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YOU CAN BE MY WINGMAN ANYTIME: WHY A UAV WON'T REPLACE A FIGHTER PILOT

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> *The future battle on the ground will be preceded by battle in the air. This will determine which of the contestants has to suffer operational and tactical disadvantages and be forced throughout the battle into adopting compromise solutions.*
>
> —German General Erwin Rommel

INTRODUCTION

Man-kind has always held a fascination for flight, from the pioneering days of the Wright brothers to man stepping on the moon. Since the days of the Red Baron and the aces of World War II the Fighter Pilot has been an iconic symbol of military heroism. A lone warrior in the vastness of the blue sky battling his foe until only one remains. In the decades since the end of the Cold War, global armed conflicts have

seen a significant increase in the use of Unmanned Aerial Vehicles (UAVs). The proliferation and well-documented successes of UAVs has caused some to question the future relevance of manned aircraft systems[1]. There are significant benefits, but also limitations associated with UAV operations. This paper will first explain the differences in UAV terminology then discuss why the UAV has popular support for replacing a manned fighter. UAVs strength and weaknesses will be analyzed in the context of employment in a contested environment and/or near peer conflict to conclude that; due to technology limitations, combined with the extremely dynamic and unpredictable nature of the Air Combat domain, the next generation of fighters will be manned. The future operating environment is a complex battle-space where a technological advantage can

[1] LGen (ret) Lloyd Campbell, Manned vs Unmanned debate, Front Line Defence I Issue 2, 2011.

mean the difference between victory and defeat. There is one area that technology still fails to match natures supreme evolution, human ingenuity and adaptability.

UNDERSTANDING TERMINOLOGY

UAVs can carry a wide variety of sensor payloads: Electro-Optics (EO); Infra-Red (IR); Synthetic Aperture Radar (SAR); Signal and Communications Intelligence (SIGINT and COMINT); Chemical, Biological and Radiation (CBR) detection systems; and radio relay equipment. Some UAVs, notably Unmanned Combat Aerial Vehicles (UCAVs), are specifically designed for combat operations and are capable of delivering offensive weapons; namely precision guided bombs and missiles[2]. NATOs classification guide for UAVs (including UCAVs) is: Class I (less than 150 kg); Class II (150 to 600 kg); and Class III (more than 600 kg). Class III UAVs are further subdivided into three categories based on increasing degrees of capability and complexity: Medium Altitude Long Endurance (MALE); High Altitude Long Endurance (HALE); and Strike/Combat[3]. Unmanned Aerial Systems (UAS) refers to the complete capability package incorporating the ground systems required to operate and support a UAV. UAS versus UAV terminology is important when discussing potential cost and manning comparative benefits of manned versus unmanned combat aircraft. The level of autonomy is of significant importance when framing the argument. Most UAVs have varying levels of autonomy. This autonomy features heavily in take-off, landing, transit, set route navigation and loiter phases of flight. Commonality amongst current UCAVs is that

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[2] LGen (ret) Lloyd Campbell, Manned vs Unmanned debate, Front Line Defence I Issue 2, 2011.
[3] NATO UAS Classification Guide, September 2009.

kinetic weapon employment is not conducted autonomously and missions are not flown without a man in the loop. During the listed autonomous phases of the mission the UAV is monitored by the man in the loop. During phases of the mission when direct control of a UAV is required (for dynamic commands or kinetic employment) the UAV is 'remotely piloted' from the ground station. Remotely Piloted Aircraft (RPA) more appropriately describes all current UCAV operations where a pilot on the ground is in control of the aircraft using autonomy (or auto pilot) modes to reduce workload and operator complexity. The term Drone in the context of this argument refers to any type of UAV that is able to employ all of its possible capabilities (including kinetic) autonomously or 'without a man in the loop'. A fully automated drone conducting air to air combat or close air support in a dynamic environment is not within the scope of this paper, as that concept is aspirational lacking technology reality or development traction. Within the temporal context of this papers argument, it will be concluded that the next generation of fighters (namely the F22 and JSF replacements) will not be replaced by UCAVs or Drones.

