The Future of UAVs: Lessons from the "Great War"

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Abstract: Unmanned Aerial Vehicles have undergone profound changes in the past seven decades. They have become common on all battlefields and are used by many sides including terrorist and non-state organizations. This paper theorizes that the next step in UAV development will likely parallel the development in war planes during World War I. That means, specialized UAVs will be designed for air-to-air combat in both the interceptor and defender role. This will likely be combined for best effect with the concept of swarming. The ethical and legal issues relating to this hypothetical new form of UAVs are discussed, as well as the imperatives driving this development.

Keywords: UAVs, aerial warfare, future
Schlagwörter: Unbemannte Fluggeräte, Luftkrieg, Zukunft

1. Background

The use of UAVs (and other unmanned and autonomous vehicles on land and sea) for military purposes has risen exponentially. Virtually every national military with a claim to modernity employs UAV systems. These have gone from simple systems in which cameras have been attached to remotely guided (sometimes civilian-sourced) flyers, to large autonomous craft, able to conduct a variety of missions from observation, electronic warfare to (supposedly) pinpoint bombing.

This has been controversial, with the moral and ethical dilemmas inherent in the introduction of any new technology (notably military technology) being discussed at great length in scholarly and popular literature. This paper is divided into two parts. In the first part, I discuss the development of UAVs against a historical process, namely, the use of the air dimension in World War I, or the Great War. I argue that the dynamics of aerial warfare development in the beginning of the twentieth century will be replicated in the beginning of the twenty-first. In the second part, I expand on the implications of these changes on ethical and practical dimensions.

2. A Brief History of UAV Usage on the Battlefield

The use of radio-controlled drones can be traced to WWII. Simple unguided suicide drones were developed by the Germans and deployed as V1. These were jet-propelled drones used to attack large area targets, for example London, during the late phases of the war. Smaller drones have been used as well. One of the earlier, yet seminal uses, was the marriage of a radio-controlled toy plane with a manual camera used by the Israeli Army over Egyptian lines on the Suez Canal before 1973 (Libel and Boulter 2015: 63).

American UAVs have been used in battle since the Vietnam War, and they have become an increasingly important component of the US war strategy. The US initially focused on large, jet-propelled UAVs. The purpose of such vehicles, starting with the *Firebee*,[1] which was deployed by the US in Vietnam and Israel in Sinai, was mainly photo reconnaissance. The so-called War on Terror, following the September 11, 2001 attacks on the United States, brought about the development of armed UAVs for "pinpoint" attacks against personnel ("Targeted Killing") and occasionally, materiel.

The growing sophistication of technologies necessary for constructing drones—artificial intelligence, material science, software development, visual reception, and satellite communications, among others—enabled the development of a large variety of complex UAV types ranging from the giant jet-propelled *Global Hawk* in the HALE (High Altitude Long Endurance) role, Predator ground attack craft, Sentinel stealth intelligence craft, Raven micro ground support craft, and Switchblade suicide craft for ground troops. Other craft of similar sophistication have been developed to provide support for naval operations, both surface and submerged.

At the so-far largely experimental level, the US and other major manufacturing powers have been considering the development of large UAVs in the UCAV (Unmanned Combat Air Vehicle) role to replace manned fighters in the air, whether as truly autonomous fighters or as remotely-controlled interceptors and air-dominance fighters. Clearly, UCAVs need to have the same profile as their major targets—manned fighters—in terms of their profile and 'skill set' capabilities: they must be as powerful, agile, armed, and sensory-capable as their opponents. This has implications in terms of size, cost, and no less, development time, measured in decades, not months or years. Both the British Taranis and the US X-45 have been in development for almost a decade, and are likely to remain so for many years in the future until the development of production models. The size of such UCAVs is approximately that of a manned fighter, and the cost of developing field-worthy UCAVs is not much less than a manned fighter.

Another UAV major developer who has chosen a somewhat different path is Israel. The Israelis made the first tentative steps towards the development of reconnaissance UAVs during the clashes along the Suez Canal 1968-1970, when a radio-control flight enthusiast stationed on the canal attached a camera to a radio controlled drone, and flew several sorties over the Egyptian lines opposite his position. In parallel, the Israelis bought several Teledyne *Firebees*, which were used later during the 1973 October war. The Israelis quickly realized the usefulness of UAVs, and soon started full-scale development of a variety of platforms for intelligence (optical and electronic) roles. Some of the earlier UAVs were sold to the US military and participated in Operation Desert Storm in 2003.

