# Unmanned aerial vehicles: application and human factor

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Unmanned aerial vehicle, or UAV, is one of the latest aircrafts recently being utilized by the United States Military. Its conception has provided Air Force pilots with assurances of safe return after a combat mission, a feat never before attained in warfare's history. Since its invention in the 1920's, several technological advances have been made; extending flight distance and duration capabilities, and pay loading armaments comparable to those of manned fighter jets.

Since UAVs are usually controlled by an external pilot on Ground Control Stations, or GCS, it is unavoidable for this system to be faced with human factors, sometimes resulting in mission failures, at times even in aircraft crashes. Unmanned Aerial Vehicles: Applications and Human Factor Recenttechnologyhas introduced to us a new form of aircraft in aviation.

Perhaps due to the increasing incidents of aircraft accidents during these past decades, which often resulted in the deaths of even the most experienced pilots, airline conglomerates and military authorities had painstakingly searched for the completion of the invention of Unmanned Aircraft Vehicles, or UAV. In this paper, we shall be witnesses to a technology that has the potential to virtually eliminate pilot casualties, whether in war, espionage missions, or even in commercial flights.

We shall also see how human factors affect such technology, in terms of control and manipulation of the aircraft, and the causal possibilities of human error in accidents. Background The United States' Department of Defense defines the UAV as, " powered aerial vehicles that do not carry a human operator, use aerodynamic forces to provide vehicle lift, and can fly autonomously or be piloted remotely” (Bone, 2003, p. 2). United States’ war onterrorismhas put UAVs missions as important in the gathering of intelligence data.

Its unquestionable successes in the wars in Iraq, Kosovo, and Afghanistan had opened the military minds on its advantages during wartime. Missions that used to be reserved for Air force top guns, now the UAVs are slowly taking the front seat. UAVs have two obvious advantages over manned aircrafts: first is, they are found to be cost efficient; and it eliminates the dangers faced by the pilots’ during missions (Bone, 2003, p2). Bone cites a number of reasons on the seeming delay of the technology of UAV.

One is because the technology to effectively fly a UAV mission has only recently been made available. Another is due to the Air Force’s slowly fading silk scarf syndrome, which gave preference to manned over unmanned flight missions, thus allowing for the UAV to gain more flight hours. Yet another is due to the earlier absence of a global crisis, which could have allowed for a quicker invention of the UAV due to the extreme shortage in the U. S. military of an espionage aircraft (2003, p. 5). UAVs size varies from a few centimeters in length to that of a 747 jet liner. U. S. Department of Defense currently has in its possession five types of UAVs: The Predator and Global Hawk of the Air Force; the Pioneer by the Navy and the Marines; the Hunter and the Shadow by the Army (Bone, 2003, p2). Despite the notion that UAVs have only recently been developed in the United States, it has been in existence in aviation for almost a century. UAVs were first tested in 1920, during World War 1, but the United States did not put it into combat action. It was Germany who had laid the foundations on this technology during World War 2, with the invention of the V-1 Flying bomb.

But it was to be in theVietnam Warthat UAVs were first used as an espionage plane, with AQM-34 Firebee. Firebee epitomized what the UAV should be: versatile, easy to operate, transportable to other areas, and can easily be converted to payload missiles. In a speech by former President Bush in December of 2001, he had expressed his belief in the UAVs technology, particularly The Predator, as the future of warfare; as stated in a report to the American Congress in 2003 by Elizabeth Bone: This unmanned aerial vehicle is able to circle our enemy forces, gather intelligence, transmit information instantly back to commanders, then fire on targets with extreme accuracy…We're entering an era where unmanned vehicles of all kinds will take on greater importance" (p. 7). U. S. Military U. A. V. s 1. MQ-1 Predator: It is about half the size of an F-16 fighter jet, a tail shaped like an inverted V, and is 27 feet in length and 7 feet high. It reaches a maximum altitude of 25, 000 feet, but for the fitted video cameras to work at its best, it needs to be at about 10, 000 to 15, 000 feet in altitude.

