Unnamed Systems:

A Genuine Revolution in Military Affairs?

By Major S G Heath

The thing was incredibly strange, for it was no mere insensate machine driving on its way. Machine it was and...it picked its road as it went striding along. I began to ask myself what they could be. Were they intelligent mechanisms? Such a thing I felt was impossible....The decapitated colossus reeled like a drunken giant; but it did not fall over…and the thing was now but a mere intricate device of metal whirring to destruction. It drove along in a straight line incapable of guidance'[1]
(H G Wells *The War of the Worlds*)

In the early 1980s theories were put forward, by Soviet General Ogarkov amongst others, that NATO, in particular the United States, was undergoing a Revolution in Military Affairs (RMA).[2] It was argued that the precarious balance of conventional forces in Europe and the fact that the use of nuclear weapons was immoral and practically impossible, was causing the US to bring the Cold War to an end, by developing high technology conventional weapons that its Warsaw Pact adversaries couldn't match.[3]

The ability of protagonists to conduct military operations, without danger to one's own personnel in the medium term, is not such a fanciful notion and one which merits careful examination

Twenty years later, it is believed that this revolution is still ongoing and whilst a precise definition of the RMA continues to elude analysts, there is no doubt that warfare is conducted in a manner very different from that envisaged during the Cold War, due in most part to a military-technological revolution. Indeed, US forces continue to seek 'dominant battlefield knowledge, dominant manoeuvre, precision strike capability at long range and full dimensional protection.'[4] However, these are still activities conducted largely by human beings, manning a wide array of platforms in three environments (maritime, air and land), based on decisions made by human commanders.[5] In turn, those decisions are based on a wide array of factors ranging from the strategic to the tactical and include Rules of Engagement (ROE), the need for minimum casualties and the nature of the operating environment. But what if we were to remove human beings from the battlespace altogether?

The aim of this paper is to examine the extent to which the current RMA will be transformed by the introduction of unmanned systems, from the remotely operated to the genuinely autonomous. In doing so, it conducts a re-appraisal of our most basic and fundamental military concepts, given that the reality of risk-free war will pose serious questions about the nature of future conflict. While combat as envisaged by H G Wells is beyond the scope of this paper, the ability of protagonists to conduct military operations, without danger to one's own personnel in the medium term, is not such a fanciful notion and one which merits careful examination. As noted by the Pentagon in 1984:

'*Instead of fielding simply guided missiles or remotely piloted vehicles, we might launch completely autonomous land, sea and air vehicles capable of complex, far ranging reconnaissance and attack missions…Using this new technology, machines will perform complex tasks with little human intervention, or even with complete autonomy…The possibilities are quite startling, and could fundamentally change the nature of human conflicts.*'[6]

The analysis will commence with some definitions, then examine of the future spectrum of conflict. The paper will then outline the type of unmanned systems that are likely to be operational in each of the three environments within a specified timeframe, in order to assess their impact on a number of considerations including force structures, human resources and doctrine. Two scenarios will be studied to see if the utility of unmanned systems remains constant throughout the spectrum of conflict and whether their resulting employment is likely to alter our accepted beliefs and modus operandi. From this examination will be determined the extent to which the introduction of such systems will transform the ongoing RMA.

Of course, the idea of revolution as opposed to evolution is that the change is rapid and fundamental in nature, rather than a gradual development. What will become clear from the analysis is that, despite radical technological advances, unmanned systems will not be introduced wholescale and overnight, but will be gradually introduced as overall system technologies and enablers mature. This process will still cause fundamental alterations to our structures and doctrine, but the ethical debates stimulated by the introduction of unmanned and particularly autonomous systems will also ensure that the human is not totally removed from the battlespace within a matter of a few decades. Therefore, it can be said that the unmanned RMA will be of a continuous type rather than a discontinuous event, as experienced with the introduction of gunpowder, aircraft and nuclear weapons.

DEFINITIONS

Many different descriptions of the RMA exist, encompassing not only doctrinal and technological aspects, but also requirements for organisational and industrial structures, as well as political and information factors.[7] It is not this paper's task to comment on the merits of these arguments, but it is essential to give the revolution a basic definition. Andrew Marshall, Director of the Office of Net Assessment in the US Department of Defense, usefully defines the RMA as follows:

'…a major change in the nature of warfare brought about by the innovative application of new technologies, which combined with dramatic changes in military doctrine and operational and organisational concepts, fundamentally alters the characteristics and concepts of military operations.'[8]

Similar levels of debate concern the definition of an unmanned system. It has been argued that cruise missiles, navigating themselves to a pre-designated target after launch, or brilliant munitions which can loiter above an engagement area and then seek and destroy targets, are examples of such systems.[9] However, these are weapons, and no human beings apart from suicide bombers and kamikaze pilots are likely to ride a missile or munition all the way to the target. What is more helpful is the definition that an unmanned system is one where human beings have in the past been required to operate the platform, but can now be replaced. Maritime vessels, both surface and sub-surface, land vehicles or aircraft, both fixed and rotary wing can be supplanted either by human operators remotely controlling platforms or by utilising autonomous technologies.

In addition, new systems that are smaller than human beings are under development and could fundamentally impact the way in which war is conducted. Systems such as micro Unmanned Aerial Vehicles (UAVs), insectoids and mini Unmanned Ground Vehicles (UGVs) will, given advances in computer processing power, energy sourcing and Novel Physical Properties (NPP), be able to carry out tasks that are impossible for human beings to conduct and with their introduction, the dimensions and scale of warfare are likely to change. The paper will thus restrict its consideration to these unmanned 'platforms' and, to the smaller-than-man-technologies rather than 'weapon systems'.

