

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

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## **ABSTRACT**

Unmanned Aerial Vehicles (“UAV”) have been a part of aviation from the infancy of manned aviation; yet, have not reached their fullest potential as they are not integrated into the national airspace system (“NAS”). However, we are at the edge of technological breakthroughs to make integration a reality. Nevertheless, the regulatory construct necessary to provide safe integration of UAVs is unfinished. This thesis looks at necessary regulatory changes within the United States to allow for integration of the UAV into the NAS. I will first define the UAV and look at its historical roots. Then, I will review existing regulations and directives of manned flight that would apply to UAVs, as well as various rules specifically for UAVs that now exist. Through this examination, I will review the gaps and offer recommendations to fill regulatory holes in hopes to provide a useful contribution to the eventual integrated flight of UAVs.

## RÉSUMÉ

Les véhicules aériens non habités font partie de l'aviation depuis ses débuts. Ils n'ont pourtant pas atteint pleinement leur potentiel, n'étant pas intégrés au sein de l'espace aérien national. Cependant, les découvertes technologiques sont sur le point de rendre possible leur intégration. Mais le cadre réglementaire nécessaire pour permettre une intégration sécuritaire des véhicules aériens non habités demeure inachevé. Cette thèse porte sur les changements réglementaires nécessaires aux Etats-Unis dans le but de permettre une intégration des véhicules aériens non habités dans l'espace aérien national. Tout d'abord, je définirai les véhicules aériens non habités et retracerai leur historique. Ensuite, j'examinerai la réglementation en vigueur pour les vols avec équipage qui pourrait s'appliquer aux véhicules aériens non habités, ainsi que la réglementation spécifique à ces derniers. Enfin, je formulerai des recommandations permettant de combler les lacunes de la législation pour ainsi contribuer à l'éventuelle intégration des véhicules aériens non habités.

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# 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

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 very well be the Predator,<sup>1</sup> which has been flown by the United States Air Force ("USAF") in the skies over Iraq, Afghanistan, Bosnia, Kosovo, and Korea.<sup>2</sup> 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."<sup>3</sup> 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.<sup>4</sup>

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<sup>1</sup>See generally Richard J. Newman, *The Little Predator That Could*, Air Force Magazine, March 2002, at 49; Anthony Lazarski, Lt Col USAF, *Legal Implications of the Uninhabited Combat Aerial Vehicle*, Aerospace Power Journal (Summer 2002) at <http://www.airpower.maxwell.af.mil/airchronicles/apj/apj02/sum02/lazarski.html> (last visited Jan. 20, 2005).

<sup>2</sup>Lazarski, *supra* note 1. Predator is manufactured by General Atomics Aeronautical Systems, a San Diego based company. *Remotely Operated Aircraft Systems*, General Atomics Aeronautical Systems, at <http://www.uav.com/home/index.html> (last visited May 4, 2005).

<sup>3</sup>Newman, *supra* note 1.

<sup>4</sup>See John Pike, *Federation of American Scientists Intelligence Resource Program, Unmanned Aerial Vehicles (UAVs)* (May. 10, 2004), at <http://www.fas.org/irp/program/collect/uav.htm> (last visited Mar. 23, 2005); *Id.*

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.<sup>5</sup> Today, militaries use UAVs primarily in operations involving the traditional "dull" missions of reconnaissance and surveillance.<sup>6</sup> UAVs have also been converted by militaries into a weaponized "next generation" UAV, called unmanned combat aerial vehicles ("UCAV").<sup>7</sup> UCAVs can perform an array of dirty and dangerous offensive and defensive operations, including suppression of enemy air defenses ("SEAD"), close air support ("CAS"), defensive counterair ("DCA"), offensive counterair ("OCA"), and air interdiction ("AI").<sup>8</sup>

Notwithstanding the advantages inherent in UAV operations, there remain concerns over safety.<sup>9</sup> 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.<sup>10</sup> Therefore, safety concerns are heightened when the integration of UAVs into the unrestricted airspace of the national airspace system ("NAS") is contemplated.<sup>11</sup> As one group

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<sup>5</sup> Elizabeth Bone and Christopher Bolkcom, *Unmanned Aerial Vehicles: Background and Issues for Congress*, at 5, Washington/Congressional Research Service, RL31872 (Apr. 25, 2003) at <http://www.fas.org/irp/crs/RL31872.pdf>, (last visited Feb. 9, 2005).

<sup>6</sup> See generally Lazarski, *supra* note 1.

<sup>7</sup> See *id.*

<sup>8</sup> *Id.* See also Defense Science Board, *Defense Science Board Study on Unmanned Aerial Vehicles and Uninhabited Combat Aerial Vehicles* at 6-17 (Feb. 2004) at <http://www.acq.osd.mil/dsb/reports/uav.pdf> (last visited Mar. 24, 2005).

<sup>9</sup> Defense Science Board, *supra*, note 8, at 17-8.

<sup>10</sup> See generally *id.* at 17-8, 37.

observed, “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.”<sup>12</sup>

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 ones own NAS, but also encountering the NAS of other nations.<sup>13</sup> 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 its NAS.<sup>14</sup> In fact the full scale application of civilian UAVs have been stymied by the very problems outlined above; namely, safety concerns surrounding integration and the lack of a regulatory regime to facilitate safe integration.<sup>15</sup> Therefore, nations such as the United States are now

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<sup>11</sup> See *id.* National Airspace System is defined by the FAA as “the network of United States (U.S.) airspace: air navigation facilities, equipment, services, airports or landing areas, aeronautical charts, information/services, rules, regulations, procedures, technical information, manpower, and material. Included are system components shared jointly with the military.” FAA, *Pilot/Controller Glossary* (Feb. 17, 2005).

<sup>12</sup> Bone and Bolcom, *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 worst mishap rate was held by the Pioneer UAV (the only UAV used by the Navy and Marines), which showed 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. Defense Science Board, *supra* note 8, at 17-8. See also, *Near Hit*, Air Safety Week, Oct. 18, 2004, Vol. 18, No. 40 (In the skies over Kabul, Afghanistan, a UAV and manned jetliner have 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.).

<sup>13</sup> Defense Science Board, *supra* note 8, at 37.

<sup>14</sup> See generally, Joint Aviation Authorities (hereinafter JAA), *The Joint JAA/EUROCONTROL Initiative on UAV/ROAs: Final Report*, May 11, 2004, available at <http://198.17.75.100/news/news.html> (last visited Jan. 15 2005).

scrambling in an attempt to develop a robust regulatory construct to provide safe and secure integration of UAVs into their NAS.<sup>16</sup>

The need for UAV integration is highlighted by the USAF's recent experiences in Iraq, which has literally become an on-site experimental test-bed for a number of UAV initiatives such as equipping soldiers with hand-launched micro-UAVs and placing different sensors and/or armaments on existing UAV platforms.<sup>17</sup> 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.<sup>18</sup> In discussing the problems encountered in Iraq, the USAF Chief of Staff, General John Jumper, stated, "We've already had two mid-air collisions between UAVs and other airplanes, we have got to get our arms around this thing."<sup>19</sup> According to General Jumper, the USAF and the United State's Department of Defense ("DoD") need a system to coordinate the use of UAVs.<sup>20</sup>

Indeed, this coordination must be accomplished with eyes toward the sky and ground, as integration concerns both UAV movement through the air and the non-interference with its own and other ground-based operations. Moreover, this

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<sup>15</sup> *See id.*

<sup>16</sup> *See generally* The National Aeronautics and Space Administration (hereinafter NASA), Environmental Research Aircraft and Sensor Technology (hereinafter ERAST) Project, Certification and Regulatory Roadmap: High-Altitude Long-Endurance Unmanned Aerial Vehicles, (2002 Version 1.3) at 11-14, available at <http://www.psl.nmsu.edu/uav/roadmap/Content.htm> (last visited Mar. 19, 2005).

<sup>17</sup> *See* Nathan Hodge, *Jumper: Military Must Reorganize UAV Efforts*, Defense Daily, Apr. 29, 2005, at 7.

<sup>18</sup> *See generally id.*

<sup>19</sup> *Id.*

<sup>20</sup> *Id.*

coordination must not only include inter and intra-service interoperability with manned and unmanned aircraft, but also, as noted above, coordination with civilian airspace as the need for military UAVs to transit national and international airspace grows. This thesis will address the latter; namely, the quest to integrate the UAV into the NAS.

The primary focus of the thesis is the integration of UAVs into the NAS of the United States. However, as UAV utilization will inevitably become more global, and as military and civilian uses will eventually entail international travel through foreign NASs, international integration will also be discussed. First, I will define the UAV; showing how a UAV's characteristics are different and distinguishable from rockets or missiles, and that 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. Therefore, I will address the current international and domestic regulatory regimes that apply to UAV operations. After which, I will highlight issues that are not adequately covered by existing rules, and therefore, must be 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 frame work will have direct application to DoD and USAF operations. Further, as civilian, commercial operations for UAVs increase, the costs associated with UAV use by 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 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 Aviation Organization (“ICAO”)<sup>21</sup> and the International Telecommunications Union (“ITU”)<sup>22</sup>, to formulate a regulatory airfield that 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/vehicle that must be integrated; therefore, this chapter will begin by defining what a UAV is and what it is not, while more closely

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<sup>21</sup> ICAO is an international organization established by the 1944 Chicago Convention (*infra* note 38) to manage the safety and security of the world’s civil aviation, currently headquartered in Montreal, Canada. Chicago Convention, *infra* note 38, at art. 1-10, and 43-79. For more information on the purposes and roles of ICAO, See <http://www.icao.org/>; Assad Kotaite, *Security of International Civil Aviation—Role of ICAO*, 7 *Annals Air & Space L.* 95 (1982).

<sup>22</sup> The ITU was created initially as the International Telegraph Union before the turn of the 20<sup>th</sup> Century, 17 May 1865, and is the oldest specialized agency of the United Nations. It is organized by international treaty, known as the International Telecommunications Constitution and Convention, *Constitution and Convention of the International Telecommunication Union*, Dec. 22, 1992 (Geneva: ITU, 1992), and is headquartered in Geneva, Switzerland. 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://itu.org/>; J. Wilson, *The International Telecommunication Union and the Geostationary Satellite Orbit: An Overview*, 23 *Ann. Air & Sp. L.* 249 (1998).

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, the evolution of the UAV will be explored.

This stroll down the halls of history will show that early in the development of the UAV, the militaries of the United States and Great Britain saw the utility of a remotely controlled, unmanned aircraft, around the same time such militaries were developing manned military 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. However, over time, 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 common place in military operations. With the successful fielding of UAV technology, many national militaries found the utility of the UAV quite desirable, and now the UAV andUCAV 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 non-military uses for the UAV began to be envisioned and exploited. Therefore, this initial chapter 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 three different names: Remotely Operated Aircraft (“ROAs”) as used by civil U.S. agencies such as the Federal Aviation Administration (“FAA”) and the National Aeronautics and Space Administration (“NASA”), Remotely Piloted Vehicles (“RPV”), a pre-Gulf War term used primarily by the United States during the Vietnam War, or the more common term unmanned aerial vehicle (“UAV”), used by militaries and European countries.<sup>23</sup> For purposes of this work, the acronym UAV/ROA will be used in the remaining text as the term “ROA” more properly delineates flying unmanned vehicles as aircraft; however, I will also retain the more common term, “UAV”.

Interestingly, however, one author finds the distinction made by the FAA in using the term “aircraft” instead of the more universally applied term “vehicle,” somewhat troublesome.<sup>24</sup> According to that author, the FAA decided to use the term “aircraft” because it noted that it was responsible for regulating “aircraft” and not “vehicles”.<sup>25</sup> The FAA has defined ROAs as “aircraft capable of flight beyond visual line of sight under remote or autonomous control for civil (non-DoD) purposes. A UAV is not operated for sport or hobby and does not transport passengers or

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<sup>23</sup> See generally Laurence Newcome, Unmanned aviation: A Brief History of Unmanned Aviation 1-9 (2004); JAA, *supra* note 14.

<sup>24</sup> Newcome, *supra* note 23, at 4 -5.

<sup>25</sup> *Id.*

crew.”<sup>26</sup> While this definition limits ROAs to non-military UAV/ROAs, and does not consider the potential of UAV/ROA carrying passengers, it must be kept in mind that the definition is by the FAA, for FAA purposes. Additionally, at least for now, and arguably in the foreseeable future, UAV/ROA technology does not include passenger travel.

Notwithstanding these limits, the concern lies deeper in the use of the term “aircraft” as it may exclude particular UAV/ROAs, and therefore, such excluded UAV/ROAs 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 UAV/ROAs as rates would be higher for them as compared to UAV/ROAs operators who are able to take advantage of FAA regulatory certification.<sup>27</sup> Such excluded “vehicles” would potentially include small or micro UAV/ROAs.<sup>28</sup>

Nevertheless, it would seem that the overarching goal of any regulatory body chartered with 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

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<sup>26</sup> FAA Draft Advisory Circular, “Unmanned Air Vehicle Design Criteria,” Section 6.j, 15 July 1994, noted in Matthew T. DeGarmo, *Issues Concerning Integration of Unmanned Aerial Vehicles in Civil Airspace*, at 2 n.2 (Nov. 2004) at [http://www.mitre.org/work/tech\\_papers/tech\\_papers\\_04/04\\_1232/04\\_1232.pdf](http://www.mitre.org/work/tech_papers/tech_papers_04/04_1232/04_1232.pdf) (last visited Mar. 19, 2005).

<sup>27</sup> See generally Newcome, *supra* note 23, at 4 -5.

<sup>28</sup> *Id.*

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.<sup>29</sup> To the extent smaller UAV/ROAs would need to avail themselves of the same national airspace system, e.g., airspace, airports, and air traffic management (“ATM”) services, it would seem only logical that regulations promulgated by governmental aviation authorities would be applicable to such UAV/ROAs, 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 UAV/ROAs that do not or will not need to extensively integrate into the NAS, to have less burdensome rules, which will maintain the lower costs inherent in UAV/ROA operations.<sup>30</sup>

Further, the FAA is not alone in describing UAV/ROAs as aircraft. British aviation authorities also use the term “aircraft” in defining a UAV/ROA as “an aircraft that is designed, or modified, to carry no human pilot and is operated under remote control or in some autonomous mode of operation.”<sup>31</sup> 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.

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<sup>29</sup> 14 C.F.R. §§ 21, 23, 31, 34, 36, 43, 91, 121, 135, and 137 (2004).

<sup>30</sup> For example, *The Joint JAA/EUROCONTROL Initiative on UAV/ROAs: Final Report*, supra note 14, at annex 1 of the main body of the report includes a sample regulatory framework for “light” UAV/ROAs. That report defines light UAV/ROAs as “those with a maximum take-off mass below 150kg, and a maximum speed not exceeding 70kts, that are operated within 500 metres of the UAV-pilot and not more than 400 ft above ground level.”

<sup>31</sup> Civil Aviation Authority (U.K.), *CAP 722--Unmanned Aerial Vehicle Operations in UK Airspace – Guidance*, Chapter 1, § 2.1(2002).

A more salient argument, however, might be that the term ROA precludes aerial vehicles that are not “remotely” operated but are programmed to autonomously operate, either by an undeviating, pre-programmed 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.<sup>32</sup> This distinction is highlighted in current versions of *Jane’s All the World’s Aircraft*, which define RPV as “remotely piloted vehicle (pilot in other aircraft or on ground); contrast UAV,” and then make a distinction by defining UAV as “unmanned (or uninhabited) aerial vehicle; contrast RPV”.<sup>33</sup>

While there is a reasonable argument that the yellow-brick road of UAV/ROA 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 designed to operate in mixed airspace.<sup>34</sup> Clearly, the initial integration of UAV/ROAs must include human remote operation,

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<sup>32</sup> See Matthew T. DeGarmo, *Issues Concerning Integration of Unmanned Aerial Vehicles in Civil Airspace*, at 2-49 (Nov. 2004) at [http://www.mitre.org/work/tech\\_papers/tech\\_papers\\_04/04\\_1232/04\\_1232.pdf](http://www.mitre.org/work/tech_papers/tech_papers_04/04_1232/04_1232.pdf) (last visited Mar. 19, 2005).

<sup>33</sup> *Jane’s All the World’s Aircraft* 38-9 (Paul Jackson Ed., 2001-2002)

<sup>34</sup> See generally Newcome, *supra* note 23 at 114. This flight was of the UAV/ROA Aerosondes, which on 22 September 1997 flew totally autonomously for one hour; from takeoff to landing, it flew under continuous autopilot. (*Our First Fully Robotic Flight*, at <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/ROA, which is ideal for remote observation such as Antarctica, Canadian Northern Regions, and Australian interior. See generally J.A. Curry, J. Maslanik, J.O. Pinto, S. Drobot, and J. Cassano, *Applications of Aerosondes for RIME*, at [http://polarmet.mps.ohio-state.edu/RIME-01/pdf\\_docs/curry.pdf](http://polarmet.mps.ohio-state.edu/RIME-01/pdf_docs/curry.pdf) (last visited Apr. 29, 2005); <http://www.aerosonde.com/index.php>.

or at the very least monitoring. Even the infamous 2001 nonstop flight of 7,500 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.<sup>35</sup> 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 ROA/UAV.<sup>36</sup>

It is fair to say that the current and foreseeable future of UAV/ROA 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 UAV/ROAs into the NAS.<sup>37</sup>

As aircraft, UAV/ROAs 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, otherwise known as the Chicago Convention ("Chicago Convention"), to manage the safety and security

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<sup>35</sup> See generally 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 at [http://avtoday.com/cgi/av/show\\_mag.cgi?pub=av&mon=1004&file=UAV/ROAsenteringthe.htm](http://avtoday.com/cgi/av/show_mag.cgi?pub=av&mon=1004&file=UAV/ROAsenteringthe.htm) (lasted visited Jan. 11, 2005).

<sup>36</sup> See Jefferson Morris, *USAF No Longer Viewing Global Hawk as an Autonomous System*, *Aerospace Daily*, Dec. 5, 2003, at 1

<sup>37</sup> 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.

of international civil aviation.<sup>38</sup> The annexes to the Chicago Convention define 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.<sup>39</sup> Also of note, the Chicago Convention further defines 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.”<sup>40</sup> Therefore, it follows that the regulatory framework to integrate UAV/ROAs 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 therefore, not a UAV/ROA. 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 discriminants 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

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<sup>38</sup> Convention on International Civil Aviation, Dec. 7, 1944, 61 Stat. 1180, 15 U.N.T.S. 295 (hereinafter “Chicago Convention”). 52 allied and neutral nations participated in this International Civil Aviation Conference that drafted and signed the Chicago Convention.

<sup>39</sup> *Id.*, annex 2, § 1.

<sup>40</sup> *Id.*

payload. Ballistic or semi ballistic vehicles, cruise missiles, and artillery projectiles are not considered unmanned aerial vehicles.<sup>41</sup>

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 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 DoD for UAV testing, development, and procurement,<sup>42</sup> 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/ROA 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 non-lethal payload. Ballistic or semi ballistic vehicles,

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<sup>41</sup> Department of Defense, *Unmanned Aerial Vehicles Roadmap 2002-2027*, 2 (December 2002), at [http://www.acq.osd.mil/usd/UAV/ROA\\_roadmap.pdf](http://www.acq.osd.mil/usd/UAV/ROA_roadmap.pdf) (last visited 15 Jan. 2005).

<sup>42</sup> Amy Butler and David A. Fulghum, *U.S. Air Force Wants to be Pentagon's UAV Manager but the Plan has Army and Navy Officials Worried*, *Aviation Week & Space Technology* (March 7, 2005)

cruise missiles, and artillery projectiles are not considered unmanned aerial vehicles.”<sup>43</sup>

In addition to a definition, within the UAV/ROA genre there are, as noted by the above reference to lighter or micro UAV/ROAs, different classifications of UAV/ROAs that draw distinction not only on size, but also flying altitude and applications. For example, the most commercially viable utility of UAV/ROAs 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.<sup>44</sup> These UAV/ROAs have been called by DoD, NASA, FAA, and others as “high altitude, long endurance” or “HALE” UAV/ROAs. For purposes of this work, this classification will be referred to as HALE UAV/ROAs.<sup>45</sup>

In its roadmap for the certification and regulatory future of HALE UAV/ROAs, NASA’s Environmental Research Aircraft and Sensor Technology (“ERAST”) project defines a HALE UAV/ROA 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.”<sup>46</sup>

HALE UAV/ROAs 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

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<sup>43</sup> Department of Defense, *DOD Dictionary of Military and Associated Terms*, Joint Publication 1-02 (Nov. 30, 2004) at <http://www.dtic.mil/doctrine/jel/doddict/index.html> (last visited Apr. 20, 2005)

<sup>44</sup> 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).

<sup>45</sup> NASA, *ERAST Project, Concept of Operations: High-Altitude Long-Endurance Unmanned Aerial Vehicles 1* (Version 1.2).

<sup>46</sup> NASA Certification Roadmap, *supra* note 16, at 6.



