Increasing autonomy in weapons systems: 10 examples that can inform thinking

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PRELIMINARY RESEARCH REPORT

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This paper was written by Daan Kayser as a preliminary output of the Automated Decision Research project of Stop Killer Robots, in conjunction with PAX.

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INTRODUCTION

This paper highlights ten weapons systems with features that might be informative to considerations around autonomy in weapons systems. It seeks to showcase the diversity of types of weapon systems that are used in a variety of domains, as well as the increase in capabilities; including scope of operation, type of targets, number of systems operating together and range activities that can be undertaken without a human operator. These point to trends in autonomy which could be useful to identify areas where regulation may be necessary to ensure compliance with ethical and legal norms.

Weapons detecting targets

Weapons that detect targets and apply force to them based on sensor inputs have been around for years. Such systems are distinct from those where a human operator sets the specific location and point in time at which force should occur. For the large part these have been 'defensive' weapon systems , often fixed in their location and co-located with their human operator, and with fixed 'target profiles' limiting the types of targets they can engage.

However, in recent years technological developments have led to an increase in the capabilities of weapon systems with autonomous functions, including a larger geographical area and duration of operation, and the potential for more complex or changeable target profiles. This expanded scope of independent operation has raised concerns regarding how human 'control' is applied to such systems, or how they are understood to be sufficiently 'predictable'. The changing nature of target profiles has also raised related concerns, as well as perceived risks of a 'dehumanization' in the use of force. These themes are central to international legal discussions regarding constraints on autonomy in weapons systems.

Trends

In the past few years we have seen an increase in the number and diversity of producers, changes in the types of environment for which autonomous weapons systems are proposed, and changes in the capabilities of weapon systems with increasing autonomy.

Producers
An increasing number of companies, from a growing number of countries, are developing unpiloted weapon systems with increasingly autonomous functions. In the past it was mainly the USA, Western Europe, South Korea and Israel that were leading in this field. Recent years have seen a greater presence of producers from China, Russia, Turkey, and Eastern Europe. More broadly, nearly every country that has a substantial domestic weapon development capability is also adding autonomous functions to its products.

Environments and platforms

Autonomy in most weapon system's targeting was initially focused against target objects in domains that are generally less complex - the sea (subsurface and surface) and the air. An exception to this would be landmines, which also use sensors to detect and apply force to targets, and were associated with significant humanitarian problems. However other weapon systems with autonomous functions were used in simpler environments, that present a more uniform terrain to navigate through, and fewer fixed objects and vehicles to interact with, which also results in an easier background against which to correctly identify intended targets. More recently, however, we have seen an increase in the number of unmanned ground vehicles (UGVs) - with mixed operational success due to the complexity of the environment. Currently UGVs still require a human operator to remotely navigate them through the environment. In the air, there has been a significant expansion in the production of loitering munitions, aerial vehicles that can attack targets on the ground. Such systems can search for a potential target in a designated geographical area for a certain period of time. When striking targets on the land, these systems can bring together uncertainty regarding specifically when and where force will occur, with the comparative abundance and diversity of civilians and objects on the ground. Therefore many current loitering munitions are reported to have a human operator who must approve a strike before the munition engages a target.

Capabilities and characteristics

Looking at the capabilities of weapon systems with autonomous functions, recent years have seen increases in:

- the potential duration and geographical area of operation;
- the types of targets that systems can be programmed to identify and engage
- the number of systems that can operate together; and
- the types of task that can be performed without human involvement.

The ability to make parts smaller and lighter, combined with longer battery life, have expanded the time and geographical area of operation. Developments in automatic target recognition due to advancements in information technology (including processing power, big data, neural networks, pattern recognition) and sensors (including electro-optical and infrared cameras) have led to the potential for a wider variety of target profiles.[1] Recent years have also seen an emphasis on swarming technology, with military projects in, for example, China, the United States, Russia and Turkey. Currently most swarms are either remote controlled or preprogramed, but countries and companies are prioritising capabilities to develop autonomously functioning swarms. Easily exchangeable components and payloads – including various cameras and sensors (including electro-optical, thermal and sonar), electronic warfare systems, and a range of 'weapons' or warheads for the actual application of force (whether intended to be lethal or not) - have expanded the range of possible applications. When deployed in swarms different systems can be fitted with different payloads to create a range of operational options. Various weapon systems described in this report are examples of this development, including the Drone 40, the Kargu, the Yari and the Robotic Combat Vehicle. An important cross-cutting trend is the reduction in costs of new technological components. This contributes to companies and militaries adopting more modular approaches and experimenting more with different capabilities. The reduction also enables expendability- such as is seen in many loitering munitions that are destroyed in the process of striking a target object.

