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*521 THE UAV AND THE CURRENT AND FUTURE REGULATORY CONSTRUCT FOR INTEGRATION INTO THE NATIONAL AIRSPACE SYSTEM

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***522** I. INTRODUCTION

Science has not yet mastered prophecy. We predict too much for the next year and yet far too little for the next ten.

-- Neil Armstrong

***523** UNMANNED AERIAL VEHICLES, otherwise known as UAVs, are becoming commonplace tools in the belt of the world's militaries. The most well known UAV may be the Predator, [FN1] which has been flown by the United States Air Force ("USAF") in the skies over Iraq, Afghanistan, Bosnia, Kosovo, and Korea. [FN2] As one writer put it, "Predator was an instant hit because it could transmit live video footage of enemy actions to commanders on the ground and aircrews above the battlefield. It illuminated targets for precision weapons fired from afar. It even, on occasion, fired its own weapons, a rarity for a UAV." [FN3] While the Predator is a slow moving aircraft, it, and other UAVs, attract attention not only because of the novelty of flying without a pilot on board, but also because of their low cost of operations without risking the life of a pilot. [FN4]

The philosophy underlying UAV operations entails a combination of safety, by not putting pilots in harm's way, while performing missions involving the "3-Ds" (dull, dirty, or dangerous operations) and performing these missions at a generally lower cost than manned flight. [FN5] Today, militaries use UAVs primarily in operations involving the traditional "dull" missions of reconnaissance and surveillance. [FN6] Militaries have also converted UAVs into weaponized "next generation" UAVs, called unmanned combat aerial vehicles ("UCAV"). [FN7] UCAVs can perform an array of dirty and dangerous offensive and defensive operations, including suppression of enemy air defenses ("SEAD"), close air ***524** support ("CAS"), defensive counterair ("DCA"), offensive counterair ("OCA"), and air interdiction ("AI"). [FN8]

Notwithstanding the advantages inherent in UAV operations, concerns over safety remain. [FN9] Currently, safety issues have been somewhat mitigated by the fact that most military uses of UAVs occur in areas of operations, combat zones, or in restricted airspace where interaction with civilian aircraft is minimal. [FN10] Safety concerns, therefore, are heightened when the integration of UAVs into the unrestricted airspace of the national airspace system ("NAS") is contemplated. [FN11] One group observed that “the lower procurement cost of UAVs must be weighed against their greater proclivity to crash, while the minimized risk should be weighed against the dangers inherent in having an unmanned vehicle flying in airspace shared with manned assets.” [FN12]

Yet, there is a growing need to fly military UAVs through the NAS to and from areas of operations, which would not only include transiting a country's own NAS but also encountering the ***525** NASs of other nations. [FN13] However, most nations, including the United States, do not have a regulatory scheme in place to allow civilian, let alone military, UAVs to transit through their NAS. [FN14] In fact, the full scale application of civilian UAVs has been stymied by the very problems outlined above--namely, safety concerns surrounding integration and the lack of a regulatory regime to facilitate safe integration. [FN15] Nations such as the United States, therefore, are now scrambling in an attempt to develop a robust regulatory construct to provide safe and secure integration of UAVs into their NAS. [FN16]

The need for UAV integration is highlighted by the USAF's recent experiences in Iraq, which has literally become an onsite experimental test-bed for a number of UAV initiatives such as equipping soldiers with hand-launched micro-UAVs and placing different sensors and armaments on existing UAV platforms. [FN17] The United States has approximately 750 UAVs stationed in and around Iraq, and UAV operations have been confusing command and control elements and causing jammed radio frequencies. [FN18] In discussing the problems encountered in Iraq, the former USAF Chief of Staff, General John Jumper, stated, “[W]e've already had two mid-air collisions between UAVs and other airplanes, we have got to get our arms around this thing.” [FN19] According to General Jumper, the USAF and the United States Department of Defense (“DoD”) need a system to coordinate the use of UAVs. [FN20]

Indeed, this coordination must be accomplished with eyes toward the sky and ground, as integration concerns both UAV movement through the air and the noninterference with its own and other ground-based operations. Moreover, this coordination***526** must not only include inter- and intraservice interoperability with manned and unmanned assists, but also, as noted above, coordination with civilian airspace as the need for military UAVs to transit national and international airspace grows. This Thesis addresses the latter-- the quest to integrate the UAV into the NAS.

The primary focus of this Thesis is the integration of UAVs into the NAS of the United States. However, as UAV utilization inevitably globalizes, and as military and civilian uses will eventually entail international travel through foreign NASs, international integration will also be discussed. First, this Thesis will define the UAV, showing how a UAV's characteristics are different and distinguishable from rockets or missiles, and how as aircraft, UAVs are already governed by portions of the current air law regime. This process of defining the UAV will also involve a historical review of the UAV, showing how current UAV uses and technologies evolved at a very slow pace. While there are many causes for this slow development, the current and future uses of UAVs, both within and outside the military, are bright and progressive. Nevertheless, the lack of a congruent regulatory regime stands in the flight path of full optimization. This Thesis will address the current international and domestic regulatory regimes that apply to UAV operations. Then, this Thesis will highlight inadequately covered issues by existing rules, and must be therefore addressed to allow for full integration.

While much of the legal framework will be civilian in nature, it directly impacts DoD operations. To the extent that military UAVs need to fly outside the current restricted environment and transit the NAS as does manned flight, much of the civilian regulatory framework will have direct application to DoD and USAF operations. Further, as civilian, commercial operations for UAVs increase, the costs associated with UAV use by the DoD will decrease as more mass-produced, commercially available UAVs are able to be adapted for DoD purposes.

The future of the UAV is an open book waiting to be written. How fast the pages flow through history depends not only on technological advances but also on the political will of nations. The will of nations--individually through civilian and military regulatory bodies and aviation authorities and collectively through international organizations like the International Civil ***527** Aviation Organization (“ICAO”) [FN21] and the International Telecommunications Union (“ITU”) [FN22]--to formulate a regulatory airfield will allow UAVs to take off and sustain effective, efficient, and safe flight.

II. UAVS: PAST, PRESENT, AND FUTURE OPERATIONS

In order to address the integration of UAVs into the NAS, it is important to review what type of aircraft or vehicle must be integrated; therefore, this Chapter will begin by defining what a UAV is and what it is not, while more closely delineating its defining characteristics. Moreover, the road ahead is best understood and navigated with an understanding of the road already traveled. Thus, in order to fully understand what a UAV is, this Chapter will explore the evolution of the UAV.

This stroll down the halls of history will show that early in the development of the UAV--around the same time such militaries were developing manned military aircraft--the militaries of the United States and Great Britain saw the utility of a remotely controlled, unmanned aircraft. Nevertheless, funding and political quicksand provided a slow-moving technological and operational development production line, which in turn led to a fairly slow evolution for the UAV. Over time, however, the abilities of the UAV to do the 3-Ds in a cost-effective manner formed a loud and continual knock at the door of full scale development. As militaries began to rediscover the utility of the UAV, money and corresponding technological and developmental breakthroughs led to UAVs becoming more commonplace in military operations.***528** With the successful fielding of UAV technology, many national militaries found the utility of the UAV quite desirable, and now the UAV and UCAV are considered an important, yet not fully integrated, tool for the modern-day warrior.

As with so many developments by the military, governmental funding and technological advancement spurred adoption by the civilian sector as nonmilitary uses for the UAV began to be envisioned and exploited. This initial chapter, therefore, will also take a brief snapshot of the current UAV panorama, both military and civilian, as well as look forward to projected developments on the horizon. Since humans will always be drawn to the air and the feeling of freedom that operating an aircraft in flight brings, the culmination of UAV integration may very well find UAVs doing all operations that are dull, dirty, and dangerous; relegating, or maybe elevating, manned flight to flying simply for the thrill of flight.

A. Uav Defined

UAVs are generally identified by a number of different titles: Remotely Operated Aircraft ("ROAs") as previously used by civil United States agencies such as the Federal Aviation Administration ("FAA") and the National Aeronautics and Space Administration ("NASA"); Unmanned Aircraft ("UA") or Unmanned Aircraft Systems ("UAS") as currently used by the FAA; [FN23] Drone or Remotely Piloted Vehicles ("RPV"), pre-Gulf War terms; or the more common term, Unmanned Aerial Vehicle ("UAV"), used by most militaries and many European countries. [FN24] For purposes of this Thesis, the acronym UAV will be used because it is the more traditional term. However, this author makes a distinct note that the term "UAS" encapsulates a more accurate vision of the UAV. First, it defines the UAV as an aircraft and not a vehicle, and second, as will be explored later, it views the UAV as a system, not just an aircraft.

Interestingly, however, one author finds the distinction made by the FAA in using the term "aircraft," instead of the more universally***529** applied term "vehicle," somewhat troublesome. [FN25] According to that author, the FAA decided to use the term "aircraft" because the FAA was responsible for regulating "aircraft" and not "vehicles." [FN26] The FAA has defined a UA as "a device that is used or intended to be used for flight in the air that has no onboard pilot. This includes all classes of airplanes, helicopters, airships, and translational lift aircraft that have no onboard pilot. A UA is an aircraft as defined in 14 CFR 1.1." [FN27]

The concern in the use of the term "aircraft" is that it may exclude particular UAVs, and therefore, such excluded UAVs would be beyond the scope of any regulatory regime established by the FAA designed to facilitate full integration. This would then ultimately affect insurance rates for operators of such excluded UAVs as rates would be higher for them as compared to UAV operators who are able to take advantage of FAA regulatory certification. [FN28] Such excluded vehicles would potentially include small or micro-UAVs. [FN29]

Nevertheless, the overarching goal of any regulatory body responsible for securing safe navigation and use of a nation's airways should be focused on systems that pose greater danger to passenger, crew, and third-parties on the ground. Some objects that use the air, such as balloons or model aircraft, can simply be regulated by limiting location of use. The concern of the FAA may simply be on those systems that for commercial viability must avail themselves of the same operating airspace as piloted commercial aircraft, and which form a significant danger to existing air traffic. The FAA does regulate small aircraft and balloons, but to a lesser, and arguably proper, extent. [FN30] To the extent smaller UAVs would need to avail themselves of the same national airspace system (for example, airspace, airports, and air traffic management ("ATM") services), logically, regulations promulgated by governmental aviation authorities would apply to such UAVs, even if such regulations imposed different rules on the lighter, less dangerous aircraft. As will be highlighted later, it may actually be to the benefit of manufacturers and operators of UAVs that do not or will not need to extensively***530** integrate into the NAS, to have less burdensome rules, which will maintain the lower costs inherent in UAV operations. [FN31]

Further, the FAA is not alone in describing UAVs as aircraft. British aviation authorities also use the term "aircraft" in defining a UAV as "[a]n aircraft which is designed, or modified, to carry no human pilot and is operated under remote control or in some autonomous mode of operation." [FN32] Likewise, for purposes of FAA use, this researcher feels the term "aircraft" is the proper focus of the FAA or any national aviation regulatory authority addressing the issue of integration into the NAS.

A more salient argument, however, might be that the terms "UA" or "UAS" precludes aerial vehicles that are not remotely operated but are programmed to autonomously operate, either by an undeviating, preprogrammed course, or through autonomous computer operations based on input and decision making by on-board computers that adjust course; technology for the latter is being tested, but yet to be fully realized. [FN33] This distinction is highlighted in current versions of Jane's All the World's Aircraft, which define "RPV" as "[r]emotely piloted vehicle (pilot in other aircraft or on ground); contrast UAV," and then make a distinction by defining "UAV" as "[u]nmanned (or uninhabited) aerial vehicle; contrast RPV." [FN34]

While there is a reasonable argument that the yellow-brick road of UAV technology may ultimately end with fully computerized and autonomously operated aircraft interacting within the NAS with increased safety due to the lack of human error, that future is not current reality as national aviation authorities grapple with integration issues. There are RPVs that safely operate in an autonomous fashion; however, these aerial vehicles are not ***531** designed to operate in mixed airspace. [FN35] Clearly, the initial integration of UAVs must include human remote operation, or at the very least monitoring. Even the infamous 2001 nonstop flight of 7500 nautical miles from the United States to Australia by Northrop Grumman's Global Hawk--which, with its advanced onboard computers, coupled with advanced GPS navigation, autonomously performed piloting functions--had on-the-ground pilots in the United States and Australia to monitor and remotely operate the Global Hawk through each nation's air traffic control systems. [FN36] Moreover, it is interesting to note that the USAF now views the future of the Global Hawk as a remotely piloted aircraft and not a fully autonomous UAV. [FN37]

It is fair to say that the current and foreseeable future of UAV technology requires remote operations for integration into a nation's airspace. Therefore, it is "remotely operated" aircraft that must be the focus of the FAA, or any national aviation regulatory authority, in the development of a system to integrate UAVs into the NAS. [FN38]

As aircraft, UAVs fall within certain specified definitional parameters. For example, the term "aircraft" is defined by ICAO, the international organization created by the 1944 Convention on International Civil Aviation ("Chicago Convention") to manage***532** the safety and security of international civil aviation. [FN39] The annexes to the Chicago Convention define an aircraft as "[a]ny machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth's surface," as would be the case with a missile or rocket. [FN40] Also of note, the Chicago Convention further defines an airplane, or aeroplane, as "[a] power-driven heavier-than-air aircraft, deriving its lift in flight chiefly from aerodynamic reactions on surfaces which remain fixed under given conditions of flight." [FN41] Therefore, it follows that the regulatory framework to integrate UAVs does not need to address missiles or other kinds of similar projectiles, such as the infamous cruise missile, because while they may be "unmanned" systems, they are neither airplane nor aircraft as defined by ICAO, and thus are not UAVs. Further, and more to the point, missiles and rockets are not designed for civilian use or integration into the civil aviation environment.

Moreover, as noted in the following statement by the DoD, the DoD definition of "UAV" also excludes missiles:

> Because they are both unmanned aircraft, the distinction between cruise missile weapons and UAV weapon systems is occasionally confused. The key discriminates are (1) UAVs are equipped and employed for recovery at the end of their flight, and cruise missiles are not, and (2) munitions carried by UAVs are not tailored and integrated into their airframe whereas the cruise missile's warhead is. This distinction is clearly made in the Joint Publication 1-02 DoD Dictionary's definition of a UAV:

A powered, aerial vehicle that does not carry a human operator, uses aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or non-lethal payload. Ballistic or semi ballistic vehicles, cruise missiles, and artillery projectiles are not considered unmanned aerial vehicles. [FN42]

***533** It does not go without notice that even with the DoD's use of the term "vehicle," its reference to "aerodynamic forces to provide lift" fits nicely into the ICAO definitions of aircraft and airplane.

If the DoD finds it necessary to retain the term "unmanned," maybe unmanned aircraft or "UA" would be a better delineation from unmanned vehicles that do not fly, than the term UAV. While it could be argued that UAV maintains the potential for a fully autonomous pilotless aircraft as compared to the term ROA or RPV, so would the term UA. Nevertheless, while this researcher disagrees with the use of the term "UAV," it is also clearly recognized that UAV is overwhelmingly the most used and globally accepted term. However, as the USAF lobbies to become the centralized lead within the DoD for UAV testing, development, and procurement, [FN43] replacing "aircraft" for the term "vehicle" would clearly place the platform more squarely within its parameters of operational designation, and may add to the legitimacy of this USAF initiative.

Nevertheless, it is this DoD definition, tailored to include the term "aircraft" that I will use as the definition for UAV in this work. Namely:

> A powered, aerial [aircraft] that does not carry a human operator, uses aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or nonlethal payload. Ballistic or semiballistic vehicles, cruise missiles, and artillery projectiles are not considered unmanned aerial vehicles. [FN44]

In addition to a definition, within the UAV genre there are, as noted by the above reference to lighter or micro-UAVs, different classifications of UAVs that draw distinction not only on size, but also flying altitude and applications. For example, the most commercially viable utility of UAVs will probably be at very high altitudes for uses in telecommunications relay and remote sensing, which have the potential of replacing very expensive low-Earth-orbit satellites. [FN45] These UAVs have been called by the ***534** DoD, NASA, FAA, and others as "high altitude, long endurance" or "HALE" UAVs. For purposes of this work, this classification will be referred to as HALE UAVs. [FN46]

In its roadmap for the certification and regulatory future of HALE UAVs, NASA's Environmental Research Aircraft and Sensor Technology ("ERAST") project defines a HALE UAV as an "aircraft that is capable of flying at or above 45,000 feet, for a period of 24 hours or longer, and can be operated through both remote or autonomous means." [FN47]

HALE UAVs are of particular interest to airspace regulators due to the fact that while they are capable of operating at levels above 45,000 feet, they "generally spend most of their time in Class A . . . airspace above 18,000 feet where they are under positive air traffic control." [FN48] Therefore, the HALE UAV, or as delineated by European aviation authorities, UAVs with service-induced applications, forms the largest future user of commercial airspace, and potentially ATM and airport services. [FN49]

Medium-altitude UAVs will also need to be launched from an airfield or airport, but will generally perform operations at 18,000 feet or below. [FN50] They are referred to by European aviation authorities as having platform-based applications. These UAVs are primarily used by militaries and other governmental bodies for operations such as ground or infrastructure monitoring. [FN51] For purposes of this work, this classification will be delineated into medium-altitude, long-endurance

UAVs or "MALEs," and the less descriptive medium altitude UAVs.

The final classification is the lower altitude UAVs, which operate below 1500 feet and are currently primarily technology-***535** based applications. This classification is currently dominated by scientific and academic organizations working on smaller, more power-efficient UAVs. [FN52] The military also has a variety of UAVs in this classification, to include tactical-weapon and surveillance platforms. [FN53] This classification also includes small and lightweight UAVs that closely resemble remotely operated model airplanes used by hobbyists and can be either launched literally from the hand or by small launch platforms. For purposes of this work, this classification will be referred to as micro-, mini-, tactical- or low-altitude UAVs.

B. History of UAVs

The process of defining, delineating, and classifying UAVs is incomplete without understanding how the UAV evolved into its current and future manifestations. Early versions of the UAV were designed to operate more like flying bombs or cruise missiles, with armament built-in as part of the airframe, rather than the above-defined UAV. Over time, however, technology allowed the UAV to not only be remotely operated, but also evolve into either nonweaponized aircraft or aircraft capable of bombing a target with armaments that could be separated from the aircraft.

The dreams of early UAV pioneers began to form alongside manned aviation; however, the development of a finished, usable product came at a slow pace-- much slower than manned flight. [FN54] While it could be argued that UAVs were actually developed before manned aircraft, as most aviation discoverers first created unmanned versions, these unmanned models were simply to test the airworthiness and durability of the airframe--in other words, a means to an end and not the end product. [FN55]

First included in Jane's All the World's Aircraft in 1920, UAVs were tested before and during World War I but not used in combat. [FN56] These early pilotless aircraft, however, were merely flying bombs with no in-flight control and designed to crash after a ***536** certain programmed period of flight. [FN57] Nevertheless, in developing these aerial torpedoes or flying bombs, the limiting factor of pilotless stabilization became a large obstacle. With a pilot onboard, an aircraft could be righted during flight; without a pilot, stabilization had to be done by the machine.

In the second decade of the 20th century, inventors Elmer Sperry and his son, Lawrence, solved the dilemma of stabilization by developing gyrostabilizers, which were initially invented for use on United States Navy ships. [FN58] Early aviation inventor and businessman Glenn Hammond Curtiss assisted the Sperrys in adapting the idea for heavier-than-air aircraft by testing various versions on Curtiss-built aircraft. [FN59] In 1914, after almost four years of trial and error, the Sperrys demonstrated during France's Airplane Safety Competition that a system of gyrostabilizers could enable an airplane to remain stable without a pilot touching the controls for a portion of the flight. [FN60] Their work in gyrostabilization was also noted as the most noteworthy aviation achievement in 1914. [FN61]

In addition to the advances in aerial stabilization provided by the Sperry Gyroscopic stabilizer, their work also led to the development of an automatic pilot system. Lawrence Sperry first demonstrated an automatic pilot system in 1912 by flying a Curtiss seaplane with an installed Sperry autopilot. [FN62] While Lawrence Sperry and his father made many technological advances that made pilotless aviation a possibility, their work in manned aviation is of no little significance. [FN63] In fact, as one aviation historian***537** declared, "[Lawrence Sperry] did more than any other inventor to bring about safety in flying, and automatic piloting of aircraft." [FN64]

The Sperrys continued research in automated piloting by attempting to develop a prototype aerial torpedo for the U.S. Navy. [FN65] In 1915, Elmer Sperry was appointed to the Naval Consultant Board, the mirror of a similar board of British scientists previously created in England. [FN66] Businessman and inventor Peter Hewitt was also associated with this board and teamed up with Sperry to develop for the U.S. Navy two types of aerial torpedoes: one that could fly for preset distances into ships and one that could be remotely controlled from another airplane. [FN67] By 1917, they had succeeded in flying

Curtiss N-9 seaplanes on thirty-mile preprogrammed flights, albeit, with a pilot on board using the Sperry autopilot system.

Nevertheless, the use of an automatic-piloting system was not the only method desired by the U.S. Navy to control these aerial torpedoes; the Navy also contracted for a remote-control system. By 1917, research on remotely controlling vehicles had already begun. In fact, a giant step toward wireless control from a separate or remote location was already taken by Nikola Tesla, who in 1898 successfully demonstrated a radio-control system he called "telautomaton." [FN68] Nikola Tesla was a Serbian electrical engineer-inventor and immigrant to the United States who obtained fame and fortune for his work in electricity, particularly ***538** his theory of alternating current, and its use by George Westinghouse to "electrify" New York City. [FN69]

In 1898, during an Electrical Exposition in New York City, Tesla used telautomaton to remotely control a four-foot-long boat, instructing it to turn and operate lights. [FN70] Ten years prior to Tesla's successful demonstration, Louis Brennan, an Irish inventor, remotely guided a torpedo in the English Channel; however, it was still connected by a wire. [FN71] It was Tesla who took that necessary step for application in flight: no wires attached. Interestingly, however, this scientific breakthrough was ignored at the time by the United States military for inventions deemed more practical for the Spanish-American War. [FN72]

Early in Tesla's educational endeavors, he had dreams of inventing mechanical flight, and while Tesla did not personally develop pilotless flight, his concept of telautomaton made wireless or remote control of vehicles in flight an eventual possibility. [FN73] Indeed, in-flight control was required to turn flying bombs into maneuverable and recoverable UAVs.

Both Elmer Sperry and Hewitt were acquainted with Tesla's work in remotely controlled vehicles [FN74] and knew that it was the next step in creating fully pilotless aircraft. The Sperrys and Hewitt, therefore, worked to develop a unique airframe for the aerial torpedo that would integrate a remote-control system. This aircraft was called the Curtiss Sperry Aerial Torpedo, of which only six were built. [FN75] They were only able to successfully launch and fly one out of the six. [FN76]

Nevertheless, this one flight that occurred on March 6, 1918 is what an author called "unmanned aviation's counterpart to the Wright brothers' flight 14 years earlier," as it was arguably the first pilotless flight of a specifically designed pilotless aircraft. [FN77] ***539** That one Curtiss Sperry Aerial Torpedo flew on a preprogrammed flight of approximately the length of 10 American football fields, dove in the water as planned, and was reused in further testing. [FN78] Notwithstanding the accomplishment, the flight did not include any radio-control abilities, nor could a successful flight be duplicated after an additional five attempts before all six of the Aerial Torpedoes were destroyed. [FN79] Moreover, in 1918, soon after a pilotless Curtiss N-9 did not operate as programmed, but flew off into the horizon, the Navy ended its association with Elmer Sperry and Hewitt. [FN80]

During this same time, Lawrence Sperry also attempted to develop pilotless aircraft for the U.S. Army. In 1920, Lawrence Sperry developed manned and unmanned versions of a small biplane called the Messenger, which the Army desired for short missions from the headquarters to the front line. [FN81] Like the Curtiss Sperry Aerial Torpedo, the unmanned Messengers, called Messenger Aerial Torpedoes, or "MATs," were designed as flying bombs to drop from the air after a programmed course of flight. Lawrence Sperry attempted to test a remote-control system in the MATs, but due to political and bureaucratic scuffling, radio-control development of the MATs did not culminate in remote-controlled flight. In December of 1923, Lawrence Sperry died in a puzzling aircraft mishap at sea, [FN82] and the Sperry Aircraft Company closed up shop. [FN83]

***540** While U.S. Army efforts failed to progress into true pilotless, remote-controlled flight, by 1923 the U.S. Navy's new development team headed by Carl Norden began testing radio-control equipment in an unmanned Curtiss N-9, and their efforts produced the United States' first fully unmanned, remotely controlled flight on September 15, 1924. [FN84]

Notwithstanding Norden's achievement, simultaneous testing in Britain on September 3, 1924, just twelve days prior, produced the first recorded successful and fully unmanned aircraft flight using remote-control technology. [FN85] That flight for the Royal Navy lasted thirty-nine minutes and covered a range of almost 104 kilometers or 65 miles. [FN86]

But alas, UAV development was not unique to the United States. While many enabling technologies were initially developed on North American soil, early aviation researchers in the United Kingdom began developing test models of UAVs as early as 1916 or 1917, [FN87] spurred on by the advances of inexpensive aircraft engines for use in World War I. [FN88] Interestingly, these ***541** early UAVs were equipped with radio controls; none, however, made it successfully into flight. [FN89] World War I delayed British UAV testing, and it wasn't until 1922 that full-scale experiments were conducted to develop flying torpedoes. [FN90] However, the Royal Navy first saw the utility of a pilotless aircraft operating as a true UAV, and not a missile, when they began testing unmanned aircraft as flying targets for warships. [FN91]

Thus, it is noteworthy that this latter effort to build target drones pushed the development of UAVs beyond flying torpedoes or bombs into reusable, pilotless aircraft; albeit, they were only reusable if gun ships did not hit their target. [FN92] In fact, in 1933, through the use of a UAV target drone called the Fairey Queen, the Royal Navy discovered that it was harder than first theorized to shoot down potential enemy aircraft, as it took four months to finally shoot down the Fairey Queen target drone. [FN93] The success of the Fairey Queen led to the production of the DeHavilland Queen Bee radio-controlled UAV and its use by the Royal Navy to hone antiaircraft defenses before and during World War II. [FN94] It also led to similar efforts across the Atlantic in the United States. Nevertheless, at the time only Great Britain and the United States used UAVs to train their armed forces. [FN95]

While target drones may not have been attractive to other nations at the time of Word War II, both Allied and Axis countries began to look at aerial or flying bombs as potential weapons. The German, French, Italian, Russian, and Japanese militaries all had begun (either before or during World War II) projects to ***542** develop unmanned flying bombs. [FN96] The most infamous flying bomb of World War II was Germany's simple, yet deadly, V-1 cruise-missile type “flying bomb,” and its second-edition, liquid-fueled rocket, V-2. [FN97] Both of these unmanned weapon systems led to further advances in missile and rocket technology.

