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Autonomous Weapon Systems and US Military Robotics: Unmanned Aerial and Ground Vehicles (UAV and UGV)

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Ever since the second World War and especially during the Cold War era the idea of engineering an autonomous weapon system, also known as military robot, has taken deep roots throughout military circles all across the globe. From first specimens like Goliath tracked mines and Soviet Teletanks, which now look rather funny, to top tier drones capable of delivering heavy payload hundreds of miles away removing any potential threat which could harm their operators. Countries like United States, Russia, China, France, United Kingdom, Iran, Israel, India and more are heavily investing in these futuristic programs not only in the financial sector but in the science department as well. Many think that these new weapons systems will be the future of modern warfare, although there have been some serious statements considering humanitarian aspects and the potential for human rights violations.

Unmanned Aerial Vehicles (UAVs)

The first major use of these unmanned machines by the US started in seventies, those were Unmanned Aerial Vehicles (UAV) armed with cameras and used primarily for reconnaissance. After the modernization of technologies in the eighties and especially in the nineties the interest for these UAV's and other similar machines grew rapidly. The first major contract was signed in the nineties between US Department of Defense and AAI Corporation considering the development of these vehicles. Following this many corporations and institutes saw their interests in developing such machines which could be used in civilian and military operations. Some of the prominent companies who actively produce and develop UAV's are AeroVironment Inc., Boeing, General Atomics, Lockheed Martin, Northrop Grumman and NASA.

Military drones or UAV's can be separated in three major categories: midsize military drones, which also have commercial use, large size military-specific drones and stealth combat drones. All these vehicles vary in size, power, operational range, price and capabilities.

Design of midsize military drones was focused on reconnaissance and are capable of manual or autonomous flight. These drones can be equipped with high-definition cameras, infrared or night-vision, electro-optical cameras which can capture high resolution images, and in recent years these drones are equipped with high-tech radars allowing all-weather terrain mapping and target tracking. Many of these drones are capable of creating beyond line of sight communications relay for ground-based radios, greatly improving the effectives and

awareness between troops on the ground in various terrains. The operational range of these UAV's spans between 10km to 100km, and are currently being used in almost 90 countries across the world. Although not designed to carry bombs or missiles these drones can be used as weapons, there have been reports some terrorist organizations have managed to attach almost 30kg of explosives. The future development of these drones will probably include better survivability in hostile territories, increased range, endurance and capability of releasable missiles and bombs.

Large size military-specific UAV's are combat ready drones. Capabilities of these drones far surpasses the midsize class but they are also highly expensive to produce and usually require developed military infrastructure. Armament of these UAV's may vary depending on the country, and are usually used for eliminating ground targets both infantry and armor. Operational range as well as endurance is far superior to their mid-size counterparts. Some drones of this class can have a flight time exceeding 45 hours. Communication capabilities can include wide band satellite communications both extending and expanding the amount of transmissible data. In this manner they can be deployed as communications relay. The altitude of these aerial crafts extends up to 50,000 feet. This significantly improves the survivability against potential air defense like various MANPADS. These specific drones are currently developed in 10 countries, but it is believed proliferation of UAV's will soon extend to another 20 countries signaling the beginning of their large size military-specific drone programs.

Stealth combat drones represent one of the highest levels of technological sophistication. Their production as well as their capabilities are mostly kept secret by the states and corporations developing them. Their design represents a wing-shape vehicle in order to minimize their radar signature. Additionally, implementation and application of stealth coating and low-observable features can also reflect or absorb other radio signals. Their primary objective consists of penetrating hostile territory while avoiding high-end air defense systems. Lockheed Martin and Northrop Grumman are two companies reportedly developing such UAV's. For now, only the United States is using this class of drones. But Russia, China, India, Israel and some European countries have active development programs.

