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Automation in Military Operations

Automated technology is increasingly used in military activities such as intelligence gathering, navigation and weapons delivery. This POSTnote examines current and future military applications of automation, and considers associated legal, ethical and societal issues.

Overview

- Military systems have an increasing range of automated functions but there are no fully autonomous systems in use.
- Each of the main military domains – air, land and sea – make use of automation.
- Technological challenges include on board data processing capabilities, data transfer, and power.
- Deployment of armed remotely piloted vehicles has raised various issues including the need for transparency about how they are used by governments.
- There is debate over whether a pre-emptive ban is needed on future lethal autonomous weapons systems, which could select and attack targets without human intervention.

Background

Automation has been used in various forms for decades (e.g. in guided missiles).[1] However, recent controversy over the use of remotely piloted aircraft in military operations, as well as statements by high-profile academics like Stephen Hawking about future applications of artificial intelligence, have brought the topic to public attention. There is also growing military interest in automation because of the potential to reduce the risks to personnel and cut costs. For example in 2016 automated systems will be a key theme of NATO's biannual 'Joint Warrior' exercise.[2]

The level of automation a system exhibits can be seen as a spectrum ranging from remotely piloted through to fully autonomous systems (Box 1). The most widespread use of automated technology to date has been remotely piloted air systems (RPAS). Their use in combat is a contentious topic; the NATO-led deployment of armed RPAS in Afghanistan and Iraq has been particularly high profile,[3,4] and the more recent UK deployment of armed RPAS in Syria has generated widespread debate. Concerns have also been raised over the potential for lethal autonomous weapons systems (LAWS) although there are no fully autonomous systems to date. The current and potential military applications of automation are much broader than armed conflict, as discussed in the next section.

There are three key drivers for increased automation in military operations. The first is a reluctance for military personnel to take part in dull, dirty or dangerous missions.[5,6] The second is improved functionality: machines can have better endurance and faster response times than humans.[7] And third, there is the possibility of reducing personnel numbers over the longer term, although whether this is achievable is still debated (see 'costs' section). This POSTnote discusses:

- current military applications of automated systems
- future applications and barriers to uptake
- legal, ethical and societal issues arising from their use.

Current Military Uses

Military systems already have some automated functions including navigation, take-off and landing, communications and detection.[8] This section outlines current applications of automation in intelligence, surveillance and reconnaissance and in combat. Box 2 provides an overview of UK and global activity in this area.

Intelligence, Surveillance and Reconnaissance

Intelligence, Surveillance and Reconnaissance (ISR) is the acquisition and processing of information to support military operations. Unmanned systems used to carry out ISR missions can either be remotely operated or sent on a pre-defined route.

Box 1. What is Autonomy?
Advances in technology are enabling higher levels of automation in military systems. Each of the systems discussed in this note falls into one of three categories (with some overlap between them):
- Remotely operated: The system is fully controlled by a human operator who is not in the vehicle. Vehicles are either radio controlled or connected to a support system via a fibre-optic tether.
- Semi-autonomous/automated: The system has some automatic functions that allow it to carry out parts of its operation without human intervention. This usually involves responding to inputs from sensors to carry out pre-defined actions, for example navigation along a pre-defined route.
- Fully autonomous (not yet in existence): when given a set objective, the system can understand its environment and make decisions on how to carry out tasks independent of human control. The action will be predictable but the individual steps to achieve it may not be. Such systems would be likely to have a level of artificial intelligence (AI), which is the ability of a machine to think and act intelligently. The future direction of AI is uncertain, but it is likely to have a major impact on military operations.

There can be varying levels of automation within the same system, depending on the task it is required to do. Generally the move towards greater autonomy has led to removing the pilot or driver from a military vehicle. Such systems are known as unmanned vehicles. Aerial vehicles are the most common type of unmanned vehicle, and are often referred to as remotely piloted air systems (RPAS) or ‘drones’.