1 For a brief description of the UAVs mentioned in the text, please see Appendix.

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Unlike US efforts, Israel has concentrated on the MALE (Medium Altitude, Long Endurance) role, and on propeller-driven, rather than jet UAVs. This approach simplifies maintenance in the field, as well as construction and development. The Israelis enjoyed clear successes in UAV use in the wars against Palestinian terror groups, as well as against the Syrian Army since 1985. Israeli UAVs ranging from large MALE to small soldier-carried craft, carry out missions ranging from photo and electronic reconnaissance and warfare, through target designation and artillery spotting. A breed of loitering anti-radiation drone—the HAROP—has also been developed and deployed by Israel and foreign purchasers. There are some claims that UAVs are also used in the ground attack role.[2] They are now ubiquitous at all levels of the Israeli military ranging from General Staff to field battalion levels. Israeli UAVs are also exported to other countries including the US, for a variety of military roles.[3]

A number of other countries have been developing UAV capabilities, either borrowing from the technological leaders such as Russia, Germany, Singapore (Earley 2014; Gilli and Gilli 2016) or developing their own versions such as the PRC and South Africa (O'Gorman and Abbott 2013; Zhou and Zang 2007).

2.1 Some Steps in the Development of UAVs

We should note some broad features in the developmental history of UAV use and technology relevant to the argument here.

1. Initially (approximately 1950-1970) most UAV developers focused largely on two aspects of remote controlled AV: aerial reconnaissance and use as air targets (which is outside the scope of the argument). Jet-propelled artillery missiles were also developed, but less successfully (e.g. the Geman V1 and the American Regulus) and few from this period were ever deployed. Quite often the vehicles were cobbled together by re-targeting airplanes and missiles that were already in existence.

2. The next step was the development of dedicated recon UAVs of various types, with countries such as the US focusing on UAVs that could play a role in the country's global interests (Clouet 2012), and smaller players, such as Israel, on close-to-homeland support (Blom 2010). With the improvement of communication and laser technologies in the final decade of the 20th century, additional recon roles such as target designation for artillery (naval artillery included) and electronic warfare were added.

3. The third, and as of now last step, was the conversion of UAVs to the bombing role. In the US, dedicated UAVs (the Predator series) were fitted with modified Hellfire missiles for ground attack roles. The anti-tank guided missiles were later fitted with antipersonnel warheads as a way to make them more effective, and possibly to limit collateral damage.

In the rest of this paper we shall examine the nature of a fourth step. To do so, I briefly survey the dawn of a related warfare dimension.

2 Israel has never confirmed the existence of armed drones. There is some evidence indicating that Israel does have the capability of deploying drones in the ground attack role (Newdick 2014).

3 By 2013, Israel was the primary exporter of UAVs, providing some 60% of all exports, a total of USD 4.6 billion (O'Gorman and Abbott 2013).

3. A Brief History of WWI Aviation

The beginning of World War I (the "Great War": 1914-1918) coincided with the emergence of a new industry: aviation. The first successful powered flight by the Wright Brothers (1903) was a milestone in the development of human flight, and specifically of powered flight. Following the Wrights' successful demonstration of powered, controlled flight, the air industry was developed by the Wrights and others (e.g. Benoist, Bleriot, Curtiss), of which some were professional pilots and some were amateur scientists/specialists/engineers/etc.

The Great War provided flight with great impetus. Hydrogen balloons were first used as fixed observation posts for artillery spotting. Later the Germans deployed dirigible Zeppelins to bomb London, causing relatively light damage. At the front line between the German and Allied armies in France, the use of powered airplanes developed relatively rapidly.

Initially, powered airplanes were used in observation missions. The craft were adapted civilian models. Occasional exchanges – of pistol fire, and thrown objects – between pilots, led to a demand for a machine that could 'blind' the enemy by denying them the skies. Machine guns were then mounted in various configurations on planes that engaged in, often inconclusive, dogfights. In 1915, Fokker, a Dutch company, supplied the Germans with a mechanism that allowed machine guns to fire through the propeller of a plane, giving rise to the development of fighter planes by German, British, and French militaries. In parallel, the Germans developed dedicated bombers (the 'Gotha' and others). By 1917, the Germans and later the allies were producing and deploying dedicated fighter planes (including the famous Fokker-Wolf and Camel. Cf. Gilam 1993).

