INTEGRATING DEPARTMENT OF DEFENSE UNMANNED AERIAL SYSTEMS INTO THE NATIONAL AIRSPACE STRUCTURE

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The Department of Defense (DoD) is constantly adding to the inventory of unmanned aerial systems (UAS) across all Services. Compounded by increasing mission sets for unmanned aviation, both home and abroad, DoD requires the ability to operate UAS within and throughout the US national airspace structure (NAS). The Federal Aviation Administration (FAA) has the responsibility of managing, updating, and amending federal regulations for the safe operation of aerospace vehicles within the NAS. Based on safety concerns, the FAA currently limits UAS operations within the NAS through a certification of authorization process that takes up to 60 days for approval and limits flight profiles to specific parameters. While the DoD is not satisfied with this process, as it limits UAS operations within the US, the FAA will not amend current regulations until certain operating and design parameters are met. Based upon these two views, this thesis determines if the DoD and FAA are working together in an efficient manner to develop a safe way to integrate UAS into the NAS and provides recommendations for future integration. By granting the FAA the power to incorporate all facets of UAS processes, it can define terms and develop regulations for UAS integration. The FAA must also develop a UAS categorization system and start incorporating smaller UAS that lack full integration capability in order to concentrate on the larger issue of full NAS access. These recommendations provide a point of departure for the DoD and FAA to start integrating UAS into the NAS that will benefit operations in both the civil and public sector.

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

INTEGRATING DEPARTMENT OF DEFENSE UNMANNED AERIAL SYSTEMS INTO THE NATIONAL AIRSPACE STRUCTURE, by Maj Scott W. Walker, 95 pages.

The Department of Defense (DoD) is constantly adding to the inventory of unmanned aerial systems (UAS) across all Services. Compounded by increasing mission sets for unmanned aviation, both home and abroad, DoD requires the ability to operate UAS within and throughout the US national airspace structure (NAS). The Federal Aviation Administration (FAA) has the responsibility of managing, updating, and amending federal regulations for the safe operation of aerospace vehicles within the NAS. Based on safety concerns, the FAA currently limits UAS operations within the NAS through a certification of authorization process that takes up to 60 days for approval and limits flight profiles to specific parameters. While the DoD is not satisfied with this process, as it limits UAS operations within the US, the FAA will not amend current regulations until certain operating and design parameters are met. Based upon these two views, this thesis determines if the DoD and FAA are working together in an efficient manner to develop a safe way to integrate UAS into the NAS and provides recommendations for future integration. By granting the FAA the power to incorporate all facets of UAS processes, it can define terms and develop regulations for UAS integration. The FAA must also develop a UAS categorization system and start incorporating smaller UAS that lack full integration capability in order to concentrate on the larger issue of full NAS access. These recommendations provide a point of departure for the DoD and FAA to start integrating UAS into the NAS that will benefit operations in both the civil and public sector.

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ACRONYMS

AIA	Aviation Instrument Association
CBP	Customs and Border Protection
CFR	Code of Federal Regulation
CGSC	Command and General Staff College
CJCS	Chairman of the Joint Chiefs of Staff
COA	Certification of Authorization
DoD	Department of Defense
DS&A	Detect, Sense and Avoid
ELOS	Equivalent Level of Safety
FAA	Federal Aviation Administration
FM	Field Manual
GAO	Government Accounting Office
MASPS	Minimum Aviation System Performance Standards
NAS	National Airspace Structure
OSD	Office of the Secretary of Defense
R&D	Research and Development
RTCA	Radio Technical Commission for Aeronautics
S&A	Sense and Avoid
SAA	Sense and Avoid
SC-203	Special Committee 203
UAPO	Unmanned Aircraft Program Office
UAS	Unmanned Aerial System
UAV	Unmanned Aerial Vehicle

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CHAPTER 1

INTRODUCTION

The Department of Defense (DoD) first introduced the unmanned aerial systems (UAS) as a simple surveillance platform.[1] Since that time, the UAS has evolved its battlefield role to include a vast array of military applications. No one would have guessed at the demand for UAS full-motion video and real-time data feeds to the operational warfighter. The need for their capabilities in combat operations led the Secretary of Defense to request the production of more UAS with other innovative missions for all branches of the Armed Forces. As a result, unmanned aerial vehicles (UAV) now dominate the skies over Iraq and Afghanistan where the United States military controls and operates most of the airspace structure.[2] However, flying unmanned vehicles in the national airspace structure (NAS) in the United States poses much more of a challenge for the military and all UAS producers and operators.

Background

The DoD is constantly adding to its inventory of unmanned aerial vehicles. Additionally, other governmental agencies, such as the Department of Homeland Security, are purchasing Predator UAS for a border protection role. This increase in UAS has also spurred an increase in the number of uses developed for unmanned systems, such as pipeline surveys, weather forecasting, chemical, biological, and radiological detection, national emergency management, wildfire detection, search and rescue, aerial photography and mapping, and in the future, cargo transport.[3] Because of this, there have been discussions over the last decade of how the DoD and the Federal Aviation Administration (FAA) can work together to integrate unmanned aerial systems into the NAS.[4]

Currently, unmanned aircraft can only enter the national structure if they are operating in warning or restricted airspace.[5] In some instances, the FAA allows UAS to fly on an instrument flight plan above 18,000 feet where they are under constant radar control by an FAA controller.[6] However, in order to get into the high altitude structure, a chase aircraft must escort the UAS and track it visually in order to provide for "see-and-avoid" safety measures.

The FAA currently allows UAS to operate within the NAS through a certification of authorization (COA) process; however, this process can take up to 60 days for approval and does not grant unfettered access to the NAS.[7] In some cases, the DoD can forecast requests to allow for the 60-day approval process, but it may not be practical or feasible in all circumstances. Until unmanned systems can fully integrate into the NAS, the DoD, along with all producers and operators of unmanned aerial systems, must request permission from the FAA to operate within the nations boundaries.[8] This research explores how the DoD and FAA might effectively accomplish the process of integrating UAS into the NAS through a joint effort.

Primary and Secondary Research Question

The researcher sought to answer the question: Are the DoD and FAA working together in an efficient manner to develop a safe way to integrate UAS into the NAS? The result will not only benefit the Department of Defense, the largest operator of UAS, but other governmental agencies, civil organizations, and private companies who use UAS to conduct a myriad of operations and functions within the United States as well.

To answer the overarching question, the researcher addressed the following secondary issues: Can the FAA improve the COA process to reduce the turn-around time until UAS are able to access the NAS on a regular basis? Does current available technology allow the FAA to formulate safe sense-and-avoid procedures for UAS in lieu of see-and-avoid procedures for

manned aviation? Finally, does the current acquisition and categorization of UAS by the DoD make the FAA's job of regulation, harder?

Definitions

It is important to delineate the difference between the terms UAV and UAS for the purposes of this research study. Many operators and developers of unmanned systems use these terms interchangeably: however, they are not synonymous and are therefore defined separately by the DoD in Joint Publication (JP) 1-02, *Department of Defense Dictionary of Military and Associated Terms*. According to JP 1-02, an unmanned aerial vehicle is "A powered, aerial vehicle that does not carry a human operator uses aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or non-lethal payload. Ballistic or semi-ballistic vehicles, cruise missiles, and artillery projectiles are not considered unmanned aerial vehicles. Also called UAV."[9] An unmanned aircraft system is defined as, "That system whose components include the necessary equipment, network, and personnel to control an unmanned aircraft. Also called UAS."[10] For the purposes of this research, the term UAS refers to all forms of UAV, UAS, and remotely piloted aircraft (RPA).

It is also important to define what the FAA considers see-and-avoid measures for manned aviation. The FAA definition of see-and-avoid states, "When weather conditions permit, pilots operating IFR [instrument flight rules] or VFR [visual flight rules] are required to observe and maneuver to avoid other aircraft."[11] As stated in the definition, specific right-of-way rules found in Title 14 Code of Federal Regulations (CFR) Part 91 determine the actions of each pilot performing avoidance maneuvers.[12] Unmanned aircraft cannot maintain current see-and-avoid criteria, which results in the safety dilemma alluded to in previous paragraphs.

Producers and operators of UAS have coined a new form of avoidance in an attempt to fulfill the FAA requirement of see-and-avoid: sense-and-avoid. Although not yet adopted as an official term by the FAA, sense-and-avoid refers either to using onboard aircraft sensors, or off board air or ground sensors to detect the location of other aircraft in relation to the UAS.[13] Using this aircraft locating information, the operator can take avoidance measures in accordance with the regulations found in 14 CFR Part 91.

Limitations

This thesis, while referencing many DoD requirements for UAS, is unclassified through the use of open source materials. The research seeks to determine a method for gaining quicker and easier access to the NAS while still maintaining safety. This research considers current and new technologies that only military applications may afford and will remain confined to foreseeable technology within the next 5 to 10 years, only separating from civil application where significant monetary issues are concerned.

