Figure 1 Stealth Hornets: Unmanned Aerial Vehicle and Unmanned Combat Aerial Vehicle UAV/ACAV Version of a Revolution in Military Affairs

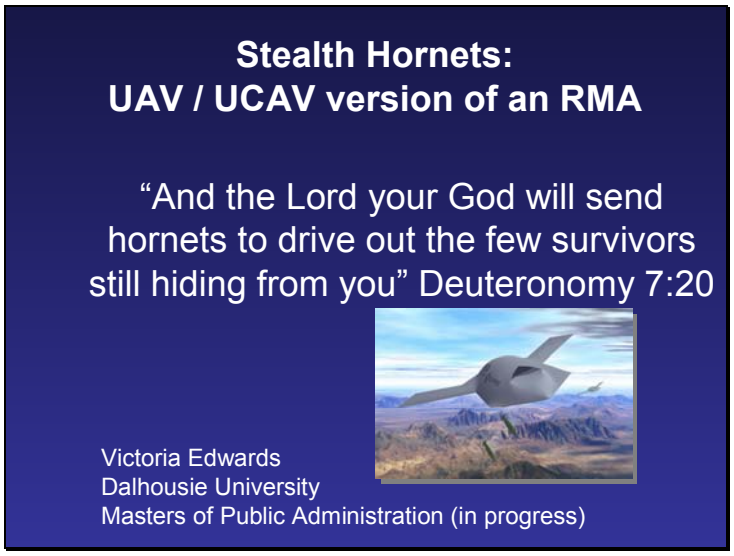
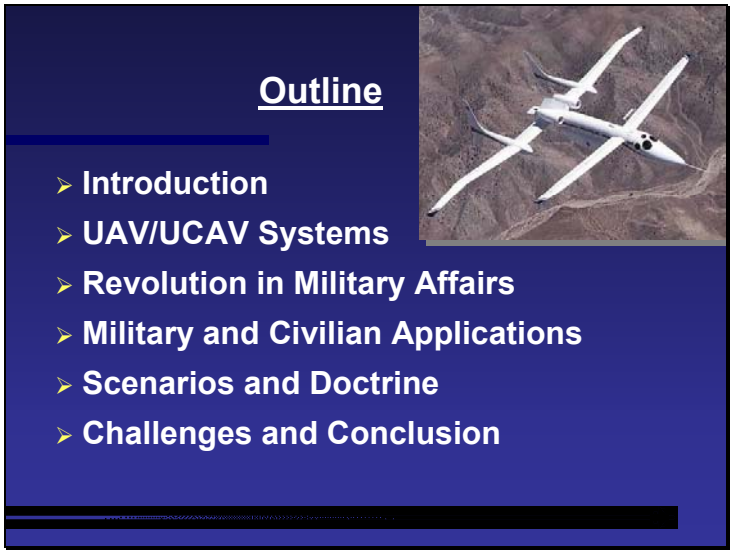


Figure 2 Outline



The stealthy Unmanned Combat Aerial Vehicle (UCAV) system is one of the next major weapons systems that will continue the Revolution in Military Affairs (RMA). The paper outlines and describes the various elements of the Unmanned Aerial Vehicle (UAV) and the evolution of military applications from information gathering missions to delivering modern stealth munitions. Next it outlines a range of actual and projected civilian applications of the UAVs. Finally, the paper points out the impact of the UAV and UCAVs on military doctrine.

Figure 3 UAV/UCAV Systems[1]