The Allies also attempted to use a pilotless flying bomb during World War II. In coordination with the U.S. Navy, U.S. Army General Henry H. “Hap” Arnold “developed a plan to use stripped-down B-17 [bombers], loaded with . . . high explosives and equipped with radio-controlled autopilots to destroy new, heavily defended German V-weapon launching sites.” [FN98] Labeled “Project Aphrodite,” this plan used a crew of two, a pilot and autopilot technician, that would take off, arm the explosives, turn control over to another aircraft or mother ship by engaging the radio-controlled autopilot, and then bail out over a safe zone or an Allied country. [FN99] The plan was extinguished soon after; of the “[f]our B-17s that were launched on 4 August 1944 one aircraft exploded over the United Kingdom, killing its crew, and the final three failed to reach their targets.” [FN100] Nevertheless, on the other side of the globe a true UAV for combat purposes was being developed for use in World War II.

In the early fall of 1944, the U.S. Navy employed in the Pacific Theater an aerial torpedo squadron to bomb Japanese targets. [FN101] While this was not a terribly new idea, the transformation of an aerial torpedo into a true UAV came when they used these aircraft to drop bombs. In October 1944, the first UCAV was employed when a Navy TDR-1 Assault Drone was loaded with a combination of bombs, which were then dropped on targets during the mission. [FN102] While the TDR-1 crashed before it returned home, its utility was proven and expanded as subsequent sorties included dropping their bomb payloads and then re-attacking during flight by diving into Japanese ships in “kamikaze” fashion. [FN103] Notwithstanding the success of these UCAVs, the operation was cancelled shortly thereafter. [FN104]

***543** After World War II, the Cold War's emphasis on stealthy reconnaissance and the political controversy produced by the U-2 shoot-down of United States pilot Francis Gary Powers over the Soviet Union provided the catalyst necessary to research, develop, and field HALE surveillance and reconnaissance aircraft. Surveillance [FN105] and reconnaissance [FN106] seem a natural fit for UAVs. In fact, the first aerial photographs were taken in 1888 from a kite invented by Frenchman Arthur Battut. [FN107]

Nevertheless, during the Cold War era of political chess between two super-powers, HALE UAV development was on a funding and fielding rollercoaster. [FN108] For example, in 1966 the USAF initiated a program to stealthily collect intelligence through a high-level surveillance UAV called the AQM-91A Firefly manufactured by Teledyne Ryan. [FN109] The USAF ordered twenty-eight, but in 1972, as relations between China began to improve, the USAF cancelled the program before any Firefly could be flown operationally. [FN110] Interestingly, prior to canceling the Firefly program, the USAF had already flown Lockheed's Mach 4 GRD-21 operationally over China. [FN111] The D-21 missions were highly classified, not only due to the nature of the operation but also the technology, since the D-21 could fly at speeds in excess of Mach 3, as well as at altitudes of up to 90,000 feet (27,432 meters). [FN112]

***544** The United States was not the only nation to find a surveillance niche for UAVs. As early as 1960, other countries were fielding UAVs dedicated to aerial reconnaissance. For example, the 1959-1960 edition of Jane's All the World's Aircraft listed the Aviolanda, Netherlands's first UAV designed for tactical photography. [FN113] Further, by 1970, Belgium, Canada, France, Germany, Italy, and the United States all had HALE or MALE UAVs dedicated to surveillance or reconnaissance. [FN114]

However, not until the Vietnam War were UAVs extensively used in surveillance and reconnaissance missions, as well as imagery reconnaissance, electronic and communication intelligence collection, psychological operations such as dropping leaflets, and even decoy operations. [FN115] Nevertheless, just as was ***545** the case after World War II, the United States mothballed many of the UAVs used in Vietnam, leaving one author to opine that such actions may have been based on a perceived threat to flying missions by pilots of pilot-on-board aircraft, or at the very least a fear that the sexy combat jobs would be filled by flying robots. [FN116]

This is an interesting hypothesis, since not until 2001 did the USAF, upon the request of its Chief of Staff, General John Jumper, convert a UAV into a weapon system. [FN117] On February 16, 2001, a Predator successfully launched a Hellfire-C laser-guided missile that struck a stationary tank. [FN118] Thereby, the Predator evolved from a solely reconnaissance MALE UAV into a UCAV. Yet, as noted, UCAVs were first used by the United States in 1944. [FN119] Therefore, the question remains, particularly for the United States, why UCAV, or even UAV technology in general, was not advanced at a faster pace. Take, as another example, the Aerosondes that flew fully autonomously from takeoff to landing for the first time during a one-hour test flight in 1997. [FN120] While the technology as well as the end goals were dramatically different, this hearkens back to 1920-24 and the work of Sperry and Norden.

While arguably there is fear by pilots, particularly of the armed forces, that UAVs pose a threat to desired operations, there are also other possibilities why UAV development moved at such a slow pace. One study commissioned by the DoD cites other reasons, such as funding battles, technology hurdles, and inter- and intra-service cultural concerns, that led to a slow-paced development and utilization of UAVs by the United States. [FN121] Nevertheless, UAVs perform a unique function that currently does not pose a threat to most pilot-on-board missions. However, as history unfolds and technology advances, removing humans from the cockpit may be heralded as one of the greatest advancements in aviation safety.

While the United States was limiting UAV development in the 1970s and 1980s, other countries were beginning to gain an appreciation for their utility. One such country was Israel. During the late 1970s and 1980s, the Israeli Defense Forces (IDF) ***546** moved their UAV program at full steam, logging thousands of hours of flight time. [FN122] In fact, IDF's use of UAVs during operations in Lebanon in 1982 is what slowly enticed the DoD to look more closely at future tactical-level intelligence gathering through MALE UAVs. [FN123]

Japan is another country that began to develop uses for the UAV. In Japan, however, UAV development not only included military uses, but also the unique role of crop spraying. Japanese research in UAV technology dates back to World War II. [FN124] Now, Japan is the largest market for civilian UAVs. [FN125] Japanese research into UAV technology resurfaced in the 1970s through Fuji Heavy Industries, which began developing a fairly full range of UAVs for both military and civilian use. [FN126] The biggest market for Japanese UAVs is in helicopter, or rotary-winged aircraft, used for agriculture and scientific observation. [FN127]

The first UAV helicopter, the Kaman "Drone" Helicopter, was developed by the United States and flew in 1953. [FN128] However, the Yamaha Motor Company of Japan seized the practical application of helicopter UAVs as a way to efficiently spray pesticides and fertilizer on Japanese farms. It began testing the concept in the mid-1980s and started full scale production and use by the early 1990s. [FN129] Currently, in Japan there are an estimated 2000 helicopter UAVs and over 8000 certified operators; most are nongovernment operated. [FN130] This makes up approximately 65% of the use of UAVs globally. [FN131]

C. Current and Future Uses of the UAV

While the history and development of the UAV has been hampered by the ups and downs of governmental funding and military on-again, off-again programs, recent advances in computer technology, computer software, light-weight materials, communication links, and global navigation has sparked an explosion ***547** of UAV funding, research, and utilization. [FN132] Interest in UAVs continues to grow throughout the globe. Today, there are over forty countries developing and using UAVs. [FN133] As far as sheer numbers go, the above-mentioned Japanese market for radio-controlled helicopters used for agricultural purposes overwhelmingly leads all numbers of UAVs currently in use. [FN134]

However, as far as the type of application or utility of UAVs, military use is by far the most common. Reportedly, ninety percent of all funding for UAV systems worldwide is for military programs. [FN135] Between 2001 and 2004, the DoD increased UAV research, development, and fielding from approximately $350 million a year to over $1 billion. [FN136] Moreover, the DoD has plans to increase spending to $3 billion a year by 2008-2009. [FN137] Thus, UAV development may become "the most dynamic sector of the aerospace industry." [FN138]

The most common military application for UAVs is surveillance by HALE or MALE UAVs. [FN139] Of these, the United States, led by the USAF, is the largest military consumer and developer in terms of the size, variety, and sophistication of UAV systems. [FN140] Israel, which has a strong market for its military-application-based UAVs, [FN141] is a distant second in UAV development, followed closely by France. [FN142] Other countries having significant UAV military development programs include the above-mentioned***548** Japan, China, South Korea, Pakistan, Russia, Australia, England, Canada, Italy, Germany, and Sweden. [FN143]

The future of UAVs will not only include continued use by the world's militaries as target drones, decoys, air-combat aircraft, [FN144] and observation platforms, but also nonmilitary use by governments and commercial entities. These uses will include the use of HALE, MALE, micro- and low-altitude UAVs as observational ***549** and sensor platforms for security and border monitoring, [FN145] traffic monitoring, [FN146] environmental and natural disaster monitoring, [FN147] and criminal surveillance. [FN148] HALE UAVs may also be used as telecommunication platforms and cargo carriers. In addition to their use as scientific experimental and monitoring platforms, low-altitude UAVs could also be used as miniature, almost undetectable, spy or surveillance aircraft [FN149] or as courier vehicles to deliver mail or packages across town, in a large indoor complex or building, or even to deliver food. [FN150] Further, there could be untapped uses of UAVs in agriculture and industry where robotic technology can assist in dull, dirty, and dangerous operations. [FN151]

HALE UAVs have the greatest potential to impact the NAS, particularly because their range will place them into or transiting through already crowded national airspace. Two potential roles of HALE UAVs bear further comment--namely, telecommunications platforms and cargo carriers. In the role of telecommunications platforms, HALE UAVs have a very bright future. UAV research coordinated through NASA's Dryden Flight Research Center is focusing on solar-powered aircraft that can operate for several months, if not years at a time. [FN152] This is expected to spawn a new generation of UAVs called "atmospheric satellites," which may be able to do work such as telecommunications***550** more efficiently and at much lower cost than current space-based satellites. [FN153]

One version of atmospheric satellite being tested and developed by the Defense Advanced Research Projects Agency ("DARPA"), which is the central research and development organization for the DoD, is called Airborne Communications

Nodes ("ACNs"). [FN154] An ACN has been described as an "airborne telephone exchange, using digital radio technology to communicate with almost any military communications system - ranging from encrypted fighter radios to militarized cellular phones - within line of sight of the platform that carries it, and to link those systems together." [FN155] ACN UAVs would allow a ground-based, forward-projected reconnaissance team with a backpack radio to talk directly to an airborne pilot over longer distances, as long as both parties were within line of sight of the ACN platform. [FN156]

Stratospheric platforms, like atmospheric satellites and ACNs, could maintain line-of-sight links with communications users over areas large enough to include the world's largest cities. The signal's travel distances would be 1000 times shorter than spaced-based satellite systems, thereby increasing system capacity and reducing power requirements on either end. [FN157] Such systems could also be extremely successful for mobile and fixed-site communications. [FN158]

Not only could these platforms provide telecommunication services, but the potential is also available to do a number of monitoring and sensor imagery currently done by expensive space-based satellites, such as monitoring weather and tracking hurricanes. Further, they could also provide more precise coverage of disaster sites such as fires, mud slides, flooding and earthquakes in order to better direct emergency resources than can be done by space-based satellite or pilot-on-board aircraft. [FN159]

UAVs could also be used as a cost-effective way to transport small amounts of cargo. While the cargo-carrying development ***551** of UAVs has not yet come to fruition, the next generation of Northrop Grumman's Global Hawk, the RQ-4B, has an increased payload capacity of almost 2998 pounds or 1360 kilograms. [FN160] This is comparable to the USAF's C-21, a military version of the Lear Jet 35A business jet, which has a cargo payload of 3153 pounds or 1433.18 kilograms. [FN161] Current versions of the Global Hawk have a length of 44 feet or 13.4 meters, which is slightly shorter than the C-21. [FN162] While the C-21's mission is not primarily cargo transportation, but personnel, [FN163] the Global Hawk is primarily a HALE UAV, which will use the increased payload capacity to carry more observational or communication equipment. Theoretically, the Global Hawk would be able to transport small amounts of cargo, as much as a C-21 without personnel, higher and further with twenty-four hours continuous operations. [FN164]

As bright as the future of UAV utilization may be, there are technological and legal hurdles in the flight-path toward full utilization. The end-goal for integration of UAVs is a "file and fly" system currently enjoyed by pilot-on-board flights. [FN165] Current law within the United States requires UAV operators to follow FAA Order 7610.4, Special Military Operations, which requires UAVs that operate outside of restricted areas to file for a Certificate of Authorization ("COA"), under rules used for "Moored Balloons, Kites, Unmanned Rockets, and Unmanned Free Balloons/Objects." [FN166] Application to the FAA for a COA must be filed sixty days prior to flying the UAV. [FN167]

The current scheme is not user-friendly for this fledgling industry, and, moreover, it is a burden on the deployment of ***552** UAVs from bases within the United States or their transit internationally. Therefore, the process of integrating UAVs into the NAS must entail a regulatory scheme that will institute necessary rules of the air, appropriate guidelines for certificates of airworthiness, and certification and licensing of UAV operators, pilots, and maintenance personnel so as to interface safely with ATM and other aircraft. The next chapter of this Thesis will look at the current legal system so as to gauge current regulatory shortfalls that must be addressed.

III. CURRENT INTERNATIONAL AND DOMESTIC LAWS GOVERNING UAV UTILIZATION AND INTEGRATION

A review of the current state of regulations that govern aviation, which would be applicable to UAV operations, is an important step in identifying the regulatory holes and possible solutions. Therefore, I will first look at the international rules governing aviation generally, then move on to the aviation regulations of the United States. Finally, I will discuss regulations and directives from the United States, Australia and the United Kingdom ("UK") that directly address UAV operations. Through this review it will become clear that integration of the UAV into the NAS is primarily a technology-driven issue, as many of these regulations can and should apply to UAVs that wish to operate in already crowded airspace. However, it will also be clear that there are still regulatory issues that must be addressed to achieve a regulatory framework wherein technology can grow the industry.

A. The Chicago Convention and Annexes Governing International Civil Aviation

Over sixty years ago, with the end of World War II in sight, delegates from the Allied and neutral nations met in Chicago to lay the foundations for the future of civil air navigation. [FN168] These delegates were forward-thinking aviation statesmen who knew that at the end of 1944 international industry, commerce, and the world's future lay on the wings of the airplane.

***553** Indeed, World War II had brought fantastic advances in the development of the airplane. [FN169] During the decade before the reemergence of war in Europe, the airplane moved from an item of novelty or sport to an effective transporter of humans and cargo. [FN170] WWII rode the wave of this development and ingenuity by developing bigger, faster, and safer human and cargo transporters. [FN171] The aviation world was poised to take a giant leap into international commercial transportation through the air.

Hence, in November 1944, the political will of most air-faring nations congregated in Chicago and created a unique document, the previously-referred-to Convention on International Civil Aviation, otherwise known as the Chicago Convention. [FN172] The Chicago Convention not only formally established in writing the international aviation principles of sovereignty and responsibility over a state's airspace, but it also created an international organization to manage the safety and security of the world's civil aviation. [FN173] That organization is the above-mentioned ICAO, which is currently headquartered in Montreal, Canada. [FN174] ICAO is part of the United Nations system and currently consists of 188 member states ("Contracting States"). [FN175]

A nation's sovereignty and responsibility over the safety and security of its airspace has been a central driver in the development of national and international aviation rules and practices, both civilian and military. [FN176] Codified in the Chicago Convention this principle is simply "that every State has complete and exclusive sovereignty over the airspace above its territory." [FN177]

***554** While the thoughts and intents of these framers were clearly on the advancement of pilot-on-board aviation, one lone article addresses, with remarkable foresight, the concept of pilotless or remotely operated aircraft. This lone article, Article 8, Pilotless Aircraft, incorporates the principles of sovereignty and responsibility and applies it to UAV operations. It reads:

> No aircraft capable of being flown without a pilot shall be flown without a pilot over the territory of a contracting State without special authorization by that State and in accordance with the terms of such authorization. Each contracting State undertakes to insure that the flight of such aircraft without a pilot in regions open to civil aircraft shall be so controlled as to obviate danger to civil aircraft. [FN178]

Clearly, this group of aviation prophets foresaw the integration of UAVs into the NAS. As discussed in the previous chapter, by the time the Chicago Convention was drafted in 1944, militaries had used rudimentary forms of UAVs, and, therefore, their military role in combat had arguably already been envisioned. In fact, one could argue that their vision included civilian uses or at least the transit of military UAVs through the NAS. With the requirement that nations must ensure that the flight of UAVs do not endanger other aircraft, drafters put the onus on each Contracting State to develop a system to ensure safe ingress, transit, and regress--in other words, the integration-- of UAVs into the NAS.

Notwithstanding the requirements of Article 8 of the Chicago Convention, Contracting States have been slow to develop rules and regulations that would allow the safe integration of UAVs into the NAS. However, this is not without merit or reason. Just as the science and technology of manned air navigation had to evolve before the Chicago Convention became a necessity to develop and promote a commercially viable system of international civil aerial aviation, UAV technology and use has had to develop to the point that such rules were necessary to progress unmanned civil aerial aviation. So now we sit at the cusp of that point in time where science and technology are beginning to evolve and now require the guidance and enabling power of the law.

While there is a dearth of law specifically drafted for UAV integration, it is helpful to review existing rules and regulations that would apply to UAV flight simply because they are aircraft ***555** traveling through the NAS. A good place to start is the Chicago Convention and its accompanying annexes. As just highlighted, the Chicago Convention will play a role in the integration of UAVs into the NAS. As the bedrock document for aviation generally, it forms the basic back-drop to future regulatory schemes.

1. Chicago Convention Articles Applicable to UAV Integration

While Article 8 of the Chicago Convention covers UAVs specifically, the Chicago Convention is primarily a document of “civil aviation.” The Chicago Convention is not applicable to “aircraft used in military, customs and police services,” otherwise defined as “state aircraft,” because nations were seemingly unwilling to give up control of their military and police aircraft to an international body. [FN179] Therefore, one could argue that, as such, the Chicago Convention sheds very little light on the vast majority of UAV use, which is military in nature. However, while Article 3 specifically states that the Chicago Convention is not applicable to state aircraft, military operations of a UAV may have to integrate into the civilian airspace of the NAS, which is heavily governed by ICAO directives. Moreover, the previous chapter showed that Article 8 was drafted at a time when the only use of UAVs had been for military missions. With that it mind, it may have only been the operation of state UAVs that Chicago Convention drafters intended to regulate under Article 8.

Further, notwithstanding this inapplicability over state aircraft, the Chicago Convention does provide that state aircraft cannot transverse the airspace or land on another nation without that nation's approval. [FN180] This, coupled with Article 8, requires the military flight of any UAV over foreign soil to obtain permission, as well as to adhere to such foreign state's regulations so as to ensure safe passage of the UAV in the NAS. Additionally, Contracting States agreed that regulations drafted to govern the affairs of state aircraft will be so drafted to have “due regard for the safety of navigation of civil aircraft.” [FN181] This requires Contracting States to draft military UAV procedures and protocols with due regard to safety of civilian aircraft--once again, with an eye toward the integration of the UAV into the NAS. Therefore, the Chicago Convention, its articles and annexes,***556** have application or bearing upon all forms of UAV utilization, including military, seeking to integrate with civilian aircraft and operations as they transit the NAS.

In addition to Articles 3 and 8 of the Chicago Convention, other articles directly affect the integration of UAVs into the NAS. Article 12, Rules of the Air, is just such an article. It states:

> Each contracting State undertakes to adopt measures to insure that every aircraft flying over or maneuvering within its territory and that every aircraft carrying its nationality mark, wherever such aircraft may be, shall comply with the rules and regulations relating to the flight and maneuver of aircraft there in force. Each contracting State undertakes to keep its own regulations in this respect uniform, to the greatest possible extent, with those established from time to time under this Convention. Over high seas, the rules in force shall be those established under this Convention. Each contracting State undertakes to insure the prosecution of all persons violating the regulations applicable. [FN182]

Article 12 is really an additional reminder that UAV operations must comply with the “rules of the air” of the nation within which it is flying, and from which it bears its mark of nationality. Moreover, upon the high seas, the rules established “from time to time under this Convention” shall be the rules in force. These rules include those established under the Chicago Convention itself and those subsequently promulgated by ICAO. Under Article 37 of the Chicago Convention, ICAO is chartered with the obligation and responsibility to “adopt and amend from time to time, as may be necessary, international standards and recommended practices,” otherwise known as “SARPs.” [FN183] These SARPs are found in the annexes to the Chicago Convention, of which there are currently eighteen. [FN184] Pertinent portions of these annexes will be addressed later.

Additionally, Article 17, Nationality of Aircraft, and Article 20, Display of Marks, apply to UAVs, since they are indeed aircraft. Article 17 states that "[a]ircraft have the nationality of the State ***557** in which they are registered." [FN185] Article 20 states, "Every aircraft engaged in international air navigation shall bear its appropriate nationality and registration marks." [FN186] Thus, UAVs must be registered in a state, [FN187] and UAVs that are involved in "international air navigation" must bear certain marks that indicate the nationality and such registration.

Further, every aircraft so engaged in "international air navigation" must carry certain documents as described in Article 29. For UAV purposes, these documents would include the aircraft's certificate of registration, certificate of airworthiness, and possibly even copies of the licenses or some identifying information regarding the licenses of the UAV's operator(s). [FN188] With regards to the certificate of airworthiness, the Chicago Convention states that "[e]very aircraft engaged in international air navigation shall be provided with a certificate of airworthiness issued or rendered valid by the State in which it is registered." [FN189]

Pilots of UAVs, though remotely located, are nonetheless pilots of an aircraft, and therefore, covered under Article 32, Licenses of Personnel, which states that pilots of "every aircraft" and "other members of the operating crew" of such aircraft "engaged in international navigation" need to have "certificates of competency and licenses issued or rendered valid by the State in which the aircraft is registered." [FN190] Thus, UAV pilots, operational engineers, and technicians will need to be licensed by the State of Registry or have such license recognized as valid under Article 33, Recognition of Certificates and Licenses.