THE CONTESTED ENVIRONMENT

When UAVs first emerged, the accepted wisdom was that they would be most useful doing tasks deemed "dull, dirty or dangerous". Included in the 'dull' category were surveillance missions requiring time and a degree of persistence that crews of manned aircraft couldn't provide. By maintaining what a former director of the Central Intelligence Agency described as an "unblinking stare" over a target for 18 hours UAV pilots can work in shifts, monitor patterns of activity on the ground and choose the best moment to fire missiles[4]. A typical "dirty" task for a UAV would be flying into a contaminated area to observe or take samples after a chemical or biological attack. The reference to 'dangerous' tasks refers to probing and testing heavily defended airspace or attacking heavily defended targets where heavy losses (to aircraft and aircrew) are considered unacceptable. The utility of the UAV on 'dangerous' missions is yet to be fully realised.

The utility of UAVs in the 'dull and dirty' category is undeniable. The persistence and endurance of the UAV over an area of 'interest' provides vital ISR information to force employers. The role of the UAV dominates this domain and military's around the world would consider this type of UAV task as the 'norm'. Recent conflicts against Al Qaeda and the Taliban, UCAVs have provided an exceptional capability conducting precision strikes against terrorists in Afghanistan and Pakistan without the requirement for boots on the ground. These benefits have resonated within political circles leading to profound support of UAV capabilities and utility. However, all of the UAV/UCAV missions have been conducted in a permissive environment; permissive because the enemy doesn't possess the capability to deny air freedom of movement within the airspace of interest. For context, when discussing a 'contested environment' this paper will focus on the employment of a UAV in an expeditionary offensive role. That is, a military's aerospace power conducting Offensive Counter Air (OCA) operations in an enemy's airspace. Many of the arguments will also directly correlate to a UAVs utility in Defensive Counter Air (DCA) operations.

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[4] Unmanned Aerial Warfare 'The Flight Of The Drones', The Economist, 08 October 2011.

In contested airspace the enemy will employ an Integrated Air Defence System (IADS) comprising of layered capabilities to detect, disrupt and ultimately destroy any unwanted air assets in its airspace. IADS capabilities consist of detection radars, Surface to Air Missiles (SAMs) and Fighters.[5] In a contested environment an OCA package will be required to survive the IADS in order to successfully achieve its mission. The OCA package will have capabilities to suppress and/or destroy the IADS radar detection and SAM systems. Dedicated Air to Air assets will 'sweep' the airspace engaging enemy air assets (mainly fighters and bombers). In the contemporary contested environment OCA missions are conducted by manned fighters, bombers and EW aircraft as there are no UAVs that can survive a robust IADs. Fighters and fighter pilots possess the inherent abilities to survive an enemy IADS. Adversary near peer fighters will be 4th and 5th generation combined with integrated SAMs of similar lethality. In recent contested environment missions, only when the environment became permissive through air dominance, superiority and suppression could 'other' aircraft (including UAVs) operate with an acceptable level of survivability[6]. To operate in a near peer and/or contested air environment the UAV will be required to possess the same inherent survivability characteristics as the OCA manned fighter package. From a simple hardware perspective, this will require the UAV to possess similar (or better) manoeuvrability, speed, electronic counter measures and offensive weapons as a manned fighter. This pure hardware requirement would place the cost of a fighter capable UAV on similar terms as a manned

[5] IADS employs many other capabilities e.g. Communications, EW detection, IR scanners, HUMIT etc. The detection and engagement components mentioned in the paper are the fundamental foundations leading to kinetic engagement.

[6] During the early days of the Lybia campaign UAVs where not utilized until NATO air superiority had been established and the no-fly zone established. During the Russian-Georgia conflict several Georgian UAVs (supplied by Israel) where shot down by Russian Air Defence systems in the Abkhaz region as the UAVs where defenceless against attack. The most famous was the shooting down of a UAV by a Russian MiG29 on 18 March 2008.

fighter. When combining the sophisticated UAS components to the UAV capability, in many respects the UAV will cost more to procure and operate than the manned fighter[7]. For this reason the UAV cost benefit factor will not be discussed further.