- **Air:** current systems are remotely piloted and are usually equipped with cameras providing operators with live video feed and images for analysis on the ground. They can also have sensors for infra-red and radar imagery.[9,3] Military RPAS vary largely size and can range from small rotary wing RPAS that usually weigh less 20kg, to large fixed wing planes.[10] The UK Army has deployed several types of RPAS in Afghanistan and Iraq,[4] including the Black Hornet, a small, hand-deployed RPAS used to look over walls and round corners.[11]
- **Sea:** current systems are mainly used for mine hunting and disposal. Since 2006 the Royal Navy has used ‘Seafox’, an unmanned underwater vehicle tethered to a mother ship, for mine hunting and disposal. In 2014, the Navy began testing the ‘Hazard’ remote-controlled boat, which can deploy a number of unmanned underwater vehicles, including Seafox, to detect and dispose of mines.[12] A number of reports say that the UK has a maritime surveillance capability gap.[13,4] The MOD is exploring options for providing part of a future capability with an aerial unmanned system. This is also being explored in a Royal Navy paper on RPAS looking out to 2050.[14]
- **Land:** current systems are mainly used in mine and bomb clearance.[15] They are generally fitted with a video camera which provides data to the operator.[16] They are also used for border surveillance,[8] for example the Israeli forces use the Guardium, an unmanned system which patrols border areas and is equipped with a camera and microphone.[17]

Weapons
Armed RPAS are used for weapons delivery. These have a human operator making the firing decisions.[18] The UK only has one type of armed RPAS in the military inventory, the Reaper, used in Afghanistan and Iraq.[4] There are also a number of automatic weapons systems in operation which can fire without human intervention, but these are not used against human targets. They are restricted to defensive functions such as the interception of artillery fire and rockets.[20,21] These systems are either stationary on land, or on ships, and are generally used for protecting military bases. Examples include the Israeli Iron Dome[22] and the US Phalanx system which has been used by the Royal Navy.[5]

Box 2. UK and Global Activity
Worldwide
The overall global market for robotics and automated technology is predicted to reach £13bn by 2025. Israel and the United States are the two biggest developers of automated technology worldwide. There are also major emerging markets for unmanned systems in China, Russia, South Korea and India. The US Department of Defense claims that China is looking to produce 42,000 unmanned air and maritime systems in 2014-2023.[19] Robotic armed stations have been deployed in South Korea for border surveillance, and in 2011 Israel deployed its Iron Dome air defence system which can track and intercept incoming missiles.
UK
There is no specific government budget for automated systems. Research and development is carried out by the Defence Science and Technology Laboratories (DSTL), which runs projects to meet requirements set by the MOD. R&D funding is split across projects in air, land and sea (see Box 3). Already-developed automated systems can also be acquired through Defence Equipment and Support (MOD’s procurement arm), often to meet an ‘urgent operational requirement’ (the UK acquired several types of UAV for operations in Afghanistan in this way). There is a strong industry base for automated technology in the UK, with companies such as BAE Systems carrying out research in the aerial arena and QinetiQ specialising in maritime autonomy research. There is no overarching military strategy for automated systems. The Government’s plan for future use of such systems may be clarified in the forthcoming Strategic Defence and Security review.

Technological and Regulatory Challenges
Advances in robotics, sensors, processing power and nanotechnology (many of which are commercially driven) are likely to come together to rapidly improve the capabilities of military systems.[23] Box 3 provides some examples of emerging applications. However, a number of technical and regulatory challenges need to be overcome before automated systems can achieve full maturity.[5]

Technical
Transferring Data
Improved sensor technology is generating ever larger volumes of data, in the form of high definition images and videos. On one mission, an MQ-9 Reaper RPAS might collect the equivalent of up to 20 laptops’ worth of data, which is transferred back to the operator for analysis over satellite links.[28,24] However, bandwidth (the availability of radio-frequencies for transmission) is often limited,[25] restricting the amount of data that can be sent. Transferring data is a major challenge for underwater vehicles because radio waves do not travel far underwater. This also means that untethered underwater vehicles cannot be remote controlled; they have to travel on pre-programmed routes

Box 3. Emerging Applications of Automation

Combat Vehicles

Systems under development have a greater degree of automation than those in use. For example, the Taranis program, a UK demonstrator for an unmanned combat air vehicle being developed by BAE Systems, will be capable of highly automated flight. The MOD is carrying investigating the options for a Future Combat Air System from 2030, for which Taranis will help provide a knowledge base. Existing RPAS were not designed for use in environments where they could come under attack. Future RPAS, including Taranis, are likely to include 'stealth' features that make them difficult to detect in flight.