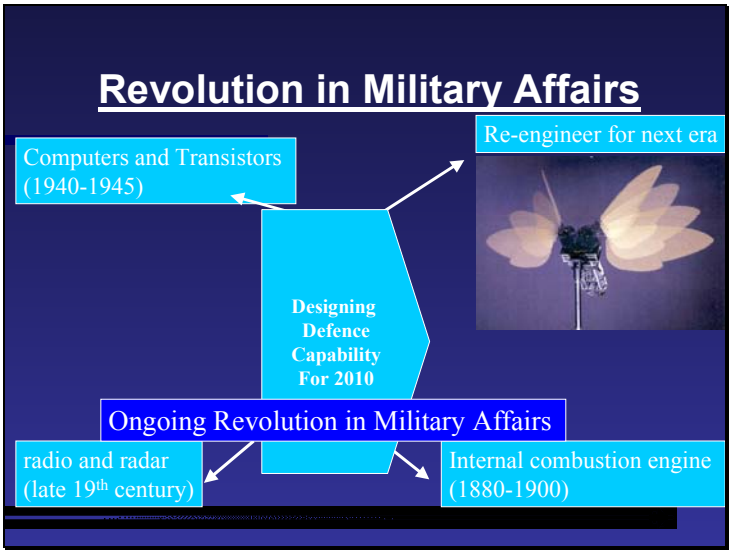
The UAV is a part of a larger system (UAV system) that typically includes the UAVs, ground vehicles, launching and recovery platforms, a flight control station, information retrieval, and data processing stations. The UAVs are small, remote controlled drones that resemble model airplanes. Although UAVs have been deployed since the Korean War, the payload normally consisted of sensors. Militaries, however, are increasingly retrofitting UAVs with munition payloads and the US Air Force plans to deploy the emerging UCAV in 2010. Once retrieved from the UAV, data is integrated "into the overall command, control, communications, and intelligence (C3I) network, supplementing information from satellites, manned surveillance aircraft … and other sources." [2] The collected data (eg. film) may be retrieved from sensor-equipped UAVs when the UAV is recovered or the UAV may transmit the information in real time, via data link, to the ground station.[3] The Multi-AUV ground control stations are often installed permanently in trucks or other vehicles, while portable ground control station (PGCS) allow tactical commanders at the front line or maritime commanders at sea to control the UAVs.[4] A downsized tactical version of a ground station, for example, was integrated and demonstrated on a submarine. [5]

The size, speed, endurance and propulsion method of UAVs vary, thus the commander's choice of UAV depends on its intended mission. The UAVs range from glider-sized, high flying, high endurance vehicles with ranges of hundreds of miles, to small, low-flying, low-endurance vehicles with ranges of tens of miles. The propulsion method ranges from propeller-driven vehicles that fly relatively slowly to jet-powered vehicles that fly in excess of 300 miles per hour.[6] Although some UAVs necessitate lengthy, hard takeoff and landing runways, others are operated from small unprepared fields or ships. While pilots on the ground can remotely pilot some UAVs using a radio link, other UAVs fly pre-programmed flight paths.

The sensor and/or munition payload of the UAVs also vary depending on its intended mission. According to Colonel Howell of the US Army, "[a]lmost anything that you can imagine can be put aboard a UAV… What drives most of these issues is cost."[7] When used to detect nuclear, biological or chemical agents and radioactivity, mines, or meteorological phenomena, the UAV is typically equipped with a combination of specialized and conventional sensors such as TV cameras, radars, infrared seekers, electronic signals intelligence equipment, and lasers.[8]

Some weaponized UAVs, however, hit ground targets with precision-guided munitions (PGMs) while others shoot down theater-range ballistic missiles just after launch, during their boost phase.[9] Howell explains that the challenge is to match the weight, power, antenna requirements of the given payload to the UAV's size and capacity.[10]

Figure 4 Revolution in Military Affairs



This paper argues that the UAVs continue the present Revolutions in Military Affairs. Some would counter that the modern revolutionary technologies, making up the UAV, such as precision munitions, reconnaissance satellites, and stealth materials do not fit the short time frame implied by the 'revolutionary' label because they were initially developed during the Cold War. Thus, the term Evolution or transformatory process in Military Affairs may be more appropriate. Those who adopt a revolutionary view argue that the RMA is not necessary rapid but it is best understood as a profound or powerful change, built on a long foundation of evolutionary change."[11] Historians agree that revolutionary changes in the techniques and technologies of war transform society and military institutions, however they dispute the implications, causes, timing and nature of the changes.[12]