Delimitations

This thesis recognizes there are multiple public and civil organizations that desire access to the NAS; however, the research focused only on coordination efforts between the DoD and FAA. It examined neither the intent nor the specific equipment aboard UAS, nor specific operations of DoD UAS except those pertaining to the safe operation of the vehicle.

Significance of the Research

The DoD safely conducts sorties with manned aircraft in the NAS on a daily basis.[14] Most of these sorties are training missions for pilot proficiency, or operational missions moving, staging, or supporting training or wartime operations. Therefore, the DoD requires the ability to

operate UAS within and throughout the national airspace structure on a regular basis for the same reasons. In wartime environments, UAS primarily conduct surveillance and reconnaissance operations. This has sparked some debate over the reasoning behind the DoD wanting access to the NAS for UAS flights over the United States. The reasoning is no different from why manned flights conduct operations within the NAS. Most sorties are training missions that allow for pilot proficiency that can become redundant when conducted in a sterile environment, such as a warning or prohibited area.[15] Whereas manned pilots must traverse controlled FAA airspace to perform training operations, they interact and understand the proper procedures for conducting these operations; the same concept applies to UAS pilots. UAS can also perform a myriad of functions that extend beyond just surveillance and reconnaissance of people. UAS can assess damage and destruction after national disasters such as hurricane Katrina, and they can perform weather predicting and weather observation operations at high altitudes without risk to onboard pilots, such as hurricane hunting. The longer loiter time and lower operating cost strongly favors the use of UAS assets over manned aircraft for these operations. UAS need to traverse NAS airspace for staging and support operations like those mentioned for manned aircraft. They must also be able to travel to and from restricted, warning, or prohibited areas where they currently conduct training, without the need of a manned chase aircraft or requesting a COA for each flight. In the future, the DoD foresees using large UAS to transport cargo to bases across the country and eventually to anywhere in the world.[16]

The FAA, however, is responsible for the safe regulation and control of all aerospace vehicles, both manned and unmanned, within the NAS.[17] "The United States Congress, through the Federal Aviation Act of 1958, vested the FAA the responsibility for maintaining safety in the NAS."[18] With the number and uses for UAS increasing each year, in both the military and

civilian sectors, the FAA is faced with the challenge of changing or amending current regulations or developing an entirely new category that incorporates most, if not all forms of UAS. The purpose of this thesis is to propose a method that will allow the DoD access to the NAS while ensuring the FAA can continue to effectively regulate, manage, and control the safe operation of aerial vehicles within the airspace structure. This research benefits all users of UAS and UAV by taking a big step toward the complicated process of integrating UAS into the NAS, along with the decreased costs associated with operating unmanned versus manned vehicles.

Assumptions

The policies and regulations imposed on unmanned aerial systems by the FAA will not change based on the operator. Therefore, the DoD and other federal government agencies will not receive an exemption over civil UAS, except during times of national emergency.[19] The appropriate channels at the appropriate level must declare a national emergency before the FAA would grant access to the NAS. While answering the primary and secondary questions, an assumption is that money and manpower can solve all problems, such as hiring an unlimited amount of employees within the FAA to speed up the COA process. However, the methods and conclusions arrived at in answering the research questions do not account for budgetary or labor concerns.

Another assumption is that manned civil and military aviation will receive priority over unmanned aviation in the event a conflict arises or safety is considered a factor. This will help to safeguard pilots and passengers of manned aircraft at the expense of unmanned vehicles should any factors arise that threatens the safety of manned aircraft both in the air and on the ground. When the FAA does regularly incorporate unmanned systems into the NAS, the assumption is air traffic will increase due to the number of governmental, non-governmental, and civil

corporations that desire to use UAS. This is due to an increase in demand for surveillance capability across a broad spectrum of sectors for which UAS are uniquely suited. Currently, "in the United States alone, approximately 50 companies, universities, and government organizations are developing and producing some 155 unmanned aircraft designs."[20] In Iraq, "more than 700 unmanned aircraft are in use for surveillance and weapons delivery."[21]

Current Title 14 CFR prohibits access of unmanned aerial vehicles to the national airspace structure. A third assumption is this regulation will need to be amended to allow UAS access to the NAS on a regular basis without going through the COA process. The researcher examined this assumption in an attempt to answer the primary question. See-and-avoid is also a factor that currently prohibits UAS from operating in the NAS on a regular basis. "See-and-avoid" is a safety element in manned aviation that depends on the pilot being able to visually acquire air traffic that may immediately, or in the near future, pose a safety hazard to the aircraft.[22] UAS have severely limited capability for an operator to "see" outside the aircraft. Consequently, the primary obstacle for gaining access to the NAS by UAS is due to a lack of ability to meet the "see-and-avoid" requirement as defined by the FAA. Therefore, the DoD may have to incorporate advances in technology on UAS to supplant this safety requirement with one termed "sense-and-avoid." The assumption is that the DoD, the FAA, or both will have to come to an agreement on what constitutes safe avoidance procedures before UAS are allowed to traverse the NAS unaided by manned aircraft.

A final and significant assumption is that neither the FAA nor the DoD is individually responsible for UAS not being able to access the NAS on a regular and recurring basis in the same manner as manned vehicles. The new and ever-increasing quantities and capabilities of UAS over the last decade have led to the current dilemma. Even though this research is specific

to the DoD, all agencies, manufacturers, and operators of UAS must come together in order to help the FAA develop a universally feasible solution to the current complicated process of approval.

Conclusion

The purpose of this chapter is to acquaint the reader with the topic of this research paper. It specifically spells out what the primary research question is along with secondary questions that need answering in order to tie the research together. It details the significance for the research and lays out specific assumptions that will be used throughout the study. Chapter 2 will discuss the resources available that focus on UAS flight within the NAS, to include DoD publications, Federal Agency regulations, Government Accounting Office reports, and previous research and theses.

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[1]The United States Air Force recently adopted the term Remotely Piloted Aircraft or RPA for short. The terms UAS and UAV are defined within the paper; however, those two along with RPA are interchangeable concerning this thesis topic. Therefore, the author will use UAS throughout the paper for consistency.

[2]Federal Aviation Administration (FAA), Docket No. FAA-2006-25714, *Unmanned Aircraft Operations in the National Airspace System* (Washington, DC: Government Printing Office, 6 February 2007).

[3]National Aeronautics and Space Administration, *Concept of Operations in the National Airspace System,* Concept of Operations Version 1.2 (New Mexico State University, 2001).

[4]Government Accounting Office (GAO), GAO-09-520, *Defense Acquisitions: Opportunities Exist to Achieve Greater Commonality and Efficiencies among Unmanned Aircraft Systems* (Washington, DC: Government Printing Office, 30 July 2009).

[5]Federal Aviation Administration, FAA Order JO7610.4N, *Special Operations* (Washington, DC: Government Printing Office, 27 August 2009).

[6]FAA Docket No. FAA-2006-25714.

[7]FAA Order JO7610.4N.

[8]Government Accounting Office (GAO), GAO-08-511, *Unmanned Aircraft Systems: Federal Actions Needed to Ensure Safety and Expand Their Potential Uses within the National Airspace System* (Washington, DC: Government Printing Office, 15 May 2008).

[9]Chairman, Joint Chiefs of Staff, Instruction 4410.01E, *Standardized Terminology For Aircraft Inventory Management* (Washington, DC: Government Printing Office, 6 November 2008), A-3.

[10]Ibid.

[11]Federal Aviation Administration, *Pilot/Controller Glossary* (11 February 2010), PCG S-2, http://www.faa.gov/air_traffic/publications/ATpubs/ATC/pcg-intro.html (accessed 20 November 2009).

[12]Code of Federal Regulation (CFR), *Title 14*, *Aeronautics and Space*, Part 91-113, Right of Way Rules (Washington, DC: Government Printing Office, 2010).

[13]The researchers interpretation based on definitions from multiple sources such as: the National Aeronautics and Space Administration, *Concept of Operations in the National Airspace System,* Concept of Operations Version 1.2 (New Mexico State University, 2001); David E. Grilley, "Resolution Requirements for Passive Sense and Avoid" (Paper, Alion Science and Technology, 26 January 2005).

[14]A sortie is the take-off and landing of a single aircraft within a single mission. If two aircraft take-off together, such as two fighter aircraft in formation, fly a mission and then return to land, regardless if they land together or separately, that is two sorties.

[15]Personal experience based on the researcher's background as a military pilot along with those of my peers.

[16]John D. Jogerst, "Airpower Trends 2010: Unmanned Aircraft Systems: Pilot Chips Instead of Wings," *Air & Space Power Journal* (Summer 2009), http://www.airpower.maxwell.af.mil/airchronicles/apj/apj09/sum09/jogerst.html (accessed 1 March 2010).

[17]Federal Aviation Administration, *History*, 3 March 2005, http://www.faa.gov/about/history/brief_history (accessed 4 January 2010).

[18]National Aeronautics and Space Administration, 4.

[19]Federal Aviation Administration (FAA), Flight Standards Service AFS-400 UAS Policy 05-01, *Unmanned Aircraft Systems Operations in the U.S. National Airspace System - Interim Operational Approval Guidance* (Washington, DC: Government Printing Office, 16 September 2005).