Great War military aviation proceeded through several steps:

1. Deployment of aircraft of civilian origin and use for reconnaissance purposes.
2. Development of organized flying units.
3. Production and deployment of dedicated fighter planes.
4. Development of bomber aircraft and of technical refinements for aerial battle and the scientific development of air combat doctrines and techniques.

4. Interdiction to 2016 and Beyond

Control of the ability to use the aerial dimension in warfare depends essentially on two factors: keeping one's own aerial assets (reconnaissance, electronic warfare in all its aspects, and bombing, from micro to macro) safe from the enemy; and denying the use of the aerial dimension from the enemy. In the Great War, this process developed haphazardly. Initial flights were the result of local initiatives. Inter-airplane clashes and aerial bombing were likewise unorganized, locally-initiated affairs using materials at hand: pilots' personal pistols and hand grenades. Flights were normally used for reconnaissance and not aggressive action. The deployment of fighter aircraft during the Great War was thus not a given. It was only after incidents between rival recon pilots grew that serious attention was paid to the need for air dominance. The overall aerial assets during WWI were essentially meagre, and interdiction against other airplanes developed in a haphazard manner until 1917, shortly before the end of the war, when dedicated fighter planes were introduced to the battlefield (e.g. the Fokker Triplane and the British Camel).

In contrast, the years since 1950 have evidenced growing sophistication of fighter interdiction techniques. Over the 20th century, the opponent has almost always been another manned fighter as the main opponent, with ground support and other tasks being enabled by manned control of the air battlespace. It could be expected that manned aircraft would continue to be the main air interdiction asset whether the opponent aircraft is manned or unmanned. With decades of experience, human-piloted interceptors are at the forefront of air dominance.

In practice this has not been the case. Where air attacks have been aimed at UAVs, three points emerge:

1. Supersonic fighters have some difficulty in shooting down relatively slow-flying, small UAVs. There are six well-documented incidents. During the recent Russia-Georgia conflict, a Russian Mig 29 shot down an Israeli-manufactured Georgian drone (21 April 2008), with another possible hit two days later. Two Hezbollah drones were intercepted and shot down by Israeli F-16s, one over land (25 April 2013), the other over the Mediterranean Sea (25 October 2013). A Hamas drone was tracked, and shot down with some difficulty deep in Israeli territory, and another was shot down over the sea in two separate incidents (6 October 2012; 14 July 2014). Finally, a Syrian (or possibly, Russian) UAV was identified by an Israeli missile battery, which fired but missed the target. A follow-up fighter jet attack was also unsuccessful (17 July 2016).[4]
2. Where such shootdowns have occurred, the expense of using a multi-million dollar fighter+missile combination would seem to weigh in favour of the cheaper UAV. The cost of flight time (USD 22,514 per hour for an F-16, triple that for an F-22. [Thompson 2013]), as well as the short-range air-to-air missile typically used is likely over USD 100,000. More troubling is the need to dedicate fighter planes to attack relatively small, cheap targets, under conditions of complete air dominance by the 'defending' party: Russia and Israel in these cases. In a full symmetric conflict, jet fighters would be dedicated for their primary roles: air superiority and interdiction against enemy aircraft and possibly ground support, which would not allow for dedication of assets against UAVs.
3. To add to the previous point, given the relative cheapness of UAVs, a swarm of small, relatively cheap UAVs (in asymmetric or symmetric warfare) could easily saturate and overwhelm a lesser number of expensive, largely sophisticated fighter planes. In other words, constructing a large number of cheap, relatively unsophisticated UAVs, perhaps schooling them with a few more sophisticated craft, could easily keep a defending side busy for a very long, and expensive, time.

4 Two US UAVs, one of them a highly stealthy RQ-170, came down in Iranian territory, though whether this was the result of electronic warfare (as the Iranians claim) or of malfunction, is not clear, so these two cases are not included (Ruegamer and Kowalewski, 2015: 17-21).

4.1. Swarming

Modern computing, combined with the relative cheapness of small and medium-sized UAVs has introduced the concept of swarming to the UAV issue. Essentially, using proprietary algorithms, UAVs can be operated in swarms of several aircraft (Cevik et al. 2013). This has the advantage not only of confusing radar and predators (i.e. jet fighters), but also allows for multiple redundancies and thus better coverage in observation and even attack missions. Crucially, given the right kind of programming, UAV swarms can be heterogeneous, with some craft in a swarm serving in the ELINT (Electronic Intelligence) role, others in recon, and others in attack against e.g. anti-aircraft radar sites (Chlestil et al. 2006; Clouet 2012).