As a practical matter, the development of the UAV followed the development of the airplane. Once could readily argue that the modern UAVs evolved from technology of the internal combustion engine (1880-1900), and radio and radar (late nineteenth century, late 1930).[13] This paper argues that the UAVs benefit most from an ongoing Revolution in Military Affairs in computers and transistors. Such computers were first developed in 1940-1945, but technological advances in the miniaturization of electronics, has increased dramatically since about the mid 1960s.[14] The micro-electrical-mechanical systems, for example permit the development of increasingly sophisticated UAVs. One of the most important military application of computers and transistors is the development of precision-guided munitions, developed during the Viet Nam war, however their accuracy has improved dramatically since the 1980s, particularly since the Gulf War.[15]

The revolution in military affairs concerns the implementation of superior cost effective operations through the "convergence, integration and merging of doctrine and technology [and organizational structure]."[16] Since the collapse of the Soviet Union, the UAVs are increasingly prominent because militaries continue to need to provide air superiority over the battlefield,

while minimizing military budgets.[17] The US DOD, for example budgeted $1.8 billion to acquire UAVs over the FY 1998-FY 2003 period.[18] This is only, however, 3 percent of the roughly $50 billion budget of the three tactical aircraft programs: the F/A-18E/F, F-22 and Joint Strike Fighter programs.[19] Thus, the investment of the UAVs are relatively modest, "notwithstanding the potentially revolutionary impact that UAVs could have on the way wars are fought in the future."[20]

In The Revolution in Military Affairs, Elinor Sloan argues that "low observable" or stealth is one of the most important RMA developments. The stealth platforms, such as UAVs are better able to penetrate high-threat areas and deliver precision-guided munitions in comparison with nonstealthy counterparts.[21] The UAVs are used on stealth missions to avoid unnecessary military and civilian casualities because "the RMA [claims that by] bringing ever advancing technology to bear on war, it can reduce collateral damage."[22] Figure military commanders will probably continue to use UAVs in reconnaissance and surveillance because "[t]he sensors onboard and use … of "UAV's" is now starting to give us views of the battle-field or possible countermeasures capabilities not previously available."[23]

Figure 5 **Military Applications**[24]

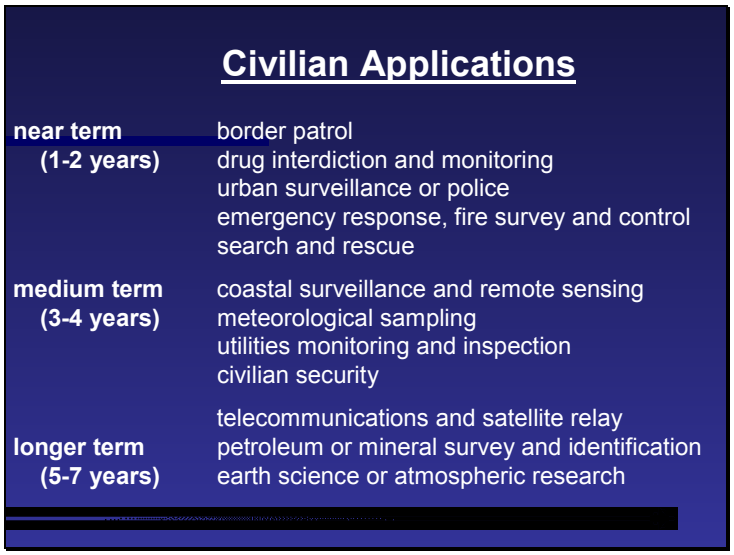
During the Cold War, the UAVs were used to accomplish military applications, chiefly information gathering missions.[25] First used during the Korean War to conduct surveillance missions, UAVs were used extensively in the Vietnam war for reconnaissance and surveillance.[26] In China, North Vietnam and the Far East the UAVs provided surveillance from 1965 to 1972 over areas that were too dangerous for manned aircraft.[27] Launched from C-130 aircraft, The Teledyne Ryan's Frisbee UAVs, for example, flew over 3,000 missions in which they supplied tactical information that satellites could not.[28] Between 1979-1987, Lockheed Corporation developed the Aquila UAV, for the DOD at a cost of about $1 billion. The Aquila, however was extremely ambitious for the cost and available technology as the DOD required "evasive maneuver, night-time target designation and an anti-jam data link capabilities."[29] The Israelis used their Mastiff and Scout UAVs to gather intelligence in the early 1980s about Syrian air defense sites located in Lebanon. In 1982, for example, the Israeli forces used UAVs "to draw fire from Syrian surface-to-air missile (SAM) sites, allowing Israeli manned fighters to locate and destroy the sites."[30]