“generally spend most of their time in Class A airspace above 18,000 feet where they are under positive air traffic control”.<sup>47</sup> Therefore, it is the HALE UAV/ROA, or as delineated by European aviation authorities, UAV/ROAs with service induced applications, which form the largest future user of commercial airspace, and potentially ATM and airport services.<sup>48</sup>

Medium altitude UAV/ROAs will also need to be launched from an airfield or airport, but will generally perform operations at 18,000 feet or below.<sup>49</sup> They are referred to by European aviation authorities as having platform based applications.<sup>50</sup> These UAV/ROAs are primarily used by militaries and other governmental bodies for operations such as ground or infrastructure monitoring.<sup>51</sup> For purposes of this work, this classification will be delineated into medium altitude, long endurance UAV/ROAs or “MALEs,” and the less descriptive medium altitude UAV/ROAs.

The final classification is the lower altitude UAV/ROAs, which operate below 1,500 feet and are currently primarily technology based applications. This classification is currently dominated by scientific and academic organizations working on smaller, more power efficient UAV/ROAs.<sup>52</sup> The military also has a

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<sup>47</sup> *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). Federal Aviation Administration’s Designation of Class A Airspace Areas, 14 C.F.R. § 71.33 (2005).

<sup>48</sup> See NASA, *supra* note 16, at 7; JAA, *supra* note 14, at 4-5.

<sup>49</sup> Aviva Brecher, Val Noronha, and Martin Herold, *UAV2003 a Roadmap For Deploying Unmanned Aerial Vehicles (UAVs) in Transportation*, 5, Dec. 2, 2003, at <http://www.ncgia.ucsb.edu/ncrst/meetings/20031202SBA-UAV2003/Findings/UAV2003-Findings-Final.pdf> (last visited Mar. 19, 2005)

<sup>50</sup> See NASA, *supra* note 16, at 7; JAA, *supra* note 14, at 4-5.

<sup>51</sup> See NASA, *supra* note 16, at 7; JAA, *supra* note 14, at 4-5.

variety of UAV/ROA in this classification, to include tactical weapon and surveillance platforms.<sup>53</sup> This classification also includes small and lightweight UAV/ROAs 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 UAV/ROAs.

## **B. HISTORY OF UAV/ROAs**

The process of defining, delineating, and classifying UAV/ROAs is incomplete without understanding how the UAV/ROA evolved into its current and future manifestations. Early versions of the UAV/ROA 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/ROA. However, over time, technology allowed the UAV/ROA to not only be remotely operated, but also evolve into either non-weaponized aircraft or into aircraft capable of bombing a target with armaments that could be separated from the aircraft.

The dreams of early UAV/ROA pioneers began to form along side manned aviation; however, the development of a finished, usable product came at a slow pace, much slower than manned flight.<sup>54</sup> While it could be argued that UAV/ROAs were actually developed before manned aircraft, as most aviation discoverers first created unmanned versions, these unmanned models were simply to test the airworthiness and

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<sup>52</sup> NASA, *supra* note 16, at 7; JAA, *supra* note 14, at 4-5.

<sup>53</sup> *UAV Categorisation*, in 2004 Yearbook: UAVs Global Perspective 156 (UVS International, Blyenburgh & Co.); Brecher, *supra* note 49 at 4.

<sup>54</sup> *See generally* Newcome, *supra* note 23, at 11-56.

durability of the airframe; or in other words, a means to an end and not the end product.<sup>55</sup>

First included in *Jane's All the World's Aircraft* in 1920, UAV/ROAs were tested before and during World War I, but not used in combat.<sup>56</sup> However, these early pilotless aircraft were merely flying bombs, with no in-flight control and designed to crash after a certain programmed period of flight.<sup>57</sup> Nevertheless, in developing these aerial torpedoes or flying bombs; the limiting factor of pilotless stabilization became a large obstacle. With a pilot on board, an aircraft could be righted during flight; without a pilot, stabilization had to be done by the machine.

In the second decade of the 20<sup>th</sup> century, inventors Elmer Sperry and his son, Lawrence, crevassed the chiasm of stabilization by developing gyrostabilizers, which were initially invented for use on U.S. Navy ships.<sup>58</sup> 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.<sup>59</sup> 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 in flight without a pilot touching the controls for a portion of

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<sup>55</sup> See generally John D. Anderson, Introduction to Flight Its Engineering and History, 24-5 (1978); Gene Gurney, Lt Col, USAF, A Chronology of World Aviation 1-4 (1965).

<sup>56</sup> Bone and Bolcom, *supra* note 5, at 6.

<sup>57</sup> See DeGarmo, *supra* note 32, at 2.

<sup>58</sup> See generally, Staff, *Historical Threads Leading to Today's Unmanned Vehicles in the USA*, in 2004 Yearbook: UAVs Global Perspective 108, 111 (UVS International, Blyenburgh & Co.).

<sup>59</sup> Newcome, *supra* note 23, at 16.

the flight.<sup>60</sup> Their work in gyrostabilization was also noted as the most noteworthy aviation achievement in 1914.<sup>61</sup>

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.<sup>62</sup> While Lawrence Sperry and his father made many technological advances that made pilotless aviation a possibility, their work in manned aviation generally is of no little significance.<sup>63</sup> In fact, as one aviation historian declared, “[Lawrence Sperry] did more than any other inventor to bring about safety in flying, and automatic piloting of aircraft.”<sup>64</sup>

The Sperrys continued research in automated piloting by attempting to develop a prototype aerial torpedo for the U.S. Navy.<sup>65</sup> In 1915, Elmer Sperry was appointed to the Naval Consultant Board; mirroring a similar board of British

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<sup>60</sup> See generally Charles H. Gibbs-Smith, *The Aeroplane: An Historical Survey of its Origins and Development* 87 (1960); *id.* The Sperrys’ invention and demonstration won a 15,000 francs prize at the competition.

<sup>61</sup> 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.).

<sup>62</sup> Charles H. Gibbs-Smith, *Aviation: An Historical Survey from its Origins to the end of World War II*, 166 (1970).

<sup>63</sup> See generally *id.* at 192-3. Gibbs-Smith 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 chiefly as a result of Sperry’s work in the United States; Sperry perfected the gyro horizon and directional gyro, and on September 24<sup>th</sup> 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.

<sup>64</sup> *Id.* at 170.

<sup>65</sup> See *id.* at 18.

scientists previously created in England.<sup>66</sup> 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.<sup>67</sup> By 1917, they had succeeded in flying Curtiss N-9 seaplanes on 30 mile preprogrammed flights; however, 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.”<sup>68</sup> 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 his theory of alternating current, and its subsequent purchase and use by George Westinghouse to “electrify” New York City.<sup>69</sup>

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

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<sup>66</sup> See Marc J. Seifer, *Wizard: The Life and Times of Nikola Tesla Biography of a Genius*, 377 (1996).

<sup>67</sup> See Newcome, *supra* note 23, at 16-7.

<sup>68</sup> 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.” (<http://www.tfcbooks.com/tesla.htm>) 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 [www.teslasciencecenter.org](http://www.teslasciencecenter.org). One author has called Tesla’s telautomaton “one of the single most important technological triumphs of the modern age.” Seifer at 200.

<sup>69</sup> See generally *id.* at 100-01.

operate lights.<sup>70</sup> Ten years previous 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.<sup>71</sup> 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.<sup>72</sup>

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.<sup>73</sup> Indeed, in flight control was required to turn flying bombs into maneuverable and recoverable UAV/ROAs.

Both Elmer Sperry and Hewitt were acquainted with Tesla's work in remotely controlled vehicles,<sup>74</sup> and knew that it was the next step in creating fully pilotless aircraft. Therefore, the Sperrys and Hewitt 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.<sup>75</sup> However, they were only able to successfully launch and fly one out of the six.<sup>76</sup>

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<sup>70</sup> *Id.* at 195.

<sup>71</sup> Staff, *History Threads*, *supra* note 58, at 110.

<sup>72</sup> *See* Newcome, *supra* note 23, at 13.

<sup>73</sup> *See generally* Seifer, *supra* note 66, at 17, 333.

<sup>74</sup> *See generally id.*, at 71, 160.

<sup>75</sup> *See* Newcome, *supra* note 23, at 18.

<sup>76</sup> *See generally id.* at 18-20.

Nevertheless, it is that one flight that occurred on 6 March 1918 that an author called the “unmanned aviation’s counterpart to the Wright Brother’s flight 14 years earlier,” as it was arguably the first pilotless flight of a specifically designed pilotless aircraft.<sup>77</sup> 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.<sup>78</sup> 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.<sup>79</sup> Moreover, in 1918, soon after a pilotless Curtiss N-9 did not operate as programmed, but flew off into the horizon, the U.S. Navy ended its association with Elmer Sperry and Hewitt.<sup>80</sup>

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 U.S. Army desired for short missions from the headquarters to the front line.<sup>81</sup> Like the Curtiss

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<sup>77</sup> *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, [www.ctie.monash.edu.au/hargrave/rpav\\_britain.html](http://www.ctie.monash.edu.au/hargrave/rpav_britain.html), 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. 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. Monash agrees that a flight on 3 September 1924, which will be discussed later, was the first successful radio controlled flight of a UAV/ROA.

<sup>78</sup> *See* Newcome, *supra* note 23, at 20.

<sup>79</sup> *See id.* at 19-20.

<sup>80</sup> *See id.*

<sup>81</sup> *Id.* at 31.

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. However, 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. Further, in December of 1923, Lawrence Sperry died in a puzzling aircraft mishap at sea,<sup>82</sup> and the Sperry Aircraft Company closed up shop.<sup>83</sup>

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

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<sup>82</sup> *See id.* 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; however, his plane was found in tact and floating three miles off the British shore. Newcome at 34.

<sup>83</sup> *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. The American Heritage History of Flight stated that “The Sperry Gyroscope Company in 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.” The American Heritage History of Flight 246 (Alvin M. Josephy, Jr., ed. 1962). 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. At [http://www.firstflight.org/shrine/lawrence\\_sperry.cfm](http://www.firstflight.org/shrine/lawrence_sperry.cfm) (last visited Apr. 5, 2005).



efforts produced the United States' first fully unmanned, remotely controlled flight on 15 September 1924.<sup>84</sup>

Notwithstanding Norden's achievement, it was simultaneous testing in Britain that on 3 September 1924, just 12 days prior, produced the first recorded successful and fully unmanned aircraft flight using remote control technology.<sup>85</sup> That flight for the Royal Navy lasted 39 minutes and covered a range of almost 104 Kilometers or 65 miles.<sup>86</sup>

But alas, UAV/ROA 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 UAV/ROAs as early as 1916-17;<sup>87</sup> spurred on by the advances of inexpensive aircraft engines for use in World War I.<sup>88</sup> Interestingly, these early UAV/ROAs were equipped with radio controls; however, none made it successfully into flight.<sup>89</sup> World War I delayed British UAV/ROA testing, and it wasn't until 1922 that full scale experiments were conducted to develop flying torpedoes.<sup>90</sup> However, it was the Royal Navy that first saw the utility of a pilotless aircraft operating as a true

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<sup>84</sup> See Newcome, *supra* note 23, at 37-8

<sup>85</sup> *Id.* at 38, 45, 139

<sup>86</sup> *Id.*

<sup>87</sup> See generally discussion in note 77, *supra*; Gurney, *supra* note 55, at 23; Gibbs-Smith, *supra* note 60, at 176.

<sup>88</sup> See Newcome, *supra* note 23, at 43-5.

<sup>89</sup> *Id.*

<sup>90</sup> *Id.*

UAV/ROA, and not a missile, when they began testing unmanned aircraft as flying targets for warships.<sup>91</sup>

Thus, it is noteworthy that this latter effort to build target drones that pushed the development of UAV/ROAs beyond flying torpedoes or bombs into reusable, pilotless aircraft; albeit, they were only reusable if gun ships did not hit their target.<sup>92</sup> In fact, in 1933, through the use of a UAV/ROA 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.<sup>93</sup> The success of the Fairey Queen led to the production of the DeHavilland Queen Bee radio-controlled UAV/ROA and its use by the Royal Navy to hone anti-aircraft defenses before and during World War II.<sup>94</sup> 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 UAV/ROAs to train their armed forces.<sup>95</sup>

While target drones may not have been attractive to other nations at the time of World War II, both Allied and Axis countries began to look at aerial or flying bombs as potential weapons. Germany, France, Italy, Russia, and Japan militaries all

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<sup>91</sup> See *id.* at 46. Apparently British interest in target drones was fueled by U.S. Army Air Corps Brigadier General Billy Mitchell's demonstration of aircraft bombing and sinking retired U.S. Navy warships. While the debate on the effectiveness of aircraft upon Navy ships brewed in the United States, in Britain the debate was attacked a little differently as the Royal Navy developed unmanned aircraft to prove that the warships could shoot down aircraft. However, it was soon noted, that anti-aircraft skills needed to improve. Newcome at 46.

<sup>92</sup> See generally *id.*

<sup>93</sup> *Id.* at 47.

<sup>94</sup> See *id.* 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 332 (C.G. Grey & Leonard Bridgman Eds., 1939).

<sup>95</sup> Newcome, *supra* note 23, at 48.

had begun either before or during World War II projects to develop unmanned flying bombs.<sup>96</sup> The most infamous flying bomb of World War II was Germany's use of the simple, yet deadly, V-1 cruise missile type "flying bomb," and its second edition, liquid fueled-rocket, V-2.<sup>97</sup> 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.<sup>98</sup> 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.<sup>99</sup> Four B-17s were launched on 4 August 1944, but one aircraft exploded over the United Kingdom, killing its crew, and the final three failed to reach their targets.<sup>100</sup> The plan was soon extinguished.<sup>101</sup> Nevertheless, it was on the other side of the globe that a true UAV/ROA for combat purposes was being developed for use in World War II.

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<sup>96</sup> *See generally id.* at 49-56.

<sup>97</sup> Gibbs-Smith, *supra* note 62, at 122.

<sup>98</sup> *See generally* Lazarski, *supra* note 1.

<sup>99</sup> *See generally id.*

<sup>100</sup> *See generally id.*

<sup>101</sup> *Id.*

In the early fall of 1944, the U.S. Navy employed in the Pacific Theater an aerial torpedo squadron to bomb Japanese targets.<sup>102</sup> While this was not a terribly new idea, the transformation of an aerial torpedo into a true UAV/ROA came when they used these aircraft to drop bombs. Thus, 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.<sup>103</sup> 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.<sup>104</sup> Notwithstanding the success of these UCAVs, the operation was cancelled shortly thereafter.<sup>105</sup>

After World War II, the Cold War’s emphasis on stealthy reconnaissance and the political quandary 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/or reconnaissance aircraft. Surveillance<sup>106</sup> and reconnaissance<sup>107</sup> seem a natural fit for UAV/ROAs. In fact, the first aerial photographs were taken in 1888 from a kite invented by Frenchman Arthur Battut.<sup>108</sup>

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<sup>102</sup> Newcome, *supra* note 23, at 68-9.

<sup>103</sup> *Id.*

<sup>104</sup> *Id.*

<sup>105</sup> *Id.*

<sup>106</sup> Surveillance is defined by DoD and NATO as “The systematic observation of aerospace, surface, or subsurface areas, places, persons, or things, by visual, aural, electronic, photographic, or other means. See also air surveillance; satellite and missile surveillance; sea surveillance. Department of Defense, *DOD Dictionary of Military and Associated Terms*, Joint Publication 1-02 (Nov. 30, 2004) at <http://www.dtic.mil/doctrine/jel/doddict/index.html> (last visited Apr. 6, 2005).

<sup>107</sup> 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

Nevertheless, during the cold war, in an era of political chess between two super-powers, HALE UAV/ROA development was on a funding and fielding rollercoaster.<sup>109</sup> For example, in 1966 the USAF initiated a program to stealthily collect intelligence through a high-level surveillance UAV/ROA called the AQM-91A Firefly manufactured by Teledyne Ryan.<sup>110</sup> The USAF ordered 28; however, in 1972 as relations between China began to improve, the USAF cancelled the program before any Firefly could be flown operationally.<sup>111</sup> Interestingly, prior to canceling the Firefly program, the USAF had already flown Lockheed's Mach 4 GRD-21 operationally over China.<sup>112</sup> As could be imagined, the D-21 missions were highly classified; not only for the operation, but also the technology as 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).<sup>113</sup>

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or potential enemy, or to secure data concerning the meteorological, hydrographic, or geographic characteristics of a particular area. Also called RECON." *Id.* Hence, 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.

<sup>108</sup> Gibbs-Smith, *supra* note 60, at 56.

<sup>109</sup> Pike, *supra* note 4 (Since 1964, the DoD has funded research and development of 11 different UAV/ROAs; yet, only 3 entered into production).

<sup>110</sup> *Historical Threads*, *supra* note 58, at 109

<sup>111</sup> *See id.*

<sup>112</sup> *See generally id.*

<sup>113</sup> DeGarmo, *supra* note 32, at 1-3. "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." (Parsch,

The United States wasn't the only nation to find a surveillance niche for UAV/ROAs. As early as 1960, other countries were fielding UAV/ROAs 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/ROA designed for tactical photography.<sup>114</sup> Further, by 1970, Belgium, Canada, France Germany, Italy and the United States all had HALE or MALE UAV/ROAs dedicated to surveillance and/or reconnaissance.<sup>115</sup>

However, it was not until the Vietnam War that UAV/ROAs were 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.<sup>116</sup> Nevertheless, just as was the case after World War II, the United States mothballed many of the UAV/ROAs used in

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Andreas, *Directory of U.S. Military Rockets and Missiles*, at <http://www.designation-systems.net/dusrm/index.html> (last visited Apr 7, 2005)).

<sup>114</sup> *Jane's All The World's Aircraft* 191 (Leonard Bridgman Ed., 1959-60).

<sup>115</sup> *Jane's All The World's Aircraft* 510-23 (John W.R. Taylor Ed., 1969-70).

<sup>116</sup> See Bone and Bolcom, *supra* note 5, at 6; Newcome, *supra* note 23, at 68-9. There were three main U.S. UAV/ROAs flown in operations during the Vietnam War, the AQM-34 lightning Bug, QH-50 Antisubmarine Helicopter, and GTD-21. The most heavily used was the AQM-34, known as the Lightning Bug, which flew 3,435 combat sorties, and over 100,000 feet (30,480 meters) of reconnaissance film taken and recovered. Newcome at 83-6.

Laurence Newcome recounts the following account of 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, 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. Newcome at 90.

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.<sup>117</sup>

It is an interesting hypothesis as it wasn't until 2001 that the USAF, upon the request of its Chief of Staff, General John Jumper, converted a UAV/ROA into a weapon system.<sup>118</sup> On 16 February 2001, a Predator successfully launched a Hellfire-C laser guided missile that struck a stationary tank.<sup>119</sup> Thereby, the Predator evolved from a solely reconnaissance MALE UAV/ROA into aUCAV. Yet, as noted,UCAVs were first used by the United States in 1944.<sup>120</sup> Therefore, the question remains, particularly for the United States, whyUCAV, or even UAV/ROA 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.<sup>121</sup> While the technology as well as the end goals were dramatically different, it seems to harken back to 1920-24 and the work of Sperry and Norden.

While it could be argued that there is fear by pilots, particularly of the armed forces, that UAV/ROAs pose a threat to desired operations, there are also other possibilities why UAV/ROA development moved at such a slow pace. One study commissioned by DoD cites other reasons, such as funding battles, technology

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<sup>117</sup> Newcome, *supra* note 23, at 91.

<sup>118</sup> David Fulghum, *Star Unmanned Aircraft Faces Bureaucratic Fight*, in *World News & Analysis*, Aviation Week & Space Technology, Mar. 12, 2001 at 29.

<sup>119</sup> Lazarski, *supra* note 1.

<sup>120</sup> *See* Newcome *supra* note 23, at 68-69.

<sup>121</sup> *See* discussion in note 34, *supra*.

hurdles, and inter and intra-service cultural concerns, that led to a slow paced development and utilization of UAV/ROAs by the United States.<sup>122</sup> Nevertheless, UAV/ROAs 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/ROA 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”) moved their UAV/ROA program full steam, logging thousands of hours of flight time.<sup>123</sup> In fact, it was IDF’s use of UAV/ROAs during operations in Lebanon in 1982 that slowly enticed the DoD to look closer at future tactical level intelligence gathering through MALE UAV/ROAs.<sup>124</sup>

Japan is another country that began to develop uses for the UAV/ROA. In Japan, however, UAV/ROA development not only included military uses, but also the unique role of crop spraying. Japanese research in UAV/ROA technology dates back to World War II.<sup>125</sup> Now, Japan is the largest market for civilian UAV/ROAs.<sup>126</sup> Japanese research into UAV/ROA technology resurfaced in the 1970s through Fuji Heavy Industries, which began developing a fairly full range of UAV/ROAs for both

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<sup>122</sup> Defense Science Board, *supra* note 8, at 5-6.

<sup>123</sup> Bone and Bolkcom, *supra* note 5, at 2.

<sup>124</sup> *See Id.*

<sup>125</sup> *See* Newcome, *supra* note 23, at 54-5.