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Additionally, it is necessary to define autonomous systems. Systems with Artificial Intelligence (AI) attempt to replicate human cognition, behaviour and the capability to learn from mistakes. A number of techniques are used to achieve this, but the result is potentially an autonomous system that is capable of going out and achieving an assigned mission without further human instruction. It is the introduction of machines devoid of human control, which poses the greatest threat not only to our accepted notions of warfare, but of life as a whole. As de Landa recognised:

'…the moment autonomous weapons begin to select their own targets, the moment the responsibility of establishing whether a human is friend or foe is given to a machine, we will have crossed a threshold and a new era will have begun for the machinic phylum.'[10]

However, there is little consensus on a definition of ‘autonomous system’, despite much academic debate.[11] For the purposes of this paper, we shall define it as a system that ‘will be equipped with sophisticated computers and sensor systems that will allow the robot to make its own decisions without any direct human involvement’ and obviously, systems can have differing degrees of autonomy, based on the micro-processing power available.[12] It is they along with ‘remotely controlled systems’ that may be described as the two main subsets of the more generic ‘unmanned system’.

SPECTRUM OF CONFLICT

Any consideration of the impact of these new and revolutionary unmanned systems must be carried out against the conditions provided by the full spectrum of conflict. British Defence Doctrine recognises a ‘spectrum of tension’ that stretches from warfighting at one extreme to conflict prevention at the other, in a linear arrangement.[13] However, the Army’s Directorate General of Development and Doctrine sees a rather different spectrum existing from 2015 onwards.[14] Firstly, it recognises that 3 different types of operation may be in progress in a theatre of operations at any one time and that secondly it is possible to move rapidly about the spectrum without recognisable increases or decreases in intensity. This reflects the fact that warfighting can take place within peace enforcement and peacekeeping scenarios, while those types of operation may take place on the periphery of a high intensity engagement.

Today’s conflicts may become, and in the near future will certainly be, far too deadly for human beings to survive on the battlefield

This thesis is supported by General Krulak’s vision of a “three block war”.[15] Opponents will be similarly diverse: they may be conventional armed forces, or groups of ‘soldiers’ in loose organisations, with tenuous allegiances and asymmetric modus operandi and may be indistinguishable from non-combatants.[16] Both types of opponent will be well equipped, given the proliferation of advanced technology and a global arms market and thus will present a very credible threat. Nevertheless, they will also seek to offset any technical advantage by breaking moral and ethical codes, through use of civilian infrastructure and society to hide military equipment and activities. Furthermore, an increasing number of operations will take place in complex terrain, particularly urban and semi-urban areas, making the effective targeting of military campaigns and protection against enemy action all the more difficult, as events in Former Yugoslavia, Somalia and Afghanistan have demonstrated. Therefore, unmanned systems will be required to operate in a diverse spectrum of conflict against capable opposition, demonstrating utility across a range of military operations, without having to re-adjust force structures as the scenario evolves.

It is thus the requirement of this paper to look beyond 2015, into an era when operations are taking place within this new spectrum of conflict. While writers have prophesised a world in which warfare is conducted solely by robots, this remains science fiction and is not a realistic reflection of the technological advances that will be made in the foreseeable future. Given that a number of important UK equipment programmes will be approaching the latter stages of their useful lives in 2030 and require replacement capabilities, then it is sensible to use that as the date at which serious consideration should be given to the widespread employment of unmanned systems.[17]

UNMANNED SYSTEMS

Following early attempts to deploy pilotless aircraft in both World Wars, unmanned systems were largely disregarded by equipment designers until the 1960s and 1970s, when the Israelis and Americans led a resurgence in their development, as a result of the Arab-Israeli and Vietnam wars. With parallel advances in remotely controlled submersible craft for underwater exploration and attempts at building crewless tanks and robotic legged-vehicles, interest in unmanned systems has continued to grow and given the necessary enabling technology, the opportunities afforded by such platforms are multiplying rapidly. Fulsang cites four major factors as causes of the unmanned revival:

'Demographic and economic trends, the balance between quantity and quality in conventional forces, the increasing lethality of modern weapons, and the spread of international terrorism.'[18]

Firstly, due to ageing populations and the negative effects of increasingly liberal and affluent societies, the recruit base of most developed countries is shrinking. It is believed that the introduction of unmanned systems could offset this, by reducing the levels of manpower required. Secondly, these systems are viewed as one of the most effective methods of maintaining the qualitative edge over numerically superior opponents and in doing so will contribute to the 'full spectrum dominance' that the US Armed Forces aspires to, in the 2020 timeframe.[19] Thirdly, the battlefield of the future is not one in which human beings can be expected to operate effectively. Not only will the tempo of operations created by the information explosion be such that they will be unable to operate for sustained periods, but as Shaker and Wise point out:

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Tomorrow's soldier will go to war with tiny aircraft in his backpack that he will be able to fly ahead of him to smell, see and hear what lies over the hill or inside the next building

'*If unconstrained, today's conflicts may become, and in the near future will certainly be, far too deadly for human beings to survive on the battlefield. The lethality of modern weapons, including NBC munitions, hypervelocity missiles, smart bombs, lasers and other high-technology killing mechanisms, are rapidly eroding what an individual soldier's initiative or heroics can contribute towards winning or losing.…Clearly, much of the future battlefield will be too hazardous for people to operate in*.'[20]

At the same time, the tolerance of Western societies towards casualties, combatant and non-combatant, friend and foe alike, is decreasing. While recent campaigns have encouraged the idea that risks in conflict can be minimised, high intensity warfare can quickly generate a considerable number of casualties. In this scenario, the advantages of unmanned systems are obvious. Finally, the spread of international terrorism, more relevant now than ever, has meant that there are an increasing number of mundane and routine security responsibilities to be undertaken. These could be carried out by unmanned systems. As US Navy Secretary, Gordon England, has stated, they are exactly suited to conduct what are termed the D3 tasks:

'*In my judgment, unmanned systems have the same transformational potential as space. We already have unmanned systems typically doing the dull, dirty and dangerous [D3] activities that humans shun or are unable to perform, and they have generally performed well in these roles. For example, today the U.S. Navy has a deep submergence unmanned vehicle in Hawaii helping to recover the Ehime Maru from crushing depths far too deep for humans to work*.'[21]

TECHNOLOGY

Based on this renewed interest, unmanned systems will take advantage of progress in a number of technology areas. Firstly, the development of Micro Electro-Mechanical Systems (MEMS) means that miniature systems could soon be used in a wide range of applications. As James Adams has stated:

'*MEMS opens a window on to a new generation of technology that will literally transform the battlefield. Tomorrow's soldier will go to war with tiny aircraft in his backpack that he will be able to fly ahead of him to smell, see and hear what lies over the hill or inside the next building. Additional intelligence will be supplied by sensors disguised as blades of grass, pockets of sand or even clouds of dust.*'[22]

Whilst sensors the size of dust particles will not be available in this paper's time frame, micro UAVs have already been developed which could be used to give individual soldiers their own unmanned surveillance capability allowing them to 'look around the corner', without being exposed to danger.

We are faced with the prospect of equipment that does not require soldiers to operate it, but may be defeated if humans do attempt to exert control in any direct way

By 2030 these UAVs will still only be capable of short duration and distance operations, due to the immaturity of NPP and power source technology. However, as Knoth has pointed out, this area of micro development is not just restricted to UAVs:

'*A new concept for land-based military operations using small autonomous vehicles or 'insectoids' has weapons applications which cover both the lethal and non lethal weapons sectors, but also reflects trends in civilian technology and parallel developments already underway for air and space borne systems. Such robot systems are smaller, less complex and cheaper than their manned equivalents*.'[23]

Secondly, this proliferation of micro systems and the development of numerous other platforms will generate the requirement for continued advances in microchip technology. Its continued development will be necessary, because human beings will no longer be able to deal with the amount of data being presented to them. They will have to give increasing amounts of authority to machines in order to make fully informed decisions and as Thomas Adams has stated:

'*…the military systems (including weapons) now on the horizon will be too fast, too small, too numerous, and will create an environment too complex for humans to direct.…Weapons and other military systems already under development will function at increasingly higher levels of complexity and responsibility and increasingly without human intervention.…We are faced with the prospect of equipment that does not require soldiers to operate it, but may be defeated if humans do attempt to exert control in any direct way. It is easy to see a steadily decreasing role for humans in direct combat as the 21st Century progresses*.'[24]

Thus computers capable of conducting millions of calculations per second, far in excess of the abilities of the human brain, will be required, so that unmanned systems can carry out very complex tasks and decision-making, without reference to human operators. It is in this development of smart computers and AI systems that the greatest steps towards genuinely autonomous platforms will be made. However, there is a considerable debate as to the speed at which advances in AI will be achieved, although in the mid term, its utility in 'surveillance, target acquisition, autonomous combat vehicles, navigation, multi-sensor fusion, terrain analysis, signal processing, weapons maintenance aiding devices, training devices, logistic support, image interpretation, tactical decision aids and simulation' is undisputed.[25] Whilst a fully autonomous system, capable of replicating human thought processes in their entirety could not be fielded by 2030, their limited introduction over the next 30 years will generate considerable ethical debate.

The third important technological area is that of communications. As Henley has observed: 'It is taken for granted that such devices [unmanned systems] will be tied into our battlefield information networks'. [26] This will hugely increase the demand for bandwidth, in order to relay information around the battlespace. Whilst data compression techniques, allied to the use of burst transmission, will go some way to satisfying this requirement, remote control of some systems such as Unmanned Underwater Vehicles (UUVs) will be difficult, given that water is a difficult medium through which to pass radiowaves and light and acoustic signals are relatively limited in range and available bandwidth. The result will be an increasing trend towards semi-autonomous systems that will reduce the requirement for Command and Control (C2) information to be passed from controlling stations to the platforms themselves. It is also widely recognised that C2 links are vulnerable to interference, both from opponents' intentional jamming and other factors such as range, weather and atmospherics. As a result, maintaining guaranteed control over systems, especially those with a degree of autonomy or with weapons payloads, is of particular concern and therefore will require:

'…a pilot's associate, an onboard expert system…[that] if the datalink is lost, it could make logical decisions to keep the aircraft [or any other unmanned system] safe until the electronic tether is restored.'[27]

Autonomous Underwater Vehicle (AUV)

It is believed that semi-autonomous sub-surface craft will be in service by 2030 and will fundamentally alter the nature of maritime warfare

MARITIME SYSTEMS

In the maritime environment, developments in unmanned systems have focused on sub-surface operations. Currently, submarine operations are constrained by the physical size of craft required for placing personnel underwater, as well as the physiological and psychological effects imposed by long periods of isolation and sensory deprivation. Unmanned sub-surface operations would involve Autonomous Underwater Vehicles (AUVs) or UUVs undertaking missions of reconnaissance, sensor and weapon deployment, minefield mapping and clearance, as well as acting as intelligent anti-submarine warfare decoys.[28] Small craft capable of long duration deployments could be deployed singly or in fleets and be controlled by either surface vessels or manned submarines. Therefore, the initial fielding of UUVs will focus on operational scenarios in which submarines are particularly vulnerable, such as littoral operations where waters are shallow and targets are usually protected by minefields. They could also be deployed as part of the escort group to a high value asset such as an aircraft carrier and be able to 'provide a broad spectrum of data to the battlegroup'.[29] Furthermore, the US Navy is developing the 'Manta', an AUV relying on AI to conduct many of its operations.[30] Therefore, it is believed that semi-autonomous sub-surface craft will be in service by 2030 and will fundamentally alter the nature of maritime warfare. Nevertheless, there will still be a requirement for manned submarines, particularly for the control and launch of nuclear weapons.