The proliferation of this technology will come natural over time, many state and non-state commercial actors are attracted by the thought of having a remote control aerial machine capable of delivering top-notch services, for both military and civilian use. However, when discussing UAV's, we should keep in mind that these are not totally autonomous vehicles, but rather remote-control machines operated by civilian or military personnel from a distance. Further development and more frequent usage of drones clearly indicates the need for more *autonomy* for variety of reasons. First of all, UAV's are remote-controlled, thus their signals can be jammed or totally disrupted, large quantities of information usually require huge bandwidth that sometimes requires more satellites or better infrastructure. Secondly, if they are controlled via radio signals there will be some kind of delay, which for reconnaissance purposes is not that important but for real time combat situations could become crucial. Thirdly, with more sophisticated technology things like reaction time, combat and maneuver capabilities, stress and every other human factor that could potentially prove bad for completing combat assignments would be replaced with the autonomous system. Furthermore, the deployment of drones, mostly by US and UK, was done in areas where one state already has aerial superiority like in Pakistan, Somalia and until recent events in Yemen as well. The implementation of fully autonomous systems,

drones could be deployed on hostile territories with better air defenses, without the need for constant line of communication.

Some UAVs Used by the U.S. Military

The largest producer and consumer of UAV's is the United States military; it is suggested that around 11,000 drones are deployed across various sectors of the US military. Most of them are used for scouting and reconnaissance purposes, but part of the drones is armed and combat ready. Most frequent missions for these armed drones are usually *war on terror* assignments. These are some of the most popular and used military-specific drones:

General Atomics MQ-1C Gray Eagle:

Characteristics: Length 8m; Wingspan 17m; Height 2.1m; Maximum Speed 425 km/h; Cruising Speed 277 km/h; Endurance 30h

Armament: Missiles 4 x AGM-114 *Hellfire* or 8 x AIM-92 *Stinger*; Bombs 4 x GBU-44/B *Viper Strike*

General Atomics MQ-9 Reaper:

Characteristics: Length 11m; Wingspan 20m; Height 3.81m; Maximum Speed 482 km/h; Cruising Speed 313 km/h; Endurance 14h fully loaded

Armament: Missiles up to 4 x AGM-114 *Hellfire* combined with 2 x GBU-12 *Paveway* II laser guided bombs; UAV has the capability of carrying GBU-38 Joint Direct Attack Ammunition (JDAM)

General Atomics MQ-1 Predator:

Characteristics: Length 8.22m; Wingspan 14.8m; Height 2.1m; Maximum Speed 217 km/h; Cruising Speed 130-165 km/h; Endurance 24h

Armament: Missiles 2 x AGM-114 *Hellfire*; 4 x AIM-92 *Stinger*; 6 x AGM-176 *Griffin*

AAI RQ-7 Shadow:

Characteristics: Length 3.4m; Wingspan 4.3m; Height 1m; Maximum Speed 204 km/h; Cruising Speed 130km/h; Endurance 6-9h

Armament: RQ-7 Shadow is still used for surveillance purposes, but there is a plan for arming this drone in the future.

Northrop Grumman RQ-4 Global Hawk:

Characteristics: Length 14.5m; Wingspan 39.9m; Height 4.7m; Maximum Speed 629 km/h; Cruising Speed 575 km/h; Endurance 32h+

Armament: None, this drone is used for surveillance and reconnaissance.

Unmanned Ground Vehicles (UGV)

Along with the UAV's the development of unmanned ground vehicles(UGV), is becoming ever more popular across the world. The idea behind this machinery is that UGV's can serve as a supplement to the soldiers on the ground and eventually replace them in the future. The UGV's are suited to perform daily routine and boring tasks with pin-point precision and efficiency. They can be designed to withstand pressure and complete various tasks which could potentially harm or threaten the life of a soldier thus significantly improving combat effectiveness on the battlefield. The need for such vehicles was recognized by the US after the Gulf War. Transformation of the army from heavy armor and firepower to a lighter, responsive force capable of dealing lethal damage but also surviving adversaries fire power became a top priority. Development of these vehicles is more complex than the UAV's since they need to able to traverse various terrains and accomplish various military assignments. UGV's can be classified into four sections: Small robotic building and tunnel searcher; Small-unit logistic mover; Unmanned wingman ground vehicle; autonomous hunter-killer team.