Marketing autonomy

It is important to note that different companies label or represent automation and autonomy differently. For some, the term 'autonomy' is used as a positive marketing term to emphasise innovation. Others seek to emphasise the retention of human decision making, perhaps mindful of the emerging public and political debate on autonomy in weapon systems. This means that the actual nature and extent of automated functioning is not always obvious from promotional literature.

Research background

The research for this report is based on information available in the public domain, either from company websites or from trusted (military-oriented) media outlets. Not all technical and operational information about these technologies is publicly available. We have done our best to ensure the information is correct. Please contact us if you have any corrections or additions to the information provided.

The systems highlighted in this paper feature various levels of autonomy. We are not arguing that these would all be considered autonomous weapons (in the sense of using sensors to detect and apply force to targets). However they do point to trends and possibilities in increasing autonomy in weapon systems. We believe analysing these capabilities could be informative for the debate on autonomous weapons. In the coming years we will likely continue to see weapons systems with technical capabilities that further extend the features of geographical scope, duration and complexity of target profiles. Incremental developments in all of these areas may push towards greater unpredictability in the effects of weapons used. This means that rather than a watershed moment there are likely to be continued steps towards more autonomy and a reduction of the role of the human user(s) in the decision-making process.

PATENTS IN MILITARY AI AND ROBOTICS

Looking at both patents in artificial intelligence (AI) and patents in military robotics gives some insights on the main developers. Regarding AI patents in the military domain, the top three countries are the US, South Korea and China. Looking at military robotics patents granted between 2005 and 2015 the US had the most patents granted, representing 26% of the global total, followed by China (25%) and Russia (17%). However since 2016, China has overtaken the US as leader in the number of such patents per year. The majority of military AI patents between 2005 and 2019 have been in computer vision (29%) and machine learning (28%).

Military investments in robotics and information technology have also dramatically grown over the years. For example, in 2014 the US Army budget for robotics was USD 20 million, by 2018 it was up to 171 million, and in 2021, 379 million. [2]

Abbreviations

AIDTR	AI-Assisted Detection and Target Recognition
EO/IR	Electro-Optical/Infra-Red
ISR	Intelligence, surveillance and reconnaissance
km/h.	Kilometers per hour
kn.	Knots
UAV	Unmanned aerial vehicle
USV	Unmanned surface vehicle
t.	Tons

Weapons systems

1. Drone 40 (loitering munition)
2. JARI (USV)
3. Blowfish (UAV)
4. Seagull (USV)
5. Mini Harpy (loitering munition)
6. Marker (UGV)
7. KUB (loitering munition)
8. Kargu (loitering munition)
9. Robotic Combat Vehicle (UGV)
10. Agile Condor (computer pod)

DRONE 40 (LOITERING MUNITION)

Overview

The Drone 40 is a small quadcopter UAV/munition that can be fired from a 40 mm infantry grenade launcher. [3] It has GPS-based autonomous navigation and a portable 'ground station'. The operator can remotely disarm the munition and make it land for recovery. It can be used with various payloads including sensors for reconnaissance, non-lethal (smoke/flash) and lethal munitions. It includes capabilities for multiple UAV's to strike a target simultaneously.

The development of the Drone 40 was largely funded by the Australian government. Derivatives have also been developed for use with 60 mm, 81 mm and 155 mm launch platforms, with larger payload and range capacities.[4] The Drone 40 has been sold to the Australian and UK militaries. The UK has used the Drone 40 in Mali for surveillance and reconnaissance.[5] It has also been used in exercises in Poland and during drills by the US Marines. [6]

Type: Barrel launched quadcopter UAV, loitering grenade.

Developer: DefendTex.

Country: Australia.

Year: First exhibited at Australian Army Innovation Day 2016. [7]

Use: ISR, target engagement. [8]

Size: Body length of 120 mm without payload.