Progress is not restricted to the sub-surface. Until 1997, the US Navy was actively pursuing the arsenal ship concept. Such a vessel would carry 500 missiles of varying types and launch them in support of both air and land operations, whilst only having a crew of 50 personnel. Some go further and state that

Northrop Grumman's X-47A Pegasus UCAV

It is the development of Unmanned Combat Aerial Vehicles (UCAVs) that will form the basis of the unmanned revolution in 2030. These systems could fundamentally change the way in which airpower can be employed and will relieve manned aircraft of the need to conduct such D3 tasks as 'monotonous long-range flights, high-risk raids on enemy air defenses and forays into areas contaminated by biological or chemical weapons'

the vessel could be fully automated. However, reservations exist about the employment of so few personnel on such a valuable asset:

'*the concern has been expressed that small crews could seriously degrade damage control capabilities. Immediate damage control measures are often essential to the survival of a combat vessel in the event it sustains damage during combat. With a minimal crew on board the arsenal ship, questions remain unanswered as to its capability to effectively control combat damage or fire and flooding.*'[31]

Therefore, the arsenal ship would need to be protected as part of a naval battlegroup but, correctly positioned and defended, could contribute considerable firepower to both tactical land fires and strategic air operations. The advantage of operating such a vessel lies in a reduction in costs. A cut of over 70% or indeed the total elimination of crew would produce 'a life-cycle cost 50% less than that of a naval combatant' as well as simplify operational replenishment routines.[32] However, it is not believed that an arsenal ship would fundamentally change the nature of naval operations. While the vessel could go some way to replacing the aircraft carrier, as the US National Defense Panel pointed out,[33] the introduction of the JCA and the US conversion of existing Trident submarines to carry cruise missiles, would indicate that it is unlikely the arsenal ship will be deployed in the mid term.[34]

AIR SYSTEMS

Conversely, the future for UAVs is bright, with systems employed in a wide variety of roles. These range from providing the individual soldier with an immediate over-the-hill surveillance capability, to the conduct of very high-level, long-endurance operations from fixed home territory sites, fulfilling a number of intelligence-gathering, communications and offensive and defensive electronic warfare tasks. Additionally, short-range surveillance and reconnaissance UAVs, which have been operating from naval vessels since before the Gulf War, will continue to do so. However, it is the development of Unmanned Combat Aerial Vehicles (UCAVs) that will form the basis of the unmanned revolution in 2030. These systems could fundamentally change the way in which airpower can be employed and will relieve manned aircraft of the need to conduct such D3 tasks as 'monotonous long-range flights, high-risk raids on enemy air defenses and forays into areas contaminated by biological or chemical weapons',[35] as well as 'anti-access missions'.[36] As Andrew Krepinevich, the head of the Center for Strategic and Budgetary Assessments has explained:

'*The term refers to an enemy's ability to use cruise missiles to target U.S. air bases or sea lanes near a battle ground, blowing up planes or missiles before they even take off. That would nearly cripple short-range U.S. fighter planes, which need access to forward bases to be effective. UCAVs might be part of the answer for how you deal with that, to the extent that you take the person out of the aircraft, you should be able to build these things to go much greater distances.*'[37]

UCAVs will be able to operate at speeds and manoeuvre in ways that manned aircraft cannot. Human pilots can endure a maximum force of 9G, whilst remotely piloted versions of manned aircraft, such as the F102 target drone, can achieve 12G. Purpose-built UCAVs on the other hand, will be able to pull in excess of 20G, giving them the ability to out-manoeuvre both manned aircraft and anti-aircraft missiles.[38] Additionally, the removal of the pilot will reduce the size of the aerial vehicle by up to 40%, giving it increased stealth and thus survivability.[39] This could lead to a decrease in the number of systems required and therefore reduce overall costs. Given such advantages, it is likely that UCAVs will begin to replace manned aircraft towards the end of the useful life of JCA. Indeed, the Dutch government has ordered 100 JCA, of which the 2nd batch will be what is termed 'Unmanned Tactical Aircraft'.[40] However, it has also been noted that while duration, survivability and costs favour the development of UAVs and UCAVs, complex systems such as Global Hawk should not be considered as throwaway, simply because they do not have a pilot on board:

'*(Global Hawk) will likely be employed as the U2 is - outside of high threat environments such as long range SAMs. At approximately $50m each, the Global Hawk is too expensive to be considered expendable.*'[41]

Therefore, it could be argued that the doctrine for the employment of these systems may not change radically from their manned counterparts and thus not transform air operations in the fundamental manner demanded by a genuine RMA.

One contentious area of UCAV development is that of authority for weapon release. Although it is recognised that in today's manned aircraft, much work is done automatically by the system, weapon release remains a human judgement.[42] For example, UAVs identified numerous targets during Operation Allied Force in 1999; however such was the concern over collateral damage and non-combatant fratricide, all targets had to be confirmed by manned aircraft. This concern is likely to endure and as a result:

'*It is likely that unmanned vehicles will not be able to fulfil all of the missions now performed by manned aircraft. A fundamental technological problem is that UAVs have a limited ability to deal with ambiguity.…To be truly valuable in military operations, UAVs should be able to deal with ambiguity, but this ability exceeds the existing technological capabilities of sensors and computers.*'[43]