Finally, there is an operational limitation put forth in the Chicago Convention that is important to UAV reconnaissance and surveillance activities. Article 36, Photographic Apparatus, states that "[e]ach contracting State may prohibit or regulate the use of photographic apparatus in aircraft over its territory." The underlying principle upon which Article 36 is written is state sovereignty over airspace. [FN191]

***558** 2. Certain Applicable Provisions of the Annexes to the Chicago Convention

As briefly discussed above, ICAO has the obligation to promulgate international standards and recommended practices, which it has done through the adoption of annexes to the Chicago Convention. While the purpose of the Chicago Convention and the SARPs are to promote safe international aviation, [FN192] these provisions and standards permeate deep into local and national rules and regulations. [FN193] For example, Contracting States have full freedom to draft rules and regulations of air navigation within their jurisdiction, regarding standards for issuing certificates and licenses to personnel, registering aircraft, and issuing certificates of airworthiness to aircraft. But if such rules, standards, processes, and regulations do not at least meet required minimums as set by the Chicago Convention and ICAO adopted SARPs, other Contracting States do not have to recognize such certificates and licenses, and can thereby limit transit of such aircraft and personnel into their airspace. [FN194] However, the enabling power of this nonrecognition principle is in its converse recognition mandate that if Contracting States adhere to at least the minimum standards put forth by the Chicago Convention ***559** and ICAO SARPs, other Contracting States must render such certificates and licenses valid. [FN195] Thus, even for domestic, national operation of UAVs, the SARPs will have direct application regarding certification and licensing of personnel and issuing certificates of airworthiness to UAVs.

The annexes cover a wide variety of topics related to the safe and efficient movement of international civil aviation. [FN196] For the purposes of this work, I will focus on four general areas that will be necessary for full UAV integration: (1) rules of the air, to include safety issues surrounding the interface with other aircraft and ATM; (2) security; (3) certificates of airworthiness; and (4) personnel licensing.

a. Rules of the Air and Safe Interface with Other Aircraft and ATM

Rules of the air and air-traffic services are addressed in Annexes 2 and 11 of the Chicago Convention. At this time, additional discussion regarding the applicability of the SARPs generally, and specifically regarding Annex 2, is appropriate. As noted, Contracting States have the right to draft rules different than the SARPs; they must, however, file any such differences with ICAO. [FN197] These differences are then noted in supplements to the annex concerned. Further, the SARPs are written in a way that clearly states what is a required standard, and what is a recommended practice. [FN198] Note, however, that Annex 2 does not have any recommended practices, but only required standards. Additionally, as Annex 2 addresses rules of the air, it is derived from Article 12 of the Chicago Convention, which reiterates a state's sovereignty to instill its governing rules for movement***560** through its airspace. [FN199] Nevertheless, Article 12 also states that Contracting States have obligated themselves "to keep [their] own regulations in these respects uniform, to the greatest possible extent, with those established from time to time under this Convention." [FN200] Thus, Contracting States are under obligation to adhere to the greatest possible extent to Annex 2.

Annex 2 addresses the concept of "pilot in command," which is defined as "the pilot designated by the operator, or in the case of general aviation, the owner, as being in command and charged with the safe conduct of a flight." [FN201] The pilot in command is responsible for ensuring that the aircraft's flight adheres to the applicable rules of the air, unless the interests of safety absolutely necessitate deviation. [FN202] With a UAV, the pilot in command is remotely located, and therefore must rely solely on the aircraft's data inputs to determine flight and surroundings necessary to ensure that the rules of the air are followed. While on-board pilots also read instruments during flight, visual observation by the UAV pilot is solely transmitted by video link, placing the pilot in command of a UAV in a unique, and arguably a more difficult, position.

Another rule of the air that would be applicable to UAVs includes not operating the UAV in a negligent or reckless manner. [FN203] UAV pilots would have to follow the prescribed domestic rules regarding flying over "congested areas of cities, towns or settlements or over an open-air assembly of persons." [FN204] UAVs operations would need to adhere to local rules regarding spraying or dropping objects or substances, [FN205] towing other aircraft or ***561** objects, flights within restricted or prohibited areas, and performing acrobatic maneuvers. [FN206]

One of the largest technological obstacles for UAV integration is the ability to see and avoid collisions with other aircraft. [FN207] Annex 2 provides that an "aircraft shall not be operated in such proximity to other aircraft as to create a collision hazard." [FN208] An introductory note to section 3.2 of Annex 2 states, "It is important that vigilance for the purpose of detecting potential collisions be not relaxed on board an aircraft in flight, regardless of the type of flight or the class of airspace in which the aircraft is operating, and while operating on the movement area of an [airport]." [FN209] The technological hurdle for UAVs is simply that the aircraft's computers or the remotely located pilot must "see," or maybe better put, "detect," other aircraft by relying solely on electronic sensors. Generally, in aviation, direct visual reference is the last resort used in avoiding potential collisions with other aircraft, obstacles, and the surface. [FN210] New technologies must be developed to provide accurate and timely input to the aircraft and pilot to ensure the UAV can correctly maneuver and avoid other aircraft traveling through the NAS.

UAVs integrated with other aircraft will have to follow a number of rules surrounding the principle of avoiding a collision, both in the air and on the ground, in shared runways or airports. [FN211] These rules are based in terms of "rights of way" and required evasive maneuvering, which, once again, will require a remotely located pilot in command to electronically obtain data necessary to honor rights of way and take required evasive maneuvering. [FN212] There are rights of way rules for aircraft operations***562** in the vicinity of an airport that include taking off, [FN213] landing, [FN214] emergency landing, [FN215] movement on the ground and taxiing, [FN216] and for operations on the water. [FN217] A UAV will be required to avoid passing over, under or in front of other aircraft, unless it passes well clear and takes into account the effect of aircraft-wake turbulence. [FN218]

UAVs will need to display, from sunset to sunrise, "anti-collision lights intended to attract attention to the aircraft" and "navigation lights intended to indicate the relative path of the aircraft to an observer." [FN219] Further, other lights cannot be displayed if they are likely to be mistaken for such navigational lights. [FN220] This may be difficult for certain UAVs, such as mini-or micro-UAVs, as extra battery packs might increase the weight and cost of the aircraft.

Pilots in command are also required to respond to signals given by the air traffic control ("ATC"), airport personnel, or other aircraft. [FN221] These signals include those necessary for traffic control on the ground and in the air for taxiing, takeoff, and landing at airports. [FN222] Further, there are signals given by other aircraft, such as intercepting military aircraft.

[FN223] The observation and reaction to these signals will be a difficult, yet not insurmountable, task for the UAV pilot in command. [FN224] Moreover, not only are there signals from the ATC, but the pilot in command of the UAV must communicate with the ATC to request clearances and respond to queries from the ATC, intercepting aircraft, or other government officials or agents. [FN225]

There is also a requirement that the pilot in command be able to provide notice to the ATC of any unlawful interference. [FN226] For a UAV, unlawful interference would occur at the ***563** point of control by the pilot, either at his or her location or remotely by a pirated signal. Nevertheless, it would be just as imperative in a UAV flight as any other flight that notice of any “hijacking” or command and control failure be sent to the ATC or other local authorities.

Finally, regarding the visual flight rules (“VFRs”) and instrument flight rules (“IFRs”) listed in Annex 2, only those flights under direct visual control of the operator will operate under VFRs, and therefore, most UAVs will operate under IFRs. However, the real visual challenge will be in adhering to the above-enumerated rules of the air surrounding collision avoidance and signals via an electronic interface medium. [FN227]

b. Security Against Acts of Unlawful Interference

Annex 17, entitled Security-Safeguarding International Civil Aviation Against Acts of Unlawful Interference, deals with aviation security rules. These rules are not designed for the unique security issues presented by UAV operations; however, the underlying objectives can clearly be applied to UAV flights. The objectives of Annex 17 are the following:

> 2.1.1 Each Contracting State shall have as its primary objective the safety of passengers, crew, ground personnel and the general public in all matters related to safeguarding against acts of unlawful interference with civil aviation.

2.1.2 Each Contracting State shall establish an organization and develop and implement regulations, practices and procedures to safeguard civil aviation against acts of unlawful interference taking into account the safety, regularity and efficiency of flights.

2.1.3 Each Contracting State shall ensure that principles governing measures designed to safeguard against acts of unlawful interference with international civil aviation are applied to domestic operations to the extent practicable. [FN228]

The import to UAV flights is that while such “governing measures” may not exist, Contracting States must develop regulations and corresponding criteria to provide the needed level of security to safeguard UAV flights against unlawful interference. Further, as noted above, the Chicago Convention and annexes ***564** are designed to deal with international civil aviation. But, in a shrinking globe, particularly for UAVs that can operate for twenty-four hours or longer at a time, national or domestic rules should be uniform. [FN229]

Unlawful interference is not defined in the annexes, but assuredly pertains to any unlawful actions that improperly modify, change, or alter the planned flight or operations of the aircraft--thereby endangering persons or property. For UAV purposes that means the remotely located crew, as well as third parties and property on the ground.

UAV operations with remotely located pilots controlling and monitoring flight by relying solely on electronic data that flows through a communication link and relays input to and from the pilots, coupled with other inputs coming to the UAV itself during flight (such as GPS signals), produce a security environment much different than the passenger and crew-centric issues of pilot-on-board flight. Security for UAVs focuses almost exclusively on the safety of third parties--though it intrinsically addresses the safety of remotely located pilots. While many of the rules of the air discussed in the previous section can be directly applied to UAV operations with slight modifications, or with new technology developed and applied to UAVs, security rules are not so directly applicable. Therefore, safeguarding against unlawful interference of UAVs will require an initial and very active participation by national aviation authorities, such as the FAA and the Department of Homeland Security's (“DHS”) Transportation Security Administration (“TSA”). [FN230]

Annex 17 requires Contracting States to ensure that aircraft operators establish and implement written security programs to ***565** meet national requirements. [FN231] Therefore, UAV operators may have to establish such programs. Additionally, Contracting States must ensure that personnel who implement the security plan are properly selected, trained, and certified, [FN232] which may require additional training in UAV-specific issues.

In addition, Annex 17 requires Contracting States to take action to prevent weapons, explosives, or other dangerous devices that might be used to commit an act of unlawful interference from being brought onto the aircraft. [FN233] For UAV operations, this would entail screening of cargo, if applicable, and of the body of the UAV, but not of passengers. This is related to the requirement to establish security-restricted areas to ensure the integrity of the UAV and its flight. [FN234] These security areas would have to include not only where the UAV is hangered or operated, but also the location of corresponding operation centers.

Moreover, there is a requirement that operators "take adequate measures to ensure that during flight unauthorized persons are prevented from entering the flight crew compartment." [FN235] While for UAVs the "flight crew compartments" are not located on the aircraft, there will be operations centers in one or multiple locations that must be secured from unauthorized intrusions. [FN236] Additionally, with a UAV there is a risk of cyber- or radio-communication intrusion into the control of the aircraft. While yet to be drafted, the reach of security would have to entail requirements to ensure data-link security. This may very well have to be undertaken by the nations of the International Telecommunications Union. [FN237]

c. Certificates of Airworthiness

Particulars regarding certificates of airworthiness for aircraft as required under Article 31 of the Chicago Convention are addressed in Annex 8, Airworthiness of Aircraft. As noted above, under Article 38 of the Chicago Convention, Contracting States ***566** may opt out of the ICAO minimum standards for certificates of airworthiness, as well as certificates and licenses for personnel. But, by so doing, certificates and licenses issued by that state need not be recognized by other Contracting States. [FN238] Therefore, the required provisions of Annex 8 are the necessary minimum standards for international aviation. Further, as with Annex 2, there are no recommended practices, only standards. [FN239] This is one area, however, where Contracting States generally allow military aircraft to be certified as airworthy by the corresponding military authorities, the United States included. [FN240]

In order for a certificate of airworthiness to be issued, the Contracting State must approve the aircraft on "the basis of satisfactory evidence that the aircraft complies with . . . the appropriate airworthiness requirements." [FN241] The state in which the aircraft is registered, or "State of Registry," will issue a certificate of airworthiness if it is satisfied that an aircraft is "fit to fly" on the "basis of satisfactory evidence" regarding its design, construction, workmanship, materials, and equipment, and that the aircraft's flying qualities are considered necessary for airworthiness. [FN242] With regard to the design of the aircraft, there is a process of approval that requires the issuance of a type certificate. [FN243]

The type certification process is primarily for serial production of aircraft, which would be the case for many UAV manufacturers producing commercially viable platforms. [FN244] The approval of the design requires review of "drawings, specifications, reports and documentary evidence as are necessary to define the design of the aircraft and to show compliance with the design aspects of the appropriate airworthiness requirements." [FN245] Additionally, the state where the UAV is manufactured, or "State of Manufacture," must develop processes to "ensure that each aircraft, including parts manufactured by sub-***567** contractors, conforms to the approved design." [FN246] The production process must include a quality-assurance system, [FN247] and a records system to ensure that the "identification of the aircraft and of the parts with their approved design and production can be established." [FN248]

Further, a UAV's State of Registry will be required to determine procedures and standards to "ensure the continued airworthiness of the aircraft during its service life." [FN249] These requirements must address not only the maintenance necessary to achieve continued airworthiness, but also the airworthiness of the aircraft after modification, repair or replacement of a part. [FN250] Continuing airworthiness of the aircraft can be determined by the State of Registry through such actions as periodical inspections at certain, specified intervals based on date of manufacture and the type of service of the aircraft. [FN251] Because the State of Registry is not always the state where the aircraft was designed or manufactured, the State of Registry must notify the State of Manufacture, if different, [FN252] and the State of Manufacture must provide the State of Registry with information necessary to formulate requirements for continued airworthiness and safe operations of the aircraft. [FN253] Interestingly, and quite appropriately, this information must be provided by the State of Manufacture upon request from any Contracting State. [FN254] Accordingly, the UAV will need to be certified as airworthy, and manufacturers will need to obtain type certificates prior to commercial production and sale. Contracting States will also need to review maintenance and performance standards to ensure continued airworthiness of UAVs.

Unlike pilot-on-board aircraft, the UAV itself is only one part of the "system" that operates the aircraft. The pilot in command is remotely located, and communications between the aircraft and pilot are routed through communication links. All of these separately located infrastructural parts affect and control the operations***568** of the UAV just as is done with on-board control elements for pilot-on-board aircraft. Regarding this issue, officials from the United Kingdom have stated:

> Where any function of a UAV System is essential to, or can prejudice, continued safe flight and landing of the UAV, that function, and the equipment performing that function, (including equipment remote from the UAV), shall be considered as part of the aircraft for the purposes of the validity of the certificate of airworthiness of the UAV and, as such will have to comply with the applicable airworthiness requirements. [FN255]

While there is some debate on the issue, [FN256] safety seems to dictate that the UAV, for certification processes, should be viewed as a system, which includes the infrastructure that facilitates pilot control, communication, take-off, and recovery. As such, the airworthiness and type certificate would need to include "evidence" from not just the aircraft, but also the separately located command and control elements of the UAV.

d. Certifying and Licensing Personnel

As with certificates of airworthiness, the rules found in Annex 1, Personnel Licensing, form the minimum standard for international aviation. Annex 1 requires that the pilot in command or copilot of an airplane or helicopter be licensed. [FN257] As noted above, ICAO defines an airplane as a "power-driven heavier-than-air aircraft, deriving its lift in flight chiefly from aerodynamic reactions on surfaces which remain fixed under given conditions of flight." [FN258] A helicopter is defined as a "heavier-than-air aircraft supported in flight chiefly by the reactions of ***569** the air on one or more power-driven rotors on substantially vertical axes." [FN259] A UAV, as defined above, fits both of these definitions. Thus, unless ICAO and the FAA develop different standards for UAV pilots, they will have to be licensed as pilots of pilot-on-board aircraft. Note that as with certificates of airworthiness, Contracting States have allowed militaries to license their own pilots. [FN260]

Annex 1 distinguishes requirements for a pilot's license by the type of aircraft (e.g., single engine, multiple-engine, land or sea) and the purpose of flight (e.g., private, commercial, transport). [FN261] License requirements include acquired skill, knowledge, experience, age, and instruction. [FN262] The requirements are more stringent for transport, or airline, pilots than for commercial or private pilots. Further, pilots are required to have a medical fitness examination, which takes into account the demanding environment of operating an aircraft in flight. [FN263] However, UAV pilots generally do not operate in an airborne environment. Nevertheless, unless changed, such medical examinations might be required of UAV pilots.

Additionally, flight crew members will also have to be licensed. [FN264] A flight crew member is defined as a "licensed crew member charged with duties essential to the operation of an aircraft during a flight duty period," [FN265] which specifically includes the flight navigator and flight engineer. [FN266] As with pilots of UAVs, the "flight crew" will be remotely located, and may be remotely located in relation to the pilot as well as the aircraft. Moreover, certain other personnel besides pilots and flight crew members must also be licensed. These personnel include maintenance personnel such as technicians, engineers, and mechanics. [FN267]

***570** B. Applicable United States Aviation Rules: FARs and FAA Order 7610.4

1. Federal Aviation Regulations

For all aviation activities in the United States, activities by personnel licensed or certified by the United States, and for aircraft registered in the United States, the governing regulations are promulgated by the FAA in the Federal Aviation Regulations ("FARs"), which make up parts 1 through 199 of Title 14 of the Code of Federal Regulations ("CFR"), [FN268] and by the TSA in Title 49, parts 1500 through 1699, of the CFR. [FN269] As would be expected, the FAA-promulgated FARs are built upon the basic requirements found in the Chicago Convention and ICAO SARPs. They provide the national implementing requirements for registration, [FN270] airworthiness certification, [FN271] licensing of personnel, [FN272] and rules of the air. [FN273]

While the FAA has issued the above-referenced FAA Order 7610.4, which outlines a process through which a UAV operator may obtain permission to fly, the FARs do not specifically list, classify, define, refer to, or address UAVs in anyway. FAA Order 7610.4 will be further explored later; however, it refers in a general fashion to requirements found in the FARs. As with the Chicago Convention and the ICAO-promulgated SARPs, most of the FARs can be applied to UAV operations since they fit the definition of "aircraft."

The FAA defines "aircraft" very broadly as "a device that is used or intended to be used for flight in the air." [FN274] "Airplane" is defined as "an engine-driven, fixed-wing aircraft heavier than air that is supported in flight by the dynamic reaction of the air against its wings." [FN275] UAVs clearly fit these definitions. Therefore, FAR provisions dealing with rules of the air, security, licensing of personnel and airworthiness have direct application on UAV integration. Since the basis of the FARs come from the SARPs, it is not worthwhile to painstakingly dissect each provision;***571** however, a basic overview of certain provisions pertaining to UAV operations is worthwhile.

a. FAR Rules of the Air

The rules of the air are mainly found in Part 91 of Title 14 of the CFR, and are applicable to all aircraft operating within United States airspace, with many rules reaching out to include operations conducted from between three to twelve nautical miles (5.56 to 22.22 kilometers) from its coast. [FN276] Some rules, such as those rules covering maintenance and ownership, are applicable to all aircraft registered in the United States regardless of where they are operating. [FN277] As in the SARPs, the rules of the air found in Part 91 are designed to ensure safe transit through the airspace of the United States, and are premised in terms of rights of way, such as, "No person may operate an aircraft so close to another aircraft as to create a collision hazard." [FN278]

As addressed above, the Achilles' heel of UAV operations is the technology-driven obstacle to "see and avoid" or "sense and avoid." This requirement to see and avoid is stated in the FAR in these terms:

> When weather conditions permit, regardless of whether an operation is conducted under instrument flight rules or visual flight rules, vigilance shall be maintained by each person operating an aircraft so as to see and avoid other aircraft. When a rule of this section gives another aircraft the right-of-way, the pilot shall give way to that aircraft and may not pass over, under, or ahead of it unless well clear. [FN279]

UAV technology has yet to derive or establish standards or methods to achieve this very broad requirement to see or sense other aircraft in order to insure a safe operating distance. As outlined above, this is mainly due to the fact that UAV pilots and aircraft computers must rely upon electronic input from sensors to base evasive maneuvers. Interestingly, many of the solutions currently being tested rely on autonomous reaction by the UAV. [FN280] However, the issue goes further as it is also difficult for ***572** pilots of other aircraft to detect and identify UAVs, which are usually much smaller and move slower than manned aircraft.

Like most countries, the United States organizes airspace by a system of classes, based upon the altitude and the type of aircraft that must pass through that part of the airspace. [FN281] In general, airspace Classes B, C, and D relate to airspace surrounding airports where there is an increased potential for mid-air collisions. Airspace Classes A, E, and G are related to altitude and the flight operations performed at such corresponding altitudes; Class A--which is between 18,000 feet (5,486.4 meters) above sea level (usually listed as Mean Sea Level (MSL)) to 60,000 feet (18,288 meters) above MSL--is the most heavily traveled as it is used by cruising or transiting commercial traffic. [FN282] The ATC provides separation services to all flights in airspace Classes A, B, and C, and to some flights in Classes D and E. [FN283] The ATC does ***573** not provide separation services in airspace Class G. [FN284] Nevertheless, as noted above, regardless of the class of airspace, or whether ATC provides separation services, pilots are required to "see and avoid" other aircraft, weather permitting.

UAVs operating in Class A, B, C, and D airspace will need to be equipped with a two-way radio for communicating with the ATC, and the pilot will need to maintain two-way communications with the ATC at all times while in Classes A, B, and C. [FN285] In Class D, two-way communication is required during take-off and afterwards if controlled by a tower; otherwise, as soon as practicable after take-off. [FN286] Moreover, a UAV operating in Classes A, B, and C will have to be equipped with authorized transponder equipment to allow the ATC to locate and identify the aircraft. [FN287] All of this communication equipment, transponders, and even see-and-avoid equipment adds weight and cost to the UAV, which improves its safety, but adversely impacts its utility. Nevertheless, if UAVs are to increase functionality through effective ingress, transit, and regress of Class A, B, or C airspace, such equipment will be necessary and will therefore actually add to its utility.

Due to the wide variety of UAV utilities, operations will undoubtedly scale the alphabet of airspace classes. Nevertheless, the traffic in Classes A, B, and C forms basic problem for "see and avoid" technology, as most aviation traffic occurs in these classes of airspace; however, some UAVs will never need to enter or transit through these areas. Due to the characteristics of the UAV and its utility for accomplishing missions involving the 3-Ds (dull, dirty, and dangerous), many local flights will occur in Class G, known as uncontrolled airspace, and Class E. Class G airspace is usually below 1200 feet or 365.76 meters, and Class E airspace is that which is away from tower-controlled airports, above Class G, and below and above Class A. In these areas, the airspace is generally not crowded. UAVs operating in Class G and certain parts of Classes D and E airspace will have very little integration, if any, with other aircraft in that airspace, and therefore should not be required to have the same level of equipment as those that operate in the other classes of airspace. [FN288] This issue will be touched on again in the next chapter.

***574** Part 91 of Title 14 also deals with the responsibility of pilots and other crewmembers. Under the FARs, the UAV pilot in command will be responsible to determine if the aircraft is "in a condition for safe flight," which includes mechanical, electrical, and structural airworthiness. [FN289] Further, UAV pilots and crewmembers will not be able to operate or perform duties while under the influence of drugs or alcohol. These rules limit alcohol consumption to no less than eight hours before flight. [FN290] Moreover, such rules do not limit drug use to only illegal drugs but to "any drug that affects the person's faculties in any way contrary to safety." [FN291] Additionally, UAV pilots and all crewmembers will be subject to blood alcohol tests at the request of law enforcement officials. [FN292]

In addition to the regulations found in Title 14 of the CFR, the FAA also publishes orders, advisory circulars, [FN293] notices to pilots (airmen), which are more commonly known as "NOTAMs," [FN294] and temporary flight restrictions (TFRs). [FN295] Through the use of advisory circulars and NOTAMs, the FAA is able to fill the gaps within the regulations with advisory guidance that does not have to go through the long process required for promulgating regulations. Further, through the NOTAMS and TFRs, the FAA can provide more up-to-date information such as changes to restricted airspace rules and local or national weather advisories. UAV operators will obviously need to be aware of and follow applicable publications.

Of particular note for micro- or mini-UAVs is advisory circular AC 91-57, Model Aircraft Operating Standards. [FN296] While UAVs are not specifically addressed in AC 91-57, upon FAA approval, ***575** small and hand- or bungee-launched UAVs that operate below 400 feet (121.92 meters) would be able to avail themselves of the eased rules in place for remote-control model aircraft. [FN297] For example, local, state, and Federal agencies like the DHS, the California Highway Patrol, or the Environmental Protection Agency ("EPA") could use the smaller mini-UAVs like the Pointer [FN298] for border or port patrols, traffic management, or even environmental sensing or studies. [FN299] By using the same rules provided for model aircraft in AC 91-57, such agencies could use this new technology with little additional cost for certificates of airworthiness, see-and-avoid equipment, and two-way communication radios.

b. Security Regulations

Within the United States, rules regarding civil aviation security are promulgated by the TSA. The TSA was created after the attacks of September 11, 2001, to regulate security measures in all forms of commercial transportation on land, air, and sea and is now part of the DHS. [FN300] While conceivably a UAV could be used as a flying bomb, which is what they were originally developed for in the early half of the last century, the TSA is primarily focused on passenger and cargo commercial aviation by airlines ***576** or by charter, and the airports serviced thereby. [FN301] Of course, to the extent UAVs are able to function as cargo carriers and eventually passenger carriers, all such rules then in existence would be applicable. However, because UAVs can now be operated or pirated as flying bombs or missiles, it would seem that the TSA would enforce its jurisdiction over such aircraft, at least with respect to larger versions like the Global Hawk or Predator.