Swarm Technology

As communications technology improves, it will allow robotic military systems to carry out 'swarming', a battlefield tactic used to overwhelm adversaries. The US Navy recently tested a system which can rapidly launch 30 small RPAS that can operate for around 90 minutes. Small RPAS are relatively low cost and have the potential to coordinate with each other for intelligence gathering.[25,26]

Logistics

Automating military logistics could save manpower costs and reduce injury to personnel, for example due to improvised explosive devices. For example, unmanned ground vehicles could be used in a 'leader-follower' convoy where one manned vehicle leads a convoy of unmanned vehicles.

and collect data for later analysis at base. There is an increasing need for 'real-time' data processing on board the system.[5] One challenge with real-time data processing is a system's ability to interpret the data is collects reliably. An operator needs to be confident that the system has not missed vital information. There is an increasing need to develop analytics that can deal with the large volumes of data collected, (POSTnote 468),[27] which existing processing techniques have difficulty handling.[28]

Keeping Systems Secure

Many systems depend on satellite communications, for example for data transfer, or for positional information. However satellite communications are vulnerable to hacking or 'spoofing' (where a system can be redirected to false coordinates).[8] Cyber attacks can also be used to hamper system performance. For example in 2009, insurgents in Iraq used commercially available software to capture live video feeds from a US 'Predator' RPAS that was carrying out surveillance.[4]

In the maritime sector, there are concerns that unmanned underwater vehicles could be tampered with by adversaries, particularly because untethered vehicles have no communication with the operator while underwater and so cannot be monitored while on a mission. Future maritime vehicles will need to include anti-tamper systems to prevent operation in the event of capture.[8] The transition to increased automation and reliance on software means that operators need to trust that the automated functions of a system will perform as intended.

Avoiding Obstacles

Systems need to be aware of their surroundings and to be able to select new routes to avoid collisions. The automation of so-called 'sense and avoid' functions is still developing. Airborne systems pose the greatest challenge; to date, RPAS have operated in relatively uncongested airspace over Iraq and Afghanistan.[5] Existing systems are unsuitable for use in more congested airspace. Future systems, which are currently being developed, will include a combination of sensors, such as radar, motion sensing and laser.[29] Automating airborne sense and avoid systems is likely to be a challenge for the next 5-10 years.[30]

Interoperability and Networks

Future uses of automated systems are likely to involve more joint operations where air, land and sea vehicles operate together to carry out missions. This will involve vehicles sharing a greater amount of data, for example the location of obstacles or target information.[31] It will also require improved communications – both between machines and between the machine and operator – which will necessitate standardisation of communications, control systems and data links.

Battery and power

Some systems, including smaller RPAS and untethered underwater vehicles, run off battery power and consume a lot of energy. There is ongoing research in this area; some unmanned surface vehicles under development can use wave and solar power to extend operation times to up to several months.[32]

Regulatory

Regulations need to keep pace with technological developments to ensure safe operation, particularly for unmanned systems.[33] There are existing regulations for RPAS flown in the UK, and ongoing discussions over regulations for maritime systems. (Box 4)

Wider Implications

Controversy over RPAS

The use of armed RPAS has been the subject of extensive discussion within Parliament, including in reports by the House of Commons Library,[4] House of Commons Defence Select Committee[34] and All-Party Parliamentary Group on Drones.[35] The Library paper explains that the use of armed RPAS by the United States, combined with a perceived lack of transparency about their operation, has prompted questions about the UK's policy on using Reaper to conduct air strikes.[4,] The main areas of debate are as follows:

- whether their use complies with international humanitarian law[36,37]
- whether states are more likely to use force because they have access to RPAS[38]
- whether their use encourages anti-Western sentiment and radicalisation in areas affected by strikes[39,40]