Since the collapse of the Soviet Union, the UAVs have been applied to range of military applications, both information gathering and weapons delivery.[31] Specifically, the increasing speed, range and payload capacity of modern UAVs help militaries fulfill growing numbers of short notice air operations, far from home.[32] The DOD, for example, used UAVs for reconnaissance missions in Somalia, Haiti and Bosnia.[33] The UAVs are used in information gathering as key components of "increasingly dense sensor webs [that] will provide future forces with unparalleled transparency."[34] Consequently, today's UAVs incorporate the following cutting-edge intelligence-gathering technologies, "electro-optical, synthetic aperture radar, moving target indicator, SIGINT geolocation, foliage penetration, see-through-wall radar."[35] Linked to long-range, pilot less missiles or drones, sensing satellites, UAVs become extremely sophisticated space and ground-based reconnaissance systems.[36] With a weapons payload, the high-altitude, long-endurance UAVs can fly independently for hundreds of miles on preprogrammed missions and obliterate targets with little risk to military personnel.[37] The UAVs can be equipped with increasingly effective state of the art smart weapons, which are precision-guided munitions that alter their trajectories in flight to home on their targets.[38] Commanders will likely employ the new generation of UAVs, in an expanded range of missions including target designation, "long-range precision strikes against ground targets and close air support."[39] Emerging high-altitude, long-endurance UCAVs, similar to that shown in Figure 4, increase the military's power projection capabilities because they will likely the effective range of "wide area and very low circular error probability (CEP) precision strike."[40]

Figure 6 UAV/UCAV Scenarios

The UAV and UCAV will likely improve operational effectiveness in two emerging scenarios.[41] First, adversaries equipped with ballistic and cruise missiles, submarines, mines, and other "anti-access" capabilities could render forward areas inaccessible, except by an UAV. Second, UAVs/UCAVs may be effective weapons to fight or conduct peacekeeping operations, particularly in urban areas in the developing world.[42] In Operation Iraqi Freedom, for example, coalition forces flew over 10 different kinds of UAVs.[43]