[20]FAA Docket No. FAA-2006-25714, 2.

[21]Ibid.

[22]Code of Federal Regulation (CFR), *Title 14*, *Aeronautics and Space*, Part 91-111, Operating Near Other Aircraft.

CHAPTER 2

REVIEW OF LITERATURE

There are many types of literature that discuss the uses, technology, operations, acquisition, and future advances of different type of unmanned vehicles and systems. This literature can be found in the military Service doctrines of all the armed Services and Joint publications. It is available on civilian and corporate websites that are developing or have acquired their own unmanned aerial systems (UAS) for private or commercial use. Service school libraries are sources for research papers and professional journals that pertain to many aspects of UAS operations. However, when specifically looking for literature on how UAS can and should integrate into the national airspace system (NAS), the list is limited to a few organizations. Specifically, reports from the Government Accounting Office (GAO) and research studies conducted by the Department of Defense (DoD) and the Federal Aviation Administration (FAA) address this issue. There have also been hearings presented to Congress that address the need for integration and possible future steps to plan for integration that will be helpful during this research. The FAA's Title 14 Code of Federal Regulations (CFR) is the governing regulation for all aircraft flying in and around the NAS and will be referred to extensively. Following a review of the available literature, this chapter will identify the conflict that arises between the DoD, as the primary requestor for UAS integration, and that of the FAA, as the lead organization responsible for regulation and safety of the skies.

Significant Literature

The DoD and the FAA are at odds on what constitutes the safe operation of UAS in and around manned aircraft, both public and private, within the NAS. In November of 2004, the

Office of the Secretary of Defense (OSD) issued a report titled, *Airspace Integration Plan for Unmanned Aviation*. Every two years, starting in 2001, the OSD has issued a UAS roadmap that describes the 25-year DoD plan for UAS use and integration into the NAS. The latest roadmap released is titled, *FY2009-2034 Unmanned Systems Integrated Roadmap* and addresses the issue of NAS integration. The *Roadmap* states, "The OSD vision is to have 'File and Fly' access for appropriately equipped UAS by the end of 2012 while maintaining an equivalent level of safety (ELOS) to aircraft with a pilot onboard."[1] The *Roadmap* goes on to address the three issues the OSD sees as critical "to supplant the certificate of authorization (COA) process: UAS reliability, FAA regulations, and an S&A [sense & avoid] capability."[2]

The FAA writes, reviews, updates, and oversees Title 14 CFR. These regulations govern every aspect of how air vehicles, both manned and unmanned, gain access to the NAS. The FAA's current process for UAS access is based on a review and approval process, which then grants a COA for a specified period. As of the date of this publication, only one UAS, the US Air Force's Global Hawk, has been granted continual access to the NAS through the FAA designated COA process.[3] Therefore, the DoD's desire to gain access to the NAS with UAS is going at a much slower rate due to the FAAs regulation process and need to safely integrate UAS into the NAS.

Service Doctrine

The uniformed Services within the DoD are the largest owner and operator of UAS within the United States.[4] Much of the research, development, and design for UAS can be attributed to the significant budget the military receives and its desire to protect its assets, in this case, the combat pilot. Therefore, not recounting the history of UAS use from balloon reconnaissance during the US Civil War until the present, the military has been extensively

developing UAS for applications and operations since the 1980s.[5] As a result, the introduction of UAS into the battlespace led to the need to define their role and integration into Service doctrine. Now UAS roles, missions, operations, and force integration can be found in current Service and Joint doctrine publications along with operations manuals that bear similar information.

The Air Force describes the integration of UAS into its force structure through what it has termed *The U.S. Air Force Remotely Piloted Aircraft and Unmanned Aerial Vehicle Strategic Vision.*[6] Inside this document, the Service presents its vision in five separate sections. The three most important aspects of this vision are attributes that make UAS effective, challenges facing UAS developers, operators, and planners along with methods for addressing the challenges, and integration into the fighting force to enhance joint operations over the next 20-25 years.[7]

The Chairman of the Joints Chiefs of Staff (CJCS) addresses air integration issues in Joint Publication (JP) 3-30, *Command and Control for Joint Air Operations*.[8] The publication takes into consideration issues that cross all Service boundaries, such as the allocation of UAS and who has tasking authority during certain operations.[9] The significance of this Joint Publication is the separation of most of the DoD's UAS into five categories based on weight, operating altitude, and airspeed. This delineation could be very helpful when the DoD coordinates with the FAA, if classification becomes a regulatory factor for UAS integration.

The US Army has integrated UAS into its doctrine through publications called *Field Manuals* or FMs. Field Manual 3-04.155 is dedicated entirely to Army UAS operations and their employment.[10] Within this FM, the Army classifies their UAS by three types, much like Joint Publication 3-30 addressed previously. The Army classification types are, small unmanned aircraft system (SUAS), tactical unmanned aircraft system (TUAS), and medium altitude

endurance (MAE) UAS.[11] The Army then specifies the level of command and control (C2) of these UAS based on three echelons: Division and above controls MAE UAS, Brigade Combat Teams control TUAS, and Battalion and below controls SUAS.[12]

A significant problem currently exists within the DoD concerning each Service acquiring and controlling its own fleet of UAS. Therefore, Joint Publications do not apply to all DoD UAS conducting operations. Specifically, UAS that are organic to each Service and not conducting a joint mission remain under the control of their parent Service. The different doctrines of each Service drive requests for different operational capabilities across UAS research, development, and acquisition that cause problems addressed in the next section.

Government Organizations and Congressional Committee Hearings

Government research organizations primarily conduct their research for two reasons: A Congressional committee has tasked them to gather research on a specific topic, or an issue at hand has raised enough concern in the public or political sector to become a topic of interest at higher levels of management or government. In this particular area, the GAO has published many reports concerning UAS and their uses. Two reports in particular probe into this thesis topic of how to integrate UAS into the NAS. The first report, entitled *Unmanned Aircraft Systems: Federal Actions Needed to Ensure Safety and Expand Their Potential Uses within the National Airspace System*, or simply GAO-08-511, is the most relevant and discusses actions that federal agencies need to take to incorporate unmanned aircraft into the NAS. This report discusses the need for all government agencies that use UAS to collaborate with the FAA in order to work toward the goal of integration. Furthermore, it addresses the lack of regulation and classification of UAS by the FAA. The report also highlights the inherent problem the FAA faces, which will increase as UAS increase, with current FAA manpower versus the number of

COA requests that need processing. GAO-08-511 discusses the transition from military UAS applications to those of the private or commercial sector, acknowledging that the U.S. is the current leader in research and development (R&D) for UAS technology with almost two-thirds of the combined world total.[13]

The second GAO report is entitled *Defense Acquisitions: Opportunities Exist to Achieve Greater Commonality and Efficiencies among Unmanned Aircraft Systems,* more commonly known as GAO-09-520. The significance of this report lies in its research into each specific branch of the military acquisition process and how UAS for each Service are selected. It highlights that there is no designated criteria within DoD and that each Service determines its own wants, needs, and desires resulting in a plethora of UAS designs and concepts at an increased cost to the government. The importance of this report to the research relates to the current system of COA requests. Since each COA request is specific to a particular airframe and mission, the more UAS airframe designs there are, the more COAs that will need to be requested.

In March of 2006, the House of Representatives, Subcommittee on Aviation, Committee on Transportation and Infrastructure met with the FAA, DoD, Aircraft Owners and Pilots Association (AOPA), and multiple UAS technology and industry developers. The hearing discussed many aspects of UAS operations, development, and capabilities; along with the two issues the FAA identified as major safety concerns for UAS integration. These two issues are "proven unmanned aerial systems command and control redundancies" and "the need for reliable . . . detect and avoid capability so that unmanned aerial systems and vehicles in the air can sense and also avoid other aircraft."[14] The subcommittee hearing identified the growing demand for UAS in both the public and private sector, along with the increase in the number of requests to

operate in the NAS.[15] Each organization represented at the hearing made comments that both supported and hindered the need for UAS integration into the NAS. With regards to this research, the FAA commented on the multiple types of UAS available and the problem that poses for them. Specifically, "each different type of UA [unmanned aircraft] has to be evaluated separately, with each aircraft's unique characteristics being considered before its integration into the NAS can be accomplished."[16] After the conclusion of the hearing, each organization submitted short and long-term recommendations to the committee, attached to the hearing minutes, which will be addressed in this paper.

Service School Publications and Papers

Intermediate and professional level military schools provide access to research theses on UAS topics that are extensively studied and reviewed. Three specific papers from the US Army Command and General Staff College (CGSC) and the US Army War College (USAWC) contain UAS information helpful in answering this research question. The first thesis, entitled *Rise of the Unmanned Aerial Vehicle and its Effect on Manned Tactical Aviation,* looks at the potential UAS have of saturating the command and control system the DoD uses in military operations.[17] This research is helpful in determining the extent the FAA may become task saturated once UAS are allowed in the NAS on a regular basis. The report also helps determine the best method and a possible timetable for a gradual integration of UAS into the NAS.