Under CFR Title 49, UAV operators may be required to establish a security program and allow TSA inspectors to review their plans and corresponding execution. [FN302] Part of that program will require UAV operators to control access to the aircraft under an exclusive area agreement, and perform security inspections prior to operations. [FN303] Further, UAV operators may have to establish contingency plans in case of a threat of or actually pirated aircraft. [FN304]

Piracy of a UAV is a unique problem. As highlighted above, UAVs are controlled or at least monitored from one or more locations. Therefore, not only is there the concern over piracy of control signals, but also unauthorized control over the operations centers. Therefore, it would only make sense that for some remotely operated UAVs, the established security plan would require security of the control centers. Security of these control centers may be required to mirror requirements found in the FARs for pilot-on-board cockpits, which limit entry to only certain authorized personnel. [FN305]

In the event of a credible threat of tampering or piracy, UAV operators will need to perform inspections of the aircraft and operation centers. [FN306] Such threats will need to be communicated to local authorities, airports, if any, and ATCs regardless of whether such threats are received while the aircraft is on the ground or airborne. [FN307] Information regarding threats may also come from the TSA through information circulars and security directives. [FN308]

Additionally, the FARs require that any aircraft entering United States airspace, transiting internally for distances greater ***577** than ten nautical miles from its point of take-off, or entering sensitive airspace, such as around Washington, D.C., be able to be located and identified by way of a transponder and communicate through two-way equipment with ATC and other governmental authorities. [FN309] Therefore, UAVs falling within these parameters will also need identification and communication equipment. However, as discussed above, this equipment is similar to those required for any aircraft operating in Classes A, B, and C airspace.

The FARs include procedures to handle aircraft if there is ever a loss of two-way communication with the ATC or other authorities. [FN310] Under these rules, if the aircraft is flying VFR, the pilot should land as soon as practicable. However, if flying IFR, which is where many UAVs would fit, the pilot should fly the route assigned during the last communication with the ATC, the route which the pilot expected to receive from the ATC, or the filed flight plan at an altitude that is the highest of the ATC's last clearance, minimum altitude for IFR operations, or the level the pilot would expect the ATC to advise. [FN311] While UAV pilots that are required to maintain two-way communications would have to follow these rules, the situation is also similar to the problem of lost-link communications between UAVs and control centers. [FN312] By programming the UAV to autonomously follow the rules prescribed for lost two-way communications with the ATC, the predictability of UAV operations would be similar to pilot-on-board aircraft in the event of a lost signal between pilot and aircraft. [FN313] This issue will be addressed further in the next chapter.

c. Licensing of Pilots and Other Aircrew Under the FARs

As directed in the ICAO SARPs, pilots must be certified to fly the type of aircraft for the operations intended to fly. [FN314] These ***578** certificates are broken up into rules for student pilots, [FN315] recreational pilots, [FN316] private pilots (which includes balloon pilots), [FN317] commercial pilots, [FN318] airline transport pilots, [FN319] and sport pilots. [FN320] Each type of pilot is required to possess differing levels of information, skill, and experience. Further, pilots must have a medical certificate. [FN321] Medical certificates are organized into three different classes as well, depending on the safety risk associated with each type of license; larger aircraft pilots require more stringent medical certification. [FN322] The requirements are substantially lessened for pilots of gliders, balloons, or light-sport aircraft. [FN323]

Aircrew members other than pilots are also required to be certified under FAR provisions. There are separate certificates required of flight engineers [FN324] and flight navigators. [FN325] Non-aircrew members involved in aircraft operations such as mechanics [FN326] and repairmen [FN327] must also be certified under the FARs. As is the case with pilots, there are no standards for UAV airmen, engineers, technicians, mechanics, or repairmen, and therefore, testable knowledge and skill will need to be formulated by the FAA for worthwhile certification of UAV aircrews.

Finally, under the FARs, applications for licenses and certificates for pilots and other operational personnel may be denied for a period of up to a year after any state or federal conviction for illegally using, growing, processing, manufacturing, selling, possessing, transporting, or importing narcotic drugs, marihuana, depressants or stimulants. [FN328] Further, current licensed and certified personnel may have their certificates suspended or ***579** revoked for such a conviction. [FN329] These provisions would more than likely apply to associated UAV operational personnel.

d. FAR Certificates of Airworthiness

Although the FARs are built upon the Chicago Convention and SARPs, they are generally stricter than the basic minimums found in those documents. [FN330] One example in the area of airworthiness certificates that could impact civilian manufactures of UAVs is the requirement for serial manufacturers to obtain a production certificate in addition to type and airworthiness certificates. [FN331] While the type certificate looks at the design, the production certificate focuses on the manufacturing quality-control system approval and is separate and distinct under the FAA system. [FN332] This distinction and separation between the type design approval process and the quality-control system approval process is unique to the United States. [FN333]

A production certificate would require UAV manufacturers to be certified based on “examination of the supporting data and after inspection of the organization and production facilities” that the manufacturer has a quality-control system to ensure that each part used in manufacturing the UAV meets the specifications of the type certificate. [FN334] For UAV manufacturers that build pilot-on-board aircraft or parts, such as Boeing or Northrop Grumman, this will not be difficult since that part of their operation is already certified. However, for those that specialize in UAV aircraft production only, this could increase the cost of production or at least slow down the process of instituting new UAV technology in mass-produced aircraft because the certification process can take years to complete, potentially affecting the utility and technical advancement of UAVs. [FN335] Nevertheless, over time technological advances will be able to be incorporated into commercially produced UAVs, and while it will take time, just as with pilot-on-board aircraft, regulatory precautions will ***580** result in safely integrated skies, as well as increased public acceptance.

While FARs, like the ICAO SARPs, do not directly address UAVs and its rules are only incorporated by analogy to include UAVs as aircraft, as previously noted, the FAA has made an initial attempt to address the integration of UAVs through a Certificate of Authorization or “COA” process under FAA Order 7610.4, Special Military Operations, chapter 12, section 9. [FN336]

2. FAA Order 7610.4, Special Military Operations, and the COA

In 1999, the DoD recognized the need to develop a process to allow its UAVs to operate in the NAS and the working with the FAA, established an initial step that was incorporated into FAA Order 7610.4. [FN337] Under the current order, 7610.4, the general principle for UAV flights is that they “should normally be conducted” in restricted areas or warning areas. [FN338] If a UAV operator wants to fly outside restricted areas or warning areas, they must obtain a COA. [FN339]

The process to obtain a COA, however, can be cumbersome because it can take two months to obtain the authorization from the FAA, and a COA must be obtained from each FAA region the UAV seeks to operate outside of restricted or warning areas; [FN340] there are nine regions. [FN341] There is a provision for “real-time, short notice, contingency operations,” which may reduce the required sixty-day lead time to the “absolute minimum necessary***581** to safely accomplish the mission.” [FN342] COAs are valid for no longer than one year, but the entity seeking the COA may seek renewal or revalidation. [FN343] As part of the COA, the FAA authorizes the “time and route of the UAV flight to avoid risks to [other] aircraft and persons on the ground.” [FN344]

With the development of the Global Hawk, the USAF realized the utility of less controlled movement in the NAS and, in the fall of 2003, joined forces with the FAA to establish a National COA (“NCOA”) for the Global Hawk. [FN345] This NCOA process has shortened the approval time for national Global Hawk operations to five days. [FN346] However, this NCOA only applies in domestic operations that involve take-off and landing in restricted areas. [FN347]

The COA process has allowed the FAA to maintain a certain amount of control over UAV flights in unrestricted airspace, as the COA requirements attempt to incorporate certain necessary elements of the FARs. The COA application must include a detailed description of the intended flight, including the airspace classification; the physical characteristics of the UAV; how it will be piloted; what sort of traffic avoidance measures will be used as an equivalent to “see and avoid”; how it will communicate with the pilot and the ATC; the route; termination procedures if it must abort or communication is lost; and an airworthiness statement from the entity requesting the COA. [FN348]

Regarding the safety issue of “see and avoid,” the FAA requires that the UAV have a method that “provides an equivalent level of safety, comparable to see-and-avoid requirements for manned aircraft.” [FN349] The FAA suggests acceptable methods such as “radar observation, forward or side looking cameras, electronic detection systems, visual observation from one or more ground sites, monitored by patrol or chase aircraft, or a combination thereof.” [FN350]

Additionally, the FAA requires that UAVs seeking COAs be equipped with standard aircraft anti-collision lights, and they ***582** must operate during the entire flight. [FN351] Such UAVs must also be equipped with an altitude-encoding transponder as specified by the FAR. [FN352] This transponder must operate on the code assigned by the ATC, and unless otherwise authorized, the pilot in command must be able to reset the code during flight; however, if the transponder fails, the ATC has the sole discretion to cancel the flight. [FN353] As for communication with ATC facilities, instantaneous two-way radio communication with the pilot in command is required. [FN354] Nevertheless, “for limited range, short duration flights,” a request may be made for an alternate means to communicate, with the understanding that “[c]ompliance with all ATC clearances is mandatory.” [FN355]

While FAA Order 7610.4k is a stepping stone and represents the first stages of a regulatory regime to allow UAV flights outside of restricted and warning areas, it is clearly incomplete. The biggest shortcoming is that it is not “file and fly”--it generally requires sixty-days lead time. [FN356] This is due primarily from the lack of a certification procedure to allow for aircraft, as well as licensing standards for pilots and crews. [FN357] Further, it applies directly only to military operations involving UAVs--civilian UAV flights are not specifically addressed. While there have been civilian COAs issued by the FAA, [FN358] Order 7610.4 is specifically designed for military movement of UAVs, particularly since there are no procedures to certify civilian UAVs for airworthiness. [FN359] Additionally, it does not address some of the basic rules of the air necessary for ATC interface and the full utilization of civilian airports. Finally, it makes no allowances for UAV aircraft that need only fly in unrestricted and uncontrolled airspace, such as Class G airspace.

***583** C. UAV Laws of Australia, Japan, and the United Kingdom

A few countries have attempted to address the issue of UAV certification and integration into their NAS by formulating regulations and guidance that go a step beyond what is found in FAA Order 7610.4. The lead countries in this effort are Australia, Japan, and the United Kingdom. While their work is based on differing needs regarding UAV integration, their efforts are worthwhile to review as the FAA addresses UAV integration.

1. Australia

The Civil Aviation Safety Authority ("CASA") in Australia has promulgated Civil Aviation Safety Regulations ("CASR") Part 101, Unmanned Aircraft and Rocket Operations, [FN360] and CASA Advisory Circular AC-101-1(0), Unmanned Aerial Vehicle ("UAV") Operations, Design Specifications, Maintenance and Training of Human Resources [FN361] in their effort to provide guidance in the operation and manufacturing of UAVs, as well as the means whereby UAVs may safely and legally operate.

Operations of commercial UAVs are based on an operator certificate ("OC"). [FN362] The concept of obtaining an OC allows operators to obtain certificates to operate without meeting the standards associated with the Australian Air Operator Certificate ("AOC") required for pilot-on-board aircraft. [FN363] The CASA has the authority to issue an OC if it is satisfied the UAV operator or person applying for the certificate can safely conduct UAV operations by meeting the minimum requirements for the OC, as well as any other requirements the CASA feels necessary based on the type and location of the intended operations. [FN364]

While the Australian OC concept has its advantages over the current FAA Order 7610.4 system, it still is not "file and fly" and may require up to ninety days to process the initial request, with renewals done in thirty days. [FN365] In order to obtain an OC, a UAV operator should give the CASA access to the organization ***584** and the aircraft and ensure the CASA also has access to associated maintenance companies or organizations to ascertain continued compliance with regulations and, where appropriate, continued airworthiness of the UAV. [FN366] Further, the UAV operator must have a management organization capable of exercising control and supervision over any flight conducted under an OC. [FN367]

Operations conducted under an OC must follow CASA guidelines, which are based on AC-101-1(0). In formulating such guidance, the CASA recognized the complexity of the UAV system as a multi-located composite; AC-101-1(0) provides:

> The UAV comprises not just the aircraft, it also consists of the UAV ground control system, communications/datalink system, the maintenance system and the operating personnel. Thus, when considering requests for UAV operating approval, the regulator will assess the UAV system as a whole. [FN368]

Along with the concept of a UAV system, AC-101-1(0) also allows for the autonomous operations of UAVs in situations where the UAV's "performance and designated ATC communication circuits are continuously monitored" by the UAV operations aircrew, and the UAV system and pilot have the ability to take immediate control of the aircraft. [FN369]

The general operating principle for UAV operations in controlled airspace over Australia is simple: a UAV must be able to fully adhere to all requirements, including equipment and ATC regulations, placed upon pilot-on-board aircraft operating in the same class of airspace. [FN370] This translates into placing the ball in the court of the manufacturers to produce UAVs that can safely function seamlessly and with transparency as any other aircraft in that class of airspace.

For flights in airspace shared with pilot-on-board aircraft above 400 feet, or 121.92 meters, Above Ground Level ("AGL"), the UAV operator must provide a flight plan pursuant to normal IFR procedures indicating that there is no pilot on board and the specific details of the flight. [FN371] With regards to collision avoidance, the CASA may (note, that it is not required to) require***585** large UAVs to be "equipped with an SSR transponder, a collision avoidance system or forward looking television as appropriate for the type of operation." [FN372] Large UAVs are generally defined as aircraft over 150 kilograms. [FN373]

As for operations of small UAVs in unpopulated areas far from airports that operate at 400 feet, or 121.92 meter,s AGL or below, the operator or pilot is solely responsible for the safety of the flight in that the aircraft remains clear of power lines, structures, and other low-level air traffic. [FN374] Small UAVs are defined as aircraft larger than 100 grams (0.2 lbs) and generally smaller than 150 kilograms. [FN375] While the operator or pilot of a small UAV is responsible for its operations since no ATC is present to provide guidance and instruction, such operations are still subject to CASA approval and imposed flight rules. [FN376]

AC-101-1(0) also addresses procedures to be taken in the event of an emergency emanating from the loss of control over a UAV, or loss of radio contact with the ATC. The filed flight plan should detail the procedures the UAV will follow in such a circumstance. [FN377] Nevertheless, the CASA recommends that if the UAV pilot loses control, the UAV should autonomously transit to a predesignated recovery area to either be recovered or perform a flight termination action. [FN378] In the event of a loss-link situation, whatever the cause, the ATC should be briefed, [FN379] and if autonomous actions are taken by the UAV, the ATC will treat it as an emergency aircraft. [FN380] Similar to FAR requirements for loss of radio contact from the ATC and pilot-on-board aircraft, under AC-101-1(0), if the UAV pilot and the ATC lose contact, the pilot should attempt to establish alternate means of communications, such as a telephone, and the UAV should be flown "in accordance with last acknowledged instruction or should be commanded to orbit in its current position." [FN381] However, if communications with the ATC cannot be re-established, the UAV flight should be aborted. [FN382]

***586** Under AC-101-1(0), interfacing with the ATC should be conducted in similar fashion as other pilot-on-board flights. For example, when in radar-controlled airspace, the UAV should have a transponder that allows the pilot to change the code upon the request of the ATC, [FN383] and the UAV pilot should make all required position and flight reports to the appropriate ATC. [FN384] Moreover, when communicating with the ATC, the UAV call sign should always indicate that it is a UAV by stating "UNMANNED." [FN385]

While certificates of airworthiness are obtained under the "Experimental" or "Restricted" categories in Part 21 of the Australian Civil Aviation Regulations ("CAR") 1998, [FN386] AC-101-1(0) does address certain aspects of the design of the UAV that the manufacturer and operator must consider when obtaining a certificate of airworthiness. As noted above, under AC-101-1(0), the UAV system comprises both airborne and ground-based equipment, and this system should be designed so as to minimize the chance of component failure that would prevent a safe UAV flight and recovery. [FN387] However, the design criteria listed in AC-101-1(0) are given in only broad, general terms, with no specific technology prescribed. This is clearly indicated by the following guidance to consult with the CASA through the process:

> Because of the wide range of airborne vehicles and ground stations which potentially form part of a UAV system and the wide diversity of possible operations, some design criteria may apply to all UAV systems and some may be unique to a type or class of UAV. Thus, the potential developer of a UAV system is encouraged to consult with CASA prior to commencement of a project. [FN388]

Finally, with regards to certification of the UAV pilot, which the CASA calls a controller, CASR 1998 Part 101 requires the controller to have obtained a radio operator's certificate of proficiency, passed an aviation license theory examination, passed an instrument rating theory examination, completed a UAV operations course conducted by the UAV manufacturer for the type of UAV to be operated, and have at least five hours experience***587** operating the UAV outside controlled airspace. [FN389] Interestingly, however, while the CASA requires UAV pilots to have many of the same skills required of pilot-on-board aircraft, it recognizes that the medical requirements for UAV pilots do not need to be as stringent as pilot-on-board aircrews since the operating environment is much different. [FN390] Nevertheless, CASA requires that UAV aircrews "abstain from the use of stimulants, drugs or alcohol in the same manner as the driver of a motor vehicle;" note, however, that it does not state "in the same manner as a pilot of manned aircraft." [FN391]

2. Japan

As previously discussed, Japan represents the most commercially successful adaptation of UAVs anywhere in the world with their widespread use of rotary UAVs for agriculture applications. The Japanese Ministry of Agriculture, Forest, and Fisheries ("MAFF"), along with its affiliated association, the Japanese Agriculture Aviation Association ("JAAA"), originally promoted the concept of rotary UAVs in agriculture. [FN392] As part of this promotion of UAV research, development, and use, the JAAA established safety standards for UAVs in the areas of flight performance, airframes, and inspection and maintenance. [FN393] Through these standards, the JAAA has been able to enforce safe operations of these rotary UAVs, not just in agriculture, but also for observation and environmental compliance. [FN394] Additionally, the JAAA has developed a system that requires operators to receive mandated training and certification specifically designed for rotary UAV operations, as well as a system to register all the aircraft as well as users or customers. [FN395]

As well as this JAAA regulatory construct meets the current needs within Japan--and has fostered wide spread commercial application of this technology-- it is, nevertheless, not designed to provide for full integration in all classes of airspace. [FN396] The ***588** JAAA safety standards and certification and registration system are basically to operate rotary UAVs in uncontrolled airspace, spraying on a field and moving on to the next field or base of operations, with most flights, if not all, probably below 400 feet (121.92 meters) AGL. [FN397]

3. United Kingdom

The United Kingdom Civil Airspace Authority ("CAA") regulatory framework was initially developed in 2002 as a response to pressure from the British UAV community [FN398] and was outlined in the CAA document entitled, "CAP 722--Unmanned Aerial Vehicle Operations in UK Airspace - Guidance" ("CAP 722"). [FN399] The introductory paragraph of CAP 722 provides a good summary of the philosophy of the requirements within:

> It is CAA policy that UAVs operating in the UK must meet the same or better safety and operational standards as manned aircraft. Thus UAV operations must be as safe as manned aircraft insofar as they must not present or create a hazard to persons or property in the air or on the ground greater than that attributable to the operations of manned aircraft of equivalent class or category. [FN400]

Thus, similar to the Australian regulations, UAVs operating in the UK had to conform to operational standards similar to those for pilot-on-board aircraft. However, as the above-quoted paragraph indicates, the power was within the CAA to establish safety and operational standards beyond those required for such pilot-on-board aircraft. Nevertheless, while these rules were a good head start, the industry was unable to take advantage of the regulations as technology, particularly "see and avoid," had not yet risen to the level required under the regulations. [FN401] You have probably noted that this paragraph was written in past tense, indicating an effect that no longer applies.

In fact, CAP 722 is no longer applicable to most UAVs in the UK. The newly created European Aviation Safety Agency ("EASA") retains the authority to regulate larger or nonexperimental UAVs for nations of the European Union ("EU"), under ***589** which the United Kingdom is a member state. [FN402] Under EU law, EU Member States' policies and procedures would only apply to "UAVs specifically designed or modified for research, experimental or scientific purposes and likely to be built in small numbers, and UAVs operated by the police or similar services," or smaller UAVs with a mass of no more than 150 kilograms (330.7 lbs). [FN403] The EASA has yet to establish a regulatory framework for the UAVs over which they have jurisdiction.

But, in May of 2004, a task force, commissioned by the Joint Aviation Authorities of Europe ("JAA") and the European Organization for the Safety of Air Navigation ("EUROCONTROL") to look into the integration of UAVs in the European NAS, issued a final report ("Task Force Final Report"), which is referred to and referenced at times throughout this Thesis. [FN404] While the Task Force Final Report has yet to be fully incorporated into an EASA regulation (as just noted, all aeronautical regulatory, certification, and licensing duties for EU member states has now been turned over to the EASA) [FN405] part of the report included a recommended regulation for light UAVs. [FN406]

The Task Force Final Report defined light UAVs as "those with a maximum take-off mass below 150kg [330.7 lbs], and a maximum speed not exceeding 70kts [knots], that are operated within 500 meters [1640.42 feet] of the UAV-pilot and not more than 400 ft [121.92 meters] above ground level," [FN407] and have "an impact kinetic energy that does not exceed 95KJ [FN408] when assessed***590** against both a high speed and free-fall impact scenario." [FN409] The Task Force Final Report's definitional use of mass and speed to determine the kinetic energy derived therefrom goes beyond the simple weight classification used by Australia. The concept is designed to address the risk of the UAV to third parties on the ground--the more kinetic energy that could be produced by a crashing UAV, the greater the risk to persons on the ground from impact. [FN410]

This proposed regulation of light UAVs was taken in part from a policy formulated by the UK, the UK-CAA Policy for Light UAV Systems ("CAA Light UAV Policy"), which now governs light UAV operations within the UK. [FN411] Therefore, while CAP 722 is no longer applicable, and EASA has yet to issue governing regulations to replace it, the CAA Light UAV Policy currently allows light UAVs to operate in the UK under a regulatory certification and licensing regime.

The CAA Light UAV Policy uses the same classification for light UAVs listed in the Task Force Final Report. The concepts underlying the policy are simple:

> As model aircraft operations have been conducted in an adequately safe manner for many years with no airworthiness requirements in place for those below 20kg mass, and LMA [Large Model Association] oversight for heavier aircraft, the CAA has concluded that UAV Systems that are "equivalent" to existing model aircraft and have no greater capability, may be allowed to operate without obtaining airworthiness certification, subject to the UAV System complying with similar limitations and conditions to those applied to model aircraft. [FN412]

This is similar to the allowance under Australian regulations for light aircraft; the difference is the definitional inclusion under the CAA Light UAV Policy of kinetic parameters to form the subject-matter scope of the policy.

While CAP 722 is no longer in effect, certain issues addressed therein bare mentioning as the FAA addresses the issue of integration. In CAP 722, the CAA grouped UAVs into five different classes based on the type of airspace in which they are to be flown:

> ***591** Group 1. Those intended to be flown in permanent or temporarily segregated airspace (normally a Danger Area) over an unpopulated surface (normally the sea following "clear range" procedure).

Group 2. Those intended to be flown in permanent or temporarily segregated airspace (normally a Danger Area) over a surface that may be permanently or temporarily inhabited by humans.

Group 3. Those intended to be flown outside Controlled Airspace (Class F & G) in the United Kingdom Flight Information Region (UK FIR).

Group 4. Those intended to be flown inside Controlled Airspace (Class A-E) in the United Kingdom Flight Information Region and United Kingdom Upper Information Region (UK FIR and UK UIR).

Group 5. Those intended to be flown in all airspace classifications. [FN413]

This classification system does not use weight and kinetic energy equations as discussed in the Task Force Final Report; however, the CAA now uses kinetic energy in defining a light UAV. Nevertheless, initially in determining the governing rules for operations and certification of aircraft and pilots, the CAA grouped UAVs into classes based on the airspace to be used.