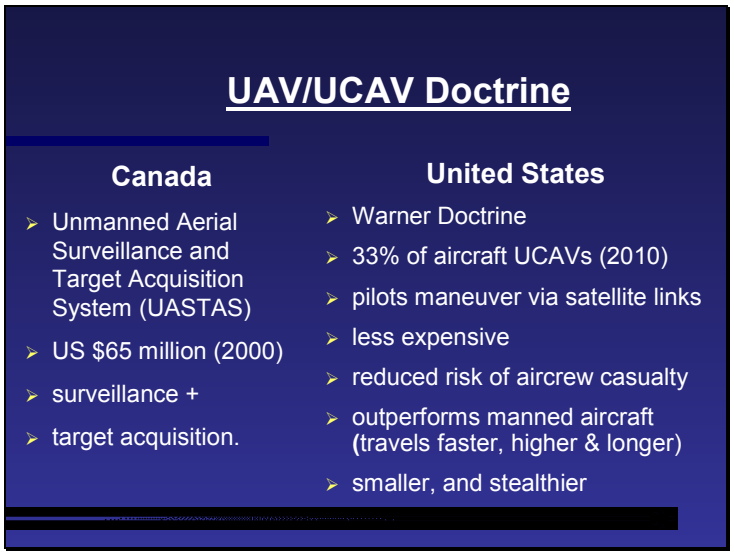
Figure 7 Civilian Application of UAVs



There are some existing corporate applications of UAVs and more are projected in future.[44] With a 148.5 kg payload capacity, the Altus II UAV can perform communications relay, cellular relay and commercial applications operations to 19,800 m.[45] The NASA and the US Department of Energy (DOE), for example have deployed the ALTUS high altitude UAV in scientific applications such as atmospheric research to understand and predict hurricane paths and assess potential damage.[46] Current legislation and regulation, however, limits the commercial applications of UAV systems.[47] Consequently, lobby groups, including the Unmanned Aerial Vehicle Systems Association, the European Unmanned Aerial Vehicle Systems Association (Euro UVS) and the Association of Unmanned Vehicle Systems International (AUVSI) conduct regular dialogue with politicians and industry to support both military and commercial use of the UAVs.[48]

As technological and regulatory issues are addressed, Frost and Sullivan predicts that the world market for UAVs will grow throughout the forecast period 1994 to 2004.[49] In "2000 And Beyond - A UAV Forecast", Katrina Herrick recommends marketing a UAV in two particular applications. First, UAVs are suitable for operations that offer operating cost advantages over manned systems. Second, UAVs are suitable for dull, dirty and dangerous missions that no other manned or space system can accomplish with similar effectiveness, accuracy and utility. [50] Specifically, Herrick believes that the first UAV systems in the commercial and civil market will be tactical fixed wing and lower-end rotary-wing.[51] Herrick considers a variety of civil UAV applications in the near term (1-2 years), medium term (3-4 years), and longer term (5-7 years).[52] The near term civil UAV applications include border patrol, drug interdiction and monitoring, urban surveillance or police, fire survey and control, emergency response and search and rescue.[53] Equipped with emergency geo-location transmitters, for example, the UAVs could be used in search and rescue missions, to home in on the location of other radio communications or radar transmitters.[54] The medium term civil UAV applications include coastal surveillance, remote sensing, meteorological sampling, utilities monitoring and inspection, and civilian security, for example of high risk government properties. [55] The longer-term civil UAV system applications include telecommunications, satellite relay, petroleum and mineral survey and identification, and very long endurance earth science or atmospheric research.[56]

Figure 8 UAV/UCAV Doctrine



The UCAV will have an impact on military doctrine as air doctrine moves from manned toward stealthy unmanned combat in the long-term. A Foreign Affairs document predicts, "unmanned systems will increasingly substitute for manned systems across warfare dimensions…[and s]tealth will likely be applied to a wider range of air, ground, sea, and perhaps space assets."[57] The French army unitė de doctrine originated as a guiding principle in the 19th century that applied analytical thought and reason to war.[58] The doctrine, that is the "what" and "how" military affairs are performed, necessitates a good understanding of changes that are in progress. Since doctrine and technology are interrelated, one also needs to understand the strategic and tactical value of knowledge.[59] Modern doctrine consists of the central beliefs the military has on the subject of war, as expressed in a set of doctrinal publications. Doctrine establishes a particular way of thinking about warfare and sets forth broad guidance for the conduct of strategy, operations and tactics in war.

After a two-year dormancy, the Canadian Army resurrected its Unmanned Aerial Surveillance and Target Acquisition System (UASTAS) requirement with secure funding of US$ 65 million in 2000. Project Director Captain Bud Walsh pointed out that Canada renewed its tactical UAV requirement "under a global requirement for a Land Force ISTAR capability identified through a review of the Army doctrine. As such, the Project staff is once more defining its UAV requirements and re-analyzing its options to compile a request for proposal."[60] The goal is to enable field commanders to carry out near real-time non-line-of-sight surveillance and target acquisition. Consequently, brigade or formation level Land Force commanders could acquire and to directly fire onto stationary or moving targets beyond the visual range of ground or airborne observers.[61]

Through the 'Warner Doctrine', the US Congress mandated that 33 percent of US deep strike aircraft should be UCAVs by the end of the decade.[62] Following a doctrine of unmanned combat, pilots located in the United States would maneuver UCAVs via satellite links. There are advantages to the unmanned combat doctrine: the UCAVs are less expensive than aircraft, there is a reduced risk of aircrew casualty, and the UCAVs may be able to outperform conventional manned aircraft.[63] Specifically, unmanned aircraft that can withstand a maximum gravitational force of 20g should be able to travel faster, higher, and longer than manned aircraft because

pilots in modern fighters are limited to 9g due to g-induced loss of consciousness. In addition, the UAV can be made considerably smaller, and thus stealthier without a pilot.[64]