The second thesis, *Military Unmanned Aircraft Systems in Support of Homeland Security,* relates how multiple organizations are using UAS in support of homeland security. This paper discusses how the Customs and Border Protection (CBP), Coast Guard, and Counter Narcotics Office (CNO) currently use UAS along the US-Mexico border to detect and track immigrants and drug traffickers entering the US.[18] These organizations currently have an

agreement with the FAA to use UAS for this purpose. The success or failure of these operations can determine new or revised steps to take in order to integrate UAS into more congested areas of the NAS. The third thesis, *Unmanned Aerial Vehicles–Revolutionary Tools in War and Peace,* looks at UAS operations as a revolutionary tool during war and peace.[19] One of the main topics compares UAS to current manned fighter aircraft, like the F-16 and F-18, based on a cost benefit of unmanned aviation over manned aviation.[20] The paper also discusses the assets of UAS, such as loiter time, versatility, and "net-centric" command and control.[21] These topics are important to the DoD and civilian companies, as well as the FAA, when determining the number and uses of UAS for future operation in the NAS.

Federal Regulations

The Federal Aviation Administration is responsible for producing, publishing, updating, and enforcing all regulations and policies that govern the flight of all vehicles within the United States. Their mission is, "to provide the safest, most efficient aerospace system in the world." and their vision is "to improve the safety and efficiency of flight."[22] Therefore, by law they are given the authority to produce and enforce CFR Title 14, *Aeronautics and Space*. Title 14 specifically addresses or references most aspects of aviation in the NAS. The document itself is updated on a yearly basis.[23] Since the advent of UAS, the regulations have evolved to accommodate certain aspects of unmanned operations. The CFRs do not cover every possible aspect of aviation; therefore, if a procedure is not specifically addressed, then it is not allowed. Per the regulation, the FAA should be contacted for clarification or further guidance if the current regulations are unclear or do not exist. Because UAS are not specifically addressed in many sections of 14 CFR, their use is not arbitrarily allowed in many aspects where they could be safely employed if authorized. This facet has continued to cloud the issue of UAS operations.

Some of the most important aspects of aviation found within the CFR, and those that are of specific concern to UAS operations, deal with flying in close proximity to other aircraft, specifically manned aircraft. Within this realm, the CFR specifically addresses right-of-way rules in Section 113 of Part 91: *General Operating and Flight Rules*. This section defines the hierarchy of which aircraft has the right-of-way when two aircraft enter into close proximity of each other.[24] It also specifies that each person operating an aircraft shall remain vigilant as to see and avoid the other aircraft.[25] The definition of "see-and-avoid" and what that specifically constitutes, as well as how it can be accomplished, are significant issues for the ongoing debate between DoD and FAA. Without a pilot, the "see" function cannot be performed; thus the UAS must rely on "sensing" other air traffic. However, the FAA does not currently define "sense-and-avoid," nor has it determined what constitutes sense-and-avoid parameters so that UAS can be built or equipped to comply with the CFR. Sections 126 through 135 then explain the rules and regulations for operating within each class of airspace, from Class A to Class G. It currently does not mention the operation of UAS in either of these sections. However, Section 319 of Part 91 does delineate the operating limitations of aircraft that have an experimental certificate, which many UAS fall under during the design and testing phase.

Due to the lack of applicable information or regulations addressing UAS within the CFR, the FAA published a memorandum in September 2005 to specifically address UAS operations. Entitled *Unmanned Aircraft Systems Operations in the U. S. National Airspace System - Interim Operational Approval Guidance*, or AFS-400 UAS Policy 05-01 for short, this memorandum determines whether to allow UAS flights in the NAS. It is primarily a list of criteria UAS requestors must meet before the FAA Flight Standards Service (AFS) section will grant a COA.

Within these criteria, the first step is the certificate of waiver or authorization (COA) process that must take place before the UAS can gain access to the NAS.[26]

The COA process is outlined in FAA Order 7610.4 *Special Military Operations*, section 12 that identifies the procedures to be followed along with those found in FAA Order 7210.3, *Facility Operation and Administration, Part 6, Chapter 18.* This order describes the guidelines for receiving a grant of approval for a COA and therefore constitutes a reprieve from specific regulations within the CFR for the period specified.

Analysis of Literature

While most of the papers, articles, and doctrinal publications analyzed for this study address current and future UAS designs and their general operations, they do not address the problem of gaining access to airspace within the US. Some of the reports issued from Congressional hearings acknowledge that a problem exists regarding UAS access to the NAS; however, they do not propose a solution. The plans issued by the OSD along with reports produced by the DoD identify the areas where UAS do not meet the criteria for unrestricted access to the structure, but cite the FAA as the roadblock. However, the FAA could get help in writing and providing future federal regulations for UAS if the DoD, through collaborative efforts by the separate Services, could limit the number of designs and categories across all the different UAS airframes that currently exist or will be acquired in the future. The stringent interpretation of Title 14, along with the current COA process and a need to account for safety, has the FAA enquiring the DoDs need for continual access to the NAS with unmanned aircraft.

Current literature on this subject addresses the desires of one side of each argument. It either describes what the DoD sees as its current problems to gaining access to the NAS or what the FAA sees as its problems in allowing UAS access to the NAS under current regulations and

policies. Each side does address its specific method for dealing with the problem and the steps required to get to the ultimate goal of NAS access; however, each side's approach focuses primarily at changes the conflicting side should take. Reports from the GAO and Congressional Hearing specifically state that both the DoD and the FAA need to work together toward a mutually beneficial agreement. Unfortunately, neither the GAO nor Congress has specified steps each party should take to resolve the issue.

A majority of the articles, school papers, and military doctrines describe the current and future uses of UAS in both civil and military applications. However, in the case of military doctrine, it involves instances of operations conducted during times of war and in locations where either airspace is under military control or civilian air traffic is already at a minimum. Regarding civil uses, the articles and papers discuss the UAS associated advantages ranging from cost to flight duration. Unfortunately, they neglect to discuss how UAS should go about gaining access to the NAS, and only address operations that may be conducted once UAS have unfettered access to the system. Essentially, they have wished away many of the associated problems, as seen by the FAA, and assume that UAS operations will eventually get full access to the NAS and subsequently to international airspace as well.

The CFRs that governs aviation within the U. S. is significant to the research, because those regulations will have to be changed, amended, or revised to eventually incorporate the decisions that are made by or agreed upon by the FAA. This is not to say that the FAA is the one entity that will have to make changes in this area. Nonetheless, part of its job is to write the agreed upon changes so that they can be safely incorporated into the eventual revision of the CFR, as well as being easily read and understood by all aviators and operators.

Significance of Thesis in Relation to Existing Literature

Literature on UAS topics abounds, spanning multiple sources and formats such as books, government reports, Congressional Hearings, Federal Regulations, and military Service doctrines. Narrowing that literature to information that is specific to the thesis topic is imperative. The significant information that is left for a detailed review comes from the government reports specific to NAS integration, DoD roadmaps that detail current and future UAS operations, and current Federal Regulations and memorandums that governs US aviation. Service and Joint doctrines, along with Service school papers provide a basis for types and uses of current UAS, primarily in a wartime environment. Future uses and civilian applications are found in the DoD roadmap as well, along with civil organizations and companies looking to exploit the capabilities UAS provide once NAS access is gained.

This thesis will piece together all the literature that pertains to UAS operations within the NAS. The next chapter will provide a means by which the DoD and the FAA can work together to solve the issue of gaining access to the airspace structure. It will bring together the top ideas and aspects from each side of the debate to determine the best way forward. Along the way, definitions, perceived notions, and past administrative and operational attitudes may need to be adjusted to accommodate a collaborative effort that is both safe and satisfactory for all involved.

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[1]Office of the Secretary of Defense, *Unmanned Systems Integrated Roadmap (2009-2034)* (Washington, DC: Government Printing Office, 6 April 2009), 91.

[2]Ibid.

[3]Space War, *Global Hawk Receives First Certificate To Fly UAV In US National Airspace*, 18 August 2003, http://www.spacewar.com/reports/Global_Hawk_Receives_First_Certificate_To_Fly_UAV_In_US_National_Airspace.html (accessed 15 April 2010).

[4]FAA Docket No. FAA-2006-25714, 2.

[5]Laurence R. Newcome, *Unmanned Aviation: A Brief History of Unmanned Aerial Vehicles* (Reston, VA: American Institute of Aeronautics and Astronautics, Inc. 2004)

[6]Office of the Secretary of the Air Force, *The U.S. Air Force Remotely Piloted Aircraft and Unmanned Aerial Vehicle Strategic Vision* (Washington, DC: Government Printing Office, 2005).

[7]Ibid.

[8]Chairman, Joint Chiefs of Staff, Joint Publication (JP) 3-30, *Command and Control of Joint Air Operations* (Washington, DC: Government Printing Office, 2010).

[9]Ibid.