Small robotic building and tunnel searcher is a UGV designed for short-distance reconnaissance remotely operated by a soldier. These machines are especially effective in urban areas with cramped spaces, tunnels, caves and ruins which can potentially provide allot of hiding places for enemies, traps and are generally dangerous. Searcher UGV's are armed with high resolution cameras (infrared and night-vision), a variety of sensors can be mounted with a robotic arm for specific situations. Mobility of these vehicles is highly regarded, it is expected that searcher UGV can traverse all kinds of ruinous terrains as well as multi level buildings. Though the autonomy of the searcher is rather low, its dependent on the soldier who controls it, the UGV showed good results on the ground and during combat operations. Capability of locating traps and hidden enemy units has proven this drone significant for the assaulting troops, especially when fighting terrorists.

The small-unit logistic mover also known as the *Donkey* is a concept of supply, weapons and even wounded soldier carrier UGV which could operate across the battlefield. Ever since the ancient times logistic issues were one of the main components of a successful battle. Ammunition, food, water, weapons and various tools are needed by the soldiers in different situations, some of this can be carried by servicemen, but, heavy loads can cause unwanted fatigue resulting in negative combat effectiveness. The Donkey UGV is capable of providing solutions in this logistic situations. This small-unit logistic mover is semi-autonomous medium size precede/follow UGV with the capacity to carry a couple hundred kilos. Benefits include lightening the soldiers backpack, but also with good sensors it can follow a path across an active battlefield thus not depending on the remote control operators. Fully autonomous Donkey could provide a constant flow of supplies to soldiers whether they are in urban, rural or any other terrain without the direct line of sight to the operators, rendering potential signal jamming useless.

Unmanned wingman ground vehicle is a medium size UGV which provides assistance to small mechanized infantry and armor units that usually operate in small teams. Assistance is provided by constant reconnaissance and observation of the battlefield thus providing crucial information to the combat units. With high-tech cameras, sensors and mobility the "Wingman" can be on a non-stop scout/guard duty. This detection UGV can boost the security of the units when the soldiers are resting, camping or are just occupied by other tasks. In today's conflicts the amount of information especially in urban areas can be rather confusing making it harder for soldiers to navigate and properly manage their assets which could ultimately lead to lethal results. Wingman UGV can assist with data processing, arranging targets and detecting threats more efficiently than any human sense, with high

autonomy it requires little management.

Autonomous hunter-killer team concept is made around the idea that a couple of UGV's (5-10 vehicles) can perform duties such as ambush and termination missions while penetrating deep into the frontline of the battlefield in various terrains and weather conditions. These assignments can usually prove lethal for soldiers especially if the unit lacks the knowledge of the terrain, and the conditions are highly in favor for the enemy. In today's conflicts, especially in urban areas its usually hard to do a detailed reconnaissance despite the high-tech machinery. Hunter-killer teams can operate day and night, in all terrain/weather conditions, armed with sophisticated sensors, lethal weapons and with high degree of autonomy, these drones can easily turn the tide of the conflict while saving the lives of soldiers. Primary objective when designing these vehicles is high autonomy, meaning that they are not dependent on the human operator, augmented intelligence and enhanced local network between the UGV's in the team are the main assets. These robots when released can usually assign targets and navigate through terrain with ease, of course the human factor will be crucial when it comes to programming these machines.

Some UGVs Used by the U.S. Military

The Soldier UGV (SUGV) is a man-packed robot, highly mobile and light machine weighing around 13 kilos primarily used for scouting and reconnaissance in cramped/ruin areas. The system can be re-configured for other missions and can be augmented with a variety of sensors and even some explosive devices. The Soldier can perform tasks such as surveillance, door breach, smoke generation and more. The Soldier is a light class UGV, similar types of robots from this class are : *Cobra* man-portable robotic system used for building clearing, tunnel and sewer reconnaissance and vehicle inspection; *Dragon Runner* four wheel man-portable ground sensor UGV designed to increase situational awareness; *TALON* is a lightweight, versatile machine capable of reconnaissance as well as weapons delivery and can operate in all-weather/terrain conditions; *MATILDA* is a low cost reconnaissance robot which can be re-configured multiple ways depending on the assignment. Configurations include robotic arm, detachable breaching mechanism with explosive charges; *URBOT* is a remote control UGV capable of bomb disposal and can also be incorporated with sensors for some ad hoc reconnaissance missions.