<sup>126</sup> *See generally* Staff, *Commercial use of UAVs—Widespread in Japan*, in 2004 Yearbook: UAVs Global Perspective 138 (UVS International, Blyenburgh & Co.); *Id.* at 127.



military and civilian use.<sup>127</sup> The biggest market for Japanese UAV/ROAs is in helicopter, or rotary winged aircraft, used for agriculture and scientific observation.<sup>128</sup>

The first UAV/ROA helicopter, the Kaman Done Helicopter, was developed by the United States and flew in 1953.<sup>129</sup> However, it took the Yamaha Motor Company of Japan to seize the practical application of helicopter UAV/ROAs 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.<sup>130</sup> Currently, in Japan it is estimated that there are 2,000 helicopter UAV/ROAs, and over 8,000 certified operators; most are non-government operated.<sup>131</sup> This makes up approximately 65% of the use of UAV/ROAs globally.<sup>132</sup>

### **C. CURRENT AND FUTURE USES OF THE UAV/ROA**

While the history and development of the UAV/ROA 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 of UAV/ROA funding, research, and utilization.<sup>133</sup> Interest in UAV/ROAs continues to grow throughout the globe. Today, there are over 40 countries developing and using

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<sup>127</sup> *See id.*

<sup>128</sup> *See id.*; Newcome, *supra* note 23, at 127.

<sup>129</sup> Jane's 1959-1960, *supra* note 114, at 321.

<sup>130</sup> *Commercial use in Japan*, *supra* note 126.

<sup>131</sup> *See id.*

<sup>132</sup> Newcome, *supra* note 23, at 127.

<sup>133</sup> *See Status Report on US UAV Programmes*, in 2004 Yearbook: UAVs Global Perspective 112 (UVS International, Blyenburgh & Co.).

UAV/ROAs.<sup>134</sup> As far as sheer numbers go, the above-mentioned Japanese market for radio-controlled helicopters used for agricultural purposes overwhelming leads all numbers of UAV/ROAs currently in use.<sup>135</sup>

However, as far as the type of application or utility of UAV/ROAs, military use is by far the most common. It is reported that 90% percent of all funding for UAV/ROA systems worldwide is for military programs.<sup>136</sup> In the past two years alone, the DoD has increased UAV/ROA research, development, and fielding from approximately \$350 million a year to over \$1 billion.<sup>137</sup> Moreover, DoD has plans to increase spending to \$3 billion a year by 2008-2009.<sup>138</sup> Thus, UAV/ROA development may become “the most dynamic sector of the aerospace industry”.<sup>139</sup>

The most common military application for UAV/ROAs is surveillance by HALE or MALE UAV/ROAs.<sup>140</sup> 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/ROA systems.<sup>141</sup> Israel, which has a strong market for its

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<sup>134</sup> *UAV Categorisation*, *supra* note 53, at 156.

<sup>135</sup> *Newcome*, *supra* note 23, at 127.

<sup>136</sup> *See id.*

<sup>137</sup> *See DeGarmo*, *supra* note 32, at 1-11.

<sup>138</sup> Jefferson Morris, *DOD UAV Budget To Hold Fairly Steady In FY '06, Official Says*, Aerospace Daily and Defense Report, Feb. 10, 2005, at [http://www.aviationnow.com/avnow/news/channel\\_aerospacedaily\\_story.jsp?id=news/UAVBUDG02105.xml](http://www.aviationnow.com/avnow/news/channel_aerospacedaily_story.jsp?id=news/UAVBUDG02105.xml) (last visited May 30, 2005).

<sup>139</sup> *DeGarmo*, *supra* note 32, at 1-11. (Quoting a presentation of a UAV market study by the Teal Group at the AUVSI Unmanned Systems Symposium in August 2004.)

<sup>140</sup> *UAV Categorisation*, *supra* note 53, at 156.

<sup>141</sup> *See generally DeGarmo*, *supra* note 32, at 1-4; *Newcome*, *supra* note 23, at 130; and *UAV Categorisation*, *supra* note 53, at 156.

military application based UAV/ROAs,<sup>142</sup> is a distant second in UAV/ROA development, followed closely by France.<sup>143</sup> Other countries having significant UAV/ROA military development programs include the above-mentioned Japan, China, South Korea, Pakistan, Russia, Australia, England, Canada, Italy, Germany and Sweden.<sup>144</sup>

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<sup>142</sup> For example, even though U.S. manufacturers account for nearly two-thirds of the market, both the U.S. Armed Forces and the Department of Homeland Security have purchased Israeli made UAV/ROAs. Newcome, *supra* note 23, at 128; DeGarmo, *supra* note 32, at 1-4.

<sup>143</sup> UAV *Categorisation*, *supra* note 53 at 156.

<sup>144</sup> *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. 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 32, at 1-12,3.

The future of UAV/ROAs will not only include continued use by the world's militaries as target drones, decoys, air-combat aircraft,<sup>145</sup> and observation platforms, but also non-military use by governments and commercial entities. These uses will include the use of HALE, MALE, micro and low altitude UAV/ROAs as observational and sensor platforms for security/boarder monitoring,<sup>146</sup> traffic monitoring,<sup>147</sup> environmental/natural disaster monitoring,<sup>148</sup> and criminal surveillance.<sup>149</sup> HALE UAV/ROAs may also be used as telecommunication platforms and cargo carriers. In addition to their use as scientific experimental and monitoring platforms, low altitude UAV/ROAs could also be used as miniature, almost undetectable, spy or surveillance aircraft,<sup>150</sup> as courier vehicles to deliver mail or packages across town, in a large indoor complex or building, or even to deliver

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<sup>145</sup> 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." (*X-45 Background Info*, Boeing, at <http://www.boeing.com/defense-space/military/x-45/x45back.html> (last visited May 2, 2005).

<sup>146</sup> See Vasilios Tasikas, *Unmanned Aerial Vehicles and the Doctrine of Hot Pursuit: A New Era of Coast Guard Maritime Law Enforcement Operations*, 29 Mar. Law. 59 (2004); Rich Tuttle, *Afghanistan Operations Boost Vision of UAVs for Homeland Defense*, *Aerospace Daily*, Jan. 2, 2002, p. 7.

<sup>147</sup> See Richard A. Livingston, Richard A., *Innovative Technology: Unmanned Aerial Vehicle Provides New Traffic View*, Research & Technology Transporter, U.S. Department of Transportation, Federal Highway Administration (Jan. 2003).

<sup>148</sup> See *High Times*, *The Economist*, Dec. 11, 2003 at [http://www.economist.com/science/displaystory.cfm?story\\_id=2282185](http://www.economist.com/science/displaystory.cfm?story_id=2282185) (last visited Feb. 9, 2005); Wichner, David, *Small UAVs Geared to be Eyes in Skies*, *Arizona Daily Star*, Apr. 21, 2005, at <http://www.dailystar.com/dailystar/allheadlines/71467.php> (last visited May 2, 2005).

<sup>149</sup> See *A Flying Crime Fighter—Some Assembly Required*, *GovPro-Government Product News and Government Procurement Journal*, at <http://www.govpro.com/ASP/ViewArticle.asp?strArticleId=104386&st=1>, (last visited May 2, 2005).

<sup>150</sup> See *High Times*, *supra* note 148.

food.<sup>151</sup> Further, there could be untapped uses of UAV/ROAs in agricultural and industrial uses where robotic technology can assist in dull, dirty, and dangerous operations.<sup>152</sup>

HALE UAV/ROAs 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 UAV/ROAs bear further comment; namely, telecommunication platforms and cargo carriers. In the role of telecommunications platforms, HALE UAV/ROAs have a very bright future. UAV/ROA 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.<sup>153</sup> This is expected to spawn a new generation of UAV/ROAs called "atmospheric satellites," which may be able to do work such as telecommunications more efficiently at much lower cost than current space-based satellites.<sup>154</sup>

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 DoD, is called Airborne Communications

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<sup>151</sup> Reynish, *supra* note 35.

<sup>152</sup> See generally *UAVs Soaring Beyond Military Uses*, UAV Technical Analysis and Applications Center, New Mexico State University, at <http://www.psl.nmsu.edu/uav/news/usa/index2.php>, (last visited May 2, 2005).

<sup>153</sup> *Past Projects – Helios Prototype*, NASA Dryden Flight Research Center, at <http://www.nasa.gov/centers/dryden/history/pastprojects/Erast/helios.html> (last visited Apr. 30, 2005); Bill Sweetman, *HALE Storms to New Heights*, *Jane's International Defence Review*, Mar. 1, 2001 at [http://www.janes.com/aerospace/military/news/idr/idr010301\\_2\\_n.shtml](http://www.janes.com/aerospace/military/news/idr/idr010301_2_n.shtml) (last visited Feb 11, 2005).

<sup>154</sup> See *Helio Prototype*, *supra* note 153.

Nodes (“ACNs”).<sup>155</sup> 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.”<sup>156</sup> ACN UAV/ROAs 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.<sup>157</sup>

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, and the signal's travel distances would be 1,000 times shorter than spaced-based satellite systems; thereby, increasing system capacity and reducing power requirements on either end.<sup>158</sup> Such systems could also be extremely successful for mobile and fixed-site communications.<sup>159</sup>

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

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<sup>155</sup> *Airborne Communications Node (ACN/AJCN)*, Advanced Technology Office, Defense Advance Research Projects Agency, at <http://www.darpa.mil/ato/programs/acn.htm>, (last visited May 2, 2005).

<sup>156</sup> Sweetman, *supra* note 153.

<sup>157</sup> *See id.*

<sup>158</sup> *Id.*

<sup>159</sup> *See Helio Prototype, supra* note 153; Sweetman, *supra* note 153.

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.<sup>160</sup>

UAV/ROAs could also be used as a cost effective way to transport small amounts of cargo. While cargo carrying development of UAV/ROA has not yet come to fruition, the next generation of Northrop Grumman's Global Hawk, the RQ-4B, has the increased a payload capacity of almost 2,998 pounds or 1,360 kilograms.<sup>161</sup> 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 3,153 pounds or 1,433.18 kilograms.<sup>162</sup> Current versions of the Global Hawk have a length of 44 feet or 13.4 meters, which is slightly shorter than the C-21.<sup>163</sup> And while the C-21's mission is not primarily cargo transportation, but personnel,<sup>164</sup> and the Global Hawk is primarily a HALE UAV/ROA, which will use the increased payload capacity to carry more observational or communication sensors, in theory such a UAV/ROA would be able to transport small amounts of cargo, as much as a C-21, minus personnel, higher and further with 24 hours continuous operations.<sup>165</sup>

As bright as the future of UAV/ROA utilization maybe, there are technological and legal hurdles in the flight path toward full utilization. The end-goal for integration of UAV/ROAs is a "file and fly" system currently enjoyed by pilot-on-

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<sup>160</sup> See generally Sweetman, *supra* note 153.

<sup>161</sup> *US UAV Programmes*, *supra* note 53, at 112-3.

<sup>162</sup> *C-21*, Air Force Link Fact Sheet, at <http://www.af.mil/factsheets/factsheet.asp?fsID=88> (last visited Apr. 29, 2005)

<sup>163</sup> *Specifications: Global Hawk*, U.S. Arsenal, Associated Press, at <http://abclocal.go.com/images/wabc/USArsenal/> (last visited Apr. 30, 2005); *Id.*

<sup>164</sup> *C-21*, *supra* note 162. The C-21 can carry up to eight passengers and two crew.

<sup>165</sup> See Newcome, *supra* note 23, at 112.

board flights.<sup>166</sup> Current law within the United States requires UAV/ROA operators to follow FAA Order 7610.4, *Special Military Operations*, which requires UAV/ROAs 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.”<sup>167</sup> Application to the FAA for a COA must be filed 60-days prior to flying the UAV/ROA.<sup>168</sup>

The current scheme is not user friendly for this fledgling industry, and moreover, it is a burden on the deployment of UAV/ROAs from bases within the United States or their transit internationally. Therefore, the process of integrating UAV/ROAs 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/ROA 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.

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<sup>166</sup> Robbins, Karen, *National Next Generation Aircraft Technology Program Introducing Remotely Operated Aircraft (ROA) into the National Airspace System (NAS)*, White Paper submitted to U.S. Department of Transportation Research and Special Programs Administration (RSPA) Solicitation DTRS56-01-BAA-0002, at <http://www.erast.com/ehtml/vanguard.html>, (last visited May 2, 2005).

<sup>167</sup> Federal Aviation Agency (hereinafter FAA), *FAA Order 7610.4K Special Military Operations*, 12-9, (Aug. 2004); FAA, *FAA Order 7210.3T Facility Operation and Administration*, 18-6, (Feb. 2005). FAA Facility Operation and Administration, Part 6, Chapter 18

<sup>168</sup> *Order 7610.4K*, *supra* note 167, at 12-9-2.



### **III. CURRENT INTERNATIONAL AND DOMESTIC LAWS GOVERNING UAV/ROA UTILIZATION AND INTEGRATION**

A review of the current state of regulations that govern aviation, which would be applicable to UAV/ROA operations is an important step in determining where the regulatory holes are, as well as possible fixes. Therefore, I will first look at the international rules governing aviation generally, then move on to the aviation regulations of the United States, and finally, I will discuss regulations and directives from the United States, Australia and the United Kingdom (“UK”) that directly address UAV/ROA operations. Through this review, it will become clear that integration of the UAV/ROA into the NAS is primarily a technology driven issue as many of these regulations can and should apply to UAV/ROAs 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.<sup>169</sup> These delegates were forward thinking aviation statesman that knew that at the end of 1944, international industry, commerce, and the world’s future laid on the wings of the airplane.

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<sup>169</sup> See Chicago Convention, *supra* note 38; United States Department of State, *Proceedings of the International Civil Aviation Conference* (Vol. I and II, 1948). This meeting occurred in November and December of 1944 at Chicago, Illinois.

Indeed, World War II had brought fantastic advances in the development of the airplane.<sup>170</sup> 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.<sup>171</sup> WWII rode the wave of this development and ingenuity by developing bigger, faster, and safer people and cargo transporters.<sup>172</sup> 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.<sup>173</sup> 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.<sup>174</sup> That organization is the above-mentioned ICAO, which is currently headquartered in Montreal, Canada.<sup>175</sup> ICAO is part of the United Nations system, and is currently made up of 188 member states ("Contracting States").<sup>176</sup>

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<sup>170</sup> See Ray Bonds, *The Illustrated Directory of A Century of Flight* 156-235 (2003)

<sup>171</sup> See *id* at 144 - 55.

<sup>172</sup> See generally *id* at 230 - 31

<sup>173</sup> Chicago Convention, *supra* note 38. 52 allied and neutral nations participated in this International Civil Aviation Conference that drafted and signed the Chicago Convention.

<sup>174</sup> *Id.* at art. 1-10, and 43-79.

<sup>175</sup> See generally Kotaite, *supra* note 21.

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.<sup>177</sup> Codified in the Chicago Convention this principle is simply "that every State has complete and exclusive sovereignty over the airspace above its territory."<sup>178</sup>

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/ROA 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 ensure that the flight of such aircraft without a pilot in regions open to civil aircraft shall be controlled as to obviate danger to civil aircraft.<sup>179</sup>

Clearly, this group of aviation prophets foresaw the integration of UAV/ROAs into the NAS. As discussed in the previous chapter, by 1944, the time the Chicago Convention was drafted, militaries had used rudimentary forms of UAV/ROAs, and therefore, their military role in combat was arguably envisioned. In fact, it could be argued that their vision included civilian uses or at least the transit of military UAV/ROAs through the NAS. With the requirement that nations must ensure that the

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<sup>176</sup> See International Civil Aviation Organization, at <http://www.icao.int/index.html> (last visited May 3, 2005).

<sup>177</sup> See generally Stephen M. Shrewsbury, Major, USAF, *September 11<sup>th</sup> and the Single European Sky: Developing Concepts of Airspace Sovereignty*, 68 J. Air L. & Com. 115, 117-33 (2003).

<sup>178</sup> Chicago Convention, *supra* note 38, at art 1.

<sup>179</sup> *Id.* at art 8.

flight of UAV/ROAs 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 UAV/ROAs 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 UAV/ROAs 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/ROA technology and use has had to be developed 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/ROA integration, it is helpful to review existing rules and regulations that would apply to UAV/ROA flight simply by the fact that such are aircraft traveling through the NAS. A good place to start is the Chicago Convention and its accompanying annexes. As was just highlighted, the Chicago Convention will play a role in the integration of UAV/ROAs into the NAS, and as the bedrock document for aviation generally, it forms the basic back drop to future regulatory schemes.

### **1. Chicago Convention Articles Applicable to UAV/ROA Integration**

While Article 8 of the Chicago Convention covers UAV/ROAs 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,” as nations were seemingly unwilling to give up control of their military and police aircraft to an international body.<sup>180</sup> Therefore, it could be argued that as such, the Chicago Convention provides very little light on the vast majority of UAV/ROA 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/ROA 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 UAV/ROAs had been for military missions. With that in mind, it may have only been the operation of state UAV/ROAs that Chicago Convention drafters intended to regulate by Article 8.

Further, notwithstanding this inapplicability over state aircraft, the Chicago Convention does provide that state aircraft can not transverse the airspace or land on another nation without that nation’s approval.<sup>181</sup> This, coupled with Article 8, requires the military flight of any UAV/ROA 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/ROA 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”.<sup>182</sup> This requires Contracting States to draft military UAV/ROA procedures and protocols with due regard to safety of civilian

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<sup>180</sup> *Id.* at art 3.

<sup>181</sup> *Id.* at art 3(c).

<sup>182</sup> *Id.* at art.3(d).

aircraft; once again, with an eye toward the integration of the UAV/ROA into the NAS. Therefore, the Chicago Convention, its articles and annexes, have application or bearing upon all forms of UAV/ROA 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 UAV/ROAs 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.<sup>183</sup>

Article 12 is really an additional reminder that UAV/ROA 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. The rules so established under the Chicago Convention are in the Chicago Convention itself and in those rules established 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”.<sup>184</sup> These SARPs are found in

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<sup>183</sup> Chicago Convention, *supra* note 38, art. 12.

the annexes to the Chicago Convention, for which there are currently 18.<sup>185</sup> Pertinent portions of these annexes will be addressed later.

Additionally, Article 17, *Nationality of Aircraft*, and Article 20, *Display of Marks*, have application to UAV/ROAs, since they are indeed aircraft. Article 17 states that “aircraft have the nationality of the State in which they are registered.”<sup>186</sup> Article 20 states: “Every aircraft engaged in international air navigation shall bear its appropriate nationality and registration marks.”<sup>187</sup> Thus, UAV/ROAs must be registered in a state,<sup>188</sup> and UAV/ROAs 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/ROA 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/ROA’s operator(s).<sup>189</sup> With regards to the certificate of airworthiness, the Chicago Convention states that “every aircraft

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<sup>184</sup> *Id.* at art 37.

<sup>185</sup> 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. (Chicago Convention Articles 50a and 54(1)). Pursuant to Article 54(1) of the Chicago Convention, the Council, “for convenience,” designates the SARPs as annexes to this Convention. The Council adopts such annexes through a 2/3<sup>rd</sup> vote, and become effective within three months after its submission unless a majority of Contracting States registered disapproval. Chicago Convention, Article 90(a).

<sup>186</sup> *Id.* at art 17.

<sup>187</sup> *Id.* at art 20.

<sup>188</sup> Such registration can only take place in one State at a time, but may be transferred to another State. Chicago Convention, *supra* note 38, arts 19 and 83*bis*.

<sup>189</sup> *Id.* at art. 29.

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.”<sup>190</sup>

Pilots of UAV/ROAs, even 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”.<sup>191</sup> Thus, UAV/ROA 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 has import to UAV/ROA reconnaissance and surveillance activities. Article 36, *Photographic Apparatus*, states that, “Each 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 namely, state sovereignty over airspace.<sup>192</sup>

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<sup>190</sup> *Id.* at art. 31.

<sup>191</sup> *Id.* at art. 32.

<sup>192</sup> Contrast with the right to take aerial photographs over the high seas. It is generally recognized in International Law through treaties and State practice that over-flight and accompanying electronic surveillance in 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 from the coast, are considered part of the State’s territory including sovereignty rights over the air. *See generally* George K. Walker, *Information Warfare and Neutrality*, 33 Vand. J. Transnat’l L. 1079, 1167, 1190-1 (2000); Kay Hailbronner, *Freedom of the Air and the Convention on the Law of the Sea*, 77 A.J.I.L. 490, 503-10 (1983).



## 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,<sup>193</sup> these provisions and standards permeate deep into local, national rules and regulations.<sup>194</sup> For example, while 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, 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/or personnel into its airspace.<sup>195</sup> However, the enabling power of this non-recognition principle is in its converse recognition mandate that if Contracting States adhere to at least the minimum standards put forth by the Chicago Convention and ICAO SARPs, other Contracting

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<sup>193</sup> 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.

<sup>194</sup> 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, 20-2 (2004).

<sup>195</sup> Chicago Convention, *supra* note 38, art. 33.

States must render such certificates and licenses valid.<sup>196</sup> Thus, even for domestic, national operation of UAV/ROAs, the SARPs will have direct application regarding certification and licensing of personnel and issuing certificates of airworthiness to UAV/ROAs.

The annexes cover a wide variety of topics related to the safe and efficient movement of international civil aviation.<sup>197</sup> For the purposes of this work, I will focus on four general areas that will be necessary for full UAV/ROA 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.