UAV WEAKNESS IN A CONTESTED ENVIRONMENT

Focusing specifically on the air to air capabilities of an OCA package; Sweep, escort and target area patrol, the survivability weaknesses of UCAVs will be examined. In the OCA air to air environment sweep is dominated by the fighter pilot. His/her role is to seek out enemy fighters and destroy them; annihilation by attrition. Any air asset vulnerable to fighter attack, without the ability to defend itself, will be slaughtered. Contested airspace engagements would most likely begin with Beyond Visual Range (BVR) exchanges of firepower. Near peer BVR engagements often collapse in distance, become complex in targeting and geometry and lead to Within Visual Range (WVR) contests. WVR engagements may also occur through Rules of Engagement (ROE) restrictions, weapons restrictions/limitations, stealth or just through surprise and the fog of war. Air combat can be a complex dynamic requiring the fighter pilot to Observe, Orientate, Decide and Act (OODA) against his adversary without hesitation. The ‘OODA loop’ refers to the decision cycle (of observe, orient, decide, and act) developed by military strategist and USAF Colonel John Boyd. Boyd was a fighter pilot and originally applied his concept to tactical air combat operations. Its utility grew to the operational

[7] American Security Project, “The US and its UAVs A Cost-Benefit Analysis” Comparison table. Of note, the annual operating cost for an F22 is $11M and for the Global Hawk is $15M. The hourly operating cost for a Global Hawk is more than for the F22.

and strategic level in military soon after.[8] The approach favors agility (both cognitive and physical) over brute strength and raw power when dealing with human opponents in any endeavor. The concept determines that getting inside your opponents OODA loop (by completing the required steps quicker) provides the advantage required for victory; specially in the context of a fighter pilots engagement both BVR and WVR. “Lose sight, lose fight”, a fighter pilot term used to describe the importance of having your eyes on the enemy –‘observe’ in the OODA loop. If you cannot see your enemy your OODA loop cannot begin, if he can see you, his OODA loop continues resulting in your destruction. The concept stands true in the BVR environment with respect to sensor contact but the temporal criticality is less than WVR[9]. The orient component is vital as it relates to the fighter pilots Situational Awareness (SA) where everything he observes in all dimensions (including sight, sound, feel, time) tells the story of what has transpired but more importantly what range of possibilities and options exist at that moment. As soon as the fighter pilot ‘acts’ the dynamics of the situation will change immediately requiring the OODA loop to recycle. In air combat an error in the Observe, Orient and Decide components of the OODA loop are fatal. Hesitation (even if the component assessments are correct) in the OODA loop is also fatal.

The sight, sound and feel inputs into the OODA loop are of vital importance. High fidelity 3D plus peripheral visual input in the WVR engagement is the most important. Current camera and display technology cannot replace the SA a fighter pilot gains from looking directly at the enemy combined with peripheral assessment of his

[8] Taught in US military academies, Canadian Forces College, Australian Forces College, the UK Command and Staff College and many others.

[9] Temporal delay in a WVR engagement leading to defeat is measured in fractions of a second. In a BVR engagement the same temporal delay would be measured in seconds.

surrounds. Imagine driving your car in a race, but you are required to do so looking solely at the vehicles reversing camera image. Intuitively you know that you are disadvantaged by the mere thought of it; that same disadvantage would be suffered by the UCAV operator in an air to air engagement. Although a camera technically can achieve a 52 megapixel resolution there is much more to 'vision' than that. Our eyes are able to look around a scene and dynamically adjust based on subject matter, whereas cameras capture a single still image. Even video is just a series of still images. This trait accounts for many of our commonly understood advantages over cameras. For example, our eyes can compensate as we focus on regions of varying brightness, can look around to encompass a broader angle of view, or can alternately (and near instantaneously) focus on objects at a variety of distances[10]. "Your eye and my eye are a bit like digital cameras too. [They're] just a different kind of digital camera," says Tobi Delbruck, the chief scientific officer at iniLabs. "However, we have machine vision that is as good as possible with existing architecture and hardware, but compared to biology, machine vision is pathetically poor."[11] Remember the fighter pilot phrase, 'lose sight, lose fight'!