This implies enormous difficulties for the defender against UAVs. Attempting to knock out specific craft would be complicated by the need to identify those specific craft that function for e.g. ELINT and airborne warning and overcoming the potential of highly networked swarms where redundancy in tasks, and the ability to shift functions between craft is the norm (Cevik et al. 2013).

4.2. UAV Interdiction: A Brief Summary

As the use of UAVs becomes more common, it is clear that from the defender's side UAVs represent a growing problem. This is true for both symmetric and asymmetric warfare. In both cases, the attacker would find it relatively easy to deploy mixed swarms of varied sophistication and capabilities. If good communications and decision-making software are included in the mix-not impossible, given globalization of techniques and hardware-some form of swarm intelligence should almost be a given. Where the attacker is the "weaker" side in asymmetric warfare, the swarm (or even several individual craft) would be much less sophisticated. The defender could of course deploy overwhelming force to destroy such attempts without difficulty, although the cost would be exponentially higher for the defender than for the unsophisticated attacker. And, given that interception ratios in the real examples provided above are about 83, some of the attacking UAVs may well reach their target.

There are of course some ground solutions, either in existence or in development to defend against UAVs. However, these (like anti-aircraft defences in the Great War) are limited in their effectiveness, and have not been tried on the battlefield. Thus we must look elsewhere for UAV defence.

5. The Next Step: UAV Interceptors

By the end of the Great War, fighter planes of some sophistication were the norm on the Western front, and to a much more limited extent, in the Middle East and Mesopotamia (Iraq of today). Their deployment made the use of airplanes for tactical and strategic purposes, from observation, bombing to communication extremely hazardous, as unarmed aircraft were easy prey.

What characterized fighter planes from 1917 onward was the optimization of the craft-airframe, engine, avionics and weapons-for the destruction of other aircraft. In passing, it ought to be noted that the weapons used were relatively light machine guns, chosen largely for rate of fire and light weight. The airframes themselves were relatively fragile and unarmoured, and could be rendered inoperable with relative ease by small calibre shots in the right place (engine, struts, frame, or pilot). Later aircraft during the century were progressively better armoured, less vulnerable, and able to fly even with severe damage.

The vulnerability of UAVs – notably the light UAVs that can be constructed by weaker parties in an asymmetric conflict – is significant. Engine, frame, avionics and computer controller are all vulnerable to interdiction, kinetic and/or electronic. Nevertheless, the problem from the defending war-planner's perspective is complex. The cost of eliminating a UAV must include (a) the cost of the intercepting airframe (in most concrete cases seen above, a multi-million dollar fighter) and its flight time, (b) the cost of the ammunition (an air-to-air missile), (c) a multiple of these in case of a swarm, since all the UAVs would need to be eliminated to ensure intercepting the threat.

This implies that technologically sophisticated UAV producers must consider the lesson of the Great War: the need to develop and deploy relatively cheap, purpose-designed interceptor UAVs.[5] Like the fighters in 1917-18, these would have relatively robust airframes capable of fast aerial manoeuvring (far better than potential opponents), high speeds for pursuit, situational awareness, and sophisticated programmable targeting and IFF (Identify Friend/Foe).

Three scenarios must be considered:

One-on-one: Where a single fighter UAV tries to intercept an intruder UAV. Most likely this scenario would replicate the Great War dogfights. More sophisticated weaponry and avionics would likely tilt things toward the interceptor. However, the interceptor would need to carry extremely complex situational awareness receptors in various wavelengths, as well as the processing power to utilize them, or extremely broadband ties to its base. Both options would increase weight and come at a cost of speed, range, and maneuverability.

Swarm-on-one: A more sophisticated option would be to employ fighter UAVs in networked swarms, preferably heterogeneous swarms, with some of the elements/units providing information for the actual fighters, whether those are armed with some standoff weapon (missile, laser, microwave, or light gun) or are configured as kamikaze.

Swarm-on-swarm: For the attacker, the obvious strategy is to deploy a swarm: a mix of decoys and operational craft (kamikaze, observation, ELINT, or bombing) to lower costs and ensure high interception costs. Sophisticated networking and handing-off algorithms would allow the swarm to operate even if some of the swarm members are deducted due to malfunction or enemy action. Sophisticated swarm software, including the necessary sensors and hand-off coding are unlikely to be fully available to weak sides in asymmetric conflict (the current obsession among many war planners) which would ensure the domination of swarms made by technology leaders for some time to come.