## **2a. Rules of the Air and Safe Interface with Other Aircraft and ATM**

Rules of the air and air traffic services are addressed in Annex 2 and Annex 11 of the Chicago Convention. At this time it is appropriate to discuss a little more regarding the applicability of the SARPs generally, and specifically regarding Annex 2. As noted, Contracting States have the right to draft rules different than the SARPs; however, they must file with ICAO any such differences.<sup>198</sup> These differences are then noted in supplements to the annex concerned. Further, the SARPs are written in a way that it is clear as to what is a required standard, and what is a recommended

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<sup>196</sup> *Id.*

<sup>197</sup> 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*; Annex 18, *The Safe Transport of Dangerous Goods by Air*.

<sup>198</sup> Chicago Convention, *supra* note 38, at art. 38. A review of the filed differences reveals that most deal with differences in terminology, or involve more stringent practices.

practice.<sup>199</sup> Note, however, that Annex 2 does not have any recommended practices, but are all 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 through its airspace.<sup>200</sup> Nevertheless, Article 12 also states that Contracting States have obligated themselves "to keep its own regulations in these respects uniform, to the greatest possible extent, with those established from time to time under this Convention".<sup>201</sup> 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."<sup>202</sup> Placed upon the pilot in command is the responsibility to ensure that the flight of the aircraft adheres to the applicable rules of the air, unless deviation is absolutely necessitated by the interests of safety.<sup>203</sup> With a UAV/ROA, the pilot in command is remotely located, and therefore, must avail him or herself solely of data inputs from the aircraft 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/ROA pilot is solely transmitted by video link; placing the pilot in command of a UAV/ROA in a unique, and arguably a more difficult position.

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<sup>199</sup> A review of the annexes will reveal that recommended practices are annotated in italics and marked by the heading "Recommendation".

<sup>200</sup> Chicago Convention, *supra* note 38, art. 12.

<sup>201</sup> *Id.*

<sup>202</sup> Chicago Convention, *supra* note 38, Annex 2, *Rules of the Air*, (9th ed. 2001) at § 1.1.

<sup>203</sup> *Id.* at § 2.3.1.

Other rules of the air that would be applicable to UAV/ROAs include not operating the UAV/ROA in a negligent or reckless manner.<sup>204</sup> UAV/ROA 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”.<sup>205</sup> UAV/ROAs operations would need to adhere to local rules regarding spraying or dropping objects or substances,<sup>206</sup> towing other aircraft or objects, flights within restricted or prohibited areas, and performing acrobatic maneuvers.<sup>207</sup>

One of the biggest technological obstacles for UAV/ROA integration is the ability to “see and avoid” collisions with other aircraft.<sup>208</sup> Annex 2 provides that an “aircraft shall not be operated in such proximity to other aircraft as to create a collision hazard.”<sup>209</sup> An introductory note to section 3.2 of Annex 2 states, “It is

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<sup>204</sup> *Id.* at § 3.1.1.

<sup>205</sup> *Id.* at § 3.1.2.

<sup>206</sup> *Id.* at 3.1.4. As noted above, UAV/ROAs 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 UAV/ROAs. 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, The 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 generally* James C. Duncan, *Employing Non-lethal Weapons*, 45 *Naval L. Rev.* 1 at 43 (1998); Ingrid Detter, *The Law of War*, 2nd Ed. 158 (2000); Joint Publication 1-02, *supra* note 43.

<sup>207</sup> Chicago Convention, Annex 2, *supra* note 202, at §§ 3.1.2, 3.1.4, 3.1.7, 3.1.10.

<sup>208</sup> *Id.* at 3.2. *See also* JAA, *supra* note 14, at 52-3

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].”<sup>210</sup> The technological hurdle for UAV/ROAs is simply that the aircraft’s computers and/or the remotely located pilot must “see,” or maybe better put, “detect,” other aircraft 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.<sup>211</sup> New technologies must be developed to provide accurate and timely input to the aircraft and pilot to ensure the UAV/ROA can correctly maneuver and avoid other aircraft traveling through the NAS.

UAV/ROAs integrated with other aircraft will have to follow a number of rules surrounding the principle of avoiding a collision, both while in the air and on the ground in shared runways or airports.<sup>212</sup> 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.<sup>213</sup> There are right of way rules for aircraft operations in the vicinity of an airport, to include taking-off,<sup>214</sup> landing,<sup>215</sup>

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<sup>209</sup> Chicago Convention, Annex 2, *supra* note 202, at § 3.2.1.

<sup>210</sup> *Id.* at § 3.2.

<sup>211</sup> *See* JAA, *supra* note 14, at 52.

<sup>212</sup> Chicago Convention, Annex 2, *supra* note 202, at § 3.2.

<sup>213</sup> *Id.* at 3.2.2.

<sup>214</sup> *Id.* at 3.2.2.6.

<sup>215</sup> *Id.* at 3.2.2.5.

emergency landing,<sup>216</sup> movement on the ground and taxing,<sup>217</sup> and for operations on the water.<sup>218</sup> A UAV/ROA will be obligated to avoid passing over, under or in front of the other aircraft, unless it passes well clear and takes into account the effect of aircraft wake turbulence.<sup>219</sup>

UAV/ROAs 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”.<sup>220</sup> Further, other lights can not be displayed if they are likely to be mistaken for such navigational lights.<sup>221</sup> This may be difficult for certain UAV/ROAs, such as mini or micro UAV/ROAs, 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 air traffic control (“ATC”) or airport personnel, or by other aircraft.<sup>222</sup> These signals include those necessary for traffic control on the ground and in the air for taxing, take-off, and landing at airports.<sup>223</sup> Further, there are signals given by other aircraft, such as intercepting military aircraft.<sup>224</sup> The observation and reaction to these signals will be

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<sup>216</sup> *Id.* at 3.2.2.5.3.

<sup>217</sup> *Id.* at 3.2.2.7.

<sup>218</sup> *Id.* at 3.2.6.

<sup>219</sup> *Id.* at 3.2.2.1.

<sup>220</sup> *Id.* at 3.2.3.1.

<sup>221</sup> *Id.*

<sup>222</sup> *Id.* at 3.4, appendix 1.

<sup>223</sup> *Id.* at 3.4, appendix 1 §§ 4, 5.

<sup>224</sup> *Id.* at 3.4, appendix 1 § 2.

difficult, yet not an insurmountable task for the UAV/ROA pilot in command.<sup>225</sup>

Moreover, not only are there signals from the ATC, but the pilot in command of the UAV/ROA must communicate with the ATC to requests clearances and respond to queries from the ATC, intercepting aircraft, or other government officials or agents.<sup>226</sup>

There is also a requirement that the pilot in command be able to provide notice to the ATC of any unlawful interference.<sup>227</sup> For a UAV/ROA, unlawful interference would occur at the 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/ROA 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, with regards to visual flight rules (“VFR”) and instrument flight rules (“IFR”) as listed in Annex 2, only those flights under direct visual control of the operator will operate VFR, and therefore, most UAV/ROAs will operate IFR. 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.<sup>228</sup>

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<sup>225</sup> Note the successful flight of the Global Hawk in 2001 from the United States to Australia in which remotely located pilots interfaced with air traffic controllers at both ends of the flight. *See Morris, supra* 35.

<sup>226</sup> Chicago Convention, Annex 2, *supra* note 202, at § 3.6.

<sup>227</sup> *Id.* at § 3.8.

<sup>228</sup> *Id.* at chapters 4, 5.

## **2b. 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/ROA operations; however, the underlying objectives can clearly be applied to UAV/ROA flights. The objectives of Annex 17 are: 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) “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;” and 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.”<sup>229</sup> The import to UAV/ROA 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/ROA flights against unlawful interference. Further, as noted above, the Chicago Convention and annexes are designed to deal with international civil aviation; however, in a shrinking globe, particularly for UAV/ROAs that can operate for 24-hours or longer at a time, national or domestic rules should be uniform.<sup>230</sup>

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<sup>229</sup> Chicago Convention, *supra* note 38, Annex 17, *Security; Safeguarding International Civil Aviation Against Acts of Unlawful Interference*, (7th ed. 2002) at §§ 2.1.1-2.1.3.

<sup>230</sup> See generally NASA Certification Roadmap, *supra* note 16, at 49.



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 and/or property. For UAV/ROA purposes that means the remotely located crew, as well as third-party persons and property on the ground.

UAV/ROA operations with remotely located pilot(s) relying solely on electronic data to control and monitor flight all flowing through a communication link to relay input to and from the pilot(s), coupled with other inputs coming to the UAV/ROA itself during flight, such as GPS signals, produces a security environment much different than the passenger and crew centric issues of pilot-on-board flight. Security for UAV/ROAs focuses almost exclusively on the safety of third parties; although intrinsic is the safety of the remotely located pilot(s). While many of the rules of the air discussed in the previous section can be directly applied to UAV/ROA operations with slight modifications or with new technology developed and applied to UAV/ROAs, security rules are not so directly applicable. Therefore, safeguarding against unlawful interference of UAV/ROAs 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").<sup>231</sup>

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<sup>231</sup> 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 229, at §§ 3.1.1, 3.1.3.

Annex 17 requires Contracting States to ensure that aircraft operators establish and implement written security programs to meet national requirements.<sup>232</sup> Therefore, UAV/ROA operators may have to establish such programs. Additionally, Contracting States must ensure that personnel who implement its security plan are properly selected, trained, and certified,<sup>233</sup> which may require additional training in UAV/ROA 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.<sup>234</sup> For UAV/ROA operations, this would not entail passenger screening, but cargo, if applicable, and the body of the UAV/ROA; we all recall the terrorist attack of September 11, 2001.<sup>235</sup> This is related to the requirement to establish security-restricted areas to ensure the integrity of the UAV/ROA and its flight.<sup>236</sup> These security areas would have to include not only where the UAV/ROA is hangered and/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.”<sup>237</sup> While for UAV/ROAs the “flight crew compartment” is not

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<sup>232</sup> Chicago Convention, Annex 17, *supra* note 229, at § 3.3.1.

<sup>233</sup> *Id.* at §§ 3.4.1-3.4.3.

<sup>234</sup> *Id.* at § 4.1. *See also* discussion regarding LOAC, *supra* note 206.

<sup>235</sup> *See also* DeGarmo, *supra* note 32, at 2-29, 3-2.

<sup>236</sup> Chicago Convention, Annex 17, *supra* note 229, at § 4.7.

<sup>237</sup> *Id.* at § 4.2.3.

co-located on the aircraft, there will be an operations center in one or multiple locations that must be secured from unauthorized intrusions.<sup>238</sup> Additionally, with a UAV/ROA there is the 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 ITU.<sup>239</sup>

### **2c. 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 may opt out of the ICAO minimum standards for certificates of airworthiness, as well as certificates and licenses for personnel; however, by so doing, certificates and licenses issued by that state need not be recognized by other Contracting States.<sup>240</sup> 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.<sup>241</sup> 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.<sup>242</sup>

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<sup>238</sup> 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 35.

<sup>239</sup> See discussion of the ITU, *supra* note 22.

<sup>240</sup> Chicago Convention, *supra* note 38, arts. 33, 38.

<sup>241</sup> Chicago Convention, *supra* note 38, Annex 8, *Airworthiness of Aircraft*, (9th ed. 2001) at (x).

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”.<sup>243</sup> The state in which the aircraft is registered, or “State of Registration,” 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.<sup>244</sup> With regards to the design of the aircraft, there is a process of approval that requires the issuance of a type certificate.<sup>245</sup>

The Type certification process is primarily for serial production of aircraft, which would be the case for many UAV/ROA manufacturers producing commercially viable platforms.<sup>246</sup> 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.”<sup>247</sup> Additionally, the state where the UAV/ROA is manufactured, or “State of Manufacture,” must develop processes to “ensure that each aircraft, including parts manufactured by sub-contractors, conforms

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<sup>242</sup> See Office of the Secretary of Defense (“OSD”), *Airspace Integration Plan for Unmanned Aviation*, 15 (Nov. 2004).

<sup>243</sup> Chicago Convention, Annex 8, *supra* note 241, at § 3.2.

<sup>244</sup> JAA, *Supra* note 14, Enclosure 3, at 3.

<sup>245</sup> Chicago Convention, Annex 8, *supra* note 241, at § 1.3.

<sup>246</sup> *Id.* at § 1.1.

<sup>247</sup> *Id.* at § 1.3.1.

to the approved design”.<sup>248</sup> The production process must include a quality assurance system,<sup>249</sup> 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”.<sup>250</sup>

Further, a UAV/ROA’s State of Registry will be required to determine procedures and standards to “ensure the continued airworthiness of the aircraft during its service life.”<sup>251</sup> These requirements must address the maintenance necessary to achieve continued airworthiness, but also the airworthiness of the aircraft after modification, repair or replacement of a part.<sup>252</sup> 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.<sup>253</sup> 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 Design, if different,<sup>254</sup> and the State of Design must provide the State of Registry with information necessary to formulate requirements for continued airworthiness and safe operations of the aircraft.<sup>255</sup> Interestingly, and quite appropriately, this information must be provided by the State of Design upon request from any

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<sup>248</sup> *Id.* at § 2.2.1.

<sup>249</sup> *Id.* at § 2.2.3.

<sup>250</sup> *Id.* at § 2.2.4.

<sup>251</sup> *Id.* at § 4.2.1.

<sup>252</sup> *Id.* See also Chicago Convention, *supra* note 38, Annex 6, *Operation of Aircraft*, (8th ed. 2002).

<sup>253</sup> Chicago Convention, Annex 8, *supra* note 241, at § 3.2.3.

<sup>254</sup> *Id.* at § 4.3.1.

<sup>255</sup> *Id.* at § 4.3.2.

Contracting State.<sup>256</sup> Accordingly, the UAV/ROA will need to be certified as airworthy, and manufactures will need to obtain type certificates prior to commercial production and sale. Additionally, Contracting States will need to review maintenance and performance standards to ensure continued airworthiness of UAV/ROAs.

Unlike pilot-on-board aircraft, the aircraft that makes up the UAV/ROA 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 of the UAV/ROA just as is done with co-located 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.<sup>257</sup>

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<sup>256</sup> *Id.*

<sup>257</sup> JAA, *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/ROA system as follows:

*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).*

JAA, *supra* note 14, at 11.

While the issue is somewhat debated,<sup>258</sup> it seems dictated by safety that the UAV/ROA 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/ROA.

## **2d. 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 co-pilot of an airplane or helicopter be licensed.<sup>259</sup> As noted above, ICAO defines 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.”<sup>260</sup> A helicopter is defined as: “A heavier-than-air aircraft supported in flight chiefly by the reactions of the air on one or more power-driven rotors on substantially vertical axes.”<sup>261</sup> A UAV/ROA, as defined above, fits these definitions. Thus, unless ICAO and the FAA develop different standards for UAV/ROA 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.<sup>262</sup>

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<sup>258</sup> DeGarmo, *supra* note 32, at 2-47-51.

<sup>259</sup> Chicago Convention, *supra* note 38, Annex 1, *Personnel Licensing*, (9th ed. 2001), at § 2.1.1.1.

<sup>260</sup> *Id.* at § 1.1.

<sup>261</sup> *Id.*

<sup>262</sup> OSD, *supra* note 242, at 16.

Annex 1 distinguishes requirements for a pilot's license based on distinctions of the type of aircraft, e.g., single engine, multiple-engine, land or sea, and the purpose of flight, e.g., private, commercial, transport.<sup>263</sup> License requirements include acquired skill, knowledge, experience, age, and instruction.<sup>264</sup> 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.<sup>265</sup> However, UAV/ROA pilots generally do not operate in an airborne environment. Nevertheless, unless changed, such medical examinations might be required of UAV/ROA pilots.

Additionally, flight crew members will also have to be licensed.<sup>266</sup> 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,”<sup>267</sup> which specifically includes the flight navigator and flight engineer.<sup>268</sup> As with pilots of UAV/ROAs the “flight crew” will be remotely located, and may be remotely located from the pilot as well as the aircraft. Moreover, certain other personnel besides pilots and flight crew members also must be licensed. These personnel include maintenance personnel such as technicians, engineers, and mechanics.<sup>269</sup>

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<sup>263</sup> Chicago Convention, Annex 1, *supra* note 259241, at §§ 2.1-2.22.

<sup>264</sup> *Id.* at §§ 2.1-2.18.

<sup>265</sup> *See* JAA, *supra* note 14, at 58. *See also* Chicago Convention, Annex 1, *supra* note 259241, at § 6.

<sup>266</sup> Chicago Convention, Annex 1, *supra* note 259241, at § 1.2.1.

<sup>267</sup> *Id.* at § 1.1.

<sup>268</sup> *Id.* at § 1.2.

<sup>269</sup> *Id.* at § 4.2.



## **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”),<sup>270</sup> and the TSA in Title 49 parts 1500 through 1699 of the CFR.<sup>271</sup> 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,<sup>272</sup> airworthiness certification,<sup>273</sup> licensing of personnel,<sup>274</sup> and rules of the air.<sup>275</sup>

While the FAA has issued the above-referenced FAA Order 7610.4, which outlines a process through which a UAV/ROA operator may obtain permission to fly, the FARs do not specifically list, classify, define, refer, or address UAV/ROAs in anyway. FAA Order 7610.4 will be further explored later; however, it refers in a general fashion to requirements found in the FAR. As with the Chicago Convention

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<sup>270</sup> Federal Aviation Regulations, 14 C.F.R. §§ 1.1-198.17 (2005).

<sup>271</sup> Transportation Security Regulations, 49 C.F.R. §§ 1500.01 – 1572.45 (2005).

<sup>272</sup> 14 C.F.R. §§ 45.1-49.63.

<sup>273</sup> *Id.* at §§ 21.1-43.17.

<sup>274</sup> *Id.* at §§ 61.1-67.451.

<sup>275</sup> *Id.* at §§ 71.1-105.49.

and the ICAO promulgated SARPs, most of the FARs can be applied to UAV/ROA 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”.<sup>276</sup> 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.”<sup>277</sup> UAV/ROAs clearly fit these definitions. Therefore, FAR provisions dealing with rules of the air, security, licensing of personnel and airworthiness have direct application on UAV/ROA integration. Since the basis of the FARs come from the SARPs, it is not worthwhile to painstakingly dissect each provision; however, a basic overview of certain provisions pertaining to UAV/ROA operations is worthwhile.

#### **1a. FAR Rules of the Air**

The rules of the air are mainly found in Section 91 of Title 14 of the CFR, and are applicable for all aircraft operating within United States airspace; with many rules reaching out to include operations conducted from between 3 to 12 nautical miles (5.56 to 22.22 kilometers) from its coast.<sup>278</sup> Some rules, such as those rules covering maintenance and ownership, are applicable for all aircraft registered in the United States regardless of where they are operating.<sup>279</sup> As in the SARPs, the rules of the air found in Section 91 are designed to ensure safe transit through the airspace of the

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<sup>276</sup> *Id.* at § 1.1.

<sup>277</sup> *Id.*

<sup>278</sup> *Id.* at §§ 91.1, 91.101, 91.701, 91.801.

<sup>279</sup> *Id.* at §§ 91.401, 91.501, 91.601, 91.1001.

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”.<sup>280</sup>

As addressed above, the Achilles’ heal, if you will, of UAV/ROA operations is the technological 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.<sup>281</sup>

UAV/ROA 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 the UAV/ROA pilot and/or 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/ROA.<sup>282</sup> However, the issue goes further as it is also difficult for pilots of other aircraft to detect and identify UAV/ROAs, 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.<sup>283</sup> In general, airspace Classes B, C, and D relate to airspace

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<sup>280</sup> *Id.* at § 91.111(a).

<sup>281</sup> *Id.* at 91.113(b).

<sup>282</sup> *See generally* OSD, *supra* note 242, at 19-27.

<sup>283</sup> 14 C.F.R. §§ 91.126 - 91.135. A summary of U.S. airspace classes:

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; with Class A, which is between 18,000 feet or 5,486.4 meters from sea level, usually listed as Mean Sea Level (“MSL”), to 60,000 feet or 18,288 meters MSL, being the most heavily traveled as it is used by cruising or transiting commercial traffic.<sup>284</sup> The ATC provides separation services to all flights in airspace Classes A, B, and C, and to some flights in Classes D and E.<sup>285</sup> The ATC does not provide separation services in airspace Class G.<sup>286</sup> 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.

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- Class A airspace exists from Flight Level (FL) 180, which is 18,000 feet (5,486.4 meters) from sea level (Mean Sea Level (MSL)) to FL600 (60,000 feet (18,288 meters) MSL). Flights within Class A airspace must be flying under IFR and under the control of the ATC.
  - Class B airspace surrounds major airports (generally up to 10,000 feet (3,048 meters) MSL) to reduce mid-air collision potential, and requires the ATC control of IFR and VFR flights.
  - 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, and requires establishing and maintaining communications with the ATC, but VFR flights do not receive separation service.
  - Class E airspace is like the background of controlled airspace as it includes all other airspace in which IFR and VFR flights are allowed, and it while it 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 also includes airspace above Class A or FL600.
  - Class G airspace is also called uncontrolled airspace because the ATC does not control the aircraft in it. It 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 242, at 5.