Even if in the next thirty years the available computing power continues to rise at the rate predicted by Moore's Law, and if progress in sensor resolution is also maintained, there is likely to be a fundamental ethical conundrum facing commanders: are they willing to trust an autonomous UCAV to select and engage the correct target in a complex environment, where the distinction between combatant and non-combatant is at best blurred and in the worst case almost indiscernible? Additionally, the enemy will seek to capitalise on this dilemma by means of deception and until AI systems can recognise when they are being deceived, then it is unlikely that the authority for weapon release will be delegated to a machine alone. As the US Defense Advanced Research and Projects Agency (DARPA) has made clear of its UCAV programme:

'*The degree of autonomy permitted to the vehicle is expected to vary throughout the mission, and lethal operations will require human authorisation…*'[44]

Nevertheless, in 2030 we are likely to see both manned aircraft and a mix of UAVs and UCAVs undertaking a wide variety of tasks. Long range and duration reconnaissance will be the sole preserve of UAVs, while 'Suppression of Enemy Air Defences (SEAD), politically sensitive missions, interdiction, battle damage assessment, theatre missile defence and high altitude strike' may be carried out by either autonomous or remotely controlled systems.[45] Support to the tactical formations of the land component will also be unmanned. As Vickers has stated:

'*A deep-strike brigade might comprise a long-range missile regiment, a stealthy attack helicopter regiment, and an information warfare regiment equipped with unmanned aerial vehicles.*'[46]

However, what is also clear from this analysis is that human beings will remain in the loop for the engagement of targets in Close Air Support missions and those conducted in complex scenarios, even if the ordnance is itself delivered from a UCAV. In doing so, this will confirm the belief that the impact of these systems on the RMA will be of a more evolutionary rather than revolutionary nature.

LAND SYSTEMS

Given the relatively simple nature of their respective environments, the development of unmanned systems for the maritime and air components has progressed well. However, the same cannot be said of UGVs. To date, only small numbers have been produced, with in-service equipments restricted to remote controlled mine and bomb/ordnance disposal devices. These vehicles are not technically complex and the operator has to have sight of the terrain over which the UGV is operating. This is a limiting factor, given that either a physical link or considerable bandwidth required. Thus there is a need for autonomous terrain navigation, but the ability of UGVs to determine the nature of the obstacles in their path and how to negotiate them requires the integration of sophisticated sensor recognition, micro-processing and mechanical reactions. As has been stated:

The best choice for a (future) MBT for the 2010 time frame is a vehicle system consisting of a manned control vehicle 'armed' with a variable number of semi-autonomous tele-directed robotic surrogates as its main weapon

'*there is a requirement for a high level of image understanding by the vehicle's vision system. Achieving this and making the whole process of route planning and cross country driving autonomous is the most difficult aspect of the automation of fighting vehicles.*'[47]

Sixteen years on from this quote, there is still a great deal of development to be carried out before vehicles of the same mobility and flexibility as today's manned systems, can be fielded. Nevertheless, DARPA remain committed to developing UGVs with further prototyping of small Unmanned Ground Combat Vehicles (UGCV) in the next two years.[48] However, these vehicles weigh less than 2000Kg and do not seek to replace the capability offered by current platforms, but could augment the combat power available to early entry expeditionary forces. Despite these limited aspirations, considerable debate centres on whether the next generation of MBTs and combat vehicles should be unmanned, given the range and lethality of modern anti-armour weapons. Notwithstanding advances in Defensive Aids Suites, MBTs and other vehicles will still be highly vulnerable. Therefore cheaper high-volume UGVs may be an alternative. However, given the continuing challenges posed by autonomous terrain navigation, it is likely that the first fielded variants of UGVs will be platforms requiring control by a manned variant. As Dobbs stated:

'*I would propose that the best choice for a (future) MBT for the 2010 time frame is a vehicle system consisting of a manned control vehicle "armed" with a variable number of semi-autonomous tele-directed robotic surrogates as its main weapon.*'[49]

Thus a tank squadron could consist of a small number of manned C2 vehicles and a larger number of UGVs. These could be sent ahead of manned formations to 'motor down strategic roads where soldiers fear mines or ambushes'.[50] Alternatively, manned vehicles could be sent forward to determine a route for a column of unmanned systems to follow. This greatly simplifies the terrain recognition required of the UGV and is termed 'Non-line-of-sight leader-follower'.[51] However, considerable challenges to fielding an unmanned ground force remain. The C2, logistic resupply, friend/foe recognition and ROE are but a few of the issues that would need to be resolved before a force with a mix of manned and unmanned systems could be deployed. Thus it is hard to be optimistic about the employment of UGVs in the 2030 timeframe, except in specialist roles such as combat engineering and long range strike, both of which can utilise remotely controlled systems to conduct operations.

CONSIDERATIONS

In the analysis of future developments, a number of major considerations have emerged. Firstly, the concept of what constitutes a combatant will change. As Finkelstein has pointed out:

'*Operators need not have the youth and strength of combat troops (although co-ordination might be important); tele-robots can be operated by older men or women, or perhaps by civilians working in shifts. Vehicles can be kept moving, limited only by fuel and maintenance constraints. Shifts of alert, rested operators would be at the controls.*'[52]

Thus the established notion of combatants wearing uniform and accepting the contract of unlimited liability will be challenged, as will the de-lineation between combatants, unlawful combatants and civilians. From an enemy perspective, there will be no demarcation between the service personnel commanding operations and the civilian controlling the unmanned systems that are operating in a different continent. This is despite the Geneva Convention laying down strict criteria for combatant status.[53] As the current law makes clear:

'*…civilians are considered as non-combatants. They are not entitled to take part in belligerency or to use arms, even in self-defence against the enemy. In return they enjoy protection under international law.*[54]

As a result of their involvement in military operations, civilians risk losing their protected status and as Dunlap has observed, it likely that:

'*Once civilian technicians or contractors become involved as "operators" in "combat operations," they risk being characterised as "unlawful combatants" under international law.*'[55]