CAP 722 also made a distinction between the UAV pilot and the UAV commander: the latter did not have to be the actual person in control of the aircraft but could be either located with the pilot or monitoring flight from a separate location. [FN414] Nevertheless, the UAV commander was tasked with the overall responsibility that the operations followed the applicable rules of the air for the class of airspace flown and the overall safety of the vehicle in flight. [FN415] Accordingly, the commander had to be licensed and appropriately rated according to airspace classification, meteorological conditions, and flight rules since he or she assumed the same operational and safety responsibilities as those of the captain or pilot in command of pilot-on-board aircraft in performing a similar mission in similar airspace. [FN416] Thus, CAP 722 required UAV commanders to be rated pilots; however, the UAV pilot, if separate from the commander, only had to meet the "training, qualifications, proficiency and currency requirements stated in the approved Flight Operations ***592** Manual" instituted by the UAV operating organization. [FN417] CAP 722 also allowed the UAV commander to assume responsibilities for more than one UAV at a time, on the condition that directing more than one UAV pilot could be done safely. [FN418]

As noted, CAP 722 was built on the regulatory philosophy that UAVs had to meet the same or better safety and operational standards as pilot-on-board aircraft. Therefore, to obtain airworthiness certificates, the design requirements were derived from existing codes of requirements applied to pilot-on-board aircraft and issued following acceptable demonstration of compliance with the applicable requirements. [FN419] Further, as part of the determination for certification, like the Australian rules, CAP 722 recognized that the UAV operates as a system and considered any equipment essential to or which could affect the safe operation and landing of the aircraft as part of the UAV, and the UAV would have to comply with applicable airworthiness requirements. [FN420] But, the lack of recognized airworthiness standards in the UAV industry and the technology hurdle of "see and avoid" hindered application of the CAP 722 certification process. [FN421]

IV. FUTURE REGULATORY CONSTRUCT

While clearly there is work to be done by regulators, after reviewing the current regulatory regime, both for pilot-on-board flight and those specifically-drafted for UAVs, I contend that a majority of the regulatory effort necessary to create UAV-specific regulations will be applying that which is already in place for other aircraft. This argument will be further explored below. Nevertheless, even if new rules were created to make UAV integration possible, it is not as much of a matter of technology forming designs and utilities that allow UAV integration, than it is formulating and promulgating words to make it so. Indeed, the Chicago Convention, ICAO SARPs, and FAA FARs did not solely make international and domestic commercial aviation the safest mode of transportation; [FN422] it took technology to build safe ***593** airplanes. Clearly, the Chicago Convention was not necessary or would not have had any real facilitative effect in 1919, after World War I. It took advancements in aviation technology before governing words could provide lift to safe flight. As has been the case in the UK and Australia, regulators bleeding ink does not automatically and safely integrate UAVs into controlled airspace.

Therefore, while reviewing the unfinished business of regulators is the focus of this final substantive chapter, most of the work left to fully integrate UAVs is unfinished business behind the chalk boards, computers, and labs of inventors, engineers, and scientists, rather than behind the desks of the FAA. Nevertheless, the type of examination necessary to give that subject due justice is beyond the scope of this Thesis and the educational training of this researcher. Thus, I will leave a more in-depth study of the technical barriers surrounding such issues as "see and avoid" and "lost data links" to other, perhaps more qualified, authors and researchers.

Be that as it may, this final chapter will provide a general overview of the remaining regulatory issues the FAA, or any other national aviation authority, should address in establishing a framework of rules that would allow integrated flight of manned and unmanned flying machines. I will do this by addressing the areas of operations and rules of the air, including security, and the certification of aircraft and aircrew while also providing suggested direction to focus efforts or take specific actions.

A. UAV Operations and Rules of the Air

1. New or Existing Rules

The initial question that must be addressed is the form that UAV operational regulations should take. There are two methods that can be used to resolve the issue: (1) create separate regulations, such as a new section in the FARs, like the sections addressing balloons, kites, unmanned rockets, [FN423] and ultralight aircraft; [FN424] or (2) amend the existing sections of the FARs found in CFR Title 14, Part 91, General Operating and Flight Rules, to cover the unique operational environment of UAVs. [FN425] The NASA ERAST project to look at the development and integration of HALE UAVs reviewed the rules found in FAR Part 91 and ***594** concluded that most of the current regulatory criteria found in this section of the FARs are already applicable or specifically do not apply. [FN426] Their conclusion, therefore, was that the most "effective and timely method” to resolve this issue would be to use Part 91 as the basis for UAV operating rules and amend where needed. [FN427]

The painstaking, while not exhaustive, review of existing international and domestic rules that could apply to UAV operations found in the previous chapter hopefully supports this conclusion. Nevertheless, not all UAV aircraft should be required to follow the same flight rules as such aircraft will not need to fly in controlled airspace. However, that is simply built into the system as operational environments are segregated into classes of airspace. As already divided and classified in ICAO SARPs and FARs, UAVs that only operate in Class G airspace will have differing requirements from those that operate in Class A. Thus, by treating the UAV similar to pilot-on board aircraft, most of the operating regulatory structure is already in place.

This approach is also advocated by a number of governmental agencies and public and private organizations looking into this issue, which, almost without exception, agree that using existing aviation regulations form the best building block for UAV integration. [FN428] Therefore, I will use the premise in this final chapter that the most effective way to create regulations for UAV integration is to incorporate, to the greatest extent possible, existing aviation regulations.

2. Classification of UAVs

The first issue that must be addressed by the FAA in incorporating existing operational rules of the air to UAV flight is the classification of aircraft, which cover such a wide and varied operational spectrum. The issue can be viewed a little differently by determining which rules should apply to a particular type or class of UAV. A classification scheme is important for UAV development to give operational parameters to system designers and manufacturers as targets to aim for in accessing an intended ***595** operational environment. There are a number of different classification schemes for UAVs currently advocated.

As mentioned earlier in this work, there exists a classification based on operating altitudes and endurance, which classification I have used throughout this work, and which is fairly universally used. [FN429] This sort of classification includes high-altitude, long-endurance, HALE UAVs, and medium-altitude, long-endurance, MALE UAVs. Militaries also classify UAVs based on operational characteristics, such as the previously explored unmanned combat aerial vehicle, UCAV, and the vertical take-off and landing UAV, VUAV, [FN430] or on the operational mission, such as the tactical UAV, TUAV. [FN431]

Some schemes focus on weight, such as the above-discussed Australian regulations. Others include weight in a formula for kinetic energy, as in the Task Force Final Report or the CAA Light UAV Policy. The advantage of this concept is that it takes into account the actual risk to third parties from a crash. Still others have advocated an even more complicated system using a combination of the classes of airspace needed for operations and the ability of the UAV to stay in that airspace, coupled with a kinetic energy concept. [FN432]

But, if the most effective way to pave the airfield for UAV integration is by adapting, to the greatest extent possible, current aviation regulations, I contend that UAVs should be classified through a system that easily fits into and can incorporate those existing rules. This could be done by applying a system to UAVs that uses the different categories of airspace already in place in the aviation regulatory construct. In essence, this is what was done in the classification grouping in CAP 722, discussed above. Under CAP 722, the UK made five groupings based on the type of airspace the UAV would fly. [FN433]

This sort of method was also proposed by the United States' Office of the Secretary of Defense (“OSD”) in its 2004 report ***596** entitled Airspace Integration Plan for Unmanned Aviation (“OSD Plan”). [FN434] In the OSD Plan, the OSD looked at the FAA's current scheme of regulating aircraft based on classifications of “class,” “category,” and “type.” [FN435] They determined that by adapting the existing FAA regulatory classification scheme, they could easily group UAVs into categories upon which specific requirements would apply. [FN436] Through this exercise, the following categorization was developed:

Cat I - an ROA similar to a radio-controlled ("RC") model aircraft.

Cat II - an ROA that does not fully comply with airspace equipage requirements and is not used similarly to RC model aircraft.

Cat III - an ROA that complies with applicable parts of 14 CFR Part 91. [FN437]

The following table taken from the OSD Plan further explains how this simple three-tier categorization scheme allows the adaptation of existing FARs into the UAV world:

FIGURE 4-1: UAV/ROA DIVISIONS BASED ON FAA DEFINITIONS

TABULAR OR GRAPHIC MATERIAL SET FORTH AT THIS POINT IS NOT DISPLAYABLE

1. The regime that operates under Visual Flight Rules ("VFR") and Instrument Flight Rules ("IFR") according to well-established***597** regulations and procedures, as closely as possible to a manned aircraft.

2. The regime where Visual Meteorological Conditions ("VMC") operations in the absence of ATC are similar to Restricted Category Aircraft operations.

3. The regime where VFR line-of-sight operations in uncontrolled airspace resemble model aircraft operations. [FN438]

Thus, by categorizing UAVs in this manner, an existing and already applied and understood system of aviation regulations, are, for the most part, able to be laid at the feet of manufacturers and operators to guide UAV operations. It provides not only for application of operational rules of the air, but also application of existing rules for aircrew and pilot licensing and certification requirements.

This categorization system also easily applies to airspace classifications. Since Category I are those UAVs that operate in visual line-of-sight similar to model aircraft, their operating parameters will be in the uncontrolled airspace of class G. Category II will be limited due to operating constraints that do not allow full adherence to the FARs, such as equipment limitations, but also due to the need to fly out of the sight of an operator, and, therefore, would not be allowed to fly in class A, B, or C airspace. Finally, Category III are those UAVs that comply with all applicable FARs, and would have access to all classes of airspace. The alignment of existing regulations and airspace accessible by each of these three categories is clearly displayed in this table taken from the OSD Plan:

FIGURE 4-2: ALIGNMENT OF UAV/ROA CATEGORIES WITH FAA REGULATIONS [FN439]

	Certified Aircraft/Cat III ROA[20]	Non-Standard Aircraft/Cat II ROA	RC Model Aircraft/Cat I ROA
FAA Regulation	14 CFR 91	14 CFR 91, 101, and 103	None (AC 91-57)
Airspace Usage	All	Class E, G, & non-joint-use Class D	Class G (<1200 ft AGL)
Airspeed Limit, KIAS	None	NTE 250 (pro-	100 (proposed)

			posed)	
Example Types	Manned	Airliners	Light-Sport	None
	Unmanned	Predator, Global Hawk	Pioneer, Shadow	Dragon Eye, Raven

***598** One could argue that this overly simplistic categorization system does not adequately address the threat to airborne and ground-based third parties since it does not account for the mass and operating speed of the UAV. For example, in theory a Category II UAV could be as large as any Category III aircraft, but since it is designed to fly in limited airspace, it would not be equipped with some safety-related equipment, such as transponders, radios, or even lights. Thus, while Category II UAVs are only designed for operations in Classes E and G, and uncontrolled portions of Class D, if, due to a pirated signal, lost link, or other malfunction, the aircraft diverges into more congested airspace or populated areas and crashes, obviously the risk to a third party increases as the kinetic energy inherent in the aircraft increases.

Be that as it may, there are always security and safety risks associated with any type of UAV. Operating rules, such as limiting flight paths to sparsely populated areas in the air and on the ground, help reduce that risk just as do safety and security equipment. The advantage of the three-category system proposed by the OSD is that it can be quickly implemented with proven, already used categories familiar to aviators. It does not require inventing new concepts that might impose unnecessary burdens upon the industry that could stifle growth and utility. Clearly an aircraft designed to provide a bird's-eye view for border security or to monitor changing environmental conditions in unpopulated areas should be encouraged to be fielded quickly without burden and, arguably, unnecessary requirements. Granted, even more complex categorizing systems that include kinetic testing would produce similar results in time, but the issue is based more on whether the industry should be burdened with complex and costly requirements based on unlikely ***599** risks. The real threat to third parties clearly lies in Category III UAVs that are intended to be fully integrated, and accordingly would be required to adhere to all applicable FARs.

I recommend that the FAA adopt the categorization system proposed by the OSD because it would allow for the adoption of existing rules upon UAV systems that wish to operate in certain segments of airspace without limiting access to those UAVs that can now safely operate under those rules, such as Category I UAVs. This system is simple and easy to understand and does not require complex and possibly unnecessary testing that takes resources from both the government and the manufacturer.

3. Category III UAV Specific Considerations for the FARs

Cat III UAVs, or those that will fly in all classes of airspace, and more particularly, Class A, B, and C airspace, will be required to adhere to all applicable operational rules found in the FARs. However, as noted, some rules do not apply, and others need to be slightly changed to address the UAV operational range. Therefore, I will review portions of Part 91 of the FARs that need to be modified for UAV operations.

a. Multiple Operations, One Pilot in Command

As previously noted, the FARs and ICAO SARPs require the pilot in command to be responsible for the safe operations of the aircraft, and that its flight follows applicable rules of the air. However, as also previously discussed, at least one jurisdiction, the UK in CAP 722, contemplated and allowed the UAV commanding pilot to command, but not necessarily personally operate, more than one UAV at a time on the stipulations that such could be done safely. [FN440] The scenario of having more than one pilot under the supervision of a commanding pilot is not without reason in a modern, technology-driven UAV operations center. Granted, such a center would only be possible in operations sophisticated enough to have sufficient monitoring of the aircraft, communications with all ATCs, and flying environments, including all other local traffic; however, such operations are not beyond immediate future realization.

Section 91.3, Responsibility and Authority of the Pilot in Command, of Title 14 of the CFR addresses the responsibility and authority of the pilot in command. I recommend that this section include ***600** a provision that allows the UAV pilot in command to perform his or her duties by direct control of the vehicle or through a pilot who is either located at or monitored from an operations center. Further, I recommend that a UAV pilot in command may simultaneously assume the prescribed responsibilities for more than one UAV aircraft when such can be done through monitoring and oversight to a level of acceptable safety by overseeing and directing the activities of one or more UAV pilots.

b. Right of Way: See and Avoid

Right of way rules may not need to be drastically amended, but they must account for the difficulty of operating in airspace with both UAVs and pilot-on-board aircraft. It is difficult not only for the UAV pilot but also for the pilot sitting in the cockpit of the pilot-on-board aircraft and the ATC. While UAV pilots must be able to electronically observe other aircraft, those other pilots must also be able to observe them. UAVs are generally smaller than other aircraft, particularly commercial airliners; even Category III UAVs will generally not be as large as pilot-on-board aircraft. Smaller profiles may make the UAV more difficult to “see and avoid.” Therefore, Category III UAVs will need to be able to send a signal electronically that is distinctly identifiable as coming from a UAV so as to provide notice to the ATC and other pilots to be on special lookout for the smaller, usually slower aircraft.

While it would be ideal for UAVs to be totally transparent to the ATC so that the ATC would not have to make a distinction between pilot-on-board aircraft and UAVs, [FN441] such may be too idealistic. While it is not unreasonable to require that the ATC be able to communicate with and instruct the UAV pilot in the same manner as pilots-on-board, the ATC may still have to provide greater separation or take different actions or precautions for UAV aircraft. This can only be done if the ATC knows they are dealing with a UAV.

Therefore, Category III UAVs will need to be equipped with identifying technology to fly and communicate safely under IFR conditions, but moreover, they will need transponders or other technology to allow other aircraft and the ATC to identify them immediately as UAV aircraft. It should not be difficult for an industry standard to come forth to establish regulatory requirements. Such standards could easily take shape during the airworthiness***601** certification process discussed in the next section. These new requirements could be placed into Subpart C, Equipment, Instrument, and Certificate Requirements, of Section 91 of the FARs. [FN442] Category II aircraft will not be able to fly under IFR conditions. The use of airborne or ground-based observers, or current forms of radar will be sufficient for seeing and avoiding Category II UAVs operating in Class D, E, and G airspace. [FN443]

c. Flight Termination Procedures

Flight termination due to a lost link, either from an equipment malfunction or jammed or pirated signal, is a security issue that clearly affects the safety of other aircraft and third parties on the ground. As required under Australian rules, [FN444] the flight plan filed for UAV operations should include procedures that will be followed in the event of required flight termination. The type of action taken should be left to the circumstances of the mission, size of the aircraft, and possibly the type of cargo, including internal equipment that might be classified or sensitive. I recommend, therefore, that options be given based on the above or other criteria. Obviously, the risk to third parties should be mitigated, to include environmental hazards from equipment or payload. The options should include autonomous actions after set periods of lost contact from the UAV control center, as well as allocated safe areas in the air and on the ground for recovery, implosion, or other forms of termination. For Category III aircraft, section 91.169, IFR Flight Plan: Information Required, of the FARs could be amended to provide this reporting requirement, as well as options and acceptable parameters for flight termination actions, which could also be placed in section 91.139, Emergency Air Traffic Rules. For Category II UAVs flying VFR, similar requirements could also be included in section 91.153, VFR Flight Plan: Information Required.

In the event of a lost-link scenario, procedures could also include a period of time allowed to re-establish communication. As briefly touched on in the previous chapter, there are rules for pilot-on-board aircraft in situations where communications between the ATC and pilot have ceased. [FN445] The same procedures ***602** could be autonomously programmed into the UAV to take effect upon a lost link with the control center. [FN446] However, care should be taken to allow these procedures to occur autonomously. Unlike pilot-on-board aircraft, a UAV that has lost manipulation from the control center must rely completely on computerized actions and reactions in flight, which would be dangerous in heavier traveled classes of airspace. Therefore, this option should only be used until communication and control is re-established prior to entering into Class B or C airspace, or the more congested areas of Class A airspace, unless technology advances to allow safe autonomous transit through such airspaces.

Integral to lost-link security is the communicating frequency between the UAV operations center and the aircraft. While the technical parameters of the issue are beyond the scope of this thesis, there seems to be work that could be done by the ITU, [FN447] on an international scale, and the FAA and Federal Communications Commission ("FCC") within the United States. Dedicated frequencies or bandwidth requirements and noninterference rules could be placed in the FARs, possibly as a part of section 91.183, IFR Radio Communications, or 91.185, IFR Operations: Two-way Radio Communications Failure, to address the unique UAV environ.

d. Flight Operations Center and the UAV System

As noted in both Australian and UK rules, the UAV is not just an aircraft, but also includes remotely located pilots, technicians, communication links, and personnel. Any changes to the FARs must account for the UAV as a system. Therefore, the definitional section, section 1, of the FARs should discuss the UAV as a system that includes the aircraft, a ground-or air-based control center, communications or data-link system, maintenance system, operating personnel, and any other equipment or personnel essential to or which could affect the safe operation and landing of the UAV.

Further, while the UAV aircraft is only one piece of the system, other pieces of that system could change midflight as it did when the Global Hawk flew from the United States to Australia.***603** [FN448] In that situation and in future scenarios, control or responsibility of the aircraft may pass to another control center, pilot, or pilot in command. This could happen not only internationally, but also domestically within the United States as UAV operators could have regional control centers for transnational flights. In such situations, the identity of the UAV pilot and the UAV commander must be clear to the ATC, with proper communications maintained with the right party at all times during the UAV flight. There should be a requirement that any flight plan include detailed information regarding any change of operational control. This could be done by further amending the above-mentioned Part 91 sections that address required flight plan information. [FN449]

e. Other Security Issues

Once the UAV is recognized as a system, security issues enlarge to encompass the whole UAV system. The principles of security and the integrity of the aircraft, to ensure that it can not be used as a weapon or flying bomb, require that any controlled area includes the whole system. This would include security from intruders into the control center and the communication link, both physically and electronically. This would require the TSA to amend those portions of Title 49 of the CFR that address security perimeters and controlled-access areas. [FN450]

As noted, there are FAA-promulgated rules regarding securing the cockpit of pilot-on-board aircraft and restricting access to such areas to only authorized persons. [FN451] These rules should be expanded to include control centers of UAVs. However, since the security of passengers is not an issue, and UAVs are generally smaller as compared with most pilot-on-board aircraft, my recommendation is that the rules for locked cockpit doors [FN452] be somewhat modified to allow access through security doors that grant entrance by card, combination, or other technology, similar to those already used in most businesses or corporations.

Nevertheless, there should be increased thought given to the security of the communication link to include security of the hardware, software, and electronic signal. The security rules will ***604** need to be amended to place the onus on the UAV operator to secure the location of equipment, to include fenced and controlled areas around communication towers, and a secured signal using some sort of encryption or signal that is difficult to intercept. Finally, as part of the security system for the communications link between the aircraft and the control center, there needs to be a requirement for redundancy of systems, which is a common requirement imposed by the FAA upon aircraft manufacturers. [FN453] Once again, these are areas that technology must answer; but, it is important to establish regulatory requirements in these areas for manufacturers and operators to be given direction to expend resources.

B. Certification of Aircraft and Personnel

1. Airworthiness Certification

The certification of pilot-on-board aircraft is based on a system of applying specifically defined codes and requirements that have been established over decades of aircraft design. It is a universal, underlying concept that the application of these codes of airworthiness, as far as is practicable, avoids any presumptions of the missions or purposes or the aircraft; [FN454] however, exceptions are made in certain situations for special-purpose aircraft such as in agriculture, which are then limited to how and where they may operate. [FN455] The problem that lies before regulators regarding UAV flight is the lack of industrial safety standards since there is not a long history of a certification process. [FN456]

Notwithstanding this problem, if UAVs are classified using the OSD system, as recommended above, the number of UAVs requiring a full certification process is reduced to some extent. Under this categorization system, only Category III UAVs will require normal airworthiness certification. Category I UAVs will follow rules for model aircraft found in AC 91-57, and Category II UAVs will apply rules similar to ultralight aircraft found in Title 14, Part 103, Ultralight Vehicles, which are "not required to ***605** meet the airworthiness certification standards specified for aircraft or to have certificates of airworthiness." [FN457] As for the Category III UAVs, which would more than likely be made up of HALE UAVs, the NASA ERAST project addressed the certification process for HALE UAVs, and proposed that a stair-step plan be used to formulate standards to obtain a regular airworthiness certificate, as well as type and production certificates along the way. [FN458] Once the standard airworthiness certificate is obtained for a Category III UAV, it will be able to operate and integrate into the NAS.

This stair-step approach builds on the familiar FAA certification processes. The proposal is really just taking a Category III UAV, in their case a HALE UAV, through the steps required for the development of almost any new aircraft system, which is at least a four-year process. [FN459] The first steps are to obtain registration for the aircraft and an experimental certificate. [FN460] While the experimental certificate is not required to obtain the standard airworthiness certificate, it would develop data helpful in later stages of the proposed stair-step process. [FN461]

Under section 21.191, Experimental Certificates, of the FARs, a research-and-development aircraft is defined as one that tests new design concepts, aircraft equipment, operating techniques, or new uses. [FN462] A UAV would be eligible for an experimental certificate, and the applicant could conduct operations as a matter of research, to determine compliance with existing airworthiness standards for similar UAVs or pilot-on-board aircraft or to determine if there is utility in further development. [FN463] The NASA ERAST project recommends this as an initial step, as it would get individuals and offices of the FAA involved and establish points of contact that might prove fruitful in later steps. [FN464] Further, it would begin to introduce the concept that the UAV is not only an aircraft, but also a system of remotely located parts that must function together to bring about operational capabilities.

***606** The next step proposed is to seek a special class type certificate from the FAA, which is the most detailed and time consuming step, as it could take at least three years to receive the type certificate. [FN465] The proposal envisions a two-part process of first drafting proposals and making presentations to the FAA using criteria and standards that exist for pilot-on-board aircraft to the greatest extent possible, upon which the FAA would review the submitted project plans and draft an Issue Paper (IP) that addresses the proposed type certification basis for the aircraft. [FN466] The end goal is that the FAA make a determination that the UAV is sufficiently similar to existing pilot-on-board aircraft certified under the provisions of FAR section 21.17(b), Designation of Applicable Regulations. [FN467] This would allow the applicant, a UAV manufacturer, to take advantage of existing airworthiness standards for differing types of already-certified aircraft. [FN468]

However, unlike these already-certified aircraft, the UAV operates as a system of remotely located parts. The concepts and submitted plans would have to indicate clearly how the UAV system is integrated and operates like the enclosed systems of pilot-on-board aircraft and that the entire system must be considered as part of the certified aircraft.

The second part of the processes in obtaining a type certificate would require the development of fully functioning systems for review, which would include technology necessary to meet existing FAR requirements. This process would also assist the FAA in the development of new certification requirements and appropriate advisory material under the FAA rulemaking authority and process set forth in Part 11, General Rulemaking Procedures, of the FARs. [FN469]

The remaining steps deal with the actual production of the UAV pursuant to the type certificate and obtaining an airworthiness certificate. The NASA ERAST project proposes that when moving into production, such be done pursuant to Subpart F, ***607** Production Under Type Certificate Only, of Part 21, Certification Procedures for Products and Parts, of the FARs. [FN470] This would allow the production and further testing of the UAV without obtaining a production certificate; however, as previously mentioned, for commercially produced and sold UAVs, manufacturing pursuant to a production certificate will be required. [FN471]

Next, the applicant would apply for an airworthiness certificate, which could be done by first obtaining a special certificate of airworthiness through a process created for special-purpose operations under sections 21.25, Issue of Type Certificate: Restricted Category Aircraft, and 21.185, Provisional Amendments to Type Certificates. [FN472] This process would allow quicker access to airspace to perform certain tasks, and, thereby, a quicker window to obtain data and establish a safety record necessary in obtaining the standard airworthiness certificate. Special-purpose operations include limited access to airspace for agricultural uses such as spraying, dusting, and seeding; livestock and predatory-animal control; forestry and wildlife conservation; aerial surveying, to include photography, mapping, and oil and mineral exploration; patrolling of pipelines, power lines, and canals; weather control; aerial advertising in the forms of skywriting, banner towing, airborne signs and public address systems; and any other operation specified by the FAA. [FN473] With successful operations through a special certificate of airworthiness, the next step would be a full airworthiness certificate, which would allow full integration into the NAS. [FN474]

While this proposed stair-step process is offered by the NASA ERAST project for certification of HALE UAVs, it could be adopted for any Category III UAV. Through this process, the Category III operator could obtain an airworthiness certification from the FAA through an already-established system, which would then lead to an easier pathway to international recognition through the Chicago Convention. [FN475] Granted, work is still needed by ICAO to address UAV operations and certification; ***608** however, if UAV operators move forward under the existing system, as outlined above, other Contracting States will, in theory, be more comfortable in granting recognition of the UAV airworthiness certificate, thereby increasing the operational parameters of the aircraft.