The OODA loop requires constant cycle without hesitation or delay. A split second in an air to air engagement can be the difference between success and failure. The fighter pilot is said to have 'lightning fast reactions', in reality he/she has a highly

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[10] http://www.cambridgeincolour.com/cameras-vs-human-eye.

[11] Unlike a camera, the human eye is part of a sophisticated information processing system. Once the eye sees an image, it is transmitted to the brain via the optic nerve; the image received by the eye is thus subjective as opposed to objective. A camera, on the other hand, is essentially a dumb system; extra processing needs to be added to cope with different color temperatures, for example. The human retina is also more sensitive than even the most advanced and specialized cameras, able to derive useful information in a vast array of light levels. Certain cameras may be able to perceive stimulus invisible to the human eye or perform specific function the human eye can't, but the eye is still a more sophisticated mechanism overall. Current UCAV cameras are sufficient to allow air to ground targeting where the focal range is relatively fixed allowing zoom and magnification to be used. A magnified vison through narrow field of view ("looking through a soda straw") is not suitable for air to air combat.

evolved and experience tailored OODA loop. Current and next generation UAVs require two-way satellite communication to do anything other than ‘pre-planned’ tasks and manoeuvres. In a dynamic environment (like an air to air engagement) the satellite commands are essential for a UAV to dynamically ‘react’. Satellite link transmissions suffer from a slight delay between operator command and UAV action/reaction. This ‘delayed reaction’ by the UAV is known in the community as ‘latency’. One significant factor influencing the amount of latency is the location of the orbit of the satellite constellation being used[12]. In the context of an air to air engagement the briefest pause between each of the OODA loop steps, even when measured in milliseconds, would allow the adversary fighter to get inside your OODA loop. Any delay before acting in an Air to Air engagement (especially WVR) results in defeat.

UAV STRENGTH IN A CONTESTED ENVIRONMENT

An achievable advantage of the UAV over the manned fighter in a contested environment is persistence and exploitable aerodynamics. As mentioned earlier, a UCAV designed with the contested environment survivability characteristics (speed, agility, EW, ECCM) combined with useable payload, would be of a similar size to current fighters. A fighter type UCAVs persistence will be increased over similar manned fighters as

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[12] Geosynchronous Earth Orbit is a stationary orbit located about 22,241 miles above the earth’s equator. Satellite constellations in GEO provide communications coverage over a majority of the earth’s surface using just a few satellites. However, due to the large distance a signal must travel, these satellites have a minimum 0.24 second signal latency. Many factors (i.e. bandwidth, encryption and atmospherics) can significantly increase latency, up to 2 seconds. Actual Predator, Reaper, Global Hawk and other Class III UAV Latency figures are classified. Latency will always occur based on the physics of distance the signal has to travel and the speed of light. Ground control stations are located at UAV recovery airfields to control takeoff and landing using a Line of Sight transmission thus practically eliminating the latency issue. Cyber vulnerability can effect latency but is not discussed in this paper

additional fuel can be carried in-place of the pilot (approx. 7% more if the fuel increase logic of a single seat variants over the 2 seat equivalent is applied). It is with Air to Air refuelling that the UCAV could remain on station beyond that practical for a fighter pilot. In an air to air engagement, the fact that a UAV was able to remain on station for hours on end prior to duelling with a manned fighter is no compensation for the visual acuity or latency weaknesses the UCAV would suffer.

The UAV could operate at a higher instantaneous and sustained ‘g-force’ than that of the manned fighter. This could be a significant advantage, especially in the WVR arena. Higher instantaneous ‘g’ would provide a momentary advantage but is negated by the UCAVs latency issue. Maintaining higher sustained ‘g’ would be countered by the fighter pilot exploiting latency by constantly changing the dynamics of a fight and/or dragging a fight vertical[13] and low energy.