[10]Headquarters, Department of the Army, Field Manual (FM) 3-04.155, *Army Unmanned Aircraft System Operations* (Washington, DC: Government Printing Office, Draft. This FM is currently in draft format; however, it is replacing FMI 3-04.155 that expired in April of 2008.

[11]Ibid.

[12]Ibid. A Division usually consists of between 10,000 and 30,000 soldiers and is commanded by a Major General (MG). A Battalion usually consists of between 300 and 1,300 soldiers and is commanded by a Lieutenant Colonel (LTC).

[13]Government Accounting Office (GAO), GAO-08-511, *Unmanned Aircraft Systems: Federal Actions Needed to Ensure Safety and Expand Their Potential Uses within the National Airspace System* (Washington, DC: Government Printing Office, 15 May 2008).

[14]U.S. Congress, House, *Hearing on Unmanned Aerial Vehicles and the National Airspace System*, 109th Cong., 2nd sess., 2006, 2.

[15]Ibid.

[16]Ibid., 6.

[17]James P. Merger, "The Rise of the Unmanned Aerial Vehicle and its Effect on Manned Tactical Aviation" (Master's thesis, Command and General Staff College, 2006).

[18]Rusty L. Weiger, "Military Unmanned Aircraft Systems in Support of Homeland Security" (Master's thesis, Army War College, 2007).

[19]Richard P. Schwing, "Unmanned Aerial Vehicles–Revolutionary Tools in War and Peace" (Master's thesis, Army War College, 2007).

[20]Ibid.

[21]Ibid.

[22]Federal Aviation Administration, *Mission*, 18 May 2009, http://www.faa.gov/about/mission/ (accessed 20 November 2009).

[23]Government Printing Office Access, *Code of Federal Regulations (CFR): Main Page,* 6 January 2010, http://www.gpoaccess.gov/CFR/ (accessed 20 November 2009).

[24]CFR *Title 14*, Part 91-113, Right of Way Rules.

[25]Ibid.

[26]Federal Aviation Administration (FAA), Flight Standards Service AFS-400 UAS Policy 05-01, *Unmanned Aircraft Systems Operations in the U.S. National Airspace System - Interim Operational Approval Guidance* (Washington, DC: Government Printing Office, 16 September 2005).

CHAPTER 3

RESEARCH METHODOLOGY

Since the mid-1990s, numerous books, articles, and research papers have been written about unmanned aerial system (UAS) employment. Many of these focus on integrating UAS into military operations and the situational advantage they provide. In the last few years, advances in technology have spurred research focused on making UAS safer for operations in the skies over populated centers and around manned civil and commercial aviation. The Federal Aviation Administration (FAA) has been extensively updating its Code of Federal Regulations (CFRs) with memorandums and procedures to allow UAS to operate within the national airspace system (NAS) on a limited basis. The Department of Defense (DoD) has published roadmaps and requests for why it should receive complete access to the NAS through its use of technological advancement, such as sense-and-avoid systems. However, no article, paper, or research thesis has tackled the problem of collecting this information and proposing a solution that addresses the interests of both the FAA and DoD.

This chapter will describe the steps taken to obtain information on the research topic. Next is a description of the methodology used to analyze the research in order to develop recommendations and conclusions present in chapter 5. This chapter concludes with strengths and weaknesses in using this methodology in light of the topic and information available.

Steps Taken to Obtain Information

The FAA's website along with its Unmanned Aircraft Program Office (UAPO) provided the information necessary to extensively study the FAA’s perspective. The CFRs and their subsequent amendments and memoranda document the status of the FAA's stance on limited

UAS access to the NAS based on a case-by-case basis as determined by the certificate of authorization (COA) process. DoD websites provide roadmaps and doctrinal manuals on how the Services are using UAS in military operations. Additional websites such as the Government Accounting Office (GAO) and the National Aeronautics and Space Administration (NASA) provide research studies on UAS as well as hearings mandated by Congressional committees. The U.S. Army Combined Arms Research Library (CARL) at Fort Leavenworth and the Muir S. Fairchild Research Information Center at Maxwell Air Force Base provided access to previous intermediate level and senior developmental level military student research papers related to the topic. The CARL research librarians provided access to several sources of information containing other papers, books, and theses pertaining to the research topic.

Research Methodology

In order to answer the primary and secondary questions posed at the beginning of this thesis, a qualitative comparison of literature published primarily by the FAA and DoD was conducted. This research material was gathered from multiple sources, analyzed, and then combined to form a safe and potentially suitable recommendation. Since few sources of literature addressed the topic of UAS integration into the NAS, multiple sources were used to gather current operations, and a concept of future operations, for UAS within the United States. The Department of Defense's concept of UAS operations in the U.S. and the FAA's requirement for integration to ensure safety were then combined with all the other sources to arrive at a proposed solution that is amenable to both the DoD and FAA. From this proposed solution, a foundation will be established that initiates the FAA’s and DoD’s coordinated effort of integrating UAS into the NAS.

Strengths and Weaknesses of Methodology

The strength of this research comes from the fact that it combines the perspectives of two organizations trying to achieve the same goal. Information gathered from multiple sources is combined to provide the best recommendation available for current operations. The DoD has a stake in gaining access to the NAS and its thoughts and desires are easily taken from roadmaps and doctrinal manuals. The FAA has updated its regulations and procedures in an attempt to accommodate UAS operations and is actively working on other solutions through its UAPO branch.

The weakness with this approach is the speed with which information becomes outdated. The qualitative approach taken in this thesis, as well as other research studies on this topic, can be quickly outdated with the speed at which technology is advancing. This method also attempts to narrow the focus to just two organizations out of hundreds with the similar interests of gaining NAS access. A difference in opinion and the relatively new nature of UAS leads to a debate about what constitutes safety of flight and the need to add and define additional terms that speak specifically to UAS operations such as substituting the term "see-and-avoid" for piloted aircraft to "sense-and-avoid" for UAS.

The qualitative comparison of the literature on this topic cannot take into account the multitude of different UAS designs that are currently being produced. Therefore, it will narrow the approach to the largest user of UAS, the DoD. By using this method, most recommendations to the DoD and FAA will accommodate other users and producers. It may also highlight the possible need for regulating UAS designs in order to comply with designated standards and therefore be granted access to the NAS.

The research methodology of this study compares the current literature available to determine if the DoD and FAA are working together to integrate UAS into the NAS. In order to answer this question, the secondary questions posed in chapter 1 must be answered along with the primary question. The next chapter will answer these questions based on the research conducted from the literature compiled and referenced in chapter 2. The answers derived from the next chapter will lead to conclusions and recommendations presented in chapter 5

CHAPTER 4

ANALYSIS

As unmanned aerial systems (UAS) and their uses expand across private, public, and commercial applications, the need to regulate their operations in the national airspace structure (NAS) will grow. For this reason, it is important that the Federal Aviation Administration (FAA) collaborate with all producers and operators of UAS, in particular the Department of Defense (DoD), currently the largest owner and operator of UAS in the United States.[1] This research investigates whether the FAA and DoD are efficiently working together to develop a safe process for integrating UAS in the NAS. In order to answer this question the research considers three specific aspects essential to make integration possible. The first aspect considers how the FAA will implement sense-and-avoid (SAA) procedures and whether or not current technology will allow SAA to operate at the same level of safety as see-and-avoid by manned aviation.[2] The second aspect is based on the DoD's acquisition and categorization of UAS and how that will affect the FAA's job of writing and managing regulations for UAS. The third aspect looks at how the FAA and DoD can improve the certificate of authorization (COA) process to speed up the approval process until UAS are able to access the NAS on a regular basis.

Organization

This chapter is organized into four distinct sections that discuss the specific research findings. Each section contributes to the development of the next, with the last section answering the primary question proposed by the thesis. The first section will

answer whether or not current technology is available to allow the FAA to formulate safe SAA procedures for UAS in lieu of the current see-and-avoid procedures in place for manned aviation. Then the research will address how the current acquisition and categorization of UAS by the DoD affects the FAA's ability to write, approve, and regulate UAS for integration into the NAS. The third section will determine if the FAA can improve the COA process to reduce the turn-around time for COA requests until UAS are able to access the NAS on a regular basis. The last section will answer the primary question of whether or not the DoD and FAA are efficiently working together to develop a safe way to integrate UAS into the NAS. This chapter closes with a summary of the findings and the conclusions the research led to concerning all the questions posed.