Thus as Cohen has summarised: 'One's function counts more heavily than one's status as a civilian' and thus there will be a requirement to review the law, as the boundaries between combatants, non-combatants and civilians become blurred.[56]

What must also be considered is the impact of the introduction of unmanned systems on the types of personnel employed by the Armed Forces. The employment of increasingly autonomous systems, will undoubtedly lead to a shift in emphasis from operators to facilitators and from soldiers to logisticians and technicians, whose responsibility is not to bear arms, but to prepare and maintain the unmanned combat systems that will undertake that task. Therefore, tomorrow's soldiers will require different skill sets and this will demand a new approach to the selection of suitable personnel. As a result, there is also likely to be an alteration of the military's traditional hierarchical structures. Such a change has been described as a re-working of the old blue/white collar descriptions of officers and NCOs into a more complex iron/blue/white and gold colour division.[57] This will inevitably lead to a re-evaluation of the need for regimental structures and the applicability of the unique ethos and culture displayed particularly by British Armed Forces.

The third issue is that of information management. It has already been stated that computers will be increasingly relied upon, to manage the vast quantities of data available to commanders, who will have access to information across traditional component and chain of command boundaries, from an all informed grid.[58] By linking the output of every battlespace sensor, commanders at every level will have the ability to view any product throughout an entire area of operations. This will radically change the way in which operations are controlled and demand a doctrine where the achievement of information superiority will become as important as gaining physical superiority. Joint Vision 2020 realises this, by stating that full dimensional protection is in part achieved by information superiority.[59] Thus campaign planners will seek to employ a variety of unmanned platforms to provide the most accurate information possible, before and during the committal of their manned counterparts. In turn this encourages the employment of numerous, expendable and low cost unmanned sensors. As Libicki has stated:

Tomorrow's soldiers…may go armed with devices 20 to 50 times more powerful than today's laptops, digital radio-based communications capable of exchanging video data, and electronic image quality maps updated in near real time by UAVs and other sensors

The tacit contract of combat throughout the ages has always assumed a basic equality of moral risk: kill or be killed. Accordingly violence in war avails itself of the legitimacy of self-defense. But this contract is void when one side begins killing with impunity

'*Tomorrow's soldiers…may go armed with devices 20 to 50 times more powerful than today's laptops, digital radio-based communications capable of exchanging video data, and electronic image quality maps updated in near real time by UAVs and other sensors.*'[60]

Thus the contribution of unmanned platforms to the Global Information Grid (GIG) will impact fundamentally on the conduct of operations and supporting doctrine, and it is partly on this basis that it could be argued that unmanned systems will transform the nature of the ongoing RMA.

While accepting this proliferation of unmanned systems, but also acknowledging that they will not replace all of their manned counterparts, there must now be an examination of how the employment of such technology will alter our accepted definitions of war, casualties, success, endstates and Centres of Gravity (CoG). The Oxford English Dictionary defines war as 'armed hostilities between esp nations or hostility or contention between people, groups etc'.[61] If we assume that by 2030 unmanned systems will not have the ability to make the conscious decision to go to war by themselves, then it can be said that the dictionary definition of war should remain valid. War will still be hostility between individual people or groups, although its conduct may not involve human beings in the same manner. The nature of war may have changed, if not the meaning.

If war remains the same activity, but conducted by different means, the ability to fight a 'proxy war' through the use of unmanned systems may lead to an increased willingness to conduct military operations. The seeds of this have already be seen in the campaigns conducted in the Gulf, Kosovo and Afghanistan, where technological superiority meant that once an opposition's air defences had been destroyed, allied air forces could operate with relative impunity throughout the adversary's battlespace. By increasing the use of unmanned systems, protagonists could be more willing to engage in combat, because the threat of human casualties and the associated negative repercussions would diminish. However, the probability of unconstrained, unmanned warfare taking place in the 2030 timeframe extremely low, given the cost and complexity of the technologies involved. Additionally, as our analysis of the spectrum of conflict has shown, warfare will take place in a politically, geographically and operationally complex environment. The result is likely to be a situation where unmanned systems are being opposed by manned systems and dismounted troops and it is within this context that some powerful ethical and moral concerns have already been raised. In his analysis of the 1999 Kosovo campaign, Ignatieff stated that:

'*The tacit contract of combat throughout the ages has always assumed a basic equality of moral risk: kill or be killed. Accordingly violence in war avails itself of the legitimacy of self-defense. But this contract is void when one side begins killing with impunity.*'[62]

Therefore, if one belligerent uses unmanned systems to fight and kill human beings without fear of death, are they then acting unjustly? Furthermore, will they gain and maintain the support of their population? As has been pointed out:

'*In Kosovo in 1999 NATO was accused of fighting the conflict using the lowest common denominator, that of making the campaign a moral crusade that had to be fought at any cost, except that of Allied casualties. What sort of message, then, would an unmanned air campaign on a civilian population give out? Could a UCAV campaign imply* we care enough to kill your population to change your behaviour but not enough to risk our lives*?*'[63]

This debate is certain to grow over the forthcoming decades, but it is interesting to note that the use of Hellfire missile-equipped Predator UAVs against the Taliban and Al Qaeda fighters in Afghanistan generated no comment of a moral or ethical nature.

The concept of what constitutes a casualty must also be examined. Current Operational Analysis predicts casualty rates in terms of both men and equipment. However, as Barnaby has stated:

'*Is it necessary for blood to be spilled in war?…Victory in an automated battle may well go to the side that can keep up battle for the longest time.*'[64]

Therefore, decision-makers would not have to concern themselves with maintaining the moral component amongst their troops and civilian populations in the face of mounting human casualties. Instead, efforts would focus on being able to produce sufficient replacement systems and getting them deployed into the battlespace. This would necessitate a re-evaluation of our current doctrine, and mass may once again become a predominant line of development while force protection, except for the most

Soon technology, particularly mini or micro robots, may allow military planners to select which individual or physical object in a building is to be destroyed. For the first time, it might be possible to target only the aggressor's leaders, leaving non-combatants untouched

complex and expensive of systems, would no longer be considered an issue. At the same time, loss of human life, when it does occur, would have more strategic significance and thus the definition of a casualty is likely to remain one restricted to human beings.