<sup>284</sup> 14 C.F.R. §§ 71.31, 71.41, 71.51, 71.61. *See also* FAA Order 7400.2E, Part 4.

<sup>285</sup> 14 C.F.R. §§ 71.31, 71.41, 71.51, 71.61.

<sup>286</sup> *Id.*

UAV/ROAs operating in Classes 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.<sup>287</sup> 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.<sup>288</sup> Moreover, the UAV/ROA 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.<sup>289</sup> All of this communication equipment, transponders, and even see and avoid equipment adds weight and cost to the UAV/ROA, which while it improves safety, also directly impacts its utility. Nevertheless, if UAV/ROAs are to increase functionality through effective ingress, transit, and regress of Classes A, B, or C airspace, such equipment will be necessary and will actually add to its utility.

Due to the wide variety of UAV/ROA utilities, operations will undoubtedly scale the alphabet of airspace classes. Nevertheless, it is the traffic in Classes A, B, and C that form basic problem for “see and avoid” technology, as most aviation traffic occurs in these classes of airspace; however, some UAV/ROAs will never need to enter or transit through these areas. Due to the characteristics of the UAV/ROA and its utility for accomplishing missions involving the 3-Ds, dull, dirty, and dangerous, many local flights will occur in Class G, know 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

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<sup>287</sup> 14 C.F.R. §§91.130(c), 91.131(c), 91.135(b).

<sup>288</sup> *Id.* at § 91.129(c).

<sup>289</sup> *Id.* at §§ 91.135(c), 91.215.

below and above Class A. In these areas, the airspace is generally not crowded. UAV/ROAs operating in Class G and certain parts of Classes D and E airspace will have very little integration, if at all, 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.<sup>290</sup> This issue will be touched on again in the next chapter.

Section 91 of Title 14 also deals with the responsibility of pilots and other crewmembers. Under the FARs, the UAV/ROA 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.<sup>291</sup> Further, UAV/ROA 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 more than eight hours before flight.<sup>292</sup> Moreover, such rules do not limit drug use to only illegal drugs, but “any drug that affects the person's faculties in any way contrary to safety.”<sup>293</sup> Additionally, UAV/ROA pilots and all crewmembers will be subject to blood alcohol tests at the request of law enforcement officials.<sup>294</sup>

In addition to the regulations found in Title 14 of the CFR, the FAA also publishes orders, advisory circulars,<sup>295</sup> notices to pilots (airman), which are more

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<sup>290</sup> *Id.* at §§ 91.126, 91.127.

<sup>291</sup> *Id.* at § 91.7.

<sup>292</sup> *Id.* at § 91.17.

<sup>293</sup> *Id.*

<sup>294</sup> *Id.* at § 91.17(c).

commonly known as “NOTAMs,”<sup>296</sup> and temporary flight restrictions (“TFRs”).<sup>297</sup> 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/ROA operators will obviously need to be aware of and follow applicable publications.

Of particular note for micro or mini UAV/ROAs is advisory circular, AC 91-57, *Model Aircraft Operating Standards*.<sup>298</sup> While UAV/ROAs are not specifically addressed in AC 91-57, upon FAA approval small, hand or bungee launched UAV/ROAs 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.<sup>299</sup> For

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<sup>295</sup> Federal Aviation Administration, *Advisory Circulars*, at [http://www.airweb.faa.gov/Regulatory\\_and\\_Guidance\\_Library/rgAdvisoryCircular.nsf/MainFrame?OpenFrameSet&CFID=2656772&CFTOKEN=99716569](http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/MainFrame?OpenFrameSet&CFID=2656772&CFTOKEN=99716569) (last visited Jun. 2, 2005).

<sup>296</sup> Federal Aviation Administration, *FAA Order 7930.2J, Notices to Airmen* (2005). The FAA has created a website, available at <https://pilotweb.nas.faa.gov/distribution/atccsc.html>, called PilotWeb, wherein pilots can find NOTAMs and other pilot specific information and links.

<sup>297</sup> Federal Aviation Administration, *Temporary Flight Restrictions Notices*, at <http://tfr.faa.gov/tfr/list.jsp> (last visited Jun. 3, 2005).

<sup>298</sup> 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.

<sup>299</sup> See generally, OSD, *supra* note 242, at 11, 48.

example, local, state, and Federal agencies like the DHS, the California Highway Patrol, or the Environmental Protection Agency (“EPA”) could use the smaller mini UAV/ROAs like the Pointer<sup>300</sup> for boarder or port patrols, traffic management, or even environmental sensing or studies.<sup>301</sup> 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.

### **1b. Security Regulations**

Within the United States, rules regarding civil aviation security are promulgated by the TSA. The TSA was created after the attack 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.<sup>302</sup> While it is conceivable that a UAV/ROA could be used as a flying bomb as that 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 or by charter, and the airports serviced thereby.<sup>303</sup> Of course, to the extent UAV/ROAs are able to function as cargo carriers and eventually passenger carriers, all such rules then in existence would be applicable. However, because UAV/ROAs can now be operated or pirated as flying bombs or missiles, it

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<sup>300</sup> Pointer is a mini UAV/ROA built by AeroVironment, a California based technology company, and used by U.S. Special Forces for reconnaissance missions. AeroVironment, *AV Pointer*, at <http://www.aerovironment.com/area-aircraft/prod-serv/pointer.html> (last visited Jun. 3, 2005).

<sup>301</sup> See also Michael A. Dornheim and Michael A. Taverna, *War on Terrorism Boosts Deployment of Mini-UAVs*, Aviation Week’s Next Century of Flight, at [http://www.aviationnow.com/content/ncof/ncf\\_n80.htm](http://www.aviationnow.com/content/ncof/ncf_n80.htm) (last visited Jun. 3, 2005).

<sup>302</sup> See generally Paul Stephen Dempsey, *Aviation Security: The Role of Law in the War Against Terrorism*, 41 Colum. J. Transnat’l L. 649 at 714.

<sup>303</sup> See generally 49 C.F.R. §§ 1545-1548.



would seem that the TSA would enforce its jurisdiction over such aircraft, at least bigger versions like the Global Hawk or Predator.

Under Title 49, UAV/ROA operators may be required to establish a security program and allow TSA inspectors to review their plans and corresponding execution.<sup>304</sup> Part of that program will require UAV/ROA operators to control access to the aircraft under an exclusive area agreement, and perform security inspections prior to operations.<sup>305</sup> Further, UAV/ROA operators may have to establish contingency plans in case of a threat of or actually pirated aircraft.<sup>306</sup>

Piracy of a UAV/ROA is a unique problem. As highlighted above, UAV/ROA 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 center(s). Therefore, it would only make sense that for some remotely operated UAV/ROAs, the established security plan would require security of the control center(s). Security of these control center(s) may be required to mirror requirements found in the FARs for pilot-on-board cockpits, which limit entry to only certain authorized personnel.<sup>307</sup>

In the event of a credible threat of tampering or piracy, UAV/ROA operators will need to perform inspections of the aircraft and operation center(s).<sup>308</sup> Such threats will need to be communicated to local authorities, airport, if any, and ATC

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<sup>304</sup> *Id.* at § 1550.3.

<sup>305</sup> *Id.* at § 1544.225

<sup>306</sup> *Id.* at §1544.301.

<sup>307</sup> 14 C.F.R. § 121.547.

<sup>308</sup> *Id.* at § 1544.303.

regardless of whether such threats are received while the aircraft is on the ground or airborne.<sup>309</sup> Information regarding threats may also come from the TSA through information circulars and security directives.<sup>310</sup>

Additionally, within the FARs there is the requirement that any aircraft entering United States airspace, transiting internally for distances greater than 10 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.<sup>311</sup> Therefore, UAV/ROAs 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.

If there is ever a loss of two-way communication between aircraft and the ATC or other authorities, the FAR includes procedures to handle the aircraft under such circumstances.<sup>312</sup> 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 UAV/ROAs 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

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<sup>309</sup> *Id.*

<sup>310</sup> *Id.* at § 1544.305.

<sup>311</sup> 14 C.F.R. §§ 99.1, 99.3. This 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.

<sup>312</sup> 14 C.F.R. § 91.185.

clearance, minimum altitude for IFR operations, or the level the pilot would expect the ATC to advise.<sup>313</sup> While UAV/ROA pilots 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 the UAV/ROA and control center(s).<sup>314</sup> By programming the UAV/ROA to autonomously following the rules proscribed for lost two-way communications with the ATC, the predictability of UAV/ROA operations would be similar to pilot-on-board aircraft in the event of a lost signal between pilot and aircraft.<sup>315</sup> This issue will be addressed further in the next chapter.

### **1c. 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.<sup>316</sup> These certificates are broken up into rules for student pilots,<sup>317</sup> recreational pilots,<sup>318</sup> private pilots—which includes balloon pilots,<sup>319</sup> commercial pilots,<sup>320</sup> airline transport pilots,<sup>321</sup> and sport pilots.<sup>322</sup> Each type of pilot is required to possess differing levels of information, skill, and experience.

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<sup>313</sup> *Id.*

<sup>314</sup> *See generally* OSD, *supra* note 242, at 31.

<sup>315</sup> *See generally id.*

<sup>316</sup> 14 C.F.R. § 61.3. As previously noted, the United States Armed Forces licenses 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 242, at 16.

<sup>317</sup> 14 C.F.R. §§ 61.81 – 61.95.

<sup>318</sup> *Id.* at §§ 61.96 – 61.101.

<sup>319</sup> *Id.* at §§ 61.102 – 61.120.

<sup>320</sup> *Id.* at §§ 61.120 – 61.141.

<sup>321</sup> *Id.* at §§ 61.151 – 61.171.

<sup>322</sup> *Id.* at §§ 61.301 – 61.329.

Further, pilots must have a medical certificate.<sup>323</sup> Medical certificates are organized into three different classes as well, depending on the safety risk associated with each type of license; obviously larger aircraft pilots require more stringent medical certification.<sup>324</sup> The requirements are substantially lessened for pilots of gliders, balloons or light-sport aircraft.<sup>325</sup>

Aircrew members other than pilots are also required to be certified under FAR provisions. There are separate certificates required of flight engineers<sup>326</sup> and flight navigators.<sup>327</sup> Non-aircrew members involved in aircraft operations such as mechanics<sup>328</sup> and repairman<sup>329</sup> must also be certified under the FAR. As is the case with pilots, there are no standards for UAV/ROA airmen, engineers, technicians, mechanics, or repairman, and therefore, testable knowledge and skill will need to be formulated by the FAA for worthwhile certification of UAV/ROA aircrew.

Finally, under the FARs, applications for licenses and certificates for pilot 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.<sup>330</sup> Further, current licenses and certified personnel may have their

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<sup>323</sup> *Id.* at § 61.23.

<sup>324</sup> *Id.* at §§ 67.1 – 67.415.

<sup>325</sup> *Id.* at § 61.239(c).

<sup>326</sup> *Id.* at §§ 63.31 – 63.43.

<sup>327</sup> *Id.* at §§ 63.51 – 63.61.

<sup>328</sup> *Id.* at §§ 65.71 – 65.95.

<sup>329</sup> *Id.* at §§ 65.101 – 65.107.

certificates suspended or revoked for such a conviction.<sup>331</sup> These provisions would more than likely apply to associated UAV/ROA operational personnel.

### **1d. FAR Certificate 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.<sup>332</sup> One example in the area of airworthiness certificates that could impact civilian manufactures of UAV/ROAs is the requirement for serial manufacturers to obtain a production certificate in addition to type and airworthiness certificates.<sup>333</sup> 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.<sup>334</sup> This distinction and separation between the type design approval process and the quality control system approval process is unique to the United States.<sup>335</sup>

A production certificate would require UAV/ROA 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/ROA meets the

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<sup>330</sup> *Id.* at §§ 61.15, 63.12, 65.12.

<sup>331</sup> *Id.*

<sup>332</sup> As noted above, FAA regulations do not require military aircraft to be certified airworthy by the FAA. Instead, these aircraft are certified through the DoD and branch of service internal airworthiness certification/flight release processes.

<sup>333</sup> 14 C.F.R. §§ 21.131-21.165.

<sup>334</sup> NASA Certification Roadmap, *supra* note 16, at 17.

<sup>335</sup> *See id.*

specifications of the type certificate.<sup>336</sup> For UAV/ROA manufacturers that build pilot-on-board aircraft or parts, such as Boeing or Northrop Grumman, this will not be difficult as that part of their operations is already certified. However, for those that specialize in UAV/ROA aircraft production only, this could increase the cost of production, or at least slow down the process of instituting new UAV/ROA technology in mass produced aircraft as the certification process can take years to complete; and hence, potentially affecting the utility and technical advancement of UAV/ROAs.<sup>337</sup> Nevertheless, over time technological advances will be able to be incorporated into commercially produced UAV/ROAs, and while it will take time, just as with pilot-on-board aircraft, regulatory installed precautions will equate into safely integrated skies, as well as increased public acceptance.

While the FARS, like the ICAO SARPs, do not directly address UAV/ROAs and its rules are only incorporated by analogy to include UAV/ROAs as aircraft, as previously noted, the FAA has made an initial attempt to address the integration of UAV/ROAs through a Certificate of Authorization or “COA” process under FAA Order 7610.4, *Special Military Operations*, Chapter 12, section 9.<sup>338</sup>

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

In 1999, DoD recognized the need to develop a process to allow its UAV/ROAs, to operate in the NAS, and working with the FAA established an initial step that was incorporated into FAA Order 7610.4.<sup>339</sup> Under the current order,

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<sup>336</sup> 14 C.F.R. §§ 21.135, 21.139, 21.143

<sup>337</sup> See generally DeGarmo, *supra* 32, at 2-48.

<sup>338</sup> See FAA Order, *supra* note 167.

<sup>339</sup> DeGarmo, *supra* note 32, at 1-5.

7610.4K, the general principle for UAV/ROAs flights is that they “should normally be conducted” in restricted areas or warning areas.<sup>340</sup> If a UAV/ROA operator wants to fly outside restricted areas or warning areas, they must obtain a COA.<sup>341</sup>

The process to obtain a COA, however, can be cumbersome in that it can take two months to obtain the authorization from the FAA, and a COA must be obtained from each FAA region the UAV/ROA seeks to operate outside of restricted or warning areas;<sup>342</sup> there are nine regions.<sup>343</sup> There is a provision for “real-time, short notice, contingency operations,” which may reduce the required 60-day lead time to the “absolute minimum necessary to safely accomplish the mission”.<sup>344</sup> COAs are valid for no longer than one year, but the entity seeking the COA may seek renewal or revalidation.<sup>345</sup> As part of the COA, the FAA authorizes the time and route of the UAV/ROA flight to avoid risks to other aircraft and persons on the ground.<sup>346</sup>

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

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<sup>340</sup> FAA Order, *supra* note 167, at § 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.

<sup>341</sup> FAA Order, *supra* note 167, at § 12-9-1.

<sup>342</sup> *See* DeGarmo, *supra* note 32, at 1-5.

<sup>343</sup> 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, Southern Region (ASO), Southwest Region (ASW), and the Western-Pacific Region (AWP). FAA, at <http://www.faa.gov/about/media/hq-org.pdf> (last visited Jun. 4, 2005).

<sup>344</sup> FAA Order, *supra* note 167, at § 12-9-2.

<sup>345</sup> *Id.* at § 12-9-2(b).

<sup>346</sup> DeGarmo, *supra* note 32, at 1-5.

FAA to establish a National COA (“NCOA”) for the Global Hawk.<sup>347</sup> This NCOA process has shortened the approval time for national Global Hawk operations to five days.<sup>348</sup> However, this NCOA only applies in domestic operations that involve take off and landing in restricted areas.<sup>349</sup>

The COA process has allowed the FAA to maintain a certain amount of control over UAV/ROA 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/ROA; 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 pilot and ATC; the route; termination procedures if it must abort or communication is lost; and an airworthiness statement from the entity requesting the COA.<sup>350</sup>

With regards to the safety issue of “see and avoid,” the FAA requires that the UAV/ROA have a method that “provides an equivalent level of safety, comparable to see-and-avoid requirements for manned aircraft”.<sup>351</sup> The FAA suggests acceptable methods such as “radar observation, forward or side looking cameras, electronic

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<sup>347</sup> *See generally id.*

<sup>348</sup> Defense Science Board, *supra* note 8, at 38.

<sup>349</sup> *Id.*

<sup>350</sup> FAA Order, *supra* note 167, at § 12-9-2(a).

<sup>351</sup> *Id.*



detection systems, visual observation from one or more ground sites, monitored by patrol or chase aircraft, or a combination thereof.”<sup>352</sup>

Additionally, the FAA requires that UAV/ROAs seeking COAs be equipped with standard aircraft anti-collision lights, and they must operate during the entire flight.<sup>353</sup> Such UAV/ROAs must also be equipped with an altitude encoding transponder as specified by the FAR.<sup>354</sup> 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.<sup>355</sup> As for communication with ATC facilities, instantaneous two-way radio communication with the pilot in command is required.<sup>356</sup> Nevertheless, “for limited range, short duration flights,” a request may be made for an alternate means to communicate; with the understanding that “compliance with all ATC clearances is mandatory”.<sup>357</sup>

While FAA Order 7610.4K is a stepping stone and represents the first stages of a regulatory regime to allow UAV/ROA flights outside of restricted and warning areas, it is clearly incomplete. The biggest short coming is that it is not “file and fly;” it generally requires 60-days lead time. This is due primarily from the lack of a certificate procedure to allow for certification of aircraft, as well as licensing

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<sup>352</sup> *Id.*

<sup>353</sup> *Id.* at §12-9-2(c).

<sup>354</sup> *Id.* at § 12-9-2(d).

<sup>355</sup> *Id.*

<sup>356</sup> *Id.* at § 12-9-2(e).

<sup>357</sup> *Id.*

standards for pilot and crew.<sup>358</sup> Further, it applies directly only to military operations involving UAV/ROAs; civilian UAV/ROA flights are not specifically addressed.

While there have been civilian COAs issued by the FAA,<sup>359</sup> Order 7610.4 is specifically designed for military movement of UAVs, particularly since there are no procedures to certify civilian UAV/ROAs for airworthiness.<sup>360</sup> 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/ROA aircraft that need only fly in unrestricted and uncontrolled airspace, such as Class G airspace.

### **C. UAV/ROA DOMESTIC LAWS OF AUSTRALIA, JAPAN, AND THE UNITED KINGDOM**

A few countries have attempted to address the issue of UAV/ROA 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/ROA integration, their efforts are worthwhile to review as the FAA addresses UAV/ROA 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*,<sup>361</sup> and CASA Advisory Circular AC-101-1(0), *Unmanned Aerial Vehicle*

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<sup>358</sup> See Defense Science Board, *supra* note 8, at 40.

<sup>359</sup> NASA Certification Roadmap, *supra* note 16, at 1. (The NASA EARST HALE UAV Certification and Regulation Roadmap notes that the FAA has issued five civilian COAs.)

<sup>360</sup> See *id.* at 10.

<sup>361</sup> Civil Aviation Safety Regulations (Austl.), *CASR 1998 Part 101—Unmanned Aircraft and Rocket Operations* (2004).

*(UAV) Operations, Design Specifications, Maintenance and Training of Human Resources*<sup>362</sup> in their effort to provide guidance in the operation and manufacturing of UAV/ROAs, as well as the means whereby UAV/ROAs may safely and legally operate.

Operations of commercial UAV/ROAs are based on a Certificate of Operations (“OC”).<sup>363</sup> 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.<sup>364</sup> The CASA has the authority to issue an OC if it is satisfied the UAV/ROA operator or person applying for the certificate can safely conduct UAV/ROA 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.<sup>365</sup>

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 90 days to process the initial request, with renewals done in 30 days.<sup>366</sup> In order to obtain an OC, a UAV/ROA operator should give the CASA access to the organization and the aircraft, and ensure the CASA also has access to associated maintenance companies or organizations to ascertain continued compliance with regulations and, where

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<sup>362</sup> Civil Aviation Safety Authority (Austl.), *Advisory Circular—AC 101-1(0): Unmanned Aerial Vehicle (UAV) Operations, Design Specification, Maintenance and Training of Human Resources* (2002).

<sup>363</sup> *Id.* at § 12.2.2.

<sup>364</sup> OSD, *supra* note 242, at 40.

<sup>365</sup> AC 101-1(0), *supra* note 362 at § 12.2.2.

<sup>366</sup> *Id.* at §§ 11.3, 11.5.

appropriate, continued airworthiness of the UAV/ROA.<sup>367</sup> Further, the UAV/ROA operator must have a management organization capable of exercising control and supervision over any flight conducted under an OC.<sup>368</sup>

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/ROA 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.<sup>369</sup>

Along with the concept of a UAV/ROA system, AC-101-1(0) also allows for the autonomous operations of UAV/ROAs in situations where the UAV/ROA's "performance and designated ATC communication circuits are continuously monitored" by the UAV/ROA operations aircrew, and the UAV/ROA system and pilot have the ability to take immediate control of the aircraft.<sup>370</sup>

The general operating principle for UAV/ROA operations in controlled airspace over Australia is simple; it is that a UAV/ROA 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.<sup>371</sup> This translates into placing

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<sup>367</sup> AC 101-1(0), *supra* note 362 at Annex 3 § 2.4.

