantage of the ongoing military revolution in information technology and intelligent technology.[281] As leading expert Paul Scharre notes: "The main rationale for building fully autonomous weapons seems to be the assumption that others might do so", which risks becoming a "self-fulfilling prophecy."[282]

The main findings of the report are:

Military application

- All the states have incorporated the development and use of AI technologies into their military strategy. AI innovation usually comes mainly from the private sector, though in countries such as Russia the military plays a bigger role in AI advancement. A few states have departments within their defence ministries that work on AI, such as Israel's C4i and the Korean Army's AI research centre.

- Most states perceive defence collaboration with the private sector as necessary. Possibly no state has pushed this further than China with its institutionalised military-civilian integration, where it has become increasingly difficult to separate civilian from military research and development.

- The military has a strong interest in cooperating with universities and research institutes. A number of countries have developed specific initiatives to stimulate this cooperation, for example Russia and its technopolis.

- In terms of weaponry, increasing autonomy can be observed across all of these states, be it through developments in their own defence departments or through national arms producers. The most striking examples are the Harpy and Skystriker in Israel, but such developments can be seen across countries.

- Only the US government has an official policy on lethal autonomous weapons, the so-called 3000.09 Directive.

UN positions on lethal autonomous weapon systems

- The majority of states included in this report are of the opinion that existing international law is adequate and there is no need for additional regulation of lethal autonomous weapons.

- Some states, such as Israel, the US and Russia, have put forward potential humanitarian and military benefits to lethal autonomous weapons. The US argues that advances in autonomy may enhance the implementation of the law of war.

- South Korea is worried about regulation hampering civilian AI research and use, and has also highlighted the benefits of defensive autonomous weapons.

- China has a more ambiguous position, in favour of a ban on the use of lethal autonomous weapons, but not on its development.

- France has put forward a proposal for a non-binding initiative (a political declaration) to regulate lethal autonomous weapons.

Ethical considerations

- France is the sole state to consider ethics within its national strategy.

- In the US, the Defense Innovation Board has been ordered to come up with ethical principles for defence, but this does appear to be a reaction to the increasing resistance coming from Silicon Valley.

Recommendations

An AI arms race is often described as a zero-sum game, but is more likely to be a no-win situation. The fact that autonomous weapon technologies, once developed, will likely proliferate widely and be available to a wide variety of actors, means that the military advantage of these systems will be temporary and limited. Furthermore, an AI arms race would be destabilising and increase the chances of conflict. It would have negative economic, political and societal impacts. The money invested in military technologies could alternatively be used for education, healthcare and other socio-economic purposes. Furthermore, an AI arms race would push states to develop autonomous systems as rapidly as possible to keep ahead of adversaries, with little time for appropriate reflection on the long-term effects of the introduction of such new technologies.

So states should not be asking 'How can we *win* the AI arms race?' but rather 'How can we *prevent* an AI arms race?' States should not aim to outpace their perceived adversaries in the development of autonomous weapons, but should aim to work together to implement clear international regulation and confidence-building measures. Therefore PAX recommends the following:

States should:

- Immediately install a moratorium on the development, production and use of lethal autonomous weapons.
- Work towards a legally binding instrument that ensures meaningful human control over the use of force and prohibits weapons that can autonomously select and attack targets.
- Develop and implement confidence-building measures to reduce the concerns that other states are developing lethal autonomous weapons.

While we believe states should lead developments towards a pre-emptive ban on lethal autonomous weapons without meaningful human control, we also believe that scientists and companies working on these and related technologies have an interest and indeed a role to play in preventing such weapons from becoming reality.

The private sector should:

- Commit to not contributing to the development of lethal autonomous weapons.
- Develop and implement clear policies and internal guidelines to this effect.

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