The paper has determined that human beings will still conduct fundamental decision-making in an era of unmanned systems and will remain the casualties in any future conflict. It follows then, that national leaders or influential individuals who seek to precipitate conflict will be our opponent's CoG and the focus for targeting efforts. CoG is currently defined as 'that aspect of the enemy's overall capability, which if attacked and eliminated, will lead to either the enemy's defeat or his wish to sue for peace through negotiations'.[65] Currently, this tends towards military resources, but developments in unmanned micro systems may allow more direct targeting of individuals. Thus nations fielding such capabilities will be able to strike swiftly at the aggressor's strategic CoG and potentially curtail conflicts, with limited damage to military forces or civilian infrastructure. As Metz suggests:

'*Soon technology, particularly mini or micro robots, may allow military planners to select which individual or physical object in a building is to be destroyed. For the first time, it might be possible to target only the aggressor's leaders, leaving non-combatants untouched*.'[66]

Conversely, those without such unmanned capabilities may resort to asymmetric style attacks on economic infrastructure and civilian populations, because targeting military systems is unlikely to destroy our will to fight. Furthermore, unmanned systems might not be controlled from the 'immediate' battlespace, but at a distance from buildings or aircraft, many miles from the target area. As a result, the battlespace will expand to encompass the control stations, which could be sited on home territory. Given that these are one of the most vulnerable elements of the unmanned system, then opponents may seek to neutralise them, rather than try to destroy the mission vehicle or interrupt the C2 link. Therefore, these two factors may extend the area of conflict, with the requisite implications for 'homeland security'.

Finally, success also needs to be redefined. Currently, to defeat one's adversary is defined as 'To diminish the effectiveness of the enemy, to the extent that he is either unable to participate in combat or at least cannot fulfil his intention.'[67] In manned conflict, once a belligerent's effective ability to fight had been reduced, then he would normally withdraw from battle. However, the same cannot be said of autonomous systems, as they will not recognise that they have been defeated, unless they are programmed to do so. By 2030 technology will be sufficiently mature for systems to have a degree of autonomy and once launched, they could conduct operations unfettered, within a set of given parameters. This doomsday scenario, however fanciful, means that there is a requirement for human beings to retain an element of control over such systems. This is likely to generate considerable complications for the employment of such platforms as have already been described within the context of UCAVs and, as Metz has argued:

'*The idea of a killing system without direct human control is frightening. Because of this, developing the "rules of engagement" for robotic warfare is likely to be extremely contentious*.'[68]

Two strands can be drawn from this. Firstly, success is likely to remain a human concept. In 2030, it will still be leaders who initiate and direct conflict and thus it will be they who will continue to define what constitutes a favourable campaign outcome. Depending on the capabilities of both belligerents, it could be achieved by eroding the adversary's will to fight by destroying his military capability, targeting his civil infrastructure or eliminating the political hierarchy. However, only human beings will be able to determine whether objectives have been achieved and that the conflict can be concluded.

Secondly, it is evident that the laws of warfare need to be updated, with ROE drawn up to allow autonomous systems to operate, but these will probably remain quite restrictive. Colonel Boone of the USAF reconnaissance-systems division has suggested that they would only be allowed to engage 'on their own', when human controllers have assigned ROE such as 'Fire in this square area only.'[69] This simply reflects the difficulties in identifying friend from foe in a continuously changing tactical situation within a complex scenario. A further complication is if the human controller were to issue an unlawful order to a system equipped with AI. The system may be able to recognise the command as unlawful, but would it be programmed to disobey or could the system alternatively choose to obey? Not only does this have serious operational implications, but legal ones as well. While primarily dealing with human responses to such questions, Osiel's table of error types goes some way to describing the programming challenges facing those designing AI equipped weapons systems.[70] No neat answers exist and it is doubtful if by 2030 they will.

SCENARIOS

Operations in 2030 will encompass a range of tasks from humanitarian assistance to warfighting and thus, in order to test the unmanned RMA theory, we should look at scenarios at these extremes of the spectrum of conflict. In warfighting, it is expected that future adversaries could deploy both conventional weapons and WMD, but would operate using orthodox doctrine, whilst at the same time maximising deception, camouflage and concealment to offset their technological disadvantages. Opponents could also employ their own unmanned systems, possibly to deliver WMD.[71] For our part, UUVs would be used to set the conditions for any amphibious operations, while UAVs and UCAVs would fulfil a wide range of missions from attacking strategic and operational CoG and tactical targets, as well as providing enabling activities in the form of Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISTAR) and SEAD to support manned air activities. Engaging forces deployed in an orthodox manner, we would be able to take advantage of the ability of unmanned systems to undertake the D3 tasks more efficiently and with less risk than their manned counterparts. Indeed, it could be said that the deployment of UCAVs and a wider range of UAVs during the Gulf War for example, would have reduced the risk to allied pilots and Special Forces operating inside Iraq. Nevertheless, the deployment of UGVs in the Gulf would still have brought immense difficulties. Despite the terrain being the least complex an autonomous system is likely to encounter, the depth and sophistication of the Iraqi defences would have proved difficult for any such vehicle to breach, without significant manned support.