Its take off and landing capabilities are similar to that of the normal aircraft, with the pilot on ground control. The Predator's main job is airborne reconnaissance and accurate target pinpointing. It is equipped with a Synthetic Aperture Radar, or SAR, enabling it to see through bad weather conditions. Newer models also have capabilities to launch smaller UAVs to carry out varying missions. Each Predator unit's estimated cost is $4. 5 million, and $30 million for the whole system (Bone, 2003, p. 25). 2. RQ-2

Pioneer: This UAV is the only type on the Navy's and Marine's arsenal (Bone, 2003, p. 29). It was obtained by the U. S. Navy in 1986 from Israel after proving its worth with their war with Lebanon. RQ-2 Pioneer is about half the size of the Predator, at 14 feet in length, and its maximum attainable altitude is 15, 000 feet. It can remain airborne for 5 hours straight, and since its acquisition, it has accumulated over 23, 000 flight hours giving support to the Navy and the Marines. The cost of Pioneer is estimated at $250, 000 to $1 million, depending on the payload (Bone, 2003, p. 30). 3. RQ-5 Hunter: The Hunter weighs 1, 600 lbs, is capable of flying at 25, 000 feet altitude, and can stay airborne for 12 hours straight.

It is equipped with E-O/IR sensor which enables it to fly in night missions. Recently, plans have been made to use Hunter to act as a reconnaissance to a squadron of attack helicopters, such as the Apache and RAH-66 Comanche, to maximize the helicopters' attack zone. In 2002, a successful experiment was made wherein Hunter's control was linked to the mainframe computers of the Apache's during flight missions. The success of the experiment greatly maximized Apache's efficiency during battle conditions. Weapons payload includes the Brilliant Anti-Armor submunition, or BAT, an effective annihilator of tanks and armored personnel carriers.

Hunter's cost with payload is $1. 2 million, ad the whole system at $30 million (Bone, 2003, p. 33). 4. RQ-7 Shadow 200: Shadow 200, a product of AAI Corporation, is 11 feet in length and has a wingp of 13 feet. It was strategically designed for brigade operations, thus its range is only 30 nm and has a flight duration of 4 hours. And although its maximum attainable altitude is 14, 000 feet, it works best at only under 8, 000 feet altitude. The Shadow is equipped with an E-O/IR sensor video camera for day or night missions, and has the capability to transmit data to ground control in real-time.

The Shadow cost is pegged at $350, 000 while the whole system is at $10. 7 million (Bone, 2003, p. 36). 5. FQM-151 Pointer: All the branches of the U. S. military have, in the past, tried to develop their own type of hand-launched Pointer that measures around 6 feet in the last 15 years, and some of them had been on war missions, particularly in gulf War and Dessert Storm. However, the design officially approved by the Military is the AeroVironment’s Pointer UAV, which weighs 10 pounds, and has a wingp of 9 feet.

It can stay afloat for 90 minutes and has an up to 3-mile operational distance from ground control, within altitudes of 100-300 feet. Pointer UAVs have been best-suited for pay loading experimental miniscule sensors and have been a popular choice for Drug Enforcement Agency, National Guard, and Special Operations Forces (Bone, 2003, p. 37). 5. RQ-4 Global Hawk: This UAV is by far the most expensive ever produced, with per unit cost amounting to $75 million (Bone, 2003, p. 39). It specializes in high altitude, long duration flights that provides near real-time videos of large geographical sections.

It is also the first ever UAV to make a successful trans-Pacific flight, when it travelled from California to Australia in April 22-23, of 2001 (Bone, 2003, p. 37). Its effectivity was tested in Afghanistan, when it flew more than 50 combat missions accumulating more than 1, 000 combat hours, despite still being on its experimental stage. Global hawk is about the size of a corporate jet, measuring 44 feet in length and weighing 26, 750 lbs. Its maximum altitude limit is almost double than that of a commercial liner, at 65, 000 feet, and is capable of flying over 35 hours without refueling.

However, Global Hawk's most apparent advantage is its capability of taking off, flying, and landing autonomously in any kind of weather. Commanders in the battle field aptly call this UAV as, " the theater commander's around-the-clock, low hanging surveillance satellite" (Bone, 2003, p. 38). Global Hawk's pay load consists of a 2, 000 pound group of sensors, which is much larger than on any of the previous UAVs. it includes an all weather SAR with a Moving Target Indicator capability, E-O digital camera, IR sensor, and a Signals Intelligence Sensor, or SIGINT, making it a virtually multi-intelligence UAV (Bone, 2003, p. 8). As a testament to its technological superiority, Global Hawk's radar-sensors and IR cameras were able to accurately pinpoint Iraqi targets in March 24-27, of 2002, despite of having a near-zero visibility on the ground due to a relentless sandstorm in Iraq.