Gladiator Tactical Unmanned Vehicle is a medium size mobile robotic system developed for US Marine Corps in order to minimize the risk and neutralize threats across the spectrum of conflicts. Gladiator can perform both scout and surveillance, reconnaissance and direct fire tasks. Other medium size UGV's include: *Multifunction Utility/Logistics Equipment Vehicle (MULE)* is a unmanned platform that can carry heavy loads of supplies and equipment across the terrain; *Mini-Flail Robotic Combat Support System (RCSS)* is a remotely operated mine neutralization system used in clearing a footpath or a small minefield; *Surveillance and Reconnaissance Ground Equipment (SARGE)* is a four wheeled all terrain vehicle capable of day/night imaging, thermal imaging and high power zoom surveillance.

Armed Robotic Vehicle is a UGV that comes in two variants, as a surveillance and fire support UGV. Though the second one can provide basic reconnaissance it lacks the sophisticated sensors and technology of the previous, surveillance and target acquisition dedicated UGV. *Robotic Armored Assault System* (second option) can be deployed with direct fire weapons with a variety of ammunition for completing different tasks. Other heavy UVG's are: *All Purpose Transport System (ARTS)* is a remote controlled 3.5-ton loader which can be transformed into a forklift, backhoe, UXO clearance vehicle or even used for

deploying specialized EOD tools; *Cooperative Ground Attack Robots (COUGAR)* is an experimental project focusing on developing better Ai, coordination and autonomy in UGV's in order to be more effective in the conflict zone. Many other heavy UGV's are still in experimental/testing phase.

Large class UGV's consist of technologies that are being implemented in machines such as tanks, transports, excavators and more in order enabling these machines to be remote controlled or have some degree of autonomy. This has been experimented on tanks like *Panther*, *M60 Panther*, *M1 Abrahams Panther II* also it has been tested on some armored vehicles like Humvee. These experiments are not only popular in the US but in the other countries as well, the Russian Armata-14 next-gen MBT is supposed to be automated in the future.

Conclusion

The proliferation of robotics and autonomous weapon systems will become a major trend in the future of warfare. These sophisticated machines guided by radars, sensors, augmented Ai, without the need for rest and able to operate equally good in all weather and terrain conditions will slowly push out the human factor in some military tasks. Though the absence of human factor can be useful in terms of better combat efficiency and less casualties it is questionable if these robots can show morals, war ethics and even mercy towards enemies, regarding them as human beings. We have already witnessed the collateral damage in places like Pakistan, Afghanistan, Yemen etc. when it comes to remote controlled drones which are operated in real time by living servicemen. The absence of direct contact and interaction on the battlefield can make civilian casualties look unimportant or even meaningless. With better autonomy, especially when it comes to killer-robots, the only interaction between the battlefield and the soldier will be a programming part of the machine when it goes onto missions and when it returns, in fact the whole interaction could probably be reduced to maintenance work. This sounds nice from a perspective of a highly advanced military, but not for those who are about to have a direct contact with these machines on the battlefield. The global community and especially the international organizations who participate in creating and sustaining international law and the customs of war need to have an active approach to these matters. The risk of misuse or just careless behavior by those who possess this technology is very high, thus the boundaries must be set and determined before the innocent pay the highest price.

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Notes:

- http://www.cnas.org/sites/default/files/publications-pdf/CNAS%20World%20of%20Drones_052115.pdf
- http://www.css.ethz.ch/content/dam/ethz/special-interest/gess/cis/center-for-securities-studies/pdfs/CSSAnalyse164-EN.pdf
- https://sin.thecthulhu.com/library/military/vehicle/Technology_Development_for_Army_Unmanned_Ground_Vehicles.pdf

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