Whatever the case, some form of interceptor – one carrying dischargeable ordnance, or a suicide attacker – would be needed to attack enemy observation/ground attack drones, and to protect against enemy interceptors.

5.1. IFF, Self-Programming, and Real War

There is a further lesson to be learned from the Great War. In the period 1914-1918, aircraft underwent a major evolutionary process. Unsuccessful designs and ideas, which in peacetime might have survived due to clever marketing and fashion in the civilian market, never made it far. In fact, they were quickly shot down by the other side. Thus the hidden dimension of battlefield UAVs is the developmental dimension. The side that responds "Firstest with the mostest [and bestest]"[6] to misquote an American general, is the one that will win. Any organism, including technical developments, exists in a Darwinian world. Those that are successful may thrive, others disappear. In war this process is accelerated, as the development in aviation during the Great War demonstrates. The same may be true of UAVs, as their use and development accelerates.

The greatest challenge interceptor UAVs will have is identifying the foe. But that foe will be constantly mutating, whether relatively slowly by weak forces in asymmetric warfare, or quickly, in the labs of strong forces in symmetric warfare. Given the anticipated speed of change, on-board target reprogramming is likely to be the fastest way to go (Peabody and Seitzer 2015; Brukman, et al. 2015). This in turn implies (notably given the necessary autonomy of UAV swarms and members) a risk of a Watchbird phenomenon (Sheckley 1953): the potential for developing targets that may be civilian, or at least non-combatant without human input.

6. The Ethics of Killer Air Drones

The ethics of drone usage in the bombardment and surveillance roles has been discussed at great length, both pro and con (Cavoukian 2012; Moreno and Dubra 2015; Oudes and Zwijnenburg 2011; Phythian 2010). Little attention has been paid, however, to the potential air-to-air role of UAVs.[7] So long as the role of air fighter UAVs is confined strictly to attacking other Unmanned Aerial Vehicles, the ethical problem is largely one of safety, rather than security or human security: the potential for shrapnel, spent ordnance, and falling vehicles over populated areas. However, the rise of sophistication among potential fighter UAVs represents a problem in potentio. How does one distinguish an enemy from a neutral UAV? And, since UAVs come in a vast array of sizes and shapes, how is the UAV to be able to identify combatants and non-combatants? While these problems are minor compared to the ethical problem of

5 The use of UCAVs (Unmanned Combat Air Vehicles), such as those developed by the US (the X-45 program) and the UK (Taranis) for UAV interception does not change the equation much: UCAVs are essentially pilotless fighter planes, intended to replace manned fighter planes in some of their roles. When intercepting slower battlefield and "weak"-party drones, they would have the weaknesses as any other jet fighter plane.

6 Attributed to General Nathan Bedford Forrest, 1871.

7 Though there has been some discussion of the ethical problems relating to UGVs (Unmanned Ground Vehicles) as well (Cartwright 2010).

ground attack UAVs, they nonetheless are likely to play a part in the development and deployment of drone warfare.

Far more problematic is the simple fact that drones are relatively easy to design and build. A great number of nations are playing catch-up to the leaders in the field of medium UAVs (Shashank and Stein 2013). Though there are limitations on the sophistication of manufacture for many nations (Gilli and Gilli 2016), we have to accept that drones and drone warfare (including morally moot practices such as ground attack) will become the norm in the future (Clouet 2012). This implies that serious thought must be given to proliferation, including interception craft.

Crucially, one category of opponents is beginning to view UAVs, notably small and micro-UAVs, as an asset. In asymmetric warfare, notably terrorist warfare (not necessarily homomorphic), UAVs represent possibilities, including major influence on civilian aircraft, human targets, and pinpoint high-value targets such as radars, transportation nexi, and random attacks on civilians and infrastructure (Bunker 2015; Miasnikov 2005). UAVs of terrorist organizations can also be used for intelligence gathering for future attacks. Moreover, there is the possibility of UAVs being stored easily in enemy territory for automated planned or opportunistic attacks (Earley 2014).

All of the above implies that UAV-owning powers will be faced with the absolute necessity of developing and deploying interceptor UAVs. It is even possible that air interceptor swarms will be needed to cover population centres and protect them against covert use of enemy UAVs.