6. Unmanned Combat Air Vehicle: UCAV is the first ever unmanned aero-system designed primarily and purely for combat missions. It is similar in size to the Air Force's Predator, at 27 feet in length and a wingp of 34 feet. Equal to manned fighter jets in weaponry and stealth capabilities, the U. S. Armed Forces plan on having one-third of its deep-strike fighter jets be unmanned by the year 2010 (Bone, 2003, p. 42). Due to its 1, 000 to 3, 000 pound-weapons payload, UCAV's primary combat mission would be SEAD, or

Suppression of Enemy Air Defense, to be followed by precision targeting of enemy installations. 7. Vertical Takeoff and Landing Tactical UAV: Commonly known as VTUAV Fire Scout, it is a helicopter-looking design intended as a replacement for the Pioneer. It is about 23 feet in length, with a maximum altitude of 20, 000 feet and maximum flight duration of 6 hours.

Its maximum distance of operations is 110 nm from the control ship and has a speed of 115 knots (Bone, 2003, p. 43). UTUAV Fire Scout, unlike the Pioneer which utilizes a net in order to be recovered in a ship, ha the capability of autonomously taking off and landing through the use of sensors. Fire Scout is an unmanned equivalent of the commercial-use Schweitzer helicopter, it ahs an E-O/IR sensor that also serves as a laser targeting designator. It is also capable of mine-detecting, and is equipped with Hellfire missiles. Fire Scouts are being utilized in special operations support and homeland security services (Bone, 2009, p. 4). 8. Dragon Eye: it is the opposite of the Global Hawk in terms of range and size. Being a 5-pounder, with just a 45 inch wingp UAV, the Dragon Eye can provide marines with over-the-hill surveillance of enemy troops, making it an ideal UAV for urban warfare, chemical, as well as biological-oriented missions.

It is portable enough to fit in a backpack and can be launched by hand or with a bungee cord. This UAV can stay aloft for 1 hour, at a height of 300-500 feet, with speeds of up to 40 mph. Because of its small frame, its production cost which includes three planes, is only at $90, 000 (Bone, 2003, p. 7). 9. Dragon Warrior: Resembling a small helicopter of about 105 inches long and flight range of 50 miles, and maximum duration of 3 hours, this will be a vertical take off and landing UAV designed for surveillance in urban areas. It will also be equipped with E-O/IR sensor camera and a laser target designator. 10. A-160 Hummingbird: The Hummingbird is also an unmanned helicopter designed to have longer flight duration and distance over the other models, with a range of 2, 000 nm and a duration lasting for 48 hours, respectively.

With its maximum flight altitude of 30, 000 feet and a speed of 130-140kt, it will greatly assist in surveillance, targeting thru laser designation, communications relaying, weapons delivery to infantries, and special operations missions (Bone, 2003, p. 49). 11. Scan Eagle: Boeing’s UAV can be optionally launched from a ship, on land, or even from a submarine. The idea if to have a horde of 4-foot UAVs linked directly on a submarine for reconnaissance purposes. 12. Eagle Eye: This type of UAV takes off like a helicopter, and then flips its rotor blades to fly like an airplane.

Its speed is up to 220 knots and has a distance of 300 miles. This type of UAV is suited for patrolling the coastline, locating ships in distress, and also has the capability to transmit videos to command centers. Production cost for the Eagle eye is at $3 million per plane (Bone, 2003, p. 50). 13. Micro Air Vehicle, MAV: unlike the UAVs, MAV is only inches in length, and production costs would be in the thousands and not in millions. As an example, the Organic Air Vehicle, or OAV, measures only 9 inches wide. It has a ducted fan design, and carries an E-O sensor, which comes in infrared or acoustic models.

Because of its very small size, MAVs can be programmed for watch-and-stare missions on enemy troops while on air, and also while on land. These MAVs can autonomously lift off and land on itself. Modifications have also been done, resulting in the advent of UCAR, or Unmanned Combat Armed Rotorcraft. These will have the capability as a reconnaissance to ground troops, as well as offensive purposes. It will also be capable of system-linking with other manned and UAVs for performing synchronized attacks (Bone, 2003, p. 51). Human Factor in UAV Flights

Since unmanned flights have slowly been gaining popularity in both military and commercial uses, perhaps it will be sooner than we expect for UAVs to replace manned flights permanently. It would be wise for us to give insights on issues concerning cognitive factors affecting the pilots, especially since accident occurrences in UAV flights have been proven to be over thirty times more common than in manned aircraft flights (McCarley & Wickens, 2005, p. 2). It is also possible for UAV pilots to be manning more than one aircraft simultaneously, entailing never-before-encountered workload pressures.

Manual v Automated Flights 1. It has been widely accepted that the effect of automation has not resulted in the elimination of human workload but the introduction of new ones, forcing the pilots to develop new strategies (McCarley & Wickens, 2005, p. 4). The changing of strategies is often the result descriptive of an imperfect system, not of the computer software type, but of the factors that even a perfectly-running automation system would not be able to detect, such as the icing of an UAV wing.