Weight: 180g (max 300 g).

Range: 20 km.

Max. time of operation: 30-60 min. [9] When carrying a 110 g payload, it can fly for about 12 min. [10]

Communication range: Can transmit data 10 km over direct line of sight. [11]

Payloads: Synthetic aperture radar, GPS and video. Explosive or armour-piercing warheads, electronic warfare, smoke/flash, laser designator.[12]

Autonomy: Autonomous flight, identifying and tracking of targets. Weapon system can distinguish the radar profile of certain targets (citing a T-72 tank).[13] The manufacturer's CEO is reported as saying the system will never 'acquire and prosecute' a target without human confirmation.[14] The operator can remotely disarm the munition and make it land for recovery.

Other: Possibility to use in a swarm. When used with a non-munition payload it is recoverable and reusable.

JARI (USV)

Overview

The JARI is an 50-foot USV that can be used for anti-submarine, anti-ship and anti-air warfare.[15] The JARI can be remotely controlled, but reportedly can also autonomously navigate and undertake combat activities in certain configurations.[16] Due to its small size and range independent oceangoing missions are unlikely, but could be used as a subsidiary mission craft for larger crewed vessels.[17] It is currently used individually, but CSOC (see below) is working for the JARI to be used in swarms. The USV has been designed for both the Chinese navy and potential export customers.[18]

Type: USV

Developer: China Shipbuilding and Offshore International Company (CSOC).

Country: China.

Year: First launched in August 2019.[19]

Use: ISR and anti-submarine, anti-surface and anti-air warfare.

Size: Length 15 m.[20]

Weight: 20 t.[21]

Speed: 42 kn.[22]

Range: 926 km.

Payloads: Electro-optical sensor, a phased array radar, a dipping sonar.[23] Remote weapon station on the foredeck armed with a 30 mm cannon and laser-guided rocket pod, 2 four-cell vertical launch systems for small surface-to-air missiles and 324 mm torpedo launchers.[24]

Autonomy: Reported to be able to autonomously navigate and undertake combat activities once it receives commands.[25] It can be remotely controlled by a shore station or from a mother ship.[26]

Other: Future possibility to be used in a swarm.[27] Modular and reconfigurable for the different mission areas.[28]

BLOWFISH (UAV)

Overview

The Blowfish is an unmanned helicopter of around two meters in length. It can be used for civilian as well as military purposes.[29] There are different versions of the Blowfish, including the A2 and the A3 with slightly different specifications. The A2 can carry multiple 60 mm mortar shells or a 35-40 mm grenade launcher. The A3 can carry different types of machine guns and has an aerodynamic design that allows for firing from various angles.[30] According to the manufacturer the Blowfish has an object recognition system that can identify different targets, such as vehicles, drones, or people. It can integrate visible light and infrared to enable multi-source target recognition and tracking.[31] The Blowfish has swarming capabilities through a self-organising network and does not have to rely on ground control.[32] The drones can "autonomously take off, avoiding colliding in the air and finding their way to their designated target. Once they receive an order to attack, they will engage the target autonomously in a coordinated manner".[33]

According to Ziyan, the Blowfish A2 is widely used for military, police and public security purposes, fire protection, maritime operations and other fields.[34] In 2020, reportedly in the context of tensions between China and India, the Chinese military had placed orders for various UAVs including the Blowfish.[35]

Type: Unmanned helicopter.

Developer: Ziyan.

Country: China.

Year: Since 2016. Exhibited at the Moscow International Defence Aerospace Exhibition in 2019.[36]

Use: ISR and target engagement. Also used in civilian applications (forestry, agriculture, shipping etc.)

Size: Length 187 cm, width 47 cm, height 71 cm.

Weight: 12 kg.[37] Max. take-off weight 40 kg.

Range: 25 km.[38]

Max. time of operation: 60 min.

Speed: 50-70 km/h (max. level flight speed 100 km/h).

Communication range: 30 km for real time High Definition video.[39]

Payload: Modular payloads including various sensors and effectors. Sensors include LiDAR, infrared, thermal imaging and visible light sensors, multispectral cameras.[40] It can carry mortars, grenade launchers and machine guns.[41]

Autonomy: Automatic take-off/hover/return, landing, automatic target recognition and tracking.[42] Automatic target engagement after approval of human operator for an attack.[43]

Other: Real-time mapping, high wind resistance.