Sense-and-Avoid vs. See-and-Avoid

One of the main differences between UAS and manned aviation is the ability to see-and-avoid other air traffic. The regulation established by Title 14 Code of Federal Regulations (CFR) Part 91: *General Operating and Flight Rules* section 113 is one of the biggest factors that currently prevent UAS from entering the NAS. The rule specifically states, "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."[3] Since UAS are by design unmanned, they cannot currently fulfill this requirement and therefore must attempt to comply by some other means. In response to a question posed by the House Subcommittee on Aviation in 2006, a representative for the UAV National Industry Team (UNITE) stated

> The need to meet the 'see and avoid' requirements of 14 CFR Part 91.113 is generally regarded as the most challenging issue for safe and routine UAS operations in the NAS. Since there is no onboard pilot to 'see' other aircraft or

> objects (e.g., gliders, balloons), satisfying this requirement involves not only an appropriate subsystem technology solution and system integration with a vehicle flight control system, but also an interpretation of equivalent or appropriate level of safety for autonomous systems that detect but do not 'see'.[4]

Therefore, the DoD lists, in its *Unmanned Systems Integrated Roadmap 2009-2034*, the SAA requirement as one of three critical issues that must be addressed in order to gain access to the NAS and supplant the COA process.[5]

Equivalent Level of Safety

Dealing with the requirement to see-and-avoid is a costly measure that the DoD currently faces when gaining access to the NAS through the COA process. Since UAS cannot accomplish see-and-avoid on their own, the DoD must implement special measures in accordance with FAA Order 7610.4 to ensure an equivalent level of safety (ELOS) is maintained. These methods include radar observation, forward or side looking cameras, electronic detection systems, visual observation from one or more ground sites, monitored by patrol or chase aircraft, or a combination thereof.[6] These measures added operational and manpower costs that were insignificant ten years ago when UAS operations conducted in the NAS were minimal, but now impose an ever-increasing cost and impact on operations due to increased UAS activity.

Currently, ground-based radars provide the primary means for providing ELOS in order to satisfy COA approval requirements. However, this process is limited due to factors such as terrain and line-of-sight (LOS) to the radar, as well as staffing requirements. In an answer to the Congressional Subcommittee, the DoD stated, "To mitigate radar limitations, DoD is developing 'sense-and-avoid' technology organic to the UA. . . . Directly related to the technology development is the need for a standard to

design and build to, and the need for data to measure the effectiveness of a given sense-and-avoid system."[7]

The DoD cited another problem with SAA procedures that must be dealt with in order to move forward with regulating the process for UAS access. Currently, the DoD uses the methods mentioned in the previous paragraphs to ensure ELOS is maintained; however, the FAA has not determined or defined what exactly ELOS is for unmanned aviation. In a prepared response to the House Congressional Subcommittee, General Atomics Aeronautical Systems comments, "The FAA has communicated that UAS's require an equivalent level of safety as manned aircraft but they need to define what that means."[8] Even under the guidelines set forth by the DoD and FAA written in FAA Order 7610.4, *Special Military Operations,* ELOS only "refers to a combination of systems and a concept of operations that reduces the chance of a midair collision to an acceptable level. At this point . . . we do not yet have all the information necessary to establish a defensible and tangible value for ELOS (e.g., 10^{-6})."[9]

In an attempt to solve the problem, the DoD developed a team to study the situation in order to better define the concept of ELOS from an unmanned aviation perspective. The research team, working out of the Air Force Research Laboratory (AFRL) at Wright Patterson Air Force Base, started out by trying to quantify a term for ELOS. The teams first step "was to reduce the phrase '. . . equivalent level of safety . . .' to engineering performance requirements."[10] The DoD followed up with this concept by stating in its *2009 Roadmap* "since the purpose of this regulation [14 CFR 91.113] is to avoid mid-air collisions, this should be the focus of technological efforts . . . rather than trying to mimic and/or duplicate human vision."[11] The *Roadmap* went on to state that

"The key to providing the 'equivalent level of safety' . . . is the provision of some comparable means of S&A [sense-and-avoid] to that provided by pilots on manned aircraft."[12] In addition to the DoD's team, the FAA endorsed the composition of a special committee, called Special Committee 203 (SC-203), put together by the Radio Technical Commission for Aeronautics (RTCA) comprised of members from the FAA, DoD, MITRE, and other Academia.[13] Their goal is to establish "a clearly defined set of Sense and Avoid functions, Levels of Safety, and methods for assessing safety."[14]

Current Progress

It is clear that both the DoD and FAA are attempting to quantify and apply some form of data to establish an ELOS for UAS. However, in addition to the problem cited by the DoD with ELOS, a second problem is the FAA has not defined what it considers SAA. Although technically ELOS and SAA are different with respect to the operation of the UAS itself, they are essentially part of the same problem. ELOS and SAA are directly proportional to each other so that gains in one aspect relate to gains in the other. It also stands to reason that by defining either ELOS or SAA would require both terms to be defined; therefore, if one is currently undefined by the FAA, then the other must be undefined as well. The closest the FAA has come to defining the term SAA was during a speech given by Mr. Randolph Babbitt, FAA Administrator, to the Aviation Instrument Association (AIA) in November of 2009. During that speech, Mr. Babbitt stated, "The definition of see and avoid for UAS is 'the capability of an unmanned aircraft system to remain well clear from and avoid collisions with other airborne traffic and vice-versa.'"[15]

The FAA is addressing this problem as well. From 2007 through 2009, the FAA spent $4.7 million for UAS research on topics such as Detect Sense and Avoid

(DS&A).[16] With the endorsement of the Special Committee previously mentioned, the FAA not only gave SC-203 the task of establishing the goals stated above, but also gave them the task of generating products for standardization. One of the most important products the committee is challenged with providing is a Minimum Aviation System Performance Standards (MASPS) for Detect, Sense and Avoid Systems for UASs.[17] RTCA is actively working on a plan to develop these standards with the help of UAS aviation industry leaders such as UNITE. "These standards will allow manufacturers to begin to build certifiable avionics for UAs [unmanned aircraft]."[18] The expected development timeline for these avionics is three to four years; until standards are developed and implemented, UAS will have restrictions imposed upon them when requesting access to the NAS.[19] The House Subcommittee received a briefing on this information in March of 2006. In the same speech he delivered to the AIA Mr. Babbitt recently stated, "We need to develop standards for the future. But we must make sure that we're all moving in the same direction before it happens. Those safety standards must be the same for everyone, even if no one's in the cockpit."[20] As of the publication date of this thesis, no such standards are available.

The problem associated with a lack of standards for SAA is the delay in technology design, testing, and fielding to meet those standards. The FAA's response to the House Subcommittee on the issue stated,

> Once the standards are developed with industry at RTCA Special Committee 203 and the FAA accepts the standards, a vendor will know the minimum acceptable requirements for the certification of their DSA avionics. Lacking these standards/requirements, an applicant may apply for certification of a technology, but . . . the FAA would not be able to make an operational evaluation."[21]

The delay compounds the problem, due to a lack of data, since UAS operations are restricted to special use airspace that constrains their numbers and flight availability. The Government Accounting Office (GAO) reiterated this view in their report to Congress entitled, *Unmanned Aircraft Systems: Federal Actions Needed to Ensure Safety and Expand Their Potential Uses within the National Airspace System*, or GAO-08-511. In this report the GAO stated, "A lack of regulations for UASs limits their operations and leads to a lack of airspace for UAS testing and evaluation and a lack of data that would aid in setting standards."[22] Within the same paragraph, the GAO went on to mention, "coordination of efforts is lacking among diverse federal agencies as well as academia and the private sector in moving UASs toward meeting the safety requirements of the national airspace system."[23]

Although the DoD is working in conjunction with various committees formed by the FAA, they have also decided to venture on their own in an attempt to solve these problems. "In June 2003, USAF's Air Combat Command (ACC) sponsored a joint working group to establish and quantify an S&A system capability for submission to the FAA."[24] The focus of this working group is to establish requirements for UAS SAA systems that fulfill the FAA's intent for collision avoidance.[25] "As a first step, the USAF Air Combat Command developed a functional-performance-requirements document to guide the design of a sense-and-avoid system."[26] Within those requirements, "the FAA and DoD reached agreement that these unmanned flight systems were aircraft based on the FAR [Federal Aviation Regulation] definition of aircraft."[27] With that in mind, the group decided that it would be more beneficial for the DoD if they stayed within the rules and regulations already established for manned aircraft. They determined that "modifying

existing regulations or drafting new ones for another class of aerial vehicle (i.e., ROA) will further isolate these systems as 'exceptional.'"[28]

Within the guidelines the working group set for themselves, they are attempting to develop a SAA system that conforms to established criteria. These criteria are formed from studies and tests made by the DoD and other credible organizations, such as NASA and the Convention on International Civil Aviation. The problem primarily associated with developing a SAA system is not avoiding cooperating traffic, but "the problem lies in detecting and tracking non-cooperative aircraft – those flying VFR [visual flight rules] without a transponder."[29] The FAA defines cooperative aircraft as, "aircraft that are being tracked by Air Traffic; or, an aircraft that has an electronic means of identification (i.e., a transponder) aboard" and non-cooperative aircraft as exactly the opposite of the definition given above.[30] According to the working group, "the SAA system shall possess the capability to detect both participating and non-participating aircraft day and night (weather permitting), notify the ROA [Remotely Operated Aircraft] pilot/operator of the contact, and determine if a potential collision hazard exists."[31] In order to accomplish this, the system must be able to survey all of the airspace within a specified angle that poses a collision hazard. The group determined the criteria for this angle to be "±110º with respect to the longitudinal axis of the ROA. . . . No regulatory guidance for search elevation exists. NASA and DoD studies showed that, in head-on scenarios, a search elevation of ±15º with respect to the flight path provided adequate coverage."[32] With these requirements as a starting point, the DoD is working on developing a system that can help both define and set the standards for SAA regulations so that UAS may operate in the NAS.