<sup>368</sup> *Id.* at § 2.6.

<sup>369</sup> AC 101-1(0), *supra* note 362, at § 4.2.

<sup>370</sup> *Id.* at § 5.2.2.

<sup>371</sup> *Id.* at § 5.1.1.

the ball in the court of the manufacturers to produce UAV/ROAs 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/ROA 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.<sup>372</sup> With regards to collision avoidance, the CASA may (note, that it is not required to) require large UAV/ROAs to be “equipped with an SSR transponder, a collision avoidance system or forward looking television as appropriate for the type of operation.”<sup>373</sup> Large UAV/ROAs are defined as generally aircraft over 100 kilograms or 220.46 lbs.<sup>374</sup>

As for operations of small UAV/ROAs in unpopulated areas not around airports that operate at 400 feet or 121.92 meters 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.<sup>375</sup> Small UAV/ROAs are defined as an aircraft larger than 100 grams (0.2 lbs) and generally smaller than 100 kilograms (220.4 lbs).<sup>376</sup> While the operator or pilot of a small UAV/ROA is responsible for its operations since no ATC is present to provide guidance and

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<sup>372</sup> *Id.* at § 5.6.1.

<sup>373</sup> *Id.* at § 5.7.2.

<sup>374</sup> CASR, *supra* note 361, at § 101.240.

<sup>375</sup> AC 101-1(0), *supra* note 362 at § 7.1.1.

<sup>376</sup> CASR, *supra* note 361, at § 101.240.

instruction, such operations are still subject to CASA approval and imposed flight rules.<sup>377</sup>

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/ROA, or loss of radio contact with the ATC. The filed flight plan should detail the procedures the UAV/ROA will follow in such a circumstance.<sup>378</sup> Nevertheless, the CASA recommends that if the UAV/ROA pilot loses control, the UAV/ROA should autonomously transit to a pre-designated recovery area where it will either be recovered or perform a flight termination action.<sup>379</sup> In the event of a loss link situation, whatever the cause, the ATC should be briefed,<sup>380</sup> and if autonomous actions are taken by the UAV/ROA, the ATC will treat it as an emergency aircraft.<sup>381</sup> 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/ROA pilot and the ATC lose contact, the pilot should attempt to establish alternate means of communications, such as a telephone, and the UAV/ROA should be flown “in accordance with last acknowledged instruction or should be commanded to orbit in its current position”.<sup>382</sup>

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<sup>377</sup> AC 101-1(0), *supra* note 362, at § 7.1.2.

<sup>378</sup> *Id.* at § 5.10.

<sup>379</sup> *Id.* at § 5.10.1.

<sup>380</sup> *Id.* at § 5.10.2.

<sup>381</sup> *Id.* at § 5.10.3.

<sup>382</sup> *Id.* at § 5.10.4.

However, if communications with ATC can not be re-established, the UAV/ROA flight should be aborted.<sup>383</sup>

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/ROA should have a transponder with the ability of the pilot to change the code upon the request of the ATC,<sup>384</sup> and the UAV/ROA pilot should make all required position and flight reports to the appropriate ATC.<sup>385</sup> Moreover, when communicating with the ATC, the UAV/ROA call sign should always indicate that it is a UAV/ROA by stating “UNMANNED”.<sup>386</sup>

While certificates of airworthiness are obtained under the “Experimental or the Restricted” category, Part 21 of the Australian Civil Aviation Regulations (“CAR”) 1998,<sup>387</sup> AC-101-1(0) does address certain aspects of the design of the UAV/ROA that the manufacturer and operator must consider when obtaining a certificate of airworthiness. As noted above, under AC-101-1(0), the UAV/ROA 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/ROA flight and recovery.<sup>388</sup> However, the design criteria listed in AC-101-1(0) are given in only broad, general terms, with no specific technology

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<sup>383</sup> *Id.*

<sup>384</sup> *Id.* at § 5.13.1.

<sup>385</sup> *Id.* at § 5.13.4.

<sup>386</sup> *Id.* at § 5.13.6.

<sup>387</sup> Civil Aviation Safety Regulations (Austl.), *CASR 1998 Part 21— Certification and Airworthiness Requirements for Aircraft and Parts* (2005).

<sup>388</sup> AC 101-1(0), *supra* note 362, at § 8.1.1.

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.<sup>389</sup>

Finally, with regards to certification of the UAV/ROA pilot, which the CASA calls controllers, CASR 1998 Part 101 requires that the controller have obtained a radio operator's certificate of proficiency, passed an aviation license theory examination, passed an instrument rating theory examination, completed a UAV/ROA operations course conducted by the UAV/ROA manufacturer for the type of UAV/ROA to be operated, and have at least five hours experience operating the UAV/ROA outside controlled airspace.<sup>390</sup> Interestingly, however, while the CASA requires UAV/ROA pilots to have many of the same skills required of pilot-on-board aircraft, it recognizes that the medical requirements for UAV/ROA pilots do not need to be as stringent as pilot-on-board aircrew since the operating environment is much different.<sup>391</sup> Nevertheless, CASA requires that UAV/ROA aircrew "abstain from 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".<sup>392</sup>

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<sup>389</sup> *Id.*

<sup>390</sup> CASR, *supra* note 361, at § 101.295.

<sup>391</sup> AC-101-1(0), *supra* note 362, at 11.3.1.

<sup>392</sup> *Id.*



## 2. Japan

As previously discussed, Japan represents the most commercially successful adaptation of UAV/ROAs anywhere in the world with their widespread use of rotary UAV/ROAs 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 UAV/ROAs in agriculture.<sup>393</sup> As part of this promotion of UAV/ROA research, development, and use, the JAAA established safety standards for UAV/ROAs in the areas of flight performance, airframes, and inspection and maintenance.<sup>394</sup> Through these standards, the JAAA has been able to enforce safe operations of these rotary UAV/ROAs, not just in agriculture, but also for observation and environmental compliance.<sup>395</sup> Additionally, the JAAA has developed a system that requires operators to receive mandated training and certification specifically designed for rotary UAV/ROA operations, as well as a system to register all the aircraft as well as users or customers.<sup>396</sup>

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.<sup>397</sup>

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<sup>393</sup> OSD, *supra* note 242, at 41.

<sup>394</sup> B. Enderle, *Commercial Applications of UAV's in Japanese Agriculture*, American Institute of Aeronautics and Astronautics at <http://www.aiaa.org/content.cfm?pageid=406&gTable=Paper&gID=2802> (last visited Jun. 8, 2005).

<sup>395</sup> *Id.*

<sup>396</sup> OSD, *supra* note 242, at 41.

The JAAA safety standards and certification/registration system is basically to operate rotary UAV/ROAs 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.<sup>398</sup>

### **3. United Kingdom**

The United Kingdom (“UK”) Civil Airspace Authority (“CAA”) regulatory framework was initially developed in 2002 as a response to pressure from the British UAV/ROA community,<sup>399</sup> and outlined in the CAA document entitled “CAP 722-- Unmanned Aerial Vehicle Operations in UK Airspace – Guidance” (“CAP 722”).<sup>400</sup> 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.

Thus, similar to the Australian regulations, UAV/ROAs 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

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<sup>397</sup> See generally Tim Mahon, *Fit to Fly in Civil Airspace*, in 2003 Yearbook 162-68, at 166 (UVS International, Blyenburgh & Co.).

<sup>398</sup> See generally *id.*

<sup>399</sup> See OSD, *supra* note 242, at 41.

<sup>400</sup> CAP 722, *supra* note 31.

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.<sup>401</sup> You have probably noted that I wrote this paragraph in past tense, or in other words, indicating an effect that no longer applies.

In fact, CAP 722 is no longer applicable to most UAV/ROAs in the UK. The newly created European Aviation Safety Agency (EASA) retains the authority to regulate larger or non-experimental UAV/ROAs for nations of the European Union (“EU”), under which the United Kingdom is a member state.<sup>402</sup> Under EU law, EU Member States’ policies and procedures would only apply to UAV/ROAs specifically designed or modified for research, experimental or scientific purposes, built in small numbers, UAV/ROAs used by local or national authorities, such as police or similar services, or smaller UAV/ROAs with a mass of no more than 150 kilograms (330.7 lbs).<sup>403</sup> The EASA has yet to establish a regulatory framework for the UAV/ROAs over which they have jurisdiction.

However, 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 UAV/ROAs in the European NAS issued a final report (“Task Force Final Report”), which report is referred to and referenced at times throughout this thesis.<sup>404</sup> While the Task Force

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<sup>401</sup> D.R. Haddon and C.J. Whittaker, *UK-CAA Policy for Light UAV Systems*, UK Civil Aviation Authority 1 (2004).

<sup>402</sup> Regulation (EC) No 1592/2002 (2002) at [http://www.easa.eu.int/doc/Regulation/BR1592\\_2002.pdf](http://www.easa.eu.int/doc/Regulation/BR1592_2002.pdf) (last visited Jun. 7, 2005). *See also id.* at 2.

<sup>403</sup> UK-CAA Policy, *supra* note 401, at 2.

<sup>404</sup> JAA, *supra* note 14.

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)<sup>405</sup> part of the report included a recommended regulation for light UAV/ROAs.<sup>406</sup>

The Task Force Final Report defined light UAV/ROAs 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 metres [1640.42 feet] of the UAV-pilot and not more than 400 ft [121.92 meters] above ground level,”<sup>407</sup> and “has an impact kinetic energy that does not exceed 95KJ<sup>408</sup> when assessed against both a high speed and free-fall impact scenario.”<sup>409</sup> The Task Force Final Report’s definitional use of mass and speed to determine the kinetic energy derived there from goes beyond the simple weight classification used by Australia. The concept is designed to address the risk of the UAV/ROA to third parties on the ground; the more

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<sup>405</sup> Joint Aviation Authorities, *Future of JAA*, at [http://www.jaa.nl/future\\_of\\_jaa/future\\_of\\_jaa.html](http://www.jaa.nl/future_of_jaa/future_of_jaa.html) (last visited Jun. 8, 2005).

<sup>406</sup> JAA, *supra* note 14, at annex 1.

<sup>407</sup> *Id.* at 1.

<sup>408</sup> 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*, at <http://en.wikipedia.org/wiki/Joule> (last visited Jun. 7, 2005).

<sup>409</sup> JAA, *supra* note 14, annex 1 at 4. Free fall “kinetic energy resulting at impact from a free fall from a height of 400ft.”

kinetic energy that could be produced by a crashing UAV/ROA, the greater the risk to persons on the ground from impact.<sup>410</sup>

This proposed regulation of light UAV/ROAs was taken in part from a policy formulated by the UK, UK-CAA Policy for Light UAV Systems (“CAA Light UAV/ROA Policy”), and which does now govern light UAV/ROA operations within the UK.<sup>411</sup> Therefore, while CAP 722 is no longer applicable and EASA has yet to issue governing regulations to replace it, the CAA Light UAV/ROA Policy currently allows light UAV/ROAs to operate in the UK under a regulatory certification and licensing regime.

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

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.<sup>412</sup>

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

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<sup>410</sup> UK-CAA Policy, *supra* note 401, at 2.

<sup>411</sup> *Id.* The policy is dated May 28, 2004.

<sup>412</sup> *Id.* at 3,4.

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 UAV/ROAs into five different classes based on the type of airspace to be flown:

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.<sup>413</sup>

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

CAP 722 also made a distinction between the UAV/ROA pilot and the UAV/ROA commander; the latter did not have to be the actual person in control of the aircraft, but could be either co-located with the pilot or monitoring flight from a separate location.<sup>414</sup> Nevertheless, the UAV/ROA commander was tasked with the

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<sup>413</sup> CAP 722, *supra* note 31, Chapter 1 § 3.1.

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.<sup>415</sup>

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.<sup>416</sup> Thus, CAP 722 required UAV/ROA commanders to be rated pilots; however, the UAV/ROA pilot, if separate from the commander, only had to meet the “training, qualifications, proficiency and currency requirements stated in the approved Flight Operations Manual” instituted by the UAV/ROA operating organization.<sup>417</sup> CAP 722 also allowed the UAV/ROA commander to simultaneously assume responsibilities for more than one UAV/ROA at a time upon the condition that directing more than one UAV/ROA pilot could be done safely.<sup>418</sup>

As noted, CAP 722 was built on the regulatory philosophy that UAV/ROAs 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

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<sup>414</sup> *Id.* at Chapter 9 § 3.1.

<sup>415</sup> *Id.*

<sup>416</sup> *Id.*

<sup>417</sup> *Id.*

<sup>418</sup> *Id.*

requirements.<sup>419</sup> Further, as part of the determination for certification, like the Australian rules, CAP 722 recognized that the UAV/ROA 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/ROA and would have to comply with applicable airworthiness requirements.<sup>420</sup> However, the lack of recognized airworthiness standards in the UAV/ROA industry and the technology hurdle of “see and avoid” hindered application of the CAP 722 certification process.<sup>421</sup>

#### **IV. FUTURE REGULATORY CONSTRUCT**

While it is clear that 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 UAV/ROAs, I contend that a majority of the regulatory effort necessary to create UAV/ROA 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/ROA integration possible, is it not more of a matter of technology forming designs and utilities that allow UAV/ROA 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;<sup>422</sup> it took technology to build safe airplanes. Clearly, the Chicago Convention was not necessary or would

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<sup>419</sup> *Id.* at Chapter 4 § 3.2.

<sup>420</sup> *Id.*

<sup>421</sup> *See* OSD, *supra* note 242, at 42.

<sup>422</sup> *See* Michael J. AuBuchon, *Choosing How Safe is Enough: Increased Antiterrorists Federal Activity and Its Effect on the General Public and the Airport/Airline Industry*, 64 J. Air L. & Com. 891, 910 (1999).



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 UAV/ROAs 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 UAV/ROAs is unfinished business behind the chalk board, 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/rules of the air, to include security, and the certification of aircraft and aircrew; while also providing suggested direction to focus efforts or take specific actions.

## **A. UAV/ROA OPERATIONS/RULES OF THE AIR**

### **1. New or Existing rules**

The initial question that must be addressed is the form UAV/ROA 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,<sup>423</sup> and ultralight aircraft<sup>424</sup> 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 UAV/ROAs.<sup>425</sup> The NASA ERAST project to look at the development and integration of HALE UAV/ROAs reviewed the rules found in FAR Part 91, and concluded that most of the current regulatory criteria found in this section of the FARs are already applicable or specifically do not apply.<sup>426</sup> 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/ROA operating rules, and amend where needed.<sup>427</sup>

The painstaking, while not exhaustive, review of existing international and domestic rules that could apply to UAV/ROA operations found in the previous chapter, hopefully supports this conclusion. Nevertheless, not all UAV/ROA 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, UAV/ROAs that only operate in Class G airspace will have differing requirements from those that operate in Class A. Thus,

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<sup>423</sup> 14 C.F.R. §§ 101.1 – 101.39.

<sup>424</sup> 14 C.F.R. §§ 103.1 – 103.23.

<sup>425</sup> See NASA Certification Roadmap, *supra* note 16, at 101.

<sup>426</sup> *Id.*

<sup>427</sup> *Id.*

by treating the UAV/ROA 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/ROA integration.<sup>428</sup> Therefore, I will use the premise in this final chapter that the most effective way to create regulations for UAV/ROA integration is to incorporate to the greatest extent possible existing aviation regulations.

## **2. Classification of UAV/ROA**

The first issue that must be addressed by the FAA in incorporating existing operational rules of the air to UAV/ROA 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/ROA. A classification scheme is important for UAV/ROA development to give operational parameters to system designers and manufacturers as targets to aim for in accessing an intended operational environment. There are a number of different classification schemes for UAV/ROAs 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 are fairly universally used.<sup>429</sup> This sort of classification includes

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<sup>428</sup> OSD, *supra* note 242, at 2, 3, 33; JAA, *supra* note 14, at 19, 25, 38, 47; CAP 722, *supra* note 31, at Chapter 3 § 3.2, Chapter 13 § 3.1, Chapter 27 §§ 3.2, 5. *See also* DeGarmo, *supra* note 32, at 3-1.

<sup>429</sup> *See* NASA Concept of Operations, *supra* note 45, 1-3; UAV Categorisation, *supra* note 53, at 155; DeGarmo, *supra* note 242, at 40.

high altitude, long endurance, HALE, UAV/ROAs, and medium altitude, long endurance, MALE UAV/ROAs. Militaries also classify UAV/ROAs based on operational characteristics, such as the previous explored unmanned combat aerial vehicle, UCAV, the vertical takeoff and landing UAV/ROA, VUAV,<sup>430</sup> or the operational mission, such as the tactical UAV/ROA, TUAV.<sup>431</sup>

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 above explored CAA Light UAV/ROA 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/ROA to stay in that airspace, coupled with a kinetic energy concept.<sup>432</sup>

However, if the most effective way to pave the airfield for UAV/ROA integration is by adapting, to the greatest extent possible, current aviation regulations, I contend that UAV/ROAs should be classified through a system that easily fits into and can incorporate those existing rules. This could be done with a system that uses the different categories of airspace already in place in the aviation regulatory construct, and apply it to UAV/ROAs. In essence, that is what was done in the

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<sup>430</sup> United States Coast Guard, *VTOL (Vertical Takeoff and Landing) Unmanned Aerial Vehicle (UAV)*, at <http://www.uscg.mil/deepwater/system/vuav.htm> (last visited Jun. 10, 2005).

<sup>431</sup> Susan Redwine, Sgt USA, *Division Fields First TUAV Platoon*, Fort Drum Blizzard Online (Jun. 5, 2005) at [http://www.drum.army.mil/sites/news/blizzard/blizzard\\_online/news.asp?id=7](http://www.drum.army.mil/sites/news/blizzard/blizzard_online/news.asp?id=7) (last visited Jun. 10, 2005).

<sup>432</sup> See DeGarmo, *supra* note 32, at 40.

classification grouping in CAP 722, discussed above. Under CAP 722, the UK made five groupings based on the type of airspace the UAV/ROA would fly.<sup>433</sup>

This sort of method was also proposed by the United States' Office of The Secretary of Defense (OSD) in its 2004 report entitled *Airspace Integration Plan for Unmanned Aviation* ("OSD Plan").<sup>434</sup> In the OSD Plan, the OSD looked at the FAA's current scheme of regulating aircraft based on classifications of "class," "category," and "type."<sup>435</sup> They determined that by adapting the existing FAA regulatory classification scheme, they could easily group UAV/ROAs into categories upon which specific requirements would apply.<sup>436</sup> 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.<sup>437</sup>

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/ROA world:

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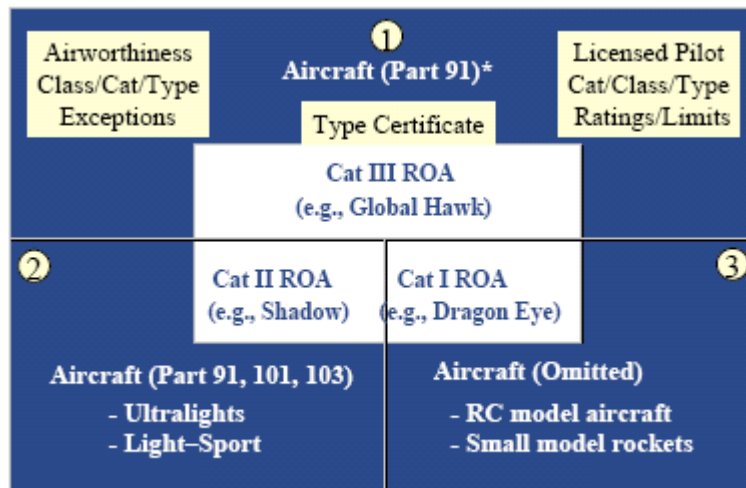
<sup>433</sup> CAP 722, *supra* note 31, at Chapter 1 § 3.1.

<sup>434</sup> OSD, *supra* note 242, at 11-14.

<sup>435</sup> *Id.* at 12.

<sup>436</sup> *Id.* at 12-14.

<sup>437</sup> *Id.* at 3.



Only "Part 91 aircraft" are certified airworthy and require licensed pilots

**Figure 4-1: UAV/ROA Divisions Based on FAA Definitions**

1. The regime that operates under Visual Flight Rules (VFR) and Instrument Flight Rules (IFR) according to well-established 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.<sup>438</sup>

Thus, by categorizing UAV/ROAs 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/ROA 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 applies easily to airspace classifications. Since Cat I are those UAV/ROAs that operate in visual line of sight similar to model aircraft, their operating parameters will be in the uncontrolled airspace of class G. Cat II will be limited due to operating constraints that do not allow full adherence to the

<sup>438</sup> *Id.* at 14.