SEAGULL (USV)

Overview

The Seagull is 12-meter-long unmanned surface vessel that is designed to be used for mine countermeasures and anti-submarine missions. For mine countermeasures it has "underwater robotic vehicles to identify and neutralize mines"[44]. It is capable of detecting, classifying, and neutralizing sea mines. For anti-submarine missions it is capable of launching lightweight torpedoes. Other types of mission include surveillance, hydrography, electronic warfare, and maritime security.[45] It can perform deep-water missions for four days at a time with line-of-sight ranges of up to 100 km.[46] It has a stabilized remotely operated 12.7 mm machine gun at the front of the vessel.[47]

Two Seagulls can be controlled simultaneously by a control station on land or on a mother ship. Elbit Systems has added the Skylark C mini-UAV to the Seagull to further enhance situational awareness and its intelligence gathering capability.[48] The Seagull has been used by the Israeli Navy in several NATO maritime exercises, including with the UK Royal Navy and the Spanish Navy.[49]

Type: USV.

Developer: Elbit Systems.

Country: Israel.

Year: Shown at the Singapore Airshow in February 2016.[50]

Use: Mine countermeasures, anti-submarine warfare, ISR, electronic warfare, maritime security, and hydrography missions.[51]

Size: Length 12 m.

Communication range: 100 km with line of sight.[52]

Speed: Max. speed of 60 km/h.[53]

Max. time of operation: More than four days.[54]

Sensors: Electro-optical/ infrared sensors, side-scan sonar or synthetic aperture sonar, forward-looking sonar or multibeam echo sounder, diver detection sonar, and dipping sonar.[55]

Payloads: Modular mission payloads including for reconnaissance and electronic warfare. It has a 12.7 mm remote controlled machine gun, light torpedo launching system and non-lethal weapon system.[56]

Payload capacity: 2,500 kg.

Autonomy: Autonomous navigation; otherwise remote controlled. It can be operated in manned and unmanned modes using line-of-sight and SATCOM data links. The Mission Control System can be located on a mother ship, command post or land vehicle and can control two vessels simultaneously.[57]

Other: It also features expendable mine disposal vehicles and diver's neutralization system.

MINI HARPY (LOITERING MUNITION)

Overview

The Mini Harpy is a loitering munition developed by Israel Aerospace Industries (IAI). It combines the capabilities of the Harop and the Harpy munitions, namely detection of broadcast radiation with electro optical capabilities.[58] It can loiter and detect radiation-emitting objects, such as radar installations. A strike is approved by a human who has a video feed of the operation. According to IAI the operator has control up to the last moment to stop an attack.[59] However the company also suggests that it has "fully autonomous" operation as an option.[60] It is unclear what the fully autonomous mode would entail, but most likely that the weapon system detects and attacks a target without the need of human approval.

The company notes: "in an age of asymmetrical warfare and fast moving targets that 'blink' for a few seconds at a time, the use of loitering munitions provides strong capabilities for closing the fire loop. Rather than relying on precise reference points, the system we developed loiters in the air waiting for the target to appear and then attacks and destroys the hostile threat within seconds".[61] The Mini Harpy is canister-launched from land, sea or helicopter platforms, and has a range of 100 km and an endurance of 120 min.[62]

Type: Fixed wing mini-UAV, loitering munition.

Developer: Israel Aerospace Industries (IAI).

Country: Israel.

Year: 2019.

Use: Loitering target engagement.

Weight: 40-45 kg (including 8 kg warhead), also reported at 400 kg per launcher of 12 munitions.[63]

Speed: Max. speed 200 Kn., loitering speed 55-85 Kn.[64]

Range: 100 km.[65]

Max. time of operation: 120 min.[66]

Payload: Radiation detection and electro-optical sensors,[67] 8 kg explosive warhead.[68]

Autonomy: Can lock on to radiation-emitting objects like radar. There is a 'human-in-the-loop' via electro-optical link, but it also reported to have a 'fully-autonomous' mode. [69]

MARKER (UGV)