In the larger picture, small UAVs-of the kind deployable by insurgent and terrorist groups-represent a phenomenon similar to the problem of SALW (Small Arms and Light Weapons [Garcia 2006; Sagranoso 2001]). Like SALW, small UAVs are easy to obtain and modify, easy to conceal, and can be devastating under certain scenarios (e.g. attacks on civilians). The proliferation of small UAVs in the civilian market, whether as toys or for other purposes, thus presents an insoluble dilemma to security designers, one that will only get worse as civilian and hobby UAVs become more sophisticated. The development of small, cheap, swarm-enabled interceptor UAVs is part of the military solution, but only one part of a problem that needs some comprehensive pre-emptive thinking.

7. Conclusion

The historical trajectory of military aviation during World War I is currently being replicated in drone warfare. We can therefore expect to see in the not-too-distant future the emergence and deployment of drones specializing in air combat. Air combat drones have many potential advantages over the methods used today to interdict drones: they would be cheaper to produce and deploy than fighter jets, and given loitering technology, would have the ability to stay on-station for longer periods of time. In an asymmetric warfare scenario, where drones, notably quadcopters are attractive alternatives for weaker forces, the presence of loitering fighter drones would provide an edge for the defender.

Swarm technology and deployment of UAVs would provide another dimension of drone use, as specialized drones, including recon, ELINT, bombardment, and other types cooperate in ensuring low-layer dominance without deploying expensive manned fighters or UCAV, whose benefits are in any case questionable in this role.

Rapid response to changing types of recon and other drones, which can be modified by users in relatively simple workshops, would require self-programming abilities inbuilt into swarms. This might become a cause for concern, should the parameters of changing target profiles not be tightly restricted to avoid a phenomenon in which fighter UAVs attack innocuous targets.

Overall, the argument presented here seems to indicate that, as in World War I, UAV users will be driven to the deployment of dedicated air-to-air interceptor UAVs. These might not present the same ethical dilemmas as attack or surveillance UAVs, though future developments might raise new, unforeseen ethical problems as well.

Appendix: UAV types mentioned in the text

Firebee	A family of jet-propelled (including supersonic models) drones. Originally a target drone developed by the Ryan Aeronautics Company in 1951, it was subsequently modified as a planned-route autonomous photo reconnaissance craft. Some variants were used to lay anti-radar chaff during the Vietnam war. Served in the Vietnam and Yom Kippur wars (1968-1975 and 1973)
Global Hawk (RQ-4)	High altitude reconnaissance jet platform. Manufactured by Northrop-Grumman. Equipped with visual, radar, and other sensors. First flew in 1998.
HAROP	Unmanned anti-radiation unmanned vehicle designed and produced by IAI. It is a *kamikaze* craft, loitering until diving and exploding on designated target.
Hellfire (missile)	Precision-attack missile for air-to-ground applications. Manufactured by Lockheed-Martin and fielded since 1982. Used extensively on US (and possibly other) attack drones in the anti-tank and anti-personnel roles.
Predator (RQ-1)	Family of US drones manufactured by General Atomics. Extensively used in both reconnaissance and ground attack roles, using missiles such as e.g. *Hellfire*. Fielded since the 1990s, and heavily used in Afghanistan and elsewhere in the "War on Terror"
Raven (RQ-11)	Man-portable, single-user tactical short range UAV. Standard UAV at the Battalion level in the US army. Manufactured by AeroVironment, the 1.6kg craft has been used extensively in combat in Iraq and Afghanistan.
Sentinel (RQ-170)	A stealth-configured reconnaissance UAV designed and produced by Lockheed Martin. It has been fielded sine 2009 apparently and deployed in Afghanistan for use over Iran and Pakistan. In 2011 a Sentinel was brought down, either through internal fault or by Iranian electronic warfare over Iranian territory.

Switchblade	Backpack-portable expendable attack UAV designed to provide over-the-hill photo reconnaissance and precision attack capabilities to infantry platoons. The 2.9kg craft is manufactured by AeroVironment and has been deployed by the US Army since 2012.
Taranis	Experimental, demonstrator stealth jet-propelled UCAV developed and tested by the UK. First autonomous flight 2013.
V-1 (Vergeltungswaffe 1)	The first fielded jet-propelled *kamikaze* drone deployed by Germany between 1944-45.
X-45	UCAV demonstration vehicle designed and tested by Boeing as a capability demonstrator for a future US UCAV. The stealth-configured craft, superficially similar to the Taranis (qv.), was first flown in 2002.

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