FARs, such as equipment limitations, but also 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, Cat III are those UAV/ROAs 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:

		Certified Aircraft / Cat III ROA <sup>20</sup>	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 (proposed)	100 (proposed)
Example Types	Manned	Airliners	Light-Sport	None
	Unmanned	Predator, Global Hawk	Pioneer, Shadow	Dragon Eye, Raven

<sup>439</sup> **Figure 4-2 Alignment of UAV/ROA Categories with FAA Regulations**

It could be argued that this overly simplistic categorization system does not adequately address the threat to air and ground-based third parties since it does not account for the mass and operating speed of the UAV/ROA. For example, in theory a Cat II UAV/ROA could be as large as any Cat III aircraft, but since it is designed to fly in limited airspace, it would not be equipped with some safety related equipment,

<sup>439</sup> *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

such as transponders, radios, or even lights. Thus, while Cat II UAV/ROAs are only designed for operations in Class E, G and uncontrolled portions of 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/ROA. 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 with 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 burdening 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 risks. The real threat to third parties clearly lies in Cat III UAV/ROAs 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 as it would allow for the adoption of existing rules upon UAV/ROA systems that wish to operate in certain segments of airspace without limiting access to those



UAV/ROAs that can now safely operate under those rules, such as Cat I UAV/ROAs. This system is simple and easy to understand, and does not require complex, possibly unnecessary, testing that takes recourse from both government and manufacturer.

### **3. Cat III UAV/ROA Specific Considerations for the FARs**

Cat III UAV/ROAs, 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 don't apply and others need to be slightly changed to address the UAV/ROA operational range. Therefore, I will review portions of Part 91 of the FARs that need to be modified for UAV/ROA operations.

#### **3a. 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/ROA commanding pilot to command, not necessarily personally operate, more than one UAV/ROA at a time on the stipulations that such could be done safely.<sup>440</sup> 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/ROA operations center. Granted, such a center would only be possible in operations sophisticated enough to have sufficient monitoring of the aircraft(s), communications with all ATCs, and flying environment, including all other local traffic; however, such operations are not beyond immediate future realization.

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<sup>440</sup> CAP 722, *supra* note 31, Chapter 9 § 3.1

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 a provision that allows the UAV/ROA pilot in command to perform his or her duties by direct control of the vehicle or through a pilot who is either co-located or monitored from an operations center. Further, that a UAV/ROA pilot in command may simultaneously assume the prescribed responsibilities for more than one UAV/ROA 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/ROA pilots.

**3b. Right of Way: See and Avoid**

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

While it would be ideal for UAV/ROAs to be totally transparent to the ATC in that the ATC would not have to make a distinction between pilot-on-board aircraft and UAV/ROAs,<sup>441</sup> such may be too idealistic. While it is not unreasonable to require that the ATC be able to communicate with and instruct the UAV/ROA 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/ROA aircraft. This can only be done if the ATC knows that they are dealing with a UAV/ROA.

Therefore, Cat III UAV/ROAs will need to be equipped with identifying technology to safely fly and communicate under IFR conditions, but moreover, they will need transponders and/or other technology to allow other aircraft and the ATC to immediately identify them as UAV/ROA 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 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.<sup>442</sup> Cat 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 see and avoid in Cat II UAV/ROAs operating in Class D, E, and G airspace.<sup>443</sup>

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<sup>441</sup> See generally JAA, *supra* note 14, at 13.

<sup>442</sup> 14 C.F.R. §§ 91.201 – 91.299.

<sup>443</sup> See NASA Certification Roadmap, *supra* note 16, at 103-4. See also Visual Flight Rules, 14 C.F.R. §§ 91.151 – 91.165.

### 3c. 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,<sup>444</sup> the flight plan filed for UAV/ROA 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 cargo, to include internal equipment which 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/ROA control center, as well as allocated safe areas in the air and on the ground for recovery, implosion, or other forms of termination. For Cat 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 be placed there or in Section 91.139, *Emergency Air Traffic Rules*. For Cat II flying VFR, similar requirements could also be included in to 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 reestablish communication. As briefly touched on in the previous chapter, there are rules for pilot-on-board aircraft in situations where communications

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<sup>444</sup> AC 101-1(0), *supra* note 362 at § 5.10.

between the ATC and pilot have ceased.<sup>445</sup> The same procedures could be autonomously programmed into the UAV/ROA to take effect upon a lost link with the control center.<sup>446</sup> However, care should be taken to allow these procedures to occur autonomously. Unlike pilot-on-board aircraft, a UAV/ROA 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 reestablished 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/ROA operations center and the aircraft. While the technical parameters of the issue is beyond the scope of this thesis, there seems to be work that could be done by the ITU,<sup>447</sup> on an international scale, and the FAA and Federal Communications Commission (“FCC”) within the United States. Dedicated frequencies and/or bandwidth requirements and noninterference rules could be placed in the FARs, possibly as part of Section 91.183, *IFR Radio Communications*, and/or 91.185, *IFR Operations: Two-way Radio Communications Failure*, to address the unique UAV/ROA environ.

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<sup>445</sup> 14 C.F.R. § 91.185.

<sup>446</sup> See generally OSD, *supra* note 242, at 31.

<sup>447</sup> See JAA, *supra* note 14, at 49. See also note on ITU, *supra* note 22.

### **3d. Flight Operations Center and the UAV/ROA System**

As noted in both Australian and UK rules, the UAV/ROA is more than just an aircraft, but includes remotely located pilots, technicians, communication links and personnel. Any changes to the FARs must account for the UAV/ROA as a system. Therefore, the definitional section, Section 1, of the FARs should discuss the UAV/ROA as a system that includes the aircraft, a ground or air based control center, communications/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/ROA.

Further, while the UAV/ROA aircraft is only one piece of the system, other pieces of that system could change mid flight as it did when the Global Hawk flew from the United States to Australia.<sup>448</sup> In that situation and in future scenarios, control and/or responsibility of the aircraft may pass onto another control center, pilot, and/or pilot in command. This could happen not just internationally, but domestic within the United States as UAV/ROA operators could have regional control centers for transnational flights. In such situations, the identity of the UAV/ROA pilot and the UAV/ROA commander must be clear to the ATC, with proper communications maintained with the right party at all times during the UAV/ROA 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.<sup>449</sup>

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<sup>448</sup> See Morris, *supra* note 35.

### 3e. Other Security Issues

Once the UAV/ROA is recognized as a system, security issues enlarge to encompass the whole UAV/ROA 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 include 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.<sup>450</sup>

As noted, there are FAA promulgated rules regarding securing the cockpit of pilot-on-board aircraft and controlling access to such areas to only authorized persons.<sup>451</sup> These rules should be expanded to include control centers of UAV/ROAs. However, since the security of passengers is not an issue and UAV/ROAs are generally smaller as compared with most pilot-on-board aircraft, my recommendation is that the rules for locked cockpit doors<sup>452</sup> 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 need to be amended to place onus on the UAV/ROA operator to secure the location of equipment, to include fenced and controlled areas

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<sup>449</sup> 14 C.F.R. §§ 91.153, 91.169.

<sup>450</sup> 49 C.F.R. §§ 1540.1 – 1540.117, 1544.1 – 1544.411, 1550.1 – 1550.7. 1562.1 – 1562.3.

<sup>451</sup> 14 C.F.R. §§ 121.313; 121.547.

<sup>452</sup> *Id.* at § 121.313.

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 aircraft and control center, there needs to be a requirement for redundancy of systems, which is a common requirement imposed by the FAA upon aircraft manufacturers.<sup>453</sup> Once again, these are areas that technology must answer; however, 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, avoid any presumption of the missions or purposes of the aircraft;<sup>454</sup> 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.<sup>455</sup> The problem that lies before regulators regarding UAV/ROA flight is the lack of industrial safety standards since there is not a long history of a certification process.<sup>456</sup>

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<sup>453</sup> Many times FAA Airworthiness Directives require specific aircraft manufactures to address systems that need redundancy to ensure safety, or airworthiness. FAA, *Airworthiness Directives*, at [http://www.airweb.faa.gov/Regulatory\\_and\\_Guidance\\_Library/rgAD.nsf/MainFrame?OpenFrameSet&CFID=1044425&CFTOKEN=71698324](http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAD.nsf/MainFrame?OpenFrameSet&CFID=1044425&CFTOKEN=71698324) (last visited Jun. 2, 2005).

<sup>454</sup> See JAA, *supra* note 14, at 18.

<sup>455</sup> See 14 C.F.R. § 21.25.

<sup>456</sup> See generally JAA, *supra* note 14, at 18-20.



Notwithstanding this problem, if UAV/ROAs are classified using the OSD system, as recommended above, the number of UAV/ROAs requiring a full certification process is reduced to some extent. Under this categorization system, only Cat III UAV/ROAs will require normal airworthiness certification. Cat I UAV/ROAs will follow rules for model aircraft found in AC 91-57, and Cat II UAV/ROAs will apply rules similar to ultralight aircraft found in Title 14, Part 103, *Ultralight Vehicles*, which are “not required to meet the airworthiness certification standards specified for aircraft or to have certificates of airworthiness”.<sup>457</sup> As for the Cat III UAV/ROAs, which would more than likely be made up of HALE UAV/ROAs, the NASA ERAST project addressed the certification process for HALE UAV/ROAs, 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.<sup>458</sup> Once the standard airworthiness certificate is obtained for a Cat III UAV/ROA, they 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 Cat III UAV/ROA, in their case a HALE UAV/ROA, through the steps required for the development of almost any new aircraft system, which is at least a four year process.<sup>459</sup> The first steps are to obtain registration for the aircraft and an experimental certificate.<sup>460</sup> While the experimental

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<sup>457</sup> 14 C.F.R. § 103.7.

<sup>458</sup> NASA Certification Roadmap, *supra* note 16, at 49.

<sup>459</sup> *See id.* at 50.

<sup>460</sup> *Id.* at 50-9.

certificate is not required to obtain the standard airworthiness certificate, it would develop data helpful in later stages of the proposed stair-step process.<sup>461</sup>

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.<sup>462</sup> A UAV/ROA 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 UAV/ROAs or pilot-on-board aircraft, or to determine if there is utility in further development.<sup>463</sup> 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.<sup>464</sup> Further, it would begin to introduce the concept that the UAV/ROA is more than just an aircraft, but a system of remotely located parts that must function together to bring about operational capabilities.

The next step proposed is to seek a special class type certificate from the FAA, which step is the most detailed and time consuming, as it could take at least three years to receive the type certificate.<sup>465</sup> 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

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<sup>461</sup> *Id.* at 53.

<sup>462</sup> 14 C.F.R. § 21.191.

<sup>463</sup> *See id.*

<sup>464</sup> NASA Certification Roadmap, *supra* note 16, at 54.

<sup>465</sup> *Id.* at 59-65.

(“IP”) that addresses the proposed type certification basis for the aircraft.<sup>466</sup> The end goal being that the FAA makes a determination that the UAV/ROA is sufficiently similar to existing pilot-on-board aircraft certificated under the provisions of FAR 21.17(b), *Designation of Applicable Regulations*.<sup>467</sup> This would allow the applicant, a UAV/ROA manufacturer, to take advantage of existing airworthiness standards for differing types of already certified aircraft.<sup>468</sup>

However, unlike these already certified aircraft, the UAV/ROA operates as a system of remotely located parts. The concepts and submitted plans would have to clearly indicate how the UAV/ROA 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 rule-making authority and process set forth in Part 11, *General Rulemaking Procedures*, of the FARs.<sup>469</sup>

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<sup>466</sup> *Id.* at 60.

<sup>467</sup> *Id.* See also 14 C.F.R. § 21.17(b)

<sup>468</sup> 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.

<sup>469</sup> 14 C.F.R §§ 11.1 – 11.201.

The remaining steps deal with the actual production of the UAV/ROA 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, *Production Under Type Certificate Only*, of Part 21, *Certification Procedures for Products and Parts*, of the FARs.<sup>470</sup> This would allow the production and further testing of the UAV/ROA without obtaining a production certificate; however, as previously mentioned, for commercially produced and sold UAV/ROAs, manufacturing pursuant to a production certificate will be required.<sup>471</sup>

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*.<sup>472</sup> 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, and 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

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<sup>470</sup> NASA Certification Roadmap, *supra* note 16, at 66-72. *See also* 14 C.F.R. §§ 21.121 – 21.130.

<sup>471</sup> NASA Certification Roadmap, *supra* note 16, at 66-7. *See also* 14 C.F.R. §§ 21.131 – 21.165.

<sup>472</sup> NASA Certification Roadmap, *supra* note 16, at 73-7. *See also* 14 C.F.R. §§ 21.25, 21.185(b).

address systems; and any other operation specified by the FAA.<sup>473</sup> With successful operations through a special certificate of airworthiness, the next step would be a full up airworthiness certificate, which would allow full integration into the NAS.<sup>474</sup>

While this proposed stair-step process is offered by the NASA ERAST project for certification of HALE UAV/ROAs, it could be adopted for any Cat III. Through this process, the Cat III operator could obtain an airworthiness certification from the FAA through an already established system, which would then lead to an easier pathway to recognition internationally by other nations through the Chicago Convention.<sup>475</sup> Granted, there is still needed work by ICAO to address UAV/ROA operations and certification; however, if UAV/ROA 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/ROA airworthiness certificate; thereby, increasing the operational parameters of the aircraft.

While the UAV/ROA 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/ROA operators and manufacturers of Cat III UAV/ROAs 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 UAV/ROAs that can meet existing concepts for safe flight. However, as manufacturers begin the process,

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<sup>473</sup> 14 C.F.R. § 21.25(b).

<sup>474</sup> NASA Certification Roadmap, *supra* note 16, at 77-82.

<sup>475</sup> *See generally id.* at 90-100.

the FAA will have an increased ability to establish standards and requirements, which in turn will speed up the process for next generation UAV/ROAs.

## **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/ROA pilot. As such, the concept of a pilot in command is a universally accepted regulatory construct.<sup>476</sup> For Cat III UAV/ROAs, 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.<sup>477</sup> This would allow persons more familiar with the engineering and technical capabilities of the UAV/ROA 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, instruments, and maybe even experience as a pilot of pilot-on-board aircraft.

The biggest issue, however, is the type of UAV/ROA specific education and flight experience necessary for the commanding pilot, as well as for all other certified airman such as flight engineers, mechanics, and technicians. That issue would need to be clearly addressed and established by the FAA. For Cat I and II pilots, since their operations will be in either uncontrolled airspace or greatly limited, they would not need to be licensed under the same requirements as Cat III pilots. The rules

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<sup>476</sup> See 14 C.F.R. §§ 61.57 – 61.58.

<sup>477</sup> See CAP 722, *supra* note 31, Chapter 9 § 3.1.

currently applicable under AC 91-57 for Cat I and Part 103 of the FARs for Cat II could easily be adapted for such pilots.<sup>478</sup>

Lastly, there is the issue of the medical certification of UAV/ROA personnel. While UAV/ROAs do fly in the air, generally their pilots do not. Therefore, it is argued that the physically demanding requirements of airborne flight are different for ground based UAV/ROA pilots, and in fact, more similar to ATC personnel.<sup>479</sup> There is merit in this argument as the interface between pilot and machine is electronically based, sitting behind a control panel on the ground. Therefore, ground based UAV/ROA pilots should not be required to receive higher than a second-class airman medical certificate, which is what is required for ATC personnel.<sup>480</sup> For those occasions that the UAV/ROA 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,<sup>481</sup> could be made applicable to UAV/ROA pilots.

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<sup>478</sup> 14 C.F.R. §§ 103.7.

<sup>479</sup> JAA, *supra* note 14, Enclosure 4, at 19.

<sup>480</sup> 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.

<sup>481</sup> 14 C.F.R. § 65.47.

### C. SUMMARY OF FURTHER ACTIONS

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

**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 technology to form equivalent 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 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/ROA 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/autonomously operated aircraft. The early history of the UAV/ROA 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 UAV/ROAs 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 markets, saturated by interest groups, and governed by a voluminous regulatory structure.<sup>482</sup>

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/ROA can take advantage of this complex system already in place, and, in fact, thrive under its rules.

While the history of the UAV/ROA 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, it can be argued 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/ROA development. As commercially viable UAV/ROAs are developed, certified, and flown into the NAS, militaries will not only benefit from

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<sup>482</sup> DeGarmo, *supra* note 32, at 1-1.

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 UAV/ROAs that will operate below 1,200 feet (365.76 meters) AGL in the line of sight of its operator at a limited airspeed. These aircraft could be categorized as Cat I UAV/ROAs. Additionally, the FAA should adopt simplified provisions to allow for UAV/ROAs 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 Cat II UAV/ROAs.

For all other UAV/ROAs, file and fly use of the NAS is still years away. However, as the industry, to include 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/ROA 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 multi-location system that makes up the UAV/ROA, as well as an operational center(s) capable of controlling multiple aircraft. Drastic regulatory changes are not necessary as technology evolves the UAV/ROA. Nevertheless, changes are necessary domestically and internationally.

This researcher recalls reading books in the 1970's that foresaw flying vehicles replacing land based cars by the mid-1990's. Sometimes technology can not keep up with the fast pace of futuristic dreamers. Be that as it may, the UAV/ROA'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.

## **BIBLIOGRAPHY**

### **A. Books (Alphabetically by Author)**

- Anderson, John D., Jr., Introduction to Flight Its Engineering and History (1978).
- Bonds, Ray, The Illustrated Directory of A Century of Flight, (2003).
- Detter, Ingrid, The Law of War, 2nd Ed. (2000).
- Gibbs-Smith, Charles H., Aviation: An Historical Survey from its Origins to the end of World War II (1970).
- Gibbs-Smith, Charles H., The Aeroplane: An Historical Survey of its Origins and Development (1960).
- Gurney, Gene, Lt Col USAF, A Chronology of World Aviation (1965).
- Jane's All The World's Aircraft (C.G. Grey & Leonard Bridgman Eds., 1939)
- Jane's All The World's Aircraft (Leonard Bridgman Ed., 1959-60).
- Jane's All The World's Aircraft (John W.R. Taylor Ed., 1969-70).
- Jane's All the World's Aircraft (Paul Jackson Ed., 2001-2002).
- Lyall, Francis, Law & Space Telecommunications (1989).
- Newcome, Laurence, Unmanned aviation: A Brief History of Unmanned Aviation (2004).
- Seifer, Marc J., Wizard The Life and Times of Nikola Tesla Biography of a Genius, (1996).
- The American Heritage History of Flight (Alvin M. Josephy, Jr., ed. 1962).

**B. Law Review, Journal, Newspaper, Magazine Articles (Print or Electronic Media) (Alphabetically by Author or Title)**

*A Flying Crime Fighter—Some Assembly Required*, GovPro-Government Product News and Government Procurement Journal, at <http://www.govpro.com/ASP/ViewArticle.asp?strArticleId=104386&st=1>, (last visited May 2, 2005).

*Airborne Communications Node (ACN/AJCN)*, Advanced Technology Office, Defense Advance Research Projects Agency, at <http://www.darpa.mil/ato/programs/acn.htm>, (last visited May 2, 2005).

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

Baird, Douglas G., *The New Face of Chapter 11*, 12 Am. Bankr. Inst. L. Rev. 69 (2004).

Bauer, Jeff, *Integrating UAVs Into the National Airspace System*, in 2004 Yearbook: UAVs Global Perspective 25 (UVS International, Blyenburgh & Co.).

Bourbonniere, Michel and Haeck, Louis, *Military Aircraft and International Law: Chicago Opus 3*, 66 J. Air L. & Com. 885 (2001).

Butler, Amy and Fulghum, David A., *U.S. air force wants to be pentagon's UAV manager but the plan has Army and Navy officials worried*, Aviation Week & Space Technology (March 7, 2005).

*Commercial use of UAVs—Widespread in Japan*, in 2004 Yearbook: UAVs Global Perspective 138-9 (UVS International, Blyenburgh & Co.).

Dempsey, Paul Stephen, *Compliance & Enforcement in International Law: Achieving Global Uniformity in Aviation Safety*, 30 N.C.J. Int'l L. & Com. Reg. 1 (2004).

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

Dornheim, Michael A, *Flying Well With Others; To carry out quick-reaction civil missions like wildfire spotting, UAV/ROAs must be part of the FAA system. Challenge is to make safety for others on the ground and in the air affordable*, Aviation Week & Space Technology, August 2, 2004, at 54.

Dornheim, Michael A. and Taverna, Michael A., *War on Terrorism Boosts Deployment of Mini-UAVs*, Aviation Week's Next Century of Flight, at [http://www.aviationnow.com/content/ncof/ncf\\_n80.htm](http://www.aviationnow.com/content/ncof/ncf_n80.htm) (last visited Jun. 3, 2005).