Overview

The Marker is an Unmanned Ground Vehicle (UGV) that can be used with a wheeled or tracked chassis.[70] It is an experimental platform to test ground robotic technologies like autonomous navigation, group interactions and artificial vision.[71] The Marker has a module to control several vehicles at a time. It reportedly uses algorithms and programmed modules to detect various targets.[72] Research agency ARF, its developer, states that the weapon system gives the operator a target designation who can then approve an engagement.[73] ARF adds that "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". [74]

The Marker is modular and can be fitted with a Kalashnikov-produced machine gun, anti-tank grenade launchers, loitering munitions, electric rockets, as well as tube-launched and towed unmanned aerial vehicles.[75] The system reportedly has a modular multispectral vision and data processing system, featuring neural network algorithms, and "2D and 3D object recognition, semantic segmentation, depth calculation, automatic self-localization, trajectory building".[76]

Russia has supposedly tested five Markers operating as an autonomous group without human involvement. The "robots, without human involvement, solved the tasks of distributing targets within the group, reaching optimal firing positions, reacting independently to operational changes in the combat situation, and exchanging target designations."[77] The Marker was also tested at the Vostochny spaceport where it patrolled the perimeter autonomously in conjunction with security guards. In the future, the developers plan to test them together with drones.

Type: UGV.

Developer: Advanced Research Foundation (ARF), together with the 'National Center for the Development of Technology and Basic Elements of Robotics' and the company Android Technics.

Country: Russia.

Year: First tested in 2019.[78]

Use: Target engagement.

Payload: Modular payloads including laser warning system, thermal sensors, day/night infrared cameras, laser rangefinder, target detection, early warning system, identification, and tracking equipment.[79] Possible weapons include a machinegun, loitering munitions, electric rockets, as well as tube-launched and towed unmanned aerial vehicles.[80]

Autonomy: Autonomous navigation, automatic target recognition.

Other: Can be used in a group/swarm and can operate with UAVs for reconnaissance.

KUB (LOITERING MUNITION)

Overview

The KUB is a loitering munition developed by Kalashnikov and ZALA Aero Group. It can be fired from a special launcher installed on naval platforms such, as the High-Speed Landing Craft BK-016 produced by Kalashnikov. In the future, a deck container launcher will be developed to launch KUB swarms.[81] After the launch, the drone can loiter in the air to detect a target and then attack it from a vertical trajectory. This allows it to attack tanks, piercing the turret from above where it "has minimal armour protection", but also other targets like air defence systems.[82] Target coordinates are specified by the operator or acquired from the targeting payload.[83] According to Kalashnikov, an operator can also upload an image to the control system of the intended target type.[84] It reportedly has AI visual identification, which can perform "real-time recognition and classification of detected objects".[85] It is intended to not be seen by traditional radar.[86]

In 2021, a naval version was developed and tested that can be used from high-speed boats and special-purpose ships.[87]

Type: Loitering munition.

Developer: Kalashnikov and ZALA Aero Group.

Country: Russia.

Year: First shown at international defence exhibition "IDEX 2019", Abu Dhabi, UAE.[88]

Use: ISR and target engagement.

Size: 1210 mm x 950 mm x 165 mm.[89]

Weight: payload maximum weight is 3 kg.[90]

Speed: 80-130 km/h. [91]

Max. time of operation: 30 min.

Payload: Sensors and explosive warhead.

Autonomy: Target coordinates are specified by the operator or acquired through automatic target recognition.[92] It can perform "real-time recognition and classification of detected objects". [93]

Other: Is intended to operate in a swarm.

KARGU (LOITERING MUNITION)

Overview

The Kargu is a multi-rotor UAV that can be used for situational awareness and as a loitering munition. The system has a portable mobile ground control station that allows the user to approve an application of force or to abort the mission.[94] The developer, STM, has stated that they believe that "ethically a human should be involved in the loop." [95] However this does not mean it is not technically possible for the Kargu to autonomously engage a target.

STM has been further developing the capabilities of the Kargu, reportedly including facial recognition, as well as increasing the diversity of the payloads the system can use. [96] According to STM, up to 30 Kargu units can operate together in a swarm while being controlled by a single ground control station. [97]

Kargu was introduced to the Turkish armed forces in 2020 with reports of further units to be delivered. [98] According to a UN report, the Kargu was also used in Libya where the "weapons systems were programmed to attack targets without requiring data connectivity between the operator and the munition." [99] Use by Azerbaijan was also reported but not confirmed. [100]

Type: Multi-rotor UAV, loitering munition.