2. The present UAV take off and landing automated procedures differ according to the model. Such that the Hunter and the Pioneer require an on-site external pilot; the Predator to be controlled on a separate aircraft within the Ground Control Site; while there are some cases, as in Global Hawk, where full automation is integrated. These differences seem to be significant, take off and landing errors make up for a majority of accidents attributed to human factors; Hunter with 67% and the Pioneer with 78%, both are externally controlled (McCarley & Wickens, 2005, p. ). 3. An external pilot of a UAV basically relies on computer imagery in controlling the aircraft. The visual quality of the imagery, however, has the possibility of being diminished due to factors affecting bandwidth, resulting in poor resolution or a delay in image uploading. Situations such as these may prejudice overall aircraft control and visibility of air traffic. This poses a clear danger in military missions, more so in the planned commercial implementation of autonomic control of commercial flights.

4. On way of solving the problem stated in #3 is by the use of enhanced reality, or synthetic vision (McCarley & Wickens, 2005, p. 7). In this system, images from the actual camera shots of a UAV will be converted to display landmarks on a given terrain, thus creating a virtual reality world that the external pilot can manipulate. The problem with this system is that pilot’s over reliance on synthetic imagery would lead to a possible neglect of some natural landmarks not visible in the imagery system. Thus, using this method would be beneficial for the UAV performance but comes with a potential risk. . One of the resulting effects of separating the pilot from the aircraft is that the pilot would be denied of his real-time sensory reactions otherwise

available in a manned aircraft, and that he would have to rely on computer monitors provided for by the cameras onboard the UAV. Hence, we can conclude that the external pilot only functions in a relatively sensory isolation from the UAV he is controlling.

It would be of utmost importance for the developers to design an alarms system to keep the pilots abreast of the real-time environmental situations and probable system failures. . Since UAV pilots are not in danger of injury or death in the event of their aircraft crashing, this could, in theory, prove to be a big difference in the pilot's risk-taking decisions, such as in going through a flight plan on a bad weather. Sensory isolation factor could be magnified during these situations (McCarley & Wickens, 2005, p. 10). 7. The accepted norm during long endurance UAV flights had been to switch control among different external pilots within a single flight.

This process usually takes on three types: First is the transfer of UAV control from one Ground Control Station to another; second is through the transfer of control from one team of operators to another, within the same GCS; and last is through the transfer of control from one pilot to another within the same team. It has been documented that a significant number of UAV accidents happened during the transfer from one pilot to another, because the GCS taking over control of the UAV was not properly briefed beforehand (McCarley & Wickens, 2005, p. 0). 8. Instances of a totalfailureof the Ground Control Station-UAV communications link would prove to be disastrous. This scenario can be considered as a human factor because of the need for the Automated Traffic Center, or ATM, to be aware of the default programs of the

UAV system in order to properly manage air traffic within their area. It would also be of the utmost importance for the external pilots themselves to be aware of the communications link failure as quickly as possible.

9. Researches on whether experienced manned pilots are better operators than novice manned pilots have ended in differing conclusions. Although generally, as the experiments revealed, experienced manned pilots reached the desired level of performance in landing and basic maneuvering skills faster than that of the novice's. Other studies, however, based on the Army's Job Assessment Software System, or JASS, revealed that piloting skills does not constitute a great deal in UAV operations, thus making the selection of top pilots as UAV operators insignificant (McCarley, & Wickens, 2005, p. 3).
10. Questions on medical qualifications of the UAV operator should also be brought into light. Since physical factors concerning high altitude temporary mental perception failure does not concern AUV pilots, still some type of medical fitness qualifications must be practiced. These must be able to determine if: the said qualifications should be more stringent or less for the UAV pilots; and, work duration limits should be established for long endurance missions.

11. Since the pressures and work load of a UAV pilot differs from that of a manned aircraft, and since formal training in flight schools are usually focused on instructing pilots for manned vehicles, which constitute less amount of time on simulations and more on the actual flight, the need arises for a training more attuned to giving more flight simulations to pilots of UAVs. This should be able to determine up to what extent trainee pilots

should spend time on simulations in order to obtain a UAV certification. 12. Technological researches must be made to improve on the controls of the external pilot.

At present, the controls of the UAV are similar to that of a radio-controlled hobbyist's plane. This design poses a problem in the directional movement of the UAV withrespectto the controller. As such, when the UAV and the pilot differ in position by 180 degrees, a rightward movement on the rudder will result in leftward movement of the UAV, and vice versa. Control rudders must be made to conform to the principle of human motion compatibility as to avoid further confusion for the pilot (McCarley & Wickens, 2005, p. 6).