In 2005, the DoD teamed up the Air Force Research Laboratory, Sensors Directorate (AFRL/SNJT) and Vehicles Directorate (RB), with another agency, the Defense Research Associates Inc. (DRA) to implement and test new systems hardware. "The goal of the program was to conduct real time SAA detection and autonomous threat traffic avoidance on a UAS."[33] Upon completion of their initial testing, the summary from the findings stated, "The key pieces of technology required to implement Sense and Avoid have been demonstrated over the past three years. Based on these demonstrations, the Air Force has launched an Advanced Technology Demonstration program to transition Sense and Avoid to the field."[34]

The program conducted tests throughout 2008 and 2009 with a SAA system attached to one of the Air Force's MQ-1 Predator UAS.[35] The next phase of testing, scheduled for 2010, will incorporate Multi Intruder Autonomous Avoidance (MIAA) and be attached to the Air Force's Global Hawk (RQ-4) UAS, the only UAS currently allowed into the NAS through an agreement with the FAA. The Office of the Secretary of Defense (OSD) also funded the program to miniaturize the system in order to incorporate it into the DoD's smaller UAS. In an effort to reduce the cost of procuring the system by each of the Services, "DRA's low-cost system was developed and demonstrated with the participation of multiple Services and UAS programs, with the objective of providing a modular capability to fulfill the requirements of a variety of platforms."[36] With the information gained from this research, the FAA needs to standardize its requirement for SAA.

The FAA and DoD are both working to advance the status of UAS into the NAS. Both organizations are participating in mutual committees looking to provide

recommendations and solutions for the current problem. Likewise, both organizations are spending millions of dollars a year conducting their own testing and data collection with the help of civil and private organizations, as well as academia from across the country. However, neither organization has taken full ownership of the problem in an effort to consolidate the gains across each committee, organization, business, or academic institution. In 2006, the FAA created a new office within its administration called the Unmanned Aircraft Program Office (UAPO) and tasked it to develop policies and regulations for UAS to operate in the NAS.[37] The office has an Air Force officer assigned to represent the needs and desires of the DoD. However, the problem with this office, stated by the GAO in its report to Congress in 2008 is, "although FAA's UAPO serves as a focal point within FAA, the office has no authority over other agencies' efforts."[38]

Current technology is available to allow the FAA to start defining and developing UAS ELOS and SAA standards. These definitions and standards will allow the government, industry, civil, private, and academic organizations to start narrowing the focus of SAA technologies. In turn, this will allow a larger and broader base of data from which the FAA can produce safe procedures for UAS integration into the NAS on a gradual basis. A significant amount of testing must still be done and the FAA is constrained by manpower in sifting through this data in an effort to reach a complete solution, which is still many years down the road.

DoD Acquisition and Categorization

The proliferation of UAS throughout the DoD in the last decade has led to a multitude of different styles, sizes, operations, requirements, and technologies in their design. These differences have become important factors, to both the DoD and FAA. The

DoD, SECDEF, and Congress are pushing to ensure the separate Services are pursuing UAS design commonality. The FAA, as the administration responsible for safe airspace integration, is concerned with the numbers of UAS produced and the lack of regulated standards across the different airframes. Therefore, this research looked into the current acquisition process used by the Services as well as the DoD categorization system into which UAS were placed. This examination helped determine whether the FAA's job of regulating and integrating UAS into the NAS was complicated by a lack of cooperation among the DoD Services.

Before looking into the acquisition and categorization the DoD used for UAS, the research pointed out a significant fact about the DoD's operations. The DoD's primary use for UAS has been in the application and extension of warfighting capabilities, primarily outside of United States borders. Therefore, the capabilities and technologies required for UAS operations are driven by warfighting needs, not integration into the airspace structure. The FAA has yet to establish regulations and standards for a variety of issues regarding UAS access to the NAS, such as SAA mentioned previously. Therefore, the DoD and its industry partners are forced to design and build UAS based on DoD operational capabilities and less on FAA perceived standards. This concept plays a significant role in the FAA's ability to implement regulations and standards, either positively, negatively, or a combination thereof. The process has already manifested itself as a point of contention between the DoD and FAA and the over 6,000 estimated UAS already in the DoD's inventory.[39]

Acquisition

To determine whether current and future DoD UAS are a help or hindrance to the FAA, it is important to look at how those UAS are procured. From 2008 through 2013, the DoD plans to spend an estimated $16 billion on additional UAS.[40] Therefore, Congress and the DoD itself attempted to incorporate the needs of all its Services into as few UAS designs as possible.[41] Based on this fact, "to manage the increased demand for unmanned aircraft systems and encourage collaboration among the military Services, the department has created the Office of Unmanned Warfare, the Unmanned Aircraft Systems Task Force, and other entities."[42] However, the GAO stated in a report to the Armed Services Committee in 2008 that, "key officials from these groups emphasized to us that they do not have direct decision-making or resource allocation authority."[43] The Services, on specific occasions, have disregarded the committee's directives to collaborate and continued with their separate programs.

In addition to the steps implemented by the DoD to collaborate, the House of Representatives also addressed the problem. During a House of Representatives Committee meeting on Appropriations in 2003, Congress stated, "growing enthusiasm may well lead to a situation in which there is no clear path toward the future of UAVs."[44] Therefore, it required the DoD to submit a UAV roadmap, which they have updated and resubmitted on a biennial basis since 2001, the most current being *Unmanned Systems Integrated Roadmap 2009-2034.* The Services have also decided to release their own Service-specific UAS roadmaps as well, such as the USAF's *Unmanned Aircraft Systems Flight Plan 2009-2047*, referenced throughout this thesis, and the Army's *Unmanned Aircraft Systems Roadmap 2010-2035*.[45]

The current procurement process allows each Service to allocate money and requirements for specific programs such as UAS. These requirements may or may not be collaborated on by more than one Service. At the same time, joint acquisition requirements can complicate the acquisition and budgeting process, thereby making it a time and cost prohibitive venture from a single Service standpoint. In 2003, the DoD implemented the Joint Capabilities and Integration Development System (JCIDS) to identify new requirements from a joint perspective.[46] However, the GAO specifically reviewed the JCIDS process and stated in its September 2008 report to the House Committee on Armed Services, "requirements continue to be driven primarily by the individual Services with little involvement from the combatant commands, which are largely responsible for planning and carrying out military operations."[47] The procurement process stated above also allows Services to identify and validate programs supporting their unique requirements through the Planning, Programming, Budgeting, and Execution system, which is not tied to the JCIDS process.[48] The Air Force's *UAS Flight Plan 2009-2047* stated, "The three key DoD corporate processes were, for the most part, bypassed for UAS procurement and fielding."[49] Therefore, the Services can bypass the recommendations of JCIDS by stating the need for, and allocating funds for, requirements specific to the Services needs and desires. This same problem was the topic of discussion addressed in 2005 when Representative Curt Weldon, of the House Armed Services Subcommittee stated,

> Aggressively fielding new types of vehicles and even building more of the same type of vehicle may be premature. We must feel confident that we have adequately addressed some of the fundamentals to ensure that unmanned air systems are designed and fielded consistent with the common communications architecture and that common standards are established for operations.[50]

The problems associated with integrating UAS design and procurement into joint capabilities and operations seem to stem from decades of inter-Service rivalry. Whatever the reasoning behind it, the need to overcome the contention is a growing concern and part of the reason for the development of joint acquisition teams. The USAF, in its *UAS Flight Plan 2009-2047,* admitted, "there are numerous UAS initiatives underway in the USAF and in the DoD that are not integrated."[51] The Air Force went on to state that, "currently UAS Acquisition is stove-piped by weapon systems. There are a number of issues . . . that would benefit from common coordinated approaches."[52] The GAO, in its research study for the Committee on Armed Services, reported that, "Service-driven acquisition processes and ineffective collaboration are key factors that have inhibited commonality among subsystems, payloads, and ground control stations. . . . .To support their respective requirements, the Services also make resource allocation decisions independently."[53]

Although there are examples of Service-specific requirements and acquisitions, the Services have made an effort to collaborate. Specific examples include the Marine Corps decision to procure the preexisting Army's Shadow system and the Navy's decision to upgrade the Air Force's current Global Hawk airframe to meet its needs. These two decisions saved time and money, but more importantly for the FAA they reduced the number of unique UAS airframes that need to be reviewed when granting a COA for NAS access. The importance of commonality and interoperability among the Services is vital to helping the FAA formulate and implement standards for UAS. This leads into how the DoD currently categorizes its UAS and how that impacts the FAA's

future decisions on regulation, as well as what it might mean for the DoD's legacy UAS aircraft should the FAA develop its own categorization structure.