Evidence is cited for and against each of the above points, but there is no clear consensus. Following its inquiry, the Defence Committee stated that it was satisfied that "*as far as possible, civilian casualties will be avoided and collateral damage minimised*" in Reaper operations.[41] However, it echoed wider calls for greater transparency "*in order to build* *public confidence about their use and to debunk myths and counter misinformation*". One of the key issues raised by critics is the psychological effect on communities where RPAS have been used continually.[42] As they are used in different contexts, it is hard to compare the impact of RPAS with other uses of firepower (e.g. manned aircraft) in a meaningful way.[3] However, there is a range of evidence suggesting that the constant presence of RPAS and the fact that they can loiter over populations for long periods compared to manned vehicles, could be a contributing factor.[43] A US study suggested that the US use of RPAS in Pakistan eroded trust and caused psychological trauma within the local community.[44]

Cost savings from automated systems

There has been no calculation of the overall cost savings associated with increasing the automation of military systems in the UK. It has the potential to save money by reducing the number of personnel needed for certain operations. However, there are costs associated with training operators, and with maintaining and transporting the systems. In the case of airborne systems, RPAS have not replaced existing front-line manned systems, but have been used as additional support in operations. Manned systems are still required as a backup. The 2010 UK Government stated that RPAS are not expected to replace manned systems in the short term, but in the long term, a mix of manned and unmanned RPAS could be used.[5] Industry stakeholders point out that in the maritime sector, unmanned vessels for roles such as ISR are usually cheaper than conventional manned ships and submarines. Some argue that as uptake of unmanned technology increases, economies of scale will deliver cost reductions.

Lethal Autonomous Weapons Systems

There is widespread concern over the potential future development of LAWS, and there are calls for a pre-emptive ban on their development. There is no internationally agreed definition, although for the purposes of the UN Convention on Certain Conventional Weapons (CCW) meeting in April 2015, LAWS were defined as being "weapons which could autonomously select and engage targets".[45,46] The 2010 UK Government stated that "the operation of weapon systems will always be under human control".[47] The US Government has said that operators of automated and autonomous weapons systems will always exercise an "appropriate level of human judgement".[48] However, a number of NGOs argue that terms such as "human control" and "appropriate level of judgement" are open to interpretation, and need to be more clearly defined.[49,50,51,52]

There is no specific international legislation on autonomous weapons systems.[53] However, any system that cannot comply with the principles of International Humanitarian Law or IHL– for example a system that cannot distinguish between civilians and combatants–is prohibited. Because of this, the UK has argued that further legislation to ban LAWS is not needed.[54] However, many argue that IHL alone is not enough to prevent LAWS being developed.[58] The Campaign to Stop Killer Robots is an international coalition of NGOs calling for a "*pre-emptive and comprehensive ban on the development, production, and use of fully autonomous weapons*".[59] This call is concerned with the decision to kill being delegated to a machine; the group argues that combat robots must be under human control to ensure humanitarian protection and effective legal control.[60]

Box 4. UK Regulation of unmanned systems

Military UAVs in the UK are subject to the same regulations as conventional military aircraft. The regulations advise that all military unmanned air systems must go through Military Aviation Authority (MAA) classification before being used. The MAA updated regulations for UAVs in January 2015, classifying them based on size, method of operation and risk posed to people on the ground. At the moment, UAVs in the UK can only fly in segregated airspace reserved for such vehicles. The UK Civil Aviation Authority will not allow UAVs to fly in non-segregated UK airspace until they can detect and avoid obstacles as proficiently as a human pilot.[55] Operators will also need to demonstrate that UAVs can operate safely if they lose their communication links. The ASTRAEA programme is a UK industry-led consortium aiming to enable the unrestricted use of RPAS in all classes of UK airspace.[56]

There is no regulation explicitly for unmanned maritime systems. However, the UK Maritime Autonomous Systems Regulatory Working Group is developing an industry code of practice to provide guidelines for the safe operation of unmanned surface systems.[57]

Technological Proliferation

As the global market for automated systems expands, they are becoming more affordable. It is now possible to build a remotely piloted air vehicle for as little as £250.[8] A wide range of states and non-state groups are therefore likely to make use of automated technology in the future. Many commentators argue that the MOD needs to change its approach to exploiting technological developments, including automation, in order to maintain a strategic advantage over its adversaries.[61] This issue will be addressed in a forthcoming POSTnote, on 'Technological Trends in Defence'.

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