Following the 'Warner Doctrine,' UAVs, initially operated as sensor platforms are transitioning to weapons carriers. The majority of UAV programs, however, remain tactical UAV systems funded by various worldwide militaries.[65] In 1996, the worldwide military UAV market amounted to approximately US $1.98 billion,[66] which had risen to $2.3 billion by 1997.[67] Through spending about $2 billion on development and procurement during the last 2 decades, the US Department of Defence has remained the world leader in UAVs. Indeed, the DoD is presently pursuing a variety of UAV efforts, including the Predator, Global Hawk, Pioneer, Outrider, and DarkStar programs.[68] In 2010, the US Air Force plans to field a stealthy UCAV.[69] In the interim, the US Air Force armed some of the Predator UAV with precision weapons for use during the war on terrorism in Afghanistan.[70]

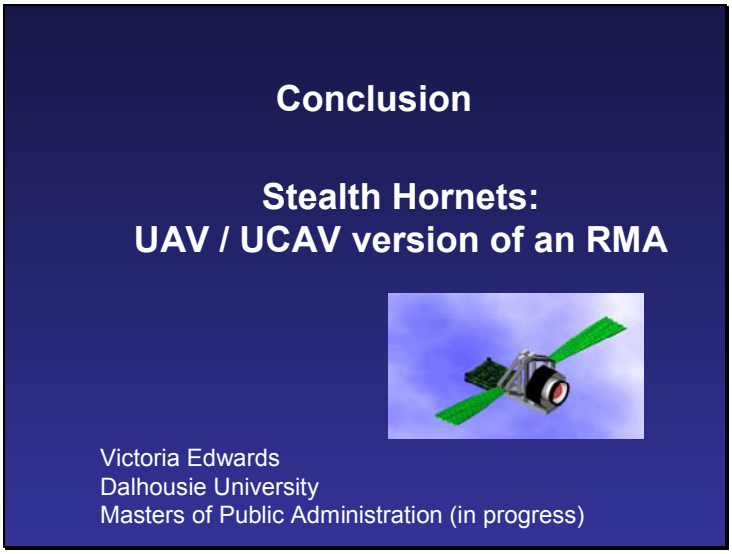
The military uses the doctrine ideas and precepts to determine how to best use technology and other elements to achieve military objectives. The strengths of doctrine is the opportunity it generates to establish priorities, identify weapons and training requirements because doctrine shapes armies, navies and air forces. Specifically, ten years ago, we lacked the "eyes" and sensor information grid consequently, "[i]t is now timely to revisit doctrine, 'standard operating procedures' and how we have institutionalized our operations."[71] Using modern technology, such as the UAVs, changes what we can do, and how do some traditional activities. Specifically, technological innovations permit the military to automatically feed and share sensor data very rapidly with other team members to achieve our business goals.[72] New classes of global positioning system and laser-guided munitions with acoustic and thermal homing explosives, for example, continue to be developed for an expanding set of delivery means, including the UAV.[73]

Figure 9 Challenges

The UAV and UCAV will likely face resistance from militaries that are more accustomed to manned aircraft. Militaries seek to be on the cutting edge of technology and tactics because they are major causes of change and the tactics or methods of warfare constantly evolve due to changes in technology. The weakness of doctrine, however, is its basis on assumptions and projections on future war, which may lead to poor force structures and mistaken strategic,