- Duncan, James C., *Employing Non-lethal Weapons*, 45 Naval L. Rev. 1 (1998).
- Dutra, Michael, *Strategic Myopia: The United States, Cruise Missiles, and the Missile Technology Control Regime*, 14 J. Transnat'l L. & Pol'y 37 (2004).
- Enderle, B., *Commerical Applications of UAV's in Japanese Agriculture*, American Institute of Aeronautics and Astronautics at <http://www.aiaa.org/content.cfm?pageid=406&gTable=Paper&gID=2802> (last visited Jun. 8, 2005).
- Fulghum, David, *Star Unmanned Aircraft Faces Bureaucratic Fight*, World News & Analysis, Aviation Week & Space Technology, Mar. 12, 2001 at 29.
- Gilson, Charles, *UAVs Steal Spotlight as Utility Multiplies*, Aviation International News, 2004, at [http://www.ainonline.com/Publications/asian/asian\\_04/d2\\_uavsp14.html](http://www.ainonline.com/Publications/asian/asian_04/d2_uavsp14.html) (last visited Mar. 19, 2005).
- Guillory, Michael E., Major USAF, *Civilianizing the Force: Is the United States Crossing the Rubicon*, 51 A.F. L. Rev. 111 (2001).
- Hailbronner, Kay, *Freedom of the Air and the Convention on the Law of the Sea*, 77 A.J.I.L. 490 (1983).
- Hedrick, Robert F., *A Close and Critical Analysis of the New General Aviation Revitalization Act*, 62 J. Air L. & Com. 385 (1996).
- High Times*, The Economist, Dec. 11, 2003 at [http://www.economist.com/science/displaystory.cfm?story\\_id=2282185](http://www.economist.com/science/displaystory.cfm?story_id=2282185) (last visited Feb. 9, 2005).
- Historical Threads Leading to Today's Unmanned Vehicles in the USA*, in 2004 Yearbook: UAVs Global Perspective 108-11 (UVS International, Blyenburgh & Co.).
- Hodge, Nathan, *Jumper: Military Must Reorganize UAV Efforts*, Defense Daily, Apr. 29, 2005, at 7.
- Klug, Heinz, *The Rule of Law, War or Terror*, 2003 Wis. L. Rev. 365 (2003).
- Kotaite, Assad, *Secrity of International Civil Aviation—Role of ICAO*, 7 Annals Air & Space L. 95 (1982).

- Lazarski, Anthony Lt Col USAF, *Legal Implications of the Uninhabited Combat Aerial Vehicle*, Aerospace Power Journal (Summer 2002) at <http://www.airpower.maxwell.af.mil/airchronicles/apj/apj02/sum02/lazarski.html> (last visited Jan. 20, 2005).
- Levine, Jay, *UAV/ROAs Taking Center Stage: Dryden Role Extends to Include Other Areas of Aeronautics Research* (Nov 2004) at [http://www.nasa.gov/centers/dryden/news/X-Press/news\\_UAV/ROA.html](http://www.nasa.gov/centers/dryden/news/X-Press/news_UAV/ROA.html) (last visited Feb. 17, 2005).
- Mahon, Tim, *Fit to Fly in Civil Airspace*, in 2003 Yearbook 162-68 (UVS International, Blyenburgh & Co.).
- Morier, Yves, *JAA and EURONCONTROL Joint UAV Initiative*, in 2004 Yearbook: UAVs Global Perspective 146-7 (UVS International, Blyenburgh & Co.).
- Morris, Jefferson, *DOD UAV Budget To Hold Fairly Steady In FY '06, Official Says*, Aerospace Daily and Defense Report, Feb. 10, 2005, at [http://www.aviationnow.com/avnw/news/channel\\_aerospacedaily\\_story.jsp?id=news/UAVBUDG02105.xml](http://www.aviationnow.com/avnw/news/channel_aerospacedaily_story.jsp?id=news/UAVBUDG02105.xml) (last visited May 30, 2005).
- Morris, Jefferson, *Global Hawk sets record on flight to Australia*, Aerospace Daily, Apr. 24, 2001, at 1.
- Morris, Jefferson, *USAF No Longer Viewing Global Hawk as an Autonomous System*, Aerospace Daily, Dec. 5, 2003, at 1.
- Munson, Kenneth, *Executive Overview: Jane's Unmanned Aerial Vehicles and Targets*, Unmanned Aerial Vehicles and Targets (Nov. 16, 2004) at [http://www.janes.com/aerospace/military/news/jUAV/ROA/jUAV/ROA041116\\_1\\_n.shtml](http://www.janes.com/aerospace/military/news/jUAV/ROA/jUAV/ROA041116_1_n.shtml) (last visited Feb. 11, 2005).
- Near Hit*, Air Safety Week, Oct. 18, 2004, Vol. 18, No. 40.
- Newcome, Laurence, *FAA-Type Regulations Will Allow UAVs to Grow*, Aviation Week's Next Century of Flight, 28 Jan. 2004.
- Newman, Richard J., *The Little Predator That Could*, Air Force Magazine, Mar. 2002, at 49.
- Parmalee, Patricia J, *Good Scouts: The Buzz About Tiny UAV/ROAs*, Aviation Week & Space Technology, Sep. 13, 2004, at 78.

- Redwine, Susan, Sgt USA, *Division Fields First TUAV Platoon*, Fort Drum Blizzard Online (Jun. 5, 2005) at [http://www.drum.army.mil/sites/news/blizzard/blizzard\\_online/news.asp?id=7](http://www.drum.army.mil/sites/news/blizzard/blizzard_online/news.asp?id=7) (last visited Jun. 10, 2005).
- Rehn, Torbjorn, *A Total Aviation System Approach to Non-Segregated Airspace Operations*, in 2004 Yearbook: UAVs Global Perspective 148-51 (UVS International, Blyenburgh & Co.).
- Reynish, William, *UAV/ROAs Entering the NAS*, Aviation Today, Oct. 2004 at [http://avtoday.com/cgi/av/show\\_mag.cgi?pub=av&mon=1004&file=UAV/ROAsenteringthe.htm](http://avtoday.com/cgi/av/show_mag.cgi?pub=av&mon=1004&file=UAV/ROAsenteringthe.htm) (last visited Jan. 11, 2005).
- Shrewsbury, Stephen M., Major, *September 11<sup>th</sup> and the Single European Sky: Developing Concepts of Airspace Sovereignty*, 68 J. Air L. & Com. 115 (2003).
- Sully, Megan, *U.S. Pours Millions Into UAV Acquisitions*, Defense News, 9 Aug. 2004.
- Status Report on US UAV Programmes*, in 2004 Yearbook: UAVs Global Perspective 112-117 (UVS International, Blyenburgh & Co.).
- Victor E. Schwartz, Victor E. and Lorber, Leah, *The General Aviation Revitalization Act: How Rational Civil Justice Reform Revitalized an Industry*, 67 J. Air L. & Com. 1269 (2002).
- Sweetman, Bill, *HALE Storms to New Heights*, Jane's International Defence Review, Mar.1, 2001 at [http://www.janes.com/aerospace/military/news/idr/idr010301\\_2\\_n.shtml](http://www.janes.com/aerospace/military/news/idr/idr010301_2_n.shtml) (last visited Feb 11, 2005).
- Sweetman, Bill, *In the tracks of the Predator: combat UAV/ROA programs are gathering speed*, Jane's International Defence Review, Jul.13, 2004 at [http://www.janes.com/aerospace/military/news/idr/idr040713\\_1\\_n.shtml](http://www.janes.com/aerospace/military/news/idr/idr040713_1_n.shtml) (last visited Jan. 20, 2005).
- Tasikas, Vasilios, *Unmanned Aerial Vehicles and the Doctrine of Hot Pursuit: A New Era of Coast Guard Maritime Law Enforcement Operations*, 29 Mar. Law. 59 (2004).
- Tuttle, Rich, *Afghanistan Operations Boost Vision of UAVs for Homeland Defense*, Aerospace Daily, Jan. 2, 2002, p. 7.
- UAV Categorisation*, in 2004 Yearbook: UAVs Global Perspective 155-63 (UVS International, Blyenburgh & Co.).

Walker, George K., *Information Warfare and Neutrality*, 33 Vand. J. Transnat'l L. 1079 (2000).

Wichner, David, *Small UAVs Geared to be Eyes in Skies*, Arizona Daily Star, Apr. 21, 2005, at <http://www.dailystar.com/dailystar/allheadlines/71467.php> (last visited May 2, 2005).

### **C. Governmental Regulations, Policy, Reports, and Briefings (Alphabetically by Author, Agency, Title or Topic)**

Beshears, Troy, LCDR, USCG, *Department of Homeland Security UAV/ROA Briefing* at <http://www.UAV/ROAforum.com/library/library.htm>, (last visited Feb. 9, 2005).

Bone, Elizabeth and Bolkcom, Christopher, *Unmanned Aerial Vehicles: Background and Issues for Congress*, Washington/Congressional Research Service, RL31872 (Apr. 25, 2003) at <http://www.fas.org/irp/crs/RL31872.pdf>, (last visited Feb. 9, 2005).

C-21, Air Force Link Fact Sheet, at <http://www.af.mil/factsheets/factsheet.asp?fsID=88> (last visited Apr. 29, 2005).

Canadian Aeronautics and Space Institute, *UAV/ROAs in the Canadian Context*, (2003) at <http://www.casi.ca/CD-ROMs/AGM/2003/UAV/ROA.html#top>, (last visited Jan. 20, 2005).

Civil Aviation Authority (U.K.), *CAP 722--Unmanned Aerial Vehicle Operations in UK Airspace – Guidance* (2002).

Civil Aviation Safety Regulations (Austl.), *CASR 1998 Part 21— Certification and Airworthiness Requirements for Aircraft and Parts* (2005).

Civil Aviation Safety Authority (Austl.), *Advisory Circular—AC 101-1(0): Unmanned Aerial Vehicle (UAV) Operations, Design Specification, Maintenance and Training of Human Resources* (2002).

Civil Aviation Safety Regulations (Austl.), *CASR 1998 Part 101—Unmanned Aircraft and Rocket Operations* (2004).

Convention on International Civil Aviation, Dec. 7, 1944, 61 Stat. 1180, 15 U.N.T.S. 295.

Defense Advanced Research Projects Agency. *FACT FILE: A Compendium of DARPA Programs*, (August 2003) at <http://www.darpa.mil/body/pdf/FINAL2003FactFilerev1.pdf> (last visited 9 Feb. 9, 2005).



- Defense Science Board, Office of the Under Secretary of Defense For Acquisition, Technology, and Logistics, *Defense Science Board Study on Unmanned Aerial Vehicles and Uninhabited Combat Aerial Vehicles* (Feb. 2004) at <http://www.acq.osd.mil/dsb/reports/uav.pdf> (last visited Mar. 24, 2005).
- Department of Defense, *DOD Dictionary of Military and Associated Terms*, Joint Publication 1-02 (Nov. 30, 2004) at <http://www.dtic.mil/doctrine/jel/doddict/index.html> (last visited Apr. 6, 2005).
- Department of Defense, *Unmanned Aerial Vehicles Roadmap 2002-2027*, (December 2002), at [http://www.acq.osd.mil/usd/UAV/ROA\\_roadmap.pdf](http://www.acq.osd.mil/usd/UAV/ROA_roadmap.pdf) (last visited 15 Jan. 2005).
- Federal Aviation Administration, *Airport and Aircraft Safety R&D Division AAR-400 Programs: Software & Digital Systems Safety Project Flight Critical Systems Architecture Design Assurance* (2004), at <http://aar400.tc.faa.gov/Programs/FlightSafety/sdss/reqcertop.htm> (last visited Mar. 14, 2005).
- Federal Aviation Administration, *Airworthiness Directives*, at [http://www.airweb.faa.gov/Regulatory\\_and\\_Guidance\\_Library/rgAD.nsf/MainFrame?OpenFrameSet&CFID=1044425&CFTOKEN=71698324](http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAD.nsf/MainFrame?OpenFrameSet&CFID=1044425&CFTOKEN=71698324) (last visited Jun. 2, 2005).
- Federal Aviation Administration, *Advisory Circulars*, at [http://www.airweb.faa.gov/Regulatory\\_and\\_Guidance\\_Library/rgAdvisoryCircular.nsf/MainFrame?OpenFrameSet&CFID=2656772&CFTOKEN=99716569](http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/MainFrame?OpenFrameSet&CFID=2656772&CFTOKEN=99716569) (last visited Jun. 2, 2005).
- Federal Aviation Administration, Advisory Circular 91-57, *Model Aircraft Operating Standards* (1981).
- Federal Aviation Administration's Designation of Class A Airspace Areas, 14 C.F.R. § 71.33 (2005).
- Federal Aviation Administration, *FAA Order 7610.4K Special Military Operations* (Aug. 2004).
- Federal Aviation Administration, *FAA Order 7210.3T Facility Operation and Administration* (Feb. 2005).
- Federal Aviation Administration, *FAA Order 7930.2J, Notices to Airmen* (2005).
- Federal Aviation Administration, *FAA Order 7400.2E, Procedures for Handling Airspace Matters*, (2004).

- Federal Aviation Administration, *Pilot/Controller Glossary* (Feb. 17, 2005) at <http://www.faa.gov/atpubs/PCG/PCG.pdf> (last visited Mar. 23, 2005).
- Federal Aviation Administration, *PilotWeb*, at <https://pilotweb.nas.faa.gov/distribution/atcsc.html> (last visited Jun. 2, 2005).
- Federal Aviation Administration, *Temporary Flight Restrictions Notices*, at <http://tfr.faa.gov/tfr/list.jsp> (last visited Jun. 3, 2005).
- Federal Aviation Regulations, 14 C.F.R. §§ 1.1-198.17 (2005).
- Haddon, D.R. and Whittaker, C.J., *UK-CAA Policy for Light UAV Systems*, UK Civil Aviation Authority (2004).
- International Civil Aviation Organization, at <http://www.icao.int/index.html> (last visited May 3, 2005).
- Joint Aviation Authorities, *The Joint JAA/EUROCONTROL Initiative on UAV/ROAs: Final Report*, May 11, 2004 at <http://198.17.75.100/news/news.html> (last visited Jan. 15 2005).
- Joint Aviation Authorities, *Future of JAA*, at [http://www.jaa.nl/future\\_of\\_jaa/future\\_of\\_jaa.html](http://www.jaa.nl/future_of_jaa/future_of_jaa.html) (last visited Jun. 8, 2005).
- Livingston, Richard A., *Innovative Technology: Unmanned Aerial Vehicle Provides New Traffic View*, Research & Technology Transporter, U.S. Department of Transportation, Federal Highway Administration (Jan. 2003).
- The National Aeronautics and Space Administration (hereinafter NASA), *Environmental Research Aircraft and Sensor Technology* (hereinafter ERAST) *Project, Concept of Operations: High-Altitude Long-Endurance Unmanned Aerial Vehicles*, (Version 1.2).
- NASA, ERAST, *Certification and Regulatory Roadmap: High-Altitude Long-Endurance Unmanned Aerial Vehicles*, (2002 Version 1.3) at <http://www.psl.nmsu.edu/uav/roadmap/Content.htm> (last visited Mar. 19, 2005)
- NASA, *Theme: Aeronautics Technology*, at [http://mynasa.nasa.gov/pdf/55403main\\_20%20AT.pdf](http://mynasa.nasa.gov/pdf/55403main_20%20AT.pdf) (last visited Feb. 11, 2005).
- Office of the Secretary of Defense (“OSD”), *Airspace Integration Plan for Unmanned Aviation*, (Nov. 2004).

*Past Projects – Helios Prototype*, NASA Dryden Flight Research Center, at <http://www.nasa.gov/centers/dryden/history/pastprojects/Erast/helios.html> (last visited Apr. 30, 2005).

Regulation (EC) No 1592/2002 (2002) at [http://www.easa.eu.int/doc/Regulation/BR1592\\_2002.pdf](http://www.easa.eu.int/doc/Regulation/BR1592_2002.pdf) (last visited Jun. 7, 2005).

Robbins, Karen, *National Next Generation Aircraft Technology Program Introducing Remotely Operated Aircraft (ROA) into the National Airspace System (NAS)*, White Paper submitted to U.S. Department of Transportation Research and Special Programs Administration (RSPA) Solicitation DTRS56-01-BAA-0002, at <http://www.erast.com/ehhtml/vanguard.html>, (last visited May 2, 2005).

Transportation Security Regulations, 49 C.F.R. §§ 1500.01 – 1572.45 (2005).

United States Coast Guard, *VTOL (Vertical Takeoff and Landing) Unmanned Aerial Vehicle (UAV)*, at <http://www.uscg.mil/deepwater/system/vuav.htm> (last visited Jun. 10, 2005).

United States Department of State, *Proceedings of the International Civil Aviation Conference* (Vol. I and II, 1948).

#### **D. Other (Alphabetically by Author, Organization, or Title)**

*Access 5 Alliance* at <http://www.access5.aero/index.html>, (last visited Feb. 2, 2005).

Aerovironment, *AV Pointer*, at <http://www.aerovironment.com/area-aircraft/prod-serv/pointer.html> (last visited Jun. 3, 2005).

Brecher, Aviva, Noronha, Val, and Herold, Martin, *UAV2003 a RoadMap For Deploying Unmanned Aerial Vehicles (UAVs) in Transportation*, Dec. 2, 2003, at <http://www.ncgia.ucsb.edu/ncrst/meetings/20031202SBA-UAV2003/Findings/UAV2003-Findings-Final.pdf> (last visited Mar. 19, 2005)

Curry, J.A., Maslanik, J., Pinto, J.O., Drobot, S., and Cassano J., *Applications of Aerosondes for RIME*, at [http://polarmet.mps.ohio-state.edu/RIME-01/pdf\\_docs/curry.pdf](http://polarmet.mps.ohio-state.edu/RIME-01/pdf_docs/curry.pdf) (last visited Apr. 29, 2005).

DeGarmo, Matthew T., *Issues Concerning Integration of Unmanned Aerial Vehicles in Civil Airspace*, (Nov. 2004) at [http://www.mitre.org/work/tech\\_papers/tech\\_papers\\_04/04\\_1232/04\\_1232.pdf](http://www.mitre.org/work/tech_papers/tech_papers_04/04_1232/04_1232.pdf) (last visited Mar. 19, 2005).

DeGarmo, Matthew T. and Nelson, Gregory M., *Prospective Unmanned Aerial Vehicle Operations in the Future National Airspace System*, American Institute of Aeronautics and Astronautics (2004).

EURO UVS, *UAV/ROAs a Vision of the Future*, (2003)  
[http://www.access5.aero/access5\\_custom/what.html#docs](http://www.access5.aero/access5_custom/what.html#docs) (last visited Feb. 11, 2005).

F Marsters, G, *Ummm...So Where Does the Pilot Sit?*, The W.Rupert Turnbull Lecture, Canadian Aeronautical and Space Institute, Apr. 28, 2003 at <http://www.casi.ca/CD-ROMs/AGM/2003/papers/Turnbull.pdf> (last visited Jan. 20, 2005).

First Flight Society Shrine at [http://www.firstflight.org/shrine/lawrence\\_sperry.cfm](http://www.firstflight.org/shrine/lawrence_sperry.cfm) (last visited Apr. 5, 2005).

Keys, Ryan, *Continued Use and Development of Unmanned Aerial Vehicles by the Military*, 2004, at <http://home.engr.utexas.edu/keysrs/Cover.htm> (last visited Mar. 23, 2005).

*Our First Fully Robotic Flight*, at <http://www.aerosonde.com/drawarticle/5> (last visited Apr. 30, 2005).

Parsch, Andreas, *Directory of U.S. Military Rockets and Missiles*, at <http://www.designation-systems.net/dusrm/index.html> (last visited Apr 7, 2005).

Phillips, Martin A, *UAVs in The Future Air Transportation System* (Nov. 2004), at [http://www.access5.aero/access5\\_custom/brief.html](http://www.access5.aero/access5_custom/brief.html) (last visited Mar. 14, 2005).

Pike, John, *Federation of American Scientists Intelligence Resource Program, Unmanned Aerial Vehicles (UAVs)* (May. 10, 2004), at <http://www.fas.org/irp/program/collect/uav.htm> (last visited Mar. 23, 2005)

Pres Release, *Aerosonde Passes 1000 Flight Hours in the Arctic*, at <http://www.aerosonde.com/newsroom.php> (last visited Feb. 11, 2005).

*Remotely Operated Aircraft Systems*, General Atomics Aeronautical Systems, at <http://www.uav.com/home/index.html> (last visited May 4, 2005).

RPAV: Remotely Piloted Aerial Vehicles, *The 'Aerial Target' and 'Aerial Torpedo' in Britian*, at [http://www.ctie.monash.edu.au/hargrave/rpav\\_britian.html](http://www.ctie.monash.edu.au/hargrave/rpav_britian.html) (last visited Apr. 5, 2005).

*Specifications: Global Hawk*, U.S. Arsenal, Associated Press, at <http://abclocal.go.com/images/wabc/USArsenal/> (last visited Apr. 30, 2005).

UAV/ROA Forum, SRA International, Inc at <http://www.UAV/ROAforum.com> (last visited Jan. 15, 2005).

*UAVs Soaring Beyond Military Uses*, UAV Technical Analysis and Applications Center, New Mexico State University, at <http://www.psl.nmsu.edu/uav/news/usa/index2.php> (last visited May 2, 2005).

Wikipedia, *Joule*, at <http://en.wikipedia.org/wiki/Joule> (last visited Jun. 7, 2005).

Wolfe, Russell C., *NASA ERAST Non-Cooperative DSA Flight Test* (July 2003), at [http://www.access5.aero/access5\\_custom/brief.html](http://www.access5.aero/access5_custom/brief.html) (last visited Mar. 14, 2005).

*X-45 Background Info*, Boeing, at <http://www.boeing.com/defense-space/military/x-45/x45back.html> (last visited May 2, 2005).