Developer: STM (Savunma Teknolojileri Mühendislik ve Ticaret).

Country: Turkey.

Year: 2020.

Use: ISR and attack capabilities.

Size: 60 cm.

Weight: 7 kg.

Range: 15 km.

Max. time of operation: 30 min.

Communication range: 5-10 km.

Payloads: Payload capacity is 1.3 kg. Options include electro optical day camera and infrared night camera, as well as fragmentation and thermobaric munitions.[101] Includes a passive wideband sensor that detects and tracks radio frequency transmissions belonging to friend and foe systems.[102]

Autonomy: Fully autonomous navigation.[103] Automatic target recognition and tracking.[104] Ability to autonomously 'fire-and-forget' through the entry of the target coordinates.[105] The system has a portable mobile ground control station that allows the user to approve an application of force or abort the mission.[106]

Other: Includes possible facial recognition capabilities and can operate in a swarm formation.[107] The 'KERKES Project' will enable the platform to operate independently of GPS.[108]

ROBOTIC COMBAT VEHICLE (UGV)

Overview

The Robotic Combat Vehicle (RCV) is a series of unmanned ground vehicles being developed in the United States. The goal is for them to work as a group. The RCV Light (RCV-L) weighs less than 10 tons and its main purpose is reconnaissance and information gathering. It has more sensors and less heavy weaponry (one anti-tank guided missile and a recoilless weapon). Its modular flat deck architecture can be used with over 20 payloads.[109] It is aimed at engaging mainly smaller and unarmoured vehicles.[110] The medium size versions are equipped with more armour and fire power to engage a broader spectrum of targets. The RCV Medium (RCV-M) will weigh around 15 tons and would have more fire power (several anti-tank guides missile, a 30mm cannon and a machine gun). At a test in 2020 it was fitted with Switchblade loitering munitions.[111] The RCV-M is more durable than the RCV-L.[112] The RCV Heavy (RCV-H) will weigh 20-25 tons[113]. It is still being developed but is intended to have the firepower and survivability of the M1 Abrams tank whilst weighing a lot less. It is intended as a partner unit for manned tanks.[114]

The RCVs will have autonomous navigation and remote-controlled weapons. The plan is to equip the systems with AI-Assisted Detection and Target Recognition (AIDTR) to "detect and recognize threat vehicles faster and more efficiently than a human". It must enable a common operational picture and "analyze threat patterns and habits, and make recommendations to the commander".[115] Currently each RCV is controlled by two operators, one as driver and one operating the weapon systems.[116] In the future the reported intention is that one operator would control several systems, where they only need to give permission to engage a target.[117]

Qinetiq is building the RCV-L.[118] Textron is building the RCV-M based on its Ripsaw mini-tank.[119] The RCV-L and RCV-M have undergone individual testing.[120] Both systems will take part in the Manned-Unmanned Teaming (MUM-T) Soldier Operational Experiment in 2022.[121]

Type: Unmanned Ground Vehicle

Developer: Qinetiq is developing the RCV-L; Textron the RCV-M.[122] The RCV-H is not yet being developed.

Country: USA.

Year: They are all prototypes. RCV-L was delivered late 2020,[123] RCV-M early 2021.[124] RCV-H is not planned to be field-tested until 2023.[125]

Use: Includes reconnaissance, electronic warfare, minesweeping, and target engagement.[126]

Size: RCV-L 568 x 223 x 238 cm; RCV-M 584 x 272 x 239 cm; RCV-H 889 x 366 x 360 cm.[127]

Weight: RCV-L around 7 t, RCV-M around 15 t, RCV-H 20-30 t.[128]

Speed: The RCV-L and RCV-M have a maximum speed of 65 km/h.[129]

Communication range: Intended to be 1.5 times the maximum range of its primary weapon.

Payload: Range of payloads, including 360 degree situational awareness sensors (EO/IR), tethered unpiloted aerial vehicle, chemical, biological and radiation detector, aided target recognition.[130] Other payloads include smoke generators and radio jammers, to missiles and canons.[131]

Autonomy: Autonomous navigation along a programmed route. 'AI-assisted' target recognition.[132] Weapons are remote controlled.[133]

Other: Intended to operate as a group.