While the UAV operates as a total system that would require certification of all the parts of that system, not just the aircraft, this process could still be adopted successfully. I recommend the above-outlined stair-step approach be used by UAV operators and manufacturers of Category III UAVs as a way to work toward full integration. The recommended path does not require much in the way of a new regulatory construct for airworthiness certificates initially, and once again, the process places the burden on manufacturers to develop and field UAVs that can meet existing concepts for safe flight. However, as manufacturers begin the process, the FAA will have an increased ability to establish standards and requirements, which in turn will speed up the process for next-generation UAVs.

2. Certification and Licensing of Personnel

As with the previously discussed areas, the use of existing rules is preferred to inventing new concepts for the UAV pilot. As such, the concept of a pilot in command is a universally accepted regulatory construct. [FN476] For Category III UAVs, it would not be unreasonable to require the pilot in command to be qualified to the same degree as pilots of pilot-on-board aircraft. However, as was recognized by the UK in CAP 722, pilots, if different from the commanding pilot, could have lesser, maybe more technical, requirements. [FN477] This would allow persons more familiar with the engineering and technical capabilities of the UAV system to have hands-on control of the aircraft. Such personnel might be able to respond to technical or mechanical problems better than a rated pilot without such a background. Nevertheless, the flight would still be under the control of a pilot in command trained in air navigational rules and instruments, and who may even be experienced as a pilot of pilot-on-board aircraft.

The biggest issue, however, is the type of UAV-specific education and flight experience necessary for the commanding pilot, as well as for all other certified airmen such as flight engineers, ***609** mechanics, and technicians. That issue would need to be addressed clearly and established by the FAA. For Category I and II pilots, since their operations will be in either uncontrolled or greatly limited airspace, they would not need to be licensed under the same requirements as Category III pilots. The rules currently applicable under AC 91-57 for Category I and under Part 103 of the FARs for Category II could easily be adapted for such pilots. [FN478]

Lastly, there is the issue of the medical certification of UAV personnel. While UAVs fly in the air, generally their pilots do not. Arguably the physically demanding requirements of airborne flight are therefore different for ground-based UAV pilots, and, in fact, more similar to ATC personnel. [FN479] There is merit in this argument since the interface between pilot and machine is electronically based, sitting behind a control panel on the ground. Therefore, ground based UAV pilots should not be required to receive higher than a second-class airman medical certificate, which is what is required for ATC personnel. [FN480] For those occasions that the UAV pilot is airborne, it would not be unreasonable to require the medical certification of such pilots to meet the level of pilot-on-board aircraft. It would also seem reasonable that all similarly applicable rules, such as maximum hours, [FN481] could be made applicable to UAV pilots.

C. Summary Of Further Actions

The following table represents a summary of the actions necessary to move the UAV towards "file and fly" integration into the NAS.

***610** FIGURE 4-3: TABLE OF ACTIONS

Issue	Actor	Action	Timing and Priority
Operational and Security Regulations and Flight Rules	FAA/TSA	Amend applicable CFRs	Hot-For Cat I, II, amend as soon as possible to allow operations
			Medium- For Cat III, amend as the first UAV/ROAs begin the process of seeking type certificate

Certificate of Airworthiness	Industry	Begin process to obtain Type, Production, and Airworthiness Certificates	Hot-For Cat III, industry must continue to establish standards and tech- nology to form equiv- alent levels of safety by using current regulatory system to obtain type certificate
International Aviation Standards	ICAO	Establish uniform aviation rules applicable to UAV/ROA	Medium-International flight of UAV/ROAs will require uniform standards and operating rules to facilitate global recognition of Contracting States' UAV/ROA certificates
Equivalent Levels of Safety	Industry ITU FCC	Develop and field d Cat III UAV/ROA that meets safety standards for pilot-on-board aircraft, as well as UAV/ROA specific requirements, such as communication link security	Hot-File and fly Cat III operations require certified UAV/ROAs that meet equivalent levels of safety

V. CONCLUSION

While the UAV has had a slow flight into the NAS, part of that flight path has been hampered with technological obstacles that are part and parcel to the concept of remotely or autonomously operated aircraft. The early history of the UAV was focused on military uses that either did not require operations in controlled airspace or in airspace more or less controlled by wartime conditions. Nevertheless, for UAVs to blossom into their full utility, they must operate in different environs. As one researcher and author put it: “Unlike the early years of aviation, UAVs do not operate in empty skies. Rather they must contend with a mature civil aviation system--one filled with aircraft, controlled and monitored by complex systems, dominated by large commercial ***611** markets, saturated by interest groups, and governed by a voluminous regulatory structure.” [FN482]

The regulatory structure that governs the NAS is primarily focused on the safe and efficient transit of aircraft. This system is designed to allow for the operation of aircraft in differing levels of complexity and congestion. The integration of the UAV can take advantage of this complex system already in place, and, in fact, thrive under its rules.

While the history of the UAV has focused on military uses, and the short-term future will be dominated by military uses, pilot-on-board aircraft had a similar starting pace. In fact, one can argue that both civilian and military aircraft development has benefited from advances in each other's genre; so will it be with military and civilian UAV development. As commercially viable UAVs are developed, certified, and flown into the NAS, militaries will not only benefit from modified operational rules, domestically and internationally, but costs to build or buy off the shelf will decrease as supply increases. However, there is work to be done.

First, the FAA should take action to allow for operations without requiring a COA through FAA Order 7610.4 for UAVs that will operate below 1200 feet (365.76 meters) AGL in the line-of-sight of its operator at a limited airspeed. These aircraft could be categorized as Category I UAVs. Additionally, the FAA should adopt simplified provisions to allow for UAVs that are designed to safely operate out of the pilot's line-of-sight at limited airspeeds in uncongested airspace not controlled by the ATC. These could be categorized as Category II UAVs.

For all other UAVs, "file and fly" use of the NAS is still years away. However, as the industry, including research conducted or funded by the Armed Forces, is able to develop equipment and systems that meet equivalent levels of safety necessitated by the FARs, the UAV will be able to easily slide into existing rules of flight, only modified slightly to account for some unique characteristics. These unique characteristics include the multilocation system that makes up the UAV, as well as operational centers capable of controlling multiple aircraft. Drastic regulatory changes are not necessary as the UAV evolves technologically. Nevertheless, changes are necessary domestically and internationally.

***612** This researcher recalls reading books in the 1970s that foresaw flying vehicles replacing land-based cars by the mid-1990s. Sometimes technology can not keep up with the fast pace of futuristic dreamers. Be that as it may, the UAV's future is not as speculative. Sure, pure autonomous flight within all parts of the NAS may not be realized as fast as some predict, but then again, only time will tell.

[FNa1]. Institute of Air and Space Law, Faculty of Law, McGill University, Montreal, Quebec. I am indeed grateful unto the United States Air Force for giving me this once-in-a-lifetime experience to further my education and professional career by obtaining an advanced degree (LL.M.) through the Institute of Air & Space Law at McGill University, Montreal. While too numerous to mention, I have had many mentors within the ranks of the Air Force who have had an instrumental hand in guiding me to this point in my career, to which I give my thanks. However, my deepest gratitude goes to my supportive wife whose tireless efforts have allowed me to devote the time and effort necessary to obtain this degree and write this thesis. Finally, I am most appreciative to the insightful and consistent assistance given by Professor Richard Janda who guided me as my thesis supervisor.

[FN1]. See generally Anthony J. Lazarski, Legal Implications of the Uninhabited Combat Aerial Vehicle, Aerospace Power J., Summer 2002, at 74-83; Richard J. Newman, The Little Predator That Could, Air Force Mag., Mar. 2002, at 49, available at http:// www.airpower.maxwell.af.mil/airchronicles/apj/apj02/sum02/lazarski.html (last visited May 29, 2006).

[FN2]. See Lazarski, supra note 1, at 75. Predator is manufactured by General Atomics Aeronautical Systems, a San Diego based company. See generally Gen. Atomics Aeronautical Sys., Remotely Operated Aircraft Systems, http:// www.uav.com/home/index.html (last visited May 26, 2006).

[FN3]. Newman, supra note 1, at 49.

[FN4]. See Newman, supra note 1, at 49; John Pike, Fed'n of Am. Scientists Intelligence Res. Program, Unmanned Aerial Vehicles (UAVs), http:// www.fas.org/irp/program/collect/uav.htm (last visited Mar. 23, 2005).

[FN5]. Elizabeth Bone & Christopher Bolkcom, Unmanned Aerial Vehicles: Background and Issues for Congress, Cong. Research Serv., RL31872, at 1 (Apr. 25, 2003), available at http://www.fas.org/irp/crs/RL31872.pdf.

[FN6]. See generally Lazarski, supra note 1, at 75.

[FN7]. See id.

[FN8]. Id.; see also Def. Sci. Bd., Dep't of Def., Defense Science Board Study on Unmanned Aerial Vehicles and Uninhabited Combat Aerial Vehicles, at 6-17 (Feb. 2004), available at http://www.acq.osd.mil/dsb/reports/UAV.pdf.

[FN9]. Id. at 17-18.

[FN10]. See generally id. at 17-18, 37.

[FN11]. See id. “National Airspace System” is defined by the FAA as “[t]he common network of U.S. airspace; air navigation facilities, equipment services, airports or landing areas; aeronautical charts, information and services; rules, regulations and procedures, technical information, and manpower and material. Included are system components shared jointly with the military.” Fed. Aviation Admin., Pilot/Controller Glossary, in Aeronautical Info. Manual: Official Guide to Basic Flight Info. & ATC Procedures (2006), available at http://www.faa.gov/ATpubs/PCG/PCG.pdf.

[FN12]. Bone & Bolkcom, supra note 5, at 5. One study prepared by the Defense Science Board compared mishap rates among three current operating UAVs, F-16s, general aviation aircraft, and long and short range commercial aircraft. While UAVs have not flown nearly the number of hours of the other aircraft, the UAV mishap rate was substantially higher. For example, the Pioneer UAV (the only UAV used by the Navy and Marines) held the worst mishap rate, with a projected mishap rate of 334 per 100,000 hours of flight. This is compared to a mishap rate of 32 for the Predator and 3 for the manned fighter F-16. However, when compared to civil aviation numbers of 1 per 100,000 hours for general aviation aircraft, 0.1 for regional commuters, and 0.01 for larger airliners, it is clear that UAVs must reduce mishap rates prior to free and full movement in civilian airspace. Def. Sci. Bd., supra note 8, at 17-18 see also Near Hit, Air Safety Wk., Oct. 18, 2004, at 4 (reporting that in the skies over Kabul, Afghanistan, a UAV and manned jetliner had a near-miss incident as the jet approached the airport for landing, thus causing the UAV to crash as a result of turbulence caused by the jet's wake).

[FN13]. Def. Sci. Bd., supra note 8, at 37.

[FN14]. See generally Joint JAA/EUROCONTROL Initiative on UAVs, UAV Task-Force Final Report (2004), available at http://198.17.75.100/news/news.html (follow “UAV Task-Force Final Report” hyperlink) (last visited Jan. 15, 2005) [hereinafter UAV Task-Force Final Report].

[FN15]. See id.

[FN16]. See generally Envtl. Research Aircraft & Sensor Tech. Project, Nat'l Aeronautics & Space Admin., Certification & Regulatory Roadmap: High-Altitude Long-Endurance Unmanned Aerial Vehicles 11-14 (Version 1.3 2002), available at http://www.psl.nmsu.edu/UAVdmap/Content.htm (last visited Mar. 19, 2005) [hereinafter NASA, Certification Roadmap].

[FN17]. See Nathan Hodge, Jumper: Military Must Reorganize UAV Efforts, Defense Daily, Apr. 29, 2005, at 7.

[FN18]. See generally id.

[FN19]. Id.

[FN20]. Id.

[FN21]. The ICAO is an international organization established by the 1944 Chicago Convention to manage the safety and security of the world's civil aviation, currently headquartered in Montreal, Canada. See generally Convention on International Civil Aviation, Dec. 7, 1944, 61 Stat. 1180, 15 U.N.T.S. 295, arts. 1-10, 43-79 [hereinafter Chicago Convention]. For more information on the purposes and roles of ICAO, see its homepage at http:// www.icao.int/ and Assad Kotaite, Security of International Civil Aviation--Role of ICAO, 7 Annals Air & Space L. 95 (1982).

[FN22]. The ITU, headquartered in Geneva, Switzerland, was created initially as the International Telegraph Union before the turn of the twentieth century, on May 17, 1865, and is the oldest specialized agency of the United Nations. ITU Overview: History, http://www.itu.int/aboutitu/overview/history.html (last visited May 27, 2006). The ITU serves three major functions: (1) regulating the radio frequency spectrum, (2) establishing rate and equipment standards for telecommunications, and (3) coordinating use of the highly desired geostationary orbit. Francis Lyall, Law & Space Telecommunications 311, 387 (1989). For more information on the ITU, see http://www.itu.int; Joseph Wilson, The International Telecommunication Union and the Geostationary Satellite Orbit: An Overview, 23 Annals Air & Space L. 249 (1998).

[FN23]. Fed. Aviation Admin., Memorandum, Unmanned Aircraft Systems Operations in the U.S. National Air Space System - Interim Operational Guidance, AFS-400 UAS Policy 05-01 (Sept. 16, 2005) available at http:// www.uavm.com/images/AFS-400_05-01_faa_uas_policy.pdf [hereinafter AFS-400 UAS Policy].

[FN24]. See generally Laurence R. Newcome, Unmanned Aviation: A Brief History of Unmanned Aerial Vehicles 1-9 (2004); UAV Task-Force Final Report, supra note 14.

[FN25]. Newcome, supra note 24, at 4-5. Note that Newcome's arguments address the term “ROA”, but are still relevant with the terms “UA” or “UAS.”

[FN26]. Id.

[FN27]. AFS-400 UAS Policy, supra note 23, para. 5.

[FN28]. See Newcome, supra note 24, at 4-5.

[FN29]. See id.

[FN30]. See 14 C.F.R. §§ 21, 23, 31, 34, 36, 43, 91, 121, 135, 137 (2006).

[FN31]. For example, the UAV Task-Force Final Report, supra note 14, annex 1, includes a sample regulatory framework for “light” UAVs. That report defines “light UAVs” as “those with a maximum take-off mass below 150kg, and a maximum speed not exceeding 70kts, that are operated within 500 meters of the UAV-pilot and not more than 400 ft above ground level.” UAV Task-Force Final Report, supra note 14, annex 1, at 1.

[FN32]. Civil Aviation Auth. (U.K.), CAP 722--Unmanned Aerial Vehicle Operations in UK Airspace - Guidance, Ch. 1, § 2.1 (2002) [hereinafter CAP 722].

[FN33]. Matthew T. DeGarmo, Issues Concerning Integration of Unmanned Aerial Vehicles in Civil Airspace § 2.4.4.2 (2004), available at http:// www.mitre.org/work/tech_papers/tech_papers_04/04_1232/04_1232.pdf.

[FN34]. Jane's All the World's Aircraft 38-39 (Paul Jackson ed., 2001-2002).

[FN35]. See generally Newcome, supra note 24, at 114. This flight was of the UAV Aerosondes, which on 22 September 1997 flew totally autonomously for one hour; from takeoff to landing, it flew under continuous autopilot. Aerosonde - Article, Aircraft: Our First Fully Robotic Flight, http:// www.aerosonde.com/drawarticle/5 (last visited Apr. 30, 2005). The Aerosondes is manufactured by Aerosonde Pty Ltd., an Australian company, and is marketed as a long endurance (up to 36 hours of operation), autonomous UAV, which is ideal for remote observation of, for example, Antarctica, the Canadian Northern Regions, and the Australian interior. See generally J.A. Curry, et al., Applications of Aerosondes for RIME, http://polarmet.mps.ohio-state.edu/RIME-01/pdf_docs/curry.pdf (last visited Apr. 29, 2005); Aerosonde - Welcome, http://www.aerosonde.com/index.php (last visited Sept. 22, 2006).

[FN36]. See Jefferson Morris, Global Hawk Sets Record on Flight to Australia, Aerospace Daily, Apr. 24, 2001, at 1; William Reynish, UAV/ROAs Entering the NAS, Aviation Today, Oct. 2004, available at http:// www.aviationtoday.com/cgi/av/show_mag.cgi? pub=av&mon=1004&file=UAVsenteringthe.htm.

[FN37]. See Jefferson Morris, USAF No Longer Viewing Global Hawk as an Autonomous System, Official Says, Aerospace Daily, Dec. 5, 2003, at 1.

[FN38]. Further, it almost goes without mentioning that the term "UAV" or "Unmanned Aerial Vehicle" is not necessarily gender-neutral. While it could be argued that the term "man" is universally seen as a gender-neutral term, "unmanned aerial vehicle" may actually be a euphemism for an aircraft piloted completely by women. The term "ROA" completely removes any use of a term that references gender.

[FN39]. Chicago Convention, supra note 21. Fifty-two allied and neutral nations participated in the International Civil Aviation Conference that drafted and signed the Chicago Convention. ICAO, http://www.icao.int/cgi/goto_m.Pl?/icaonet/dcs/7300.html (last visited July 29, 2006).

[FN40]. See Convention on International Civil Aviation, Dec. 7, 1944, 61 Stat. 1180, 15 U.N.T.S. 295, Annex 2, Rules of the Air, Ch. 1 (9th ed. 2001) [hereinafter Chicago Convention, Annex 2].

[FN41]. Id.

[FN42]. Dept. of Def., Unmanned Aerial Vehicles Roadmap 2002-2027 2 (2002).

[FN43]. Amy Butler & David A. Fulghum, New Frontiers, Aviation Wk. & Space Tech., Mar. 7, 2005, at 22-24.

[FN44]. Dept. of Def., DOD Dictionary of Military and Associated Terms, Joint Publ'n 1-02 (Apr. 14, 2006), available at http:// www.dtic.mil/doctrine/jel/doddict/index.html [hereinafter DOD Dictionary].

[FN45]. For example, "Iridium was a system of low-earth satellites. Built at a cost of billions, millions were needed each month to maintain them in low earth orbit. Its operating losses were so large that the creditors faced the choice of selling the satellites for less than 1% of what it cost to put them in orbit or firing their retrorockets and burning them up in the atmosphere." Douglas G. Baird, The New Face of Chapter 11, 12 Am. Bankr. Inst. L. Rev. 69, 74 (2004).

[FN46]. ERAST Project, Nat'l Aeronautics & Space Admin., Concept of Operations: High-Altitude Long-Endurance Unmanned Aerial Vehicles 1 (Version 1.2 2002), available at http://www.auvsi.org/faa/docs/operations.pdf [hereinafter NASA, Concept of Operations].

[FN47]. NASA, Certification Roadmap, supra note 16, at 6.

[FN48]. Id. In the United States, Class A airspace is designated from 18,000 feet (5486.4 meters) MSL (mean sea-level) to and including flight level (FL) 600, or approximately 60,000 feet (18,288 meters). 14 C.F.R. § 71.33 (2006).

[FN49]. See NASA, Certification Roadmap, supra note 16, at 7; UAV Task-Force Final Report, supra note 14, at 4-5.

[FN50]. Aviva Brecher, Val Noronha & Martin Herold, UAV 2003 a Roadmap for Deploying Unmanned Aerial Vehicles (UAVs) in Transportation 5 (2003), available at http://www.ncgia.ucsb.edu/ncrst/ (follow "Meetings" hyperlink; then "Roadmap for Deploying UAVs in Transportation" hyperlink).

[FN51]. UAV Task-Force Final Report, supra note 14, at 4-5.

[FN52]. Id. at 4-5.

[FN53]. See Brecher et al., supra note 50, at 4; UVS Int'l, UAV Categorisation, in 2004 Yearbook: UAVs Global Perspective 156 (2004) [hereinafter UAV Categorisation].

[FN54]. See generally Newcome, supra note 24, at 11-56.

[FN55]. See generally John D. Anderson Jr., Introduction to Flight Its Engineering and History 24-25 (1978); Gene Gurney, A Chronology of World Aviation 1-4 (1965).

[FN56]. Bone & Bolkcom, supra note 5, at 6.

[FN57]. See DeGarmo, supra note 34, at 1-2.

[FN58]. See generally, UVS Int'l, Historical Threads Leading to Today's Unmanned Vehicles in the USA, in 2004 Yearbook: UAVs Global Perspective 108, 111 (2004) [hereinafter Historical Threads].

[FN59]. Newcome, supra note 24, at 16.

[FN60]. See generally Newcome, supra note 24; Charles H. Gibbs-Smith, The Aeroplane: An Historical Survey of its Origins and Development 87 (1960) [hereinafter Gibbs-Smith, The Aeroplane]. The Sperrys' invention and demonstration won a 15,000 francs prize at the competition.

[FN61]. See Gurney, supra note 55, at 19. They received the Collier Trophy for the most noteworthy aviation achievement in 1914 by demonstrating the Sperry Gyroscopic stabilizer to a committee of the Aero Club of America. Id.

[FN62]. Charles H. Gibbs-Smith, Aviation: An Historical Survey from its Origins to the End of World War II 166 (1970) [hereinafter Gibbs-Smith, Aviation].

[FN63]. See generally id. at 192-93. Gibbs-Smith's historical survey provides this account of the impact of Elmer and Lawrence's work:

> Instrument flying began to be practical by the end of the war, but it was during the years 1919-29 that blind flying became successful and practical, chiefly as a result of Sperry's work in the United States; Sperry perfected the gyro horizon and directional gyro, and on September 24th 1929, Lieutenant James Doolittle, in a Sperry-equipped Consolidated NY-2 biplane, was able "to take off, fly a specific course, and land without reference to the earth." During the next decade, instrument flying was to become as routine accomplishment for all commercial and military pilots.

Id.

[FN64]. Id. at 170.

[FN65]. See Newcome, supra note 24, at 18.

[FN66]. See Marc J. Seifer, Wizard: The Life and Times of Nikola Tesla: Biography of a Genius 377 (1996).

[FN67]. See Newcome, supra note 24, at 16-17.

[FN68]. Seifer, supra note 66, at 193-95. Nikola Tesla made many scientific advances and has been called "one of the world's most influential inventors." Twenty First Century Book, http://www.tfcbooks.com/tesla.htm (last visited July 8, 2006). There are a number of projects, websites, and books dedicated to the life and scientific work of Nikola Tesla. The Nikola Tesla Science & Technology Center and Museum is in Shoreham, New York, found at http:// www.teslasciencecenter.org. One author has called Tesla's telautomaton "one of the single most important technological triumphs of the modern age." Id. at 200.

[FN69]. See generally id. at 100-01.

[FN70]. Id. at 195.

[FN71]. Historical Threads, supra note 58, at 110.

[FN72]. See Newcome, supra note 24, at 13.

[FN73]. See generally Seifer, supra note 66, at 17, 333.

[FN74]. See generally id. at 71, 160.

[FN75]. Newcome, supra note 24, at 18-19.

[FN76]. Id. at 18-20.

[FN77]. Id. at 20. There are other accounts that in 1916 "[a] radio-controlled pilotless monoplane, the Aerial Target, designed by H.P. Folland with radio gear by A.M. Low, was flown at the British Royal Aircraft Establishment at Farnborough." Gurney, supra note 55, at 23. However, another source from Australia's Monash University discounts that account as never happening, stating that the 1916 account was not an H.P. Folland designed aircraft but a Sopwith that never left the hanger. Monash Univ. Ctr. for Telecomms. & Info. Eng'g, Remote Pilots Aerial Vehicles: The "Aerial Target" and "Aerial Torpedo" in Britain, http://www.ctie.monash.edu.au/hargrave/rpav_ britain.html (last visited June 11, 2006). Further, later attempts in 1917 by a De Havilland built small mono plane and a H.P. Folland aircraft got off the ground but were either uncontrollable or later crashed and, thus, not successful enough to garner further military funding. See id. Monash agrees that a flight on 3 September 1924, which will be discussed later, was the first successful radio controlled flight of a UAV. Id.

[FN78]. See Newcome, supra note 24, at 20.

[FN79]. See id. at 19-20.

[FN80]. See id.

[FN81]. Id. at 31.