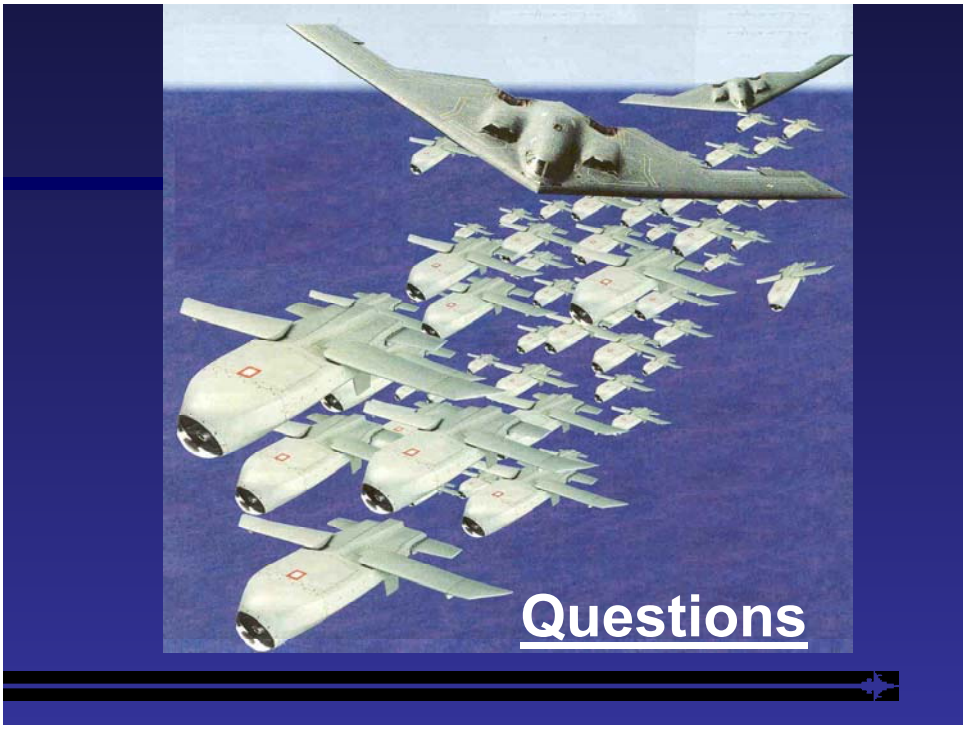
operational, or tactical capabilities. Thus, In The Transformation of War, Martin Van Creveld points out, "One very important reason for disliking a weapon was, of course, because it was new. A weapon might or might not be effective, but whenever one was introduced it always threatened to upset traditional ideas as to how war should be waged, and, indeed, what it was all about."[74] Lt Gen James Cartwright, for example, continues to advocates, for niche use of UAVs rather than the 33% split between conventional and CUAVs, "I'm not so sure there's a broad agreement on [the Warner Plan] …We've still got to figure out if there's a compelling need."[75] Cartwright points out, for example, that the US Army and Marine Corps has focused on the urban requirement in built-up, closed or complex terrain, in its urban combat centers since the 1990s. Cartwright sees that robotic type of system, such as the UAV has potential to fill niche applications, "inside buildings where you need to know what's in there before you enter, areas which are rubbled and hard to get through and high threat areas where you don't want to send a person out first." [76]

Figure 10 Conclusion



Based on the Revolution of Military Affairs theory, the UAVs represent a continuation of the current computer revolution, however the profound or powerful change built relatively slowly on a long foundation of evolutionary change. Thus, access to weaponized UAVs and UCAVs offers the powerful modern military the opportunity to fulfill the biblical story of sending hornets to drive out the hiding enemy survivors. Indeed, after completing an exam in world religious studies, the author suffered a prophetic nightmare of hornets hunting Afghani caves for Osama Bin Laden and the "Al Qaeda" international terrorist network. Similarly, civilian application of the UAV offers the opportunity to perform dull, dirty, and dangerous missions, that manned or space systems may not accomplish as effectively. Consequently, the few terrorists may have less success at hiding in a remote cave and the civilian contractor may suffer fewer casualties in determining the area at the war's end. Despite the Warner doctrine, and potential cost effectiveness of the UAV/CUAV systems, the new weapon upsets traditional ideas. Consequently, some militaries – even the Canadian Forces- will undoubtedly resist the trend from manned to unmanned aircraft systems.

Figure 11 Questions



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