AGILE CONDOR (COMPUTER POD)

Overview

The Agile condor 'pod' is not a weapon system, but an enabling technology that can be added to the MQ-9 Reaper UAV. It is an onboard high-performance embedded computer combined with machine learning, that is used to autonomously fuse and interpret sensor data to identify, classify, and 'nominate' targets of interest.[134] The sensor data comes from the sensors of the MQ-9 Reaper, that include electro-optical and infrared sensors and synthetic aperture radar. The Agile Condor pod consists of a number of compartments which can support a wide range of technologies, including commercial single-board computers, graphical processing units, SSD storage and more advanced chips.[135] The developers imagine the potential for computer technology modelled on the human brain (so-called neuromorphic architecture).[136]

Onboard processing reduces the necessary communication bandwidth as it is possible for the system to only share specific data with other platforms.[137] Also, onboard video processing helps to reduce analysis and decision-making time, which can be substantial when using UAVs with camera's for ISR. Increasingly, militaries are seeking to use machine learning to speed up the analysis of this data, as was seen with Project Maven. The Agile Condor pod would integrate this kind of technology in the platform itself. It also allows the MQ-9 to operate more autonomously in GPS- and communications-denied environments, as the technology can also be used to navigate by identifying landmarks and avoid potential threats.[138] Although it is not explicitly mentioned, the onboard processing capability could also allow it to autonomously detect, identify and engage targets. A video by one of the developers illustrates the system identifying a human target by using facial recognition and alerting an operator on the ground who reroutes a convoy passing the location. [139]

The first Agile Condor pod was delivered in 2016, and in September 2020 the Agile condor pod was tested on a MQ-9 Reaper UAV.[140]

Type: High-performance embedded computer.

Developer: Air Force Research Laboratory, SRC and General Atomics Aeronautical Systems.[141]

Country: USA.

Year: Initially developed in 2016. Tested on the MQ-9 in 2020.

Use: ISR and automatic target recognition.

Size: 156 cm in length.

Weight: Intended to weigh less than 27 kg.[142]

Sensors: Depends on the platform and its configuration.

Payload: Modular computer technologies, including single-board computers, graphics processing units, SSD's and more advanced chips.

Autonomy: Automatic target recognition.

Other: Could be added to various platforms.

CONCLUSION

This paper has highlighted ten systems with aspects of 'autonomy' in their functioning. We are not arguing that these ten systems are distinctly more problematic than many others that could have been pointed to. These examples were chosen because they point to the diversities of the systems within which automated capabilities are being incorporated: diversities in capabilities, scale of functioning, of operating environment and of country of origin.

Most of these systems retain a capacity for human decision making at the point at which force is to be applied. We broadly defined 'autonomous weapons', in our introduction, as systems that detect targets and apply force to them based on sensor inputs. The systems we have looked at here contain aspects of autonomy, but they are not necessarily 'autonomous weapons' by that definition. Yet, many of them could be configured to function in such a mode. This raises questions as to how, with longer periods of time and wider geographical areas of operation, meaningful decisions will be made as to whether certain patterns of sensor data can be taken to sufficiently represent a legitimate target. Analysing the trends in increasing autonomy in weapon systems, could be useful to identify areas where regulation may be necessary to ensure compliance with ethical and legal norms.

This paper is a preliminary output of the Automated Decision Research project, in conjunction with PAX. In 2022 we will be continuing to build an ongoing picture of autonomy in weapons systems, as well as on wider societal responses to automated decision making, in order to inform international policy making on these issues.

The Automated Decision Research project is the new monitoring and research arm of the Stop Killer Robots campaign. The Automated Decision Research team monitors legal and policy responses to AI and autonomous decision-making in wider society, as well as researching developments in autonomous weapons systems. We see responses to autonomy in weapons systems as a part of the broader landscape of social responses to automated decisions and 'autonomy' in general.

PAX is a Dutch peace organisation that works with committed citizens and partners to protect civilians against acts of war, to end armed violence and to build sustainable peace.

For any clarifications or corrections, please contact
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ENDNOTES:

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