[FN82]. See id. at 34. Apparently, Lawrence Sperry was overdue from a flight across the English Channel, and a search team found his body floating in the water as it washed ashore; his plane, however, was found intact and floating three miles off the British shore. Id.

[FN83]. See id. While the Sperry Aircraft Company dissolved, the Sperry Gyroscope Company continued to develop and work on the automatic-pilot systems developed by Lawrence Sperry. See The American Heritage History of Flight 246 (Alvin M. Josephy, Jr., ed. 1962). The American Heritage History of Flight stated that "The Sperry Gyroscope Company in the fall of 1932, had perfected an automatic pilot that made it possible for the pilot to relax in the cockpit while the plane flew itself." Id. Further, as to the accolades of Lawrence Sperry, which includes the aerial torpedo, the First Flight Society provides the following words:

Lawrence B. Sperry, 1892-1923, Inventor of the Autopilot, Turn and Bank Indicator, and Parachute Pack. Known to his fellow aviators as "Gyro," Lawrence Sperry was to many a handsome figure who might have stepped from the pages of a novel. His contributions were not in the entertainment industry, but rather in the many innovative flight instruments he constantly conceived, developed and personally tested. Among Sperry's creations are the automatic pilot, the turn and bank indicator, the seat pack parachute and retractable landing gear. He was among the first to fly at night and regularly flew night flights for the Army in 1916. He was one of the first to make parachute jumps for fun, and at the Dayton Air Show in 1918 thrilled crowds with a bold parachute jump. One of his greatest achievements in the field of military aviation was the development of the aerial torpedo. Sperry lost his life on December 13, 1923, attempting a flight from England to Holland when his plane "Messenger" went down in the English Channel. Today there is no commercial, military or private airplane in the world that is not equipped with the basic flight instruments developed by Lawrence Burst Sperry.

First Flight Shrine, Lawrence B. Sperry, http:// www.firstflight.org/shrine/lawrence_sperry.cfm (last visited Apr. 5, 2005).

[FN84]. See Newcome, supra note 24, at 37-38.

[FN85]. Id. at 38, 45, 139.

[FN86]. Id. at 45.

[FN87]. See Gibbs-Smith, The Aeroplane, supra note 60, at 176; supra note 77 and sources cited therein.

[FN88]. See Newcome, supra note 24, at 43-45.

[FN89]. Id.

[FN90]. Id.

[FN91]. See id. at 46. Apparently, British interest in target drones was fueled by United States Army Air Corps Brigadier General Billy Mitchell's demonstration of aircraft bombing and sinking retired United States Navy warships. Id. While the debate on the effectiveness of aircraft upon Navy ships brewed in the United States, in Britain the debate was approached a little differently as the Royal Navy developed unmanned aircraft to prove that the warships could shoot down aircraft. Id. It was soon noted, however, that anti-aircraft skills needed to improve. Id.

[FN92]. See generally id.

[FN93]. Id. at 47.

[FN94]. See id. The 1939 edition of Jane's All The World's Aircraft states, "The D.H. 'Queen Bee' is a variation of the 'Tiger-Moth' fitted with radio control to convert it into an air target for anti-aircraft gunnery practice ... may be used as a landplane or seaplane." Jane's All The World's Aircraft 33(c) (C.G. Grey & Leonard Bridgman eds., 1939).

[FN95]. Newcome, supra note 24, at 48.

[FN96]. See generally id. at 49-56.

[FN97]. See Gibbs-Smith, Aviation, supra note 62, at 122.

[FN98]. Lazarski, supra note 1, at 75-76.

[FN99]. See id.

[FN100]. Id.

[FN101]. Newcome, supra note 24, at 68-69.

[FN102]. Id. at 69.

[FN103]. Id.

[FN104]. Id.

[FN105]. Surveillance is defined by the DoD and NATO as "[t]he systematic observation of aerospace, surface, or subsurface areas, places, persons, or things, by visual, aural, electronic, photographic, or other means." DOD Dictionary, supra note 44.

[FN106]. Reconnaissance is defined by DoD and NATO as "[a] mission undertaken to obtain, by visual observation or other detection methods, information about the activities and resources of an enemy or potential enemy, or to secure data concerning the meteorological, hydrographic, or geographic characteristics of a particular area. Also called RECON." Id. The main difference between surveillance and reconnaissance is that the latter contemplates a specific mission to observe a specific target area or group, while surveillance is observation of all groups, terrain, events, or items in a given geographical area.

[FN107]. Gibbs-Smith, The Aeroplane, supra note 60, at 56.

[FN108]. See Pike, supra note 4. Since 1964, the DoD has funded research and development of eleven different UAVs, but only three entered into production. Id.

[FN109]. Historical Threads, supra note 58, at 108-09.

[FN110]. Id. at 109.

[FN111]. Id.

[FN112]. DeGarmo, supra note 33, at 1-3; see also Andres Parsch, Directory of U.S. Military Rockets and Missiles, http://www.designation-systems.net/dusrm/app4/d-21.html (last visited July 26, 2006) ("A total of four operational missions were eventually flown (9 Nov 1969, 16 Dec 1970, 4 Mar 1971, 20 Mar 1971), all overflying the People's Republic of China under the project code name SENIOR BOWL. Only two (the 2nd and 3rd) drones completed their flights, but in both cases the hatch with the reconnaissance camera could not be recovered because of system malfunctions and/or bad handling of the recovery effort. In July 1971, the Tagboard program was cancelled. The reasons included the poor measure of success of the SENIOR BOWL flights, and the service entry of a new generation of photo reconnaissance satellites which could produce equivalent results without the political risks of flights through denied air space").

[FN113]. Jane's All The World's Aircraft 191 (Leonard Bridgman ed., 1959-1960) [hereinafter Jane's 1959-1960].

[FN114]. Jane's All The World's Aircraft 510-23 (John W.R. Taylor ed., 1969-1970).

[FN115]. See Newcome, supra note 24, at 68-69; Bone & Bolkcom, supra note 5, at 2. There were three main United States UAVs flown in operations during the Vietnam War: the AQM-34 Lightning Bug, QH-50 Antisubmarine Helicopter, and

GTD-21. Newcome, supra note 24, at 83. The most heavily used was the AQM-34, known as the Lightning Bug, which flew 3435 combat sorties, and over 100,000 feet (30,480 meters) of reconnaissance film taken and recovered. Id. at 83. Laurence Newcome recounts the success of the AQM-34 in that war:

If the single largest contribution made by drones during the Vietnam War had to be identified, it would be from the Lightning Bug mission on 13 February 1966. On that flight, a specially modified Bug, equipped with ELINT [electronic intelligence collection] sensors and a data link to instantaneously relay the sensor data to waiting recorders, flew against a known SA-2 [high-altitude surface-to-air missile] site near, Vinh, North Vietnam, on a one-way mission. Its purpose was to lure a SA-2 into firing at it, then collect and relay the electronic parameters of the missile's radio-guidance and fusing systems up to the instant it was destroyed. The mission was successful, and its sacrifice resulted in critical improvements to American electronic countermeasures equipment, enhancing the survivability of manned aircraft for the rest of the war. This one mission was arguably responsible for keeping hundreds of American fighter and bomber airmen from being killed or imprisoned as prisoners of war over the next nine years.

Id.

[FN116]. See id. at 91.

[FN117]. David A. Fulghum, Star Unmanned Aircraft Faces Bureaucratic Fight, Aviation Wk. & Space Tech., Mar. 12, 2001, at 29.

[FN118]. Lazarski, supra note 1, at 75.

[FN119]. See Newcome, supra note 24, at 68-69.

[FN120]. See sources cited, supra note 35.

[FN121]. Def. Sci. Bd., supra note 8, at 5-6.

[FN122]. Bone & Bolkcom, supra note 5, at 2.

[FN123]. See id.

[FN124]. Newcome, supra note 24, at 54-55.

[FN125]. Id. at 127; see also UVS International, Commercial use of UAVs-- Widespread in Japan, in 2004 Yearbook: UAVs Global Perspective 138 (2004) [hereinafter Commercial Use in Japan].

[FN126]. See Commercial Use in Japan, supra note 125, at 138.

[FN127]. See id.; Newcome, supra note 24, at 127.

[FN128]. Jane's 1959-1960, supra note 113, at 321.

[FN129]. See Commercial Use in Japan, supra note 125, at 138.

[FN130]. See id.

[FN131]. Newcome, supra note 24, at 127.

[FN132]. See UVS International, Status Report on US UAV Programmes, in 2004 Yearbook: UAVs Global Perspective 112 (2004) [hereinafter US UAV Programmes].

[FN133]. See UAV Categorisation, supra note 53, at 156.

[FN134]. Newcome, supra note 24, at 127.

[FN135]. See id.

[FN136]. DeGarmo, supra note 33, at 1-11.

[FN137]. Jefferson Morris, DOD UAV Budget to Hold Fairly Steady in FY '06, Official Says, Aerospace Daily & Def. Rep., Feb. 10, 2005, at 1, available at http://www.aviationnow.com/avnow/news/channel_aerospacedaily_story.jsp?id=news/UAVBUDG02105.xml.

[FN138]. DeGarmo, supra note 33, at 1-11 (quoting a presentation of a UAV market study by the Teal Group at the AUVSI Unmanned Systems Symposium in August 2004).

[FN139]. UAV Categorisation, supra note 53, at 156.

[FN140]. See DeGarmo, supra note 33, at 1-4; Newcome, supra note 24, at 130; UAV Categorisation, supra note 53, at 156.

[FN141]. For example, even though United States manufacturers account for nearly two-thirds of the market, both the United States Armed Forces and the Department of Homeland Security have purchased Israeli made UAVs. DeGarmo, supra note 33, at 1-4; Newcome, supra note 24, at 128.

[FN142]. UAV Categorisation, supra note 53, at 156.

[FN143]. Id. One researcher summarized certain national efforts as follows:

• France is studying UCAVs as a replacement for its Rafal fighter aircraft. It has a $350 million program to produce a UCAV by 2015 that [is] capable of delivering two 500 lbs. guided bombs. France is also interested in developing or acquiring HALE and Medium Altitude Long Endurance (MALE) systems.

• The British Royal Air Force is set to acquire MALE and tactical UAV Tactical Unmanned Aerial Vehicle (TUAV) systems under its $1.3 billion Watchkeeper program.

• The Italian Air Force is seeking the development of a UCAV system and could be flying a precision strike capable aircraft by 2008.

• Sweden has developed and flown a small scale UCAV, but will likely contribute its efforts to the French UCAV program and could contribute between $70 and $90 million to the effort.

• Germany is seeking to acquire the U.S. Global Hawk. Successful tests of the Global Hawk were demonstrated in Europe in the spring of 2004.

• Israeli industries are developing a number of MALE systems, primarily for intelligence gathering. Israel is also contracted to produce a number of TUAV systems for foreign clients.

• The Russian military has evaluated several TUAVs from Russian manufacturers. Yakolev is studying the development of UCAVs; Tupolev is projected to work on a MALE; and Sukhoi is collaborating with France's Dassault on the development of a UAV.

• Australia is undertaking a comprehensive review of its UAV needs. They have expressed interest in Boeing's UCAV and the Global Hawk. The military has used their indigenous Aerosonde UAV for surveillance and communications relay during military operations in the South Pacific.

• Singapore has a HALE UAV requirement as a replacement for a manned surveillance aircraft. They are also looking into a ship-based VTOL UAV, possibly the U.S. Fire Scout.

• The South Korean government is seeking to develop a “smart” Vertical Take-Off and Landing (VTOL) UAV and is discussing the development of an improved version of the U.S. Eagle Eye tiltrotor UAV.

DeGarmo, supra note 33, at 1-12 to 1-13.

[FN144]. Next generation UCAVs, like the Boeing X-45, will be advanced stealth strike aircraft that could be used for operational missions that would include “electronic attack; suppression of enemy air defenses; intelligence, surveillance and reconnaissance; and deep strike.” Boeing, X-45 Background Info, http://www.boeing.com/defense-space/military/x-45/x45back.html (last visited May 2, 2005).

[FN145]. See Vasilios Tasikas, Unmanned Aerial Vehicles and the Doctrine of Hot Pursuit: A New Era of Coast Guard Maritime Law Enforcement Operations, 29 Tul. Mar. L.J. 59 (2004); Rich Tuttle, Afghanistan Operations Boost Vision of UAVs for Homeland Defense, Aerospace Daily & Def. Rep., Jan. 2, 2002, at 7.

[FN146]. See David Gibson, Innovative Technology: Unmanned Aerial Vehicle Provides New Traffic View, Res. & Tech. Transporter (2003).

[FN147]. See High Times, Economist, Dec. 3, 2003, at 79-81, available at http://www.economist.com/science/displaystory.cfm?story_id=2282185; David Wichner, Small UAVs Geared to be Eyes in Skies, Ariz. Daily Star, Apr. 21, 2005, at D1, available at http:// www.dailystar.com/dailystar/allheadlines/71467.php.

[FN148]. See Cyras Farivar, A Flying Crime Fighter (Some Assembly Required), N.Y. Times, Jan. 13, 2005, at G7.

[FN149]. See High Times, supra note 147, at 79-81.

[FN150]. See id.

[FN151]. See generally UAV Tech. Analysis & Applications Ctr., N.M. State Univ., UAVs Soaring Beyond Military Uses, http:// www.psl.nmsu.edu/UAV/news/usa/index2.php (last visited May 2, 2005).

[FN152]. See Bill Sweetman, HALE Storms to New Heights, Jane's Int'l. Def. Rev., Mar. 1, 2001, available at http:// www.janes.com/aerospace/military/news/idr/idr010301_2_n.shtml; NASA Dryden Flight Research Ctr., Past Projects-Helios Prototype, http:// www.nasa.gov/centers/dryden/history/pastprojects/Erast/helios.html (last visited May. 27, 2006) [hereinafter Helios Prototype].

[FN153]. See id.

[FN154]. See Advanced Tech. Office, Def. Advance Research Projects Agency, Airborne Communications Node (ACN/AJCN), http:// www.darpa.mil/ato/programs/acn/index.htm (last visited May 27, 2006).

[FN155]. Sweetman, supra note 152.

[FN156]. See id.

[FN157]. Id.

[FN158]. See Helios Prototype, supra note 152; Sweetman, supra note 152.

[FN159]. See generally Sweetman, supra note 152.

[FN160]. US UAV Programmes, supra note 132, at 112-13.

[FN161]. U.S. Air Force, Fact Sheet: C-21, http:// www.af.mil/factsheets/factsheet.asp?fsID=88 (last visited May 27, 2006) [hereinafter C-21].

[FN162]. Id.; U.S. Arsenal, Associated Press, Specifications: Global Hawk, http://abclocal.go.com/images/wabc/USArsenal/ (last visited May 27, 2006).

[FN163]. C-21, supra note 161. The C-21 can carry up to eight passengers and two crew. Id.

[FN164]. See Newcome, supra note 24, at 112.

[FN165]. Am. Tech. Alliance, White Paper, Vanguard Alliance: National Next Generation Aircraft Technology Program Introducing Remotely Operated Aircraft (ROA) into the National Airspace System (NAS), Nov. 2001 (submitted to U.S. Department of Transportation Research and Special Programs Administration (RSPA), Solicitation DTRS56-01-BAA-0002), available at http:// www.erast.com/ehtml/vanguard.html.

[FN166]. FAA, FAA Order 7610.4K, Special Military Operations, § 12-9 (Feb. 2004) [hereinafter FAA Order 7610.4K]; see also FAA, FAA Order 7210.3T, Facility Operation and Administration, § 18-5 (Feb. 2005).

[FN167]. FAA Order 7610.4K, supra note 166, § 12-9-2.

[FN168]. See generally Chicago Convention, supra note 21; U.S. Dep't of State, Proceedings of the International Civil Aviation Conference (Vol. I & II, 1948). This meeting occurred in November and December of 1944 in Chicago, Illinois.

[FN169]. See generally Ray Bonds, The Illustrated Directory of a Century of Flight 156-235 (2003).

[FN170]. See id. at 144-55.

[FN171]. See generally id. at 230-31.

[FN172]. Chicago Convention, supra note 21. Fifty-two allied and neutral nations participated in this International Civil Aviation Conference that drafted and signed the Chicago Convention. See Int'l Civ. Aviation Org., http://www.icao.int/cgi/goto_m.pl?icao/en/hist/history02.htm (last visited June 7, 2006) [hereinafter ICAO].

[FN173]. See Chicago Convention, supra note 21, arts. 1-10, 43-79.

[FN174]. See ICAO, Memorandum on ICAO, at 9, available at http:// www.icao.int/cgi/goto_m.pl?/icao/en/publmemo.pdf.

[FN175]. See ICAO, supra note 172.

[FN176]. See generally Stephen M. Shrewsbury, September 11th and the Single European Sky: Developing Concepts of Airspace Sovereignty, 68 J. Air L. & Com. 115, 117-33 (2003).

[FN177]. Chicago Convention, supra note 21, art. 1.

[FN178]. Id. art. 8.

[FN179]. See id. art. 3.

[FN180]. Id. art. 3(c).

[FN181]. Id. art. 3(d).

[FN182]. Id. art. 12.

[FN183]. See id. art. 37.

[FN184]. ICAO adopts such SARPs through the work of its Council, which is one of its permanent bodies and is elected by the General Assembly, which is held at least every three years. See id. arts. 50(a), 54(l). Pursuant to article 54(l) of the Chicago Convention, the Council, “for convenience,” designates the SARPs as annexes to this Convention. The Council adopts such annexes through a 2/3rds vote, and become effective within three months after its submission unless a majority of Contracting States registered disapproval. Id. art. 90(a).

[FN185]. Id. art. 17.

[FN186]. Id. art. 20.

[FN187]. Such registration can only take place in one State at a time but may be transferred to another State. Id. arts. 19, 83.

[FN188]. See id. art. 29.

[FN189]. Id. art. 31.

[FN190]. Id. art. 32.

[FN191]. Consider the right to take aerial photographs over the high seas in the context of airspace sovereignty. It is generally recognized in international law, in both treaties and state practice, that over-flight and accompanying electronic surveillance of all varieties are available for use by State aircraft over the high seas and within declared economic zones. However, territorial waters (those up to 12 nautical miles form the coast) are considered part of the State's territory including sovereignty rights over the air. See generally Kay Hailbronner, Freedom of the Air and the Convention on the Law of the Sea, 77 Am. J. Int'l L. 490, 503-10 (1983); George K. Walker, Information Warfare and Neutrality, 33 Vand. J. Transnat'l L. 1079, 1167, 1190-91 (2000).

[FN192]. The Preamble to the Chicago Convention states:

WHEREAS the future development of international civil aviation can greatly help to create and preserve friendship and understanding among the nations and peoples of the world, yet its abuse can become a threat to the general security; and

WHEREAS it is desirable to avoid friction and to promote that cooperation between nations and peoples upon which the peace of the world depends;

THEREFORE, the undersigned governments having agreed on certain principles and arrangements in order that international civil aviation may be developed in a safe and orderly manner and that international air transport services may be established on the basis of equality of opportunity and operated soundly and economically;

Have accordingly concluded this Convention to that end.

Chicago Convention, supra note 21.

[FN193]. See generally Paul Stephen Dempsey, Compliance & Enforcement in International Law: Achieving Global Uniformity in Aviation Safety, 30 N.C.J. Int'l L. & Com. Reg. 1, 20-22 (2004).

[FN194]. Chicago Convention, supra note 21, art. 33.

[FN195]. Id.

[FN196]. As previously noted there are 18 annexes: Annex 1, Personnel Licensing; Annex 2, Rules of the Air; Annex 3, Meteorological Service for International Air Navigation; Annex 4, Aeronautical Charts; Annex 5, Units of Measurement to be Used in Air and Ground Operations; Annex 6, Operation of Aircraft; Annex 7, Aircraft Nationality and Registration Marks; Annex 8, Airworthiness of Aircraft; Annex 9, Facilitation; Annex 10, Aeronautical Telecommunications; Annex 11, Air Traffic Services; Annex 12, Search and Rescue; Annex 13, Aircraft Accident and Incident Investigation; Annex 14, Aerodromes; Annex 15, Aeronautical Information Services; Annex 16, Environmental Protection; Annex 17, Security; Safeguarding International Civil Aviation Against Acts of Unlawful Interference; and Annex 18, The Safe Transport of Dangerous Goods by Air.

[FN197]. Chicago Convention, supra note 21, art. 38. A review of the filed differences reveals that most deal with differences in terminology or involve more stringent practices.

[FN198]. A review of the annexes will reveal that recommended practices are annotated in italics and marked by the heading “Recommendation.”

[FN199]. Chicago Convention, supra note 21, art. 12.

[FN200]. Id.

[FN201]. Chicago Convention, Annex 2, supra note 40, ch. 1.

[FN202]. Id. § 2.3.1.

[FN203]. Id. § 3.1.1.

[FN204]. Id. § 3.1.2.

[FN205]. Id. § 3.1.4. As noted above, UAVs used for military purposes may have different rules. This is the case in times of conflict where the international law of the law of war, or otherwise known as the law of armed conflict (“LOAC”), would apply to the dropping of objects or substances by military UAVs. Although a detailed discussion of LOAC is beyond the scope of this thesis, a brief outline is appropriate. LOAC is derived from two main sources: customary international law and treaty law. The treaties regulating the use of force were concluded at conferences held at The Hague, Netherlands and Geneva, Switzerland. LOAC sets boundaries on the use of force during armed conflicts through application of several principles: (1) Necessity: only that degree of force required to defeat the enemy is permitted. In addition, attacks must be limited to military objectives whose “nature, purpose, or use make an effective contribution to military action and whose total or partial destruction, capture, or neutralization at the time offers a definite military advantage”; (2) Distinction or Discrimination: requires distinguishing military objectives from protected civilian objects such as places of worship and schools, hospitals, and dwellings; (3) Proportionality: requires that military action not cause collateral damage which is excessive in light of the expected military advantage; (4) Humanity: prohibits the use of any kind or degree of force that causes unnecessary suffering; and (5) Chivalry: requires war to be waged in accordance with widely accepted formalities. See James C. Duncan, A Primer on the Employment of Non-lethal Weapons, 45 Naval L. Rev. 1, 50-52 (1998); see also Ingrid Detter, The Law of War 158-67(2d ed. 2000).

[FN206]. Chicago Convention, Annex 2, supra note 41, §§ 3.1.2, 3.1.4, 3.1.7, 3.1.10.

[FN207]. Id. § 3.2; see also UAV Task-Force Final Report, supra note 14, at 52-53.

[FN208]. Chicago Convention, Annex 2, supra note 40, § 3.2.1.

[FN209]. Id. § 3.2.

[FN210]. See UAV Task-Force Final Report, supra note 14, at 52.

[FN211]. Chicago Convention, Annex 2, supra note 40, § 3.2.

[FN212]. Id. § 3.2.2.

[FN213]. Id. § 3.2.2.6.

[FN214]. Id. § 3.2.2.5.

[FN215]. Id. § 3.2.2.5.3.

[FN216]. Id. § 3.2.2.7.

[FN217]. Id. § 3.2.6.

[FN218]. Id. § 3.2.2.1.

[FN219]. Id. § 3.2.3.1.

[FN220]. Id.

[FN221]. Id. § 3.4, app. 1.

[FN222]. Id. § 3.4, app. 1, §§ 4, 5.

[FN223]. Id. § 3.4, app. 1, § 2.

[FN224]. Note the successful flight of the Global Hawk in 2001 from the United States to Australia during which remotely located pilots interfaced with air traffic controllers at both ends of the flight. See Morris, supra note 36, at 1.

[FN225]. Chicago Convention, Annex 2, supra note 40, § 3.6.

[FN226]. Id. § 3.8.

[FN227]. Id. chs. 4, 5.

[FN228]. Convention on International Civil Aviation, Dec. 7, 1944, 61 Stat. 1180, 15 U.N.T.S. 295, Annex 17, Security; Safeguarding International Civil Aviation Against Acts of Unlawful Interference, §§ 2.1.1 2.1.3 (7th ed. 2002) [hereinafter

Chicago Convention, Annex 17].

[FN229]. See generally NASA, Certification Roadmap, supra note 16, at 49.

[FN230]. Regarding the responsibility of Contracting State to develop a national aviation security program, Annex 17 states:

> Each Contracting State shall establish and implement a written national civil aviation security programme to safeguard civil aviation operations against acts of unlawful interference, through regulations, practices and procedures which take into account the safety, regularity and efficiency of flights .... Each Contracting State shall establish an organization and develop and implement regulations, practices and procedures, which together provide the security necessary for the operation of aircraft in normal operating conditions and capable of responding rapidly to meet any increased security threat.

Chicago Convention, Annex 17, supra note 228, §§ 3.1.1, 3.1.3.

[FN231]. Chicago Convention, Annex 17, supra note 205, § 3.3.1.

[FN232]. Id. §§ 3.4.1-3.4.3.