WHERE TO FROM HERE

At a press conference in April 2015 the USAF Chief of Staff Gen. Mark Welsh said “while the Air Force will increase its reliance on remotely piloted and possibly autonomous aircraft, there will be no replacement for a fighter pilot. Having the human brain as a sensor in combat is still immensely important in our view". Welsh's comments followed a statement from Navy Secretary Ray Mabus that the service's F-35C "should be, and almost certainly will be, the last manned strike fighter aircraft the Department of the Navy will ever buy or fly." The comments highlight the differing views on future

[13] Trading airspeed for altitude trades kinetic energy for potential energy but also sacrifices the ability to sustain maximum ‘g’ due to lower airspeed.

UCAV employment, even by those in positions to influence research and development, testing and procurement. Of note, secretary Mabus followed up his statement about the F35 being the last manned strike fighter by saying “the Navy will still need fighter pilots for dogfighting but the unmanned aircraft will handle the strike missions”[14]. General Welsh’s concluding remark of “the human brain is a sensor that is extremely important in combat, and cannot be replicated well enough in unmanned systems” opens up the full AI autonomy debate and how technology falls miserably behind that of human intelligence, ingenuity and adaptability and is profoundly applicable to the dynamic air combat environment.

The US has and will continue to be a leader in UAV employment and development. The document “United States Air Force Unmanned Aircraft Systems Flight Plan 2009-2047 has a comprehensive road map for planned US UAV development. Although many sections are classified, analysis of the ‘UAV platform and role’ graph[15] lists “fighter size UAV development from approx. 2030-2047 (designated MQ-Ma, MQ-Mb and MQ-Mc) and what roles will be accomplished; ISR, SEAD, AAR, Missile Defence and EW. These specific roles in the air to air arena are discussed at length but what is glaringly obvious is the omission of the UAVs utility in conducting air combat. Explanation of ‘swarm’ and ‘loyal wingman’ concepts are discussed[16] but they are all UAV roles in support of a manned fighter. Although the unclassified sections of the USAF document don’t directly say that future UAVs can’t survive in an air to air fighter

[14] An interesting shift in stance when pushed on the topic.

[15] United States Air Force Unmanned Aircraft Systems Flight Plan 2009-2047,. p34.

[16] “Swarm’ relates to significant numbers of UAVs integrated into an air mission. They are expendable and designed to help attrite enemy fighters knowing they have minimal survivability. The issue is cost, in that they will be on par with manned fighters in-order to be effective. ‘Loyal wingman’ effectively refers to a fighter aircraft that has manned and unmanned variants. The unmanned variant can be ‘tethered’ to and controlled by the manned fighter effectively enhancing the formations firepower.

battle, the obvious omission of the UAV in that role highlights the known technology development limitations perceived in the 2009-2047 timeframe.

CONCLUSION

Achieving control of the air in a contested environment, especially in the air combat domain, the unmanned systems currently have no role to play. Autonomous air combat undertaken by unmanned platforms or drones is still a vision of hopeful aspiration and is far from reality. The history of air power is replete with examples of the gap between vision and reality becoming unbridgeable in the near-term. In the ISR and strike role, unmanned systems have proven their credentials, even though the airspace in which they have operated so far has been uncontested. The chance of survival for the current fleet of unmanned systems operating in a contested environment is minimal. Mechanical vision and Latency are two areas where UCAVs will fall victim to manned near peer adversary fighters. Here lies the dichotomy—risking human life should be the last resort, so if unmanned systems reduce such risk, they should be exploited. However as this paper has demonstrated, the UCAV of the 6th generation fighter era would not survive. What has to be understood clearly by strategic planners and procurers is that although UCAVs are a viable option for employment in dull, dirty and dangerous situations, they are not a panacea to the problems encountered by fighter pilots in a contested environment. A UCAVs operator suffering from a lack of spatial awareness and suffering from latency make them extremely vulnerable to current (and future) generation manned fighters.

This paper has not argued how AI technology fails to replicate human ingenuity, nor the fighter pilots intuitive ‘sixth sense’ allowing real-time adaptation, tenacity, survival and ultimate success over any current or next generation UCAV. At least for the foreseeable future, application of successful air power with respect to air dominance and denial will require a manned fighter.

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