Furthermore, the Gulf War raises questions about how considerable numbers of surrendering combatants would be handled by such systems. The example of Iraqis trying to surrender to a UAV exposes just one of the difficulties that need to be resolved when formulating the doctrine required for such systems.[72] Additionally, it could be said that this incident emphasises that unmanned systems will be most effective when operating alongside manned counterparts. Indeed, Black argues that the most successful use of a new piece of equipment occurs when it is integrated with old technology.[73] Furthermore, the friction and uncertainty introduced by the actions of human beings on the battlefield means that even in 2030 it is difficult to envisage autonomous systems being effectively employed, except against other autonomous or remotely controlled systems.

The destructive potential of contemporary weapons should rather provide incentive to make human control over them more positive and the more deeply informed by an understanding of moral value

The situation is even more complex in a peace support environment. The inability to recognise combatant from non-combatant makes it extremely unlikely that autonomous systems would be given authority to fire weapons, whilst operators of remotely controlled platforms will be required to demonstrate a very high degree of certainty before they engage the 'enemy' in these scenarios. Furthermore, peace enforcement is in part a matter of demonstrating intent, and the deployment of unmanned systems to conduct patrols, in urban areas instead of foot soldiers may not engender the requisite compliance amongst the local population. As Hahn and Trezior noted:

'*In the future, peacekeeping and, to a lesser extent, peace enforcement operations will remain essentially police actions, requiring a long term, highly visible, traditional infantry "presence" to create an aura of normalcy and stability.*'[74]

However, an alternative view has been put forward. By playing on people's innate fear of robots, it is argued that such systems would be particularly effective and as a result peacekeeping could become a less manpower intensive activity:

'*Most people have a "Frankenstein complex": a fear of potentially lethal devices not directly under human control. The ploy of stopping convoys by sitting down in front of them would require more nerve, and any casualties would have less propaganda impact, if they had to sit in the path of an unmanned vehicle.*'[75]

This argument is supported by the RAND Corporation who have made it clear that their strategy is one 'that removes the soldier from the street as much as possible, by instead of sending patrols and vehicles through the streets, sending UAVs and robots'.[76]

Additionally, there is a requirement for hugely sophisticated sensors in peace support operations, and remotely controlled systems currently lack the 'situational awareness' of human beings. Unless a technology package can be developed that fully replicates and integrates the visual and hearing senses, then the human being will remain the best sensor available to the commander in such scenarios. However, the Kosovo campaign demonstrated that UAVs are extremely useful in locating military positions and equipments. Additionally, they continue to

contribute to the ISTAR activities undertaken in support of the ongoing peace keeping operation.[77] Nevertheless, in such scenarios adversaries rapidly become 'surveillance aware' and the utility of overt systems steadily diminish. Until such a time as James Adams' sensors disguised as clouds of dust become reality, then it is believed that the most effective use of unmanned systems will be restricted to the early stages of a peace support campaign, near the warfighting element of the conflict spectrum.

CONCLUSION

This paper has established that very substantial technical and ethical challenges need to be overcome by 2030 before we can assert that the unmanned RMA will be truly revolutionary in nature. In this timeframe, there will be an array of air and maritime unmanned systems in service. However, UGVs will remain relatively small and slow, demonstrating poor mobility and limited protection, and as a result are unlikely to form the basis of the land component. Furthermore, until autonomous systems within any environment are able to meet the three criteria of discrimination, then they are unlikely to be allowed to engage without human authority.[78]

Nevertheless, the proliferation of unmanned systems will undoubtedly make the future's extended battlespace more deadly. This will present leaders with complicated moral judgements and as Shore has articulated, minimising technical risk can only be achieved if we marshal 'social forces' and not just 'technical forces'.[79] Turner Johnson develops this theme further by stating:

'*The destructive potential of contemporary weapons should rather provide incentive to make human control over them more positive and the more deeply informed by an understanding of moral value.*'[80]

If these arguments are accepted, then limitations should be placed on the development and employment of autonomous weapon systems. However, this will only occur when society recognises the need for restrictions to be placed on the wholesale spread of AI systems in their widest sense. Therefore, it remains to be seen if human beings will be able to retain effective control of unmanned systems in the longer term. Whatever the result, there will still be a fundamental impact on military affairs and whilst war itself may not change in definitive terms, its conduct and the way it is supported, will. Today's definitions of CoG and combatants will change and although casualties and success will remain human concepts, unmanned warfare could re-introduce the ideas of mass and attrition as preferred military doctrine. This in turn could generate a further development of the military industrial complex, with the emphasis being on high volume, low-cost systems rather than the 'silver bullets' currently being developed. Furthermore, as adversaries seek to neutralise the unmanned threat and those employing such systems target individuals rather than military forces, then the size of the battlespace will be significantly extended. All of this supports the contention that the introduction of unmanned systems en masse will produce an unparalleled RMA. It will not by 2030 be conflict of the type envisaged by H G Wells and other authors such as Isaac Asimov, but it will be well advanced, with the greatest stumbling blocks being those of mobility for UGVs and the ethical implications of deploying lethal autonomous systems.

However, as has been pointed out, war is dominated by uncertainty and because of this, in the 2030 timeframe at least, human beings will continue to play the key role in military operations. AI will not be sufficiently developed to allow battlefield robots to conduct a campaign based on the loosest of parameters defined by human computer programmers. Therefore, as Lieutenant Colonel Schultze-Rhonof prophesised in the early 1980s:

'*…only soldiers and not machines can respond to previously unforeseen situations.…since innovation, surprises and friction are typical symptoms of any war, the human capacities for analysis, synthesis and initiative acquire particular importance. Finally, only the human being has the ability to make decisions based on factors which are not comparable merely in mathematical terms.*'[81]

Therefore, it is asserted that the unmanned RMA of 2030 will be a technical revolution rather than one of a more fundamental sociological nature, with all of the profound consequences for warfare that that would entail.

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