[FN233]. Id. § 4.1. See also discussion regarding LOAC, supra note 205.

[FN234]. Chicago Convention, Annex 17, supra note 228, § 4.7.

[FN235]. Id. § 4.2.3.

[FN236]. The 2001 trans-pacific flight of the Global Hawk, for example, had pilots operating in the United States and Australia with the U.S.-based pilot relinquishing control to the Australian-based pilot one and a half hours after take-off. Morris, supra note 36, at 1.

[FN237]. See discussion of the ITU, supra note 22.

[FN238]. Chicago Convention, supra note 21, arts. 33, 38.

[FN239]. Convention on International Civil Aviation, Dec. 7, 1944, 61 Stat. 1180, 15 U.N.T.S. 295, Annex 8, Airworthiness of Aircraft, (x) (9th ed. 2001) [hereinafter Chicago Convention, Annex 8].

[FN240]. See Office of the Sec'y of Def., Dep't of Def., Airspace Integration Plan for Unmanned Aviation 15 (2004) [hereinafter OSD].

[FN241]. Chicago Convention, Annex 8, supra note 239, § 3.2.

[FN242]. UAV Task-Force Final Report, supra note 14, enclosure 3, at 3.

[FN243]. Chicago Convention, Annex 8, supra note 239, § 1.3.

[FN244]. Id. § 1.1.

[FN245]. Id. § 1.3.1.

[FN246]. Id. § 2.2.1.

[FN247]. Id. § 2.2.3.

[FN248]. Id. § 2.2.4.

[FN249]. Id. § 4.2.1.

[FN250]. Id. See generally Convention on International Civil Aviation, Dec. 7, 1944, 61 Stat. 1180, 15 U.N.T.S. 295, Annex 6, Operations of Aircraft (8th ed. 2002) [hereinafter Chicago Convention, Annex 6].

[FN251]. Chicago Convention, Annex 8, supra note 239, § 3.2.3.

[FN252]. Id. § 4.3.1.

[FN253]. Id. § 4.3.2.

[FN254]. Id.

[FN255]. UAV Task-Force Final Report, supra note 14, enclosure 3, at 4. The task force commissioned by the Joint Aviation Authorities ("JAA") of the European Union and the European Organization for the Safety of Air Navigation ("EUROCONTROL") viewed the UAV system as follows:

A UAV System comprises individual UAV System elements consisting of the flight vehicle (UAV), the "Control Station" and any other UAV System Elements necessary to enable flight, such as a "Communication link" and "Launch and Recovery Element." There may be multiple UAVs, Control Stations, or Launch and Recovery Elements within a UAV System. ("Flight" is defined as also including taxiing, takeoff and recovery/landing).

Id. at 11.

[FN256]. See generally DeGarmo, supra note 33, at 2-47 to 2-51.

[FN257]. Convention on International Civil Aviation, Dec. 7, 1944, 61 Stat. 1180, 15 U.N.T.S. 295, Annex 1, Personnel Licensing, § 2.1.1.1 (9th ed. 2001) [hereinafter Chicago Convention, Annex 1].

[FN258]. Id. § 1.1.

[FN259]. Id.

[FN260]. OSD, supra note 240, at 16.

[FN261]. Chicago Convention, Annex 1, supra note 257, § 2.1.

[FN262]. Id.

[FN263]. See UAV Task-Force Final Report, supra note 14, at 58; see also Chicago Convention, Annex 1, supra note 257, ch. 6.

[FN264]. Chicago Convention, Annex 1, supra note 257, § 1.2.1.

[FN265]. Id. § 1.1.

[FN266]. Id. §1.2.

[FN267]. Id. § 4.2.

[FN268]. Federal Aviation Regulations, 14 C.F.R. §§ 1.1-198.17 (2006).

[FN269]. Transportation Security Regulations, 49 C.F.R. §§ 1500.01-1572.405 (2005).

[FN270]. 14 C.F.R. §§ 45.1-49.63.

[FN271]. Id. §§ 21.1-43.17.

[FN272]. Id. §§ 61.1-67.415.

[FN273]. Id. §§ 71.1-105.49.

[FN274]. Id. § 1.1.

[FN275]. Id.

[FN276]. Id. §§ 91.1, 91.101, 91.701, 91.801.

[FN277]. Id. §§ 91.401, 91.501, 91.601.

[FN278]. Id. § 91.111(a).

[FN279]. Id. § 91.113(b).

[FN280]. See generally OSD, supra note 240, at 19-27.

[FN281]. 14 C.F.R. §§ 91.126-91.135. The following is a summary of United States airspace classes:

• Class A airspace exists from Flight Level (FL) 180 (18,000 feet [5,486.4 meters] Mean Sea Level (MSL)) to FL600 (60,000 feet [18,288 meters] MSL). Flights within Class A airspace must be flying under Instrument Flights Rules (IFR) and under the control of the ATC at all times.

• Class B airspace surrounds major airports (generally up to 10,000 feet [3,048 meters] MSL) to reduce mid-air collision potential by requiring ATC control of IFR and VFR (Visual Flight Rules) flights in that airspace.

• Class C airspace surrounds busy airports (generally up to 4,000 feet [1219.20 meters] Above Ground Level (AGL)) that does not need Class B airspace protection, and requires flights to establish and maintain two-way communications with the ATC[, and the] ATC provides radar separation service ....

• Class D airspace surrounds airports (generally up to 2,500 feet [762 meters] AGL) that have an operating control tower. Flights in Class D airspace must establish and maintain communications with the ATC, but VFR flights do not receive separation service.

• Class E airspace is all other airspace in which IFR and VFR flights are allowed. Although Class E airspace can extend to the surface, it generally begins at 1200 feet [365.76 meters] AGL, or 14,500 [4419.60 meters] MSL, and extends upward until it meets a higher class of airspace (A-D). It is also FL600.

• Class G airspace ... is also called uncontrolled airspace because the ATC does not control the aircraft there. Class G can extend to 14,499 feet [4419.3 meters] MSL, but generally exists below 1200 feet [365.76 meters] AGL, and below Class E airspace.

OSD, supra note 240, at 5.

[FN282]. 14 C.F.R. §§ 71.31, 71.41, 71.51, 71.61. See generally FAA, FAA Order 7400.2F Procedures for Handling Airspace Matters, pt. 4 (Feb. 2005).

[FN283]. 14 C.F.R. §§ 71.31, 71.41, 71.51, 71.61.

[FN284]. Id.

[FN285]. 14 C.F.R. §§ 91.130(c), 91.131(c), 91.135(b).

[FN286]. Id. § 91.129(c).

[FN287]. Id. §§ 91.135(c), 91.215.

[FN288]. Id. §§ 91.126, 91.127.

[FN289]. Id. § 91.7.

[FN290]. Id. § 91.17.

[FN291]. Id.

[FN292]. Id. § 91.17(c).

[FN293]. FAA, Advisory Circulars, http://www.faa.gov (follow "Advisory Circulars (ACs)" hyperlink) (last visited May 21, 2006).

[FN294]. FAA, FAA Order 7930.2J, Notices to Airmen (Feb. 2004). The FAA has created a website, available at https://pilotweb.nas.faa.gov/distribution/atcscc.html, called PilotWeb, wherein pilots can find NOTAMs and other pilot specific information and links.

[FN295]. FAA, Temporary Flight Restrictions Notices, http:// tfr.faa.gov/tfr/list.jsp (last visited May 21, 2006).

[FN296]. FAA, AC 91-57, Model Aircraft Operation Standards (1981). The complete text of AC 91-57 operating standards is as follows:

a. Select an operating site that is of sufficient distance from populated areas. The selected site should be away from noise sensitive areas such as parks, schools, hospitals, churches, etc.

b. Do not operate model aircraft in the presence of spectators until the aircraft is successfully flight tested and proven airworthy.

c. Do not fly model aircraft higher than 400 feet above the surface. When flying aircraft within 3 miles of an airport, notify the airport operator, or when an air traffic facility is located at the airport, notify the control tower, or flight service station.

d. Give right of way to, and avoid flying in the proximity of, full-scale aircraft.

Use observers to help if possible.

e. Do not hesitate to ask for assistance from any air traffic control tower or flight service station concerning compliance with these standards.

Id.

[FN297]. See generally, OSD, supra note 240, at 11, 58.

[FN298]. Pointer is a mini-UAV built by AeroVironment, a California-based technology company, and used by U.S. Special Forces for reconnaissance missions. Aerovironment, AV Pointer, http://www.avinc.com/uav_lab_project_ detail.php?id=34.html (last visited May 22, 2006).

[FN299]. See also Michael A. Dornheim & Michael A. Taverna, War on Terrorism Boosts Deployment of Mini-UAVs, Aviation Wk. & Space Tech., July 8, 2002, at 48-49, available at http://www.aerovironment.cn/news/news-archive/awpointer.html.

[FN300]. See generally Paul Stephen Dempsey, Aviation Security: The Role of Law in the War Against Terrorism, 41 Colum. J. Transnat'l L. 649, 714 (2003).

[FN301]. See generally 49 C.F.R. pts. 1546-48 (2005).

[FN302]. See id. § 1550.3.

[FN303]. See id. § 1544.225.

[FN304]. See id. §1544.301.

[FN305]. 14 C.F.R. § 121.547 (2006).

[FN306]. See 49 C.F.R. § 1544.303.

[FN307]. See id.

[FN308]. See id. § 1544.305.

[FN309]. 14 C.F.R. §§ 99.1, 99.9. This is part of the Air Defense Identification Zone (ADIZ) procedures. ADIZ means “an area of airspace over land or water in which the ready identification, location, and control of all aircraft (except for Department of Defense and law enforcement aircraft) is required in the interest of national security.” Id. § 99.3.

[FN310]. Id. § 91.185.

[FN311]. See id.

[FN312]. See generally OSD, supra note 240, at 31.

[FN313]. See generally id.

[FN314]. 14 C.F.R. § 61.3. As previously noted, the United States armed forces license their own pilots. However, the DoD and FAA have signed a memorandum of agreement whereby the FAA will accept military-rated pilots into the NAS as long as they meet or exceed civil training standards. OSD, supra note 240, at 16.

[FN315]. 14 C.F.R. §§ 61.81-61.95.

[FN316]. Id. §§ 61.96-61.101.

[FN317]. Id. §§ 61.102-61.120.

[FN318]. Id. §§ 61.120-61.141.

[FN319]. Id. §§ 61.151-61.171.

[FN320]. Id. §§ 61.301-61.329.

[FN321]. Id. § 61.23.

[FN322]. See id. §§ 67.1-67.415.

[FN323]. See id. § 61.23(c).

[FN324]. Id. §§ 63.31-63.43.

[FN325]. Id. §§ 63.51-63.61.

[FN326]. Id. §§ 65.71-65.95.

[FN327]. Id. §§ 65.101-65.107.

[FN328]. Id. §§ 61.15, 63.12, 65.12.

[FN329]. Id.

[FN330]. As noted above, FAA regulations do not require military aircraft to be certified airworthy by the faa. OSD, supra note 240, at 22. "Instead, these aircraft are certified through the military's internal airworthiness certification/flight release processes." Id.

[FN331]. See 14 C.F.R. §§ 21.131-21.165.

[FN332]. See NASA, Certification Roadmap, supra note 16, at 17.

[FN333]. See id.

[FN334]. See 14 C.F.R. §§ 21.135, 21.139, 21.143

[FN335]. See generally DeGarmo, supra 33, at 2-48.

[FN336]. See FAA Order 7610.4K, supra note 166.

[FN337]. DeGarmo, supra note 33, at 1-5.

[FN338]. FAA Order 7610.4K, supra note 166, § 12-9-1. The FAA defines warning areas as:

> [A]irspace of defined dimensions, extending from 3 nautical miles outward from the coast of the United States, that contains activity that may be hazardous to nonparticipating aircraft. The purpose of such warning areas is to warn nonparticipating pilots of the potential danger. A warning area may be located over domestic or international waters or both.

14 C.F.R. § 1.1.

[FN339]. FAA Order 7610.4K, supra note 166, § 12-9-2.

[FN340]. See DeGarmo, supra note 33, at 1-5.

[FN341]. FAA, Organizational Chart, http://www.faa.gov/about/office_org (follow “Organizational Chart” hyperlink) (last visited Sept. 30, 2006). The FAA breaks out the United States into nine regions as follows: Alaskan Region (“AAL”), Central Region (“ACE”), Eastern Region (“AEA”), Great Lakes Region (“AGL”), New England Region (“ANE”), Northwest Mountain Region (“ANM”), Southern Region (“ASO”), Southwest Region (“ASW”), and the Western-Pacific Region (“AWP)” . Id.

[FN342]. FAA Order 7610.4K, supra note 166, § 12-9-2.

[FN343]. Id. § 12-9-2(b).

[FN344]. DeGarmo, supra note 33, at 1-5.

[FN345]. See generally id.

[FN346]. Def. Sci. Bd., supra note 8, at 38.

[FN347]. Id.

[FN348]. FAA Order 7610.4K, supra note 166, § 12-9-2(a).

[FN349]. Id.

[FN350]. Id.

[FN351]. Id. § 12-9-2(c).

[FN352]. Id. § 12-9-2(d).

[FN353]. Id.

[FN354]. Id. § 12-9-2(e).

[FN355]. Id.

[FN356]. See Def. Sci. Bd., supra note 8, at 37-40.

[FN357]. See id.

[FN358]. NASA, Certification Roadmap, supra note 16, at 1 (noting that the FAA has issued five civilian COAs).

[FN359]. See id. at 10.

[FN360]. Civ. Aviation Safety Regs. 1998, at 101 (2004) (Austl.) (Unmanned Aircraft and Rocket Operations) [hereinafter CASR].

[FN361]. Civ. Aviation Safety Auth, Advisory Circular--AC 101-1(0): Unmanned Aerial Vehicle (UAV) Operations, Design Specification, Maintenance and Training of Human Resources (2002) (Austl.) [hereinafter AC 101-1(0)].

[FN362]. Id. § 12.2.2.

[FN363]. OSD, supra note 240, at 40.

[FN364]. AC 101-1(0), supra note 361, § 12.2.2.

[FN365]. See id. §§ 11.3, 11.5.

[FN366]. AC 101-1(0), supra note 361, app. 3, § 2.4.

[FN367]. Id. § 2.6.

[FN368]. Id. § 4.2.

[FN369]. Id. § 5.2.2.

[FN370]. Id. § 5.1.1.

[FN371]. See id. § 5.6.1.

[FN372]. Id. § 5.7.2.

[FN373]. CASR, supra note 360, § 101.240.

[FN374]. See AC 101-1(0), supra note 361, § 7.1.1.

[FN375]. CASR, supra note 360, § 101.240.

[FN376]. AC 101-1(0), supra note 361, § 7.1.2.

[FN377]. Id. § 5.10.1.

[FN378]. Id.

[FN379]. Id. § 5.10.2.

[FN380]. Id. § 5.10.3.

[FN381]. See id. § 5.10.4.

[FN382]. Id.

[FN383]. Id. § 5.13.1.

[FN384]. Id. § 5.13.4.

[FN385]. Id. § 5.13.6.

[FN386]. CASR, supra note 360, § 21.185, 21.191.

[FN387]. See AC 101-1(0), supra note 361, § 8.1.1.

[FN388]. Id.

[FN389]. See CASR, supra note 360, § 101.295.

[FN390]. AC-101-1(0), supra note 361, § 11.3.1.

[FN391]. Id.

[FN392]. OSD, supra note 240, at 41.

[FN393]. See Bruce Enderle, Am. Inst. of Aeronautics & Astronautics, Commercial Applications of UAV's in Japanese Agriculture http:// www.aiaa.org/content.cfm?pageid=406&gTable=Paper&gID=2802 (last visited May 13, 2006).

[FN394]. See id.

[FN395]. OSD, supra note 240, at 41.

[FN396]. See generally Tim Mahon, Fit to Fly in Civil Airspace, in 2003 Yearbook 162-68, at 166 (UVS Int'l, Blyenburgh & Co. 2003).

[FN397]. See generally id.

[FN398]. See OSD, supra note 240, at 41.

[FN399]. CAP 722, supra note 32.

[FN400]. Id.

[FN401]. D.R. Haddon & C.J. Whittaker, UK Civ. Aviation Auth., UK-CAA Policy for Light UAV Systems 1 (2004).

[FN402]. Commission Regulation 1592/2002, 2002 O.J. (L240), available at http://www.easa.eu.int/doc/Regulation/BR1592_2002.pdf; see also Haddow & Whittaker, supra note 401 at 2.

[FN403]. See Haddon & Whittaker, supra note 401, at 2.

[FN404]. UAV Task-Force Final Report, supra note 14.

[FN405]. Joint Aviation Authorities, Future of JAA, http:// www.jaa.nl/future_of_jaa/future_of_jaa.html (last visited May 13, 2006).

[FN406]. UAV Task-Force Final Report, supra note 14, annex 1, at 1.

[FN407]. Id.

[FN408]. A kilojoule (abbreviation: kJ) is a unit of energy equal to 1000 joules. Joule (symbol J, also called newton-meter, watt-second, or coulomb-volt) is the International System of Units for energy and work. The unit is pronounced to rhyme with “tool,” and is named in honor of the physicist James Prescott Joule (1818-1889). One joule is the work required to exert a force of one newton for a distance of one meter. Another way of visualizing the joule is the work required to lift a mass of about 102 grams (0.22 lbs), about the size of a small apple, for one meter under the Earth's gravity. One joule is also the work done to produce power of one watt for one second, such as when somebody takes one second to lift a small apple one meter under the Earth's gravity. Approximately one kJ of work is done when 100 kilograms (220 lbs) is lifted one meter on Earth‘s surface. Wikipedia, Joule, http:// en.wikipedia.org/wiki/Joule (last visited May 13, 2006).

[FN409]. UAV Task-Force Final Report, supra note 14, annex 1, at 4 (“Kinetic energy resulting at impact from a free fall from a height of 400 ft”). Id.

[FN410]. Haddon & Whittaker, supra note 401, at 2.

[FN411]. Id. The policy is dated May 28, 2004. Id.

[FN412]. Id. at 3-4.

[FN413]. CAP 722, supra note 32, ch. 1, § 3.

[FN414]. Id. ch. 12, § 3.1.

[FN415]. Id.

[FN416]. Id.

[FN417]. Id.

[FN418]. Id.

[FN419]. Id. ch. 4, § 3.2.

[FN420]. Id.

[FN421]. See OSD, supra note 240, at 42.

[FN422]. See Michael J. AuBuchon, Choosing How Safe is Enough: Increased Antiterrorist Federal Activity and Its Effect on the General Public and the Airport/Airline Industry, 64 J. Air L. & Com. 891, 910 (1999).

[FN423]. See 14 C.F.R. §§ 101.1-101.39 (2006).

[FN424]. See id. §§ 103.1-103.23.

[FN425]. See NASA, Certification Roadmap, supra note 16, at 101.

[FN426]. Id.

[FN427]. Id.

[FN428]. CAP 722, supra note 32, at ch. 4 § 3.2.2.1, ch. 9 § 3.1; OSD, supra note 240, at 2-3, 33; UAV Task-Force Final Report, supra note 14, at 19, 25, 38, 47; see also DeGarmo, supra note 33, at 3-1.

[FN429]. See DeGarmo, supra note 33, at 2-40; NASA, Concept of Operations, supra note 46, at 1-3; UAV Categorisation, supra note 53, at 155.

[FN430]. United States Coast Guard, VTOL (Vertical Takeoff and Landing) Unmanned Aerial Vehicle (UAV), http://www.uscg.mil/deepwater/system/vUAV.htm (last visited May 14, 2006).

[FN431]. Susan Redwine, Division Fields First TUAV Platoon, Fort Drum Blizzard Online, June 2, 2005, http:// www.drum.army.mil/sites/postnews/blizzard/blizzard_archives/news.asp? id=7&issuedate=6-2-2005 (last visited Sept. 30, 2006).

[FN432]. See DeGarmo, supra note 33, at 2-40.

[FN433]. CAP 722, supra note 32, ch. 1, § 3.

[FN434]. OSD, supra note 240, at 11-14.

[FN435]. Id. at 12.

[FN436]. Id. at 12-14.

[FN437]. Id. at 3.

[FN438]. Id. at 14.

[FN439]. Id. at 48. The terms within Figure 4-2 are further defined below.

• ROA - Cat III: capable of flying throughout all categories of airspace and conforms to Part 91, etc. (i.e., all the things a regulated manned aircraft must do including the ability to “sense-and-avoid”). Airworthiness and operator certification are required. ROA are generally built for beyond line-of-sight operations. Examples: Global Hawk, Predator

• ROA - Cat II: non-standard aircraft that perform special purpose operations. Operators must provide evidence of airworthiness and operator qualification. Cat II ROA may perform routine operations within a specific set of restrictions. Examples: Pioneer, Shadow

• ROA - Cat I: analogous to RC models as covered in AC 91-57. Operators must provide evidence of airworthiness and operator qualification. Small UAVs are generally limited to visual line-of-sight operations. Examples: Pointer, Dragon Eye

[FN440]. CAP 722, supra note 32, ch. 9, §§ 3.1-3.2.

[FN441]. See generally UAV Task-Force Final Report, supra note 14, at 13.

[FN442]. 14 C.F.R. §§ 91.201-91.299 (2006).

[FN443]. See NASA, Certification Roadmap, supra note 16, at 103-04; see also 14 C.F.R. § 91.151-91. 165.

[FN444]. AC 101-1(0), supra note 361, § 5.10.

[FN445]. 14 C.F.R. § 91.185.

[FN446]. See generally OSD, supra note 240, at 31.

[FN447]. See UAV Task-Force Final Report, supra note 14, at 49; see also supra note 22.

[FN448]. See Morris, supra note 36, at 1.

[FN449]. 14 C.F.R. § 91.169.

[FN450]. 49 C.F.R. §§ 1540.1-1540.117, 1544.1-1544.411, 1550.1-1550.7, 1562.1-1562.3 (2005).

[FN451]. 14 C.F.R. §§ 121.313, 121.547.

[FN452]. Id. § 121.313.

[FN453]. Many times FAA Airworthiness Directives require specific aircraft manufactures to address systems that need redundancy to ensure safety or airworthiness. FAA, Airworthiness Directives, http://www.airweb.faa.gov (follow “Airworthiness Directives (Ads)” hyperlink) (last visited May 14, 2006).

[FN454]. See UAV Task-Force Final Report, supra note 14, at 18.

[FN455]. See 14 C.F.R. § 21.25.

[FN456]. See generally UAV Task-Force Final Report, supra note 14, at 18-20.

[FN457]. 14 C.F.R. § 103.7.

[FN458]. See NASA, Certification Roadmap, supra note 16, at 49.

[FN459]. See id. at 50.

[FN460]. See id. at 50-59.

[FN461]. See id. at 53.

[FN462]. 14 C.F.R. § 21.191.

[FN463]. See id.

[FN464]. NASA, Certification Roadmap, supra note 16, at 54.

[FN465]. See id. at 59-65.

[FN466]. Id. at 60.

[FN467]. Id. See also 14 C.F.R. § 21.17(b).

[FN468]. These airworthiness standards are found in Parts 23, Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes; 25, Airworthiness Standards: Transport Category Airplanes; 27, Airworthiness Standards: Normal Category Rotorcraft; 29, Airworthiness Standards: Transport Rotorcraft; 31, Airworthiness Standards: Manned Free Balloons; 33, Airworthiness Standards: Aircraft Engines; and 35, Airworthiness Standards: Propellers, of Title 14 of the CFR.

[FN469]. See 14 C.F.R. §§ 11.1-11.201.

[FN470]. NASA, Certification Roadmap, supra note 16, at 66-72. See also 14 C.F.R. §§ 21.121-21.130.

[FN471]. NASA, Certification Roadmap, supra note 16, at 66-67. See also 14 C.F.R. §§ 21.131-21.165.

[FN472]. NASA, Certification Roadmap, supra note 16, at 73-77. See also 14 C.F.R. §§ 21.25, 21.185(b).

[FN473]. 14 C.F.R. § 21.25(b).

[FN474]. See NASA, Certification Roadmap, supra note 16, at 77-82.

[FN475]. See generally id. at 90-100.

[FN476]. See 14 C.F.R. §§ 61.57-61.58.

[FN477]. See CAP 722, supra note 32, ch. 9, § 3.1.

[FN478]. See 14 C.F.R. § 103.7.

[FN479]. See UAV Task-Force Final Report, supra note 14, enclosure 4, at 19.

[FN480]. See 14 C.F.R. § 65.31(c). See also 14 C.F.R. §§ 67.201-67.215. for requirements for a second-class airman medical certificate.

[FN481]. See 14 C.F.R. § 65.47.

[FN482]. DeGarmo, supra note 33, at 1-1.

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