Categorization

The FAA will have to apply some sort of categorization to UAS before regulations can be implemented. The number of UAS aircraft and the different types, sizes, and capabilities are growing and changing every day. The DoD is making an effort to consolidate their UAS requirements and aircraft types across all the Services, but still has some work and coordination issues ahead of it. The DoD has divided its UAS into three categories based on the operational capabilities of each aircraft and the airspace classes they are thought to be able to operate within based on current 14 CFR, Part 91. These categories are specific to DoD UAS, but should serve as a starting point for the FAA to define UAS categories in order to produce and conform to standardized regulations.

The FAA established the term "category" in two separate ways and defined it in 14 CFR 1: *Definitions and Abbreviations*. The first is stated, "As used with respect to the certification, ratings, privileges, and limitations of airmen, means a broad classification of aircraft."[54] This delineated the types of aircraft that fly in the NAS, such as airplanes, helicopters, gliders, or balloons. The second definition stated, "As used with respect to the certification of aircraft, means a grouping of aircraft based upon intended use or operating limitations."[55] The uses included transport, acrobatic, or utility type operations.

Although the DoD and FAA agreed that UAS are aircraft, under the first definition there is no category for UAS. The FAA could decide to add UAS aircraft to the first category under a new group, possibly labeled "UAS," which would delineate them

from airplanes, helicopters, gliders, or balloons. The FAA could also delineate UAS operations into specific types like transport, acrobatic, or utility, and then categorize them based on the second definition. Either way, the FAA will be responsible for determining the best method for categorization based on the many factors of UAS operations, designs, and limitations.

"UAs [Unmanned Aircraft] cannot be described as a single type of aircraft. UAs can be vehicles that range from a 12-ounce hand launched model to the size of a 737 aircraft."[56] This fact alone made the task of categorizing UAS difficult. However, the DoD, with the amount of experience and number of UAS in its inventory, has already divided its UAS into three categories based on operational characteristics. The Categories, labeled Cat III, Cat II, and Cat I have been aligned as closely as possible to conform to FAA regulations as seen in table 1.[57]

Table 1. DoD Proposed UAS Categories Aligned with FAA Regulations

		Certified Aircraft / UAS (Cat III)	Nonstandard Aircraft / UAS (Cat II)	RC Model Aircraft / UAS (Cat I)
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	Shadow	Dragon Eye, Raven

Source: Office of the Secretary of Defense, *Unmanned Systems Integrated Roadmap 2009-2034* (Washington, DC: Government Printing Office, 6 April 2009), 95.

The first category, labeled as Cat III, fully complies with 14 CFR, Part 91, with the exception of autonomous sense-and-avoid capabilities, and is capable of flying

throughout all categories of airspace from Cat A to Cat G.[58] These aircraft are similar to manned aircraft in size and capabilities, as well as technological capabilities, and include the Global Hawk and the Predator. The second category, labeled as Cat II, includes "nonstandard aircraft that perform special purpose operations. Cat II UAS may perform routine operations within a specific set of restrictions."[59] These aircraft perform much the same way as gliders and sport aircraft and still require a COA due to a limitation in their size and technological capabilities.[60] Therefore, Cat II UAS are unable to meet all the requirements of 14 CFR, Part 91. Examples of these aircraft are the Shadow and the Hunter. The third category, labeled as Cat I, do not fall under the regulations of 14 CFR, but must conform to the FAA's Advisory Circular (AC) 91-57 *Model Aircraft Operating Standards,* which governs operations for model aircraft. These UAS are small in nature, to the point of being hand-carried and launched, and they must operate within visual line of sight of the user; examples include the Dragon Eye and Raven.[61]

The DoD has further divided these three categories into 5 groups of UAS. These groups were determined by the Joint Unmanned Aircraft Systems Center of Excellence (JUAS COE) and are based on weight, operating altitude, and speed, with a list of examples currently in the DoD inventory depicted in figure 1.

UAS Category	Maximum Gross Takeoff Weight (lbs)	Normal Operating Altitude (ft)	Speed (KIAS)	Current/Future Representative UAS
Group 1	0-20	< 1,200 AGL	100 kts	WASP III, Future Combat System Class I, TACMAV RQ-14A/B, BUSTER, BATCAM, RQ-11B/C, FPASS, RQ-16A, Pointer, Aqua/Terra Puma
Group 2	21-55	< 3,500 AGL	< 250 kts	Vehicle Craft Unmanned Aircraft System, ScanEagle, Silver Fox, Aerosonde
Group 3	< 1,320	< 18,000 MSL		RQ-7B, RQ-15, STUAS, XPV-1, XPV-2
Group 4	> 1,320		Any Airspeed	MQ-5B, MQ-8B, MQ-1A/B/C, A-160
Group 5		> 18,000 MSL		MQ-9A, RQ-4, RQ-4N, Global Observer, N-UCAS

Note: Lighter than air vehicles will be categorized by the highest level of any of their operating criteria.

(1) Group 1 UA: Typically weighs less than 20 pounds and normally operates below 1200 feet AGL at speeds less than 250 knots.

(2) Group 2 UA: Typically weighs 21-55 pounds and normally operates below 3500 feet AGL at speeds less than 250 knots.

(3) Group 3 UA: Typically weighs more than 55 pounds but less than 1320 pounds and normally operates below 18,000 feet MSL at speeds less than 250 knots.

(4) Group 4 UA: Typically weighs more than 1320 pounds and normally operates below 18,000 feet MSL at any speed.

(5) Group 5 UA: Typically weighs more than 1320 pounds and normally operates higher than 18,000 feet MSL at any speed.

Figure 1. JUAS COE UAS Categories
Source: Office of the Secretary of Defense, *Unmanned Systems Integrated Roadmap 2009-2034* (Washington, DC: Government Printing Office, 6 April 2009), 97.

These groups do not delineate between the capabilities of the aircraft to adhere to 14 CFR, Part 91 regulations, or AC 91-57 standards. Therefore, this research recommends that the FAA determine a method of categorization, either on its own or based on the DoD's, in order to develop regulations and standards for UAS.

The DoD, as a government owner and operator of public aircraft, is not required to have its aircraft certified as airworthy by the FAA. The military certifies its own aircraft through an internal certification/flight release process agreed to through a Tri-Service memorandum of agreement.[62] This process allows the military and its industry collaborators the latitude to develop and test aircraft that meet the specific needs and requirements of military operations. "Similarly to manned military aircraft, unmanned military aircraft will also be subject to the airworthiness certification/flight release process."[63] General Atomics Aeronautical Systems, Inc. stated before the House Subcommittee on Aviation in 2006 that, "Industry-wide standards do not exist for the manufacturing and operation of unmanned aircraft as a specific class of aircraft."[64] Therefore, this could lead to problems with FAA certification of current and future UAS, as well as DoD-certified UAS gaining access to the NAS, especially with the current lack of UAS regulations and standards on which to base operational capabilities.

The acquisition and categorization process used by the DoD does not have a significantly negative impact on the FAA's ability to formulate and implement regulations regarding the use of UAS. The acquisition process itself is liable to remain a problem for the DoD from a joint capabilities and monetary standpoint, which has little effect on the FAA. The FAA may take into consideration the DoD's acquisition process when it eventually formulates standards for UAS, but is not required to do so. In addition, the DoD is not required to receive a certification from the FAA on the airworthiness of its aircraft during testing. However, it would benefit the DoD to attempt to conform to most, if not all the standards set forth by the FAA, once released, in order to facilitate quicker access to the NAS.

The categorization of the DoD's UAS will definitely help in determining the method the FAA will use to make regulations governing their operations. The FAA is currently backlogged with COA requests for the various different UAS capabilities the military requests. Due to the lack of regulations and the different capabilities of each UAS, every UAS must be evaluated separately, with each of the UAS's characteristics being considered before it is allowed into the NAS.[65] The FAA will benefit from the work already done by the DoD and the recommendations by leading UAS industry manufacturers concerning categorization. The FAA can capitalize on the data from testing and operational fielding of UAS into the NAS by both the DoD and the Customs & Border Protection (CBP).

The DoD's categorization method is not simply a cut-and-paste process the FAA can duplicate in an effort to expedite regulations, but it does allow for flexibility based on operational and physical, as well as technological characteristics. The FAA should develop its own method, take some from the DoD and others, or make a completely separate category. Regardless of the UAS categorization method, the DoD's work and experience with the categorization process will ease the FAA's job of producing a regulation framework for UAS.

The Certificate of Authorization Process

"Routine UAS access to the national airspace system poses a variety of technological, regulatory, workload, and coordination challenges."[66] This fact, back in 1997, caused the FAA and DoD to examine how UAS were currently used and what their expected uses might be in the future. At that time the FAA and DoD agreed upon and wrote the initial COA process. Subsequently, with the advent of more advanced UAS and

the extension of their operational capabilities, "the FAA and DoD determined additional guidelines were needed to ensure safety could be maintained when ROA [Remotely Operated Aircraft] were operated in the NAS outside restricted and warning areas."[67] Therefore, the FAA amended Order 7610.4 *Special Military Operations* to implement the current COA process that is used by the military today. "Since a single document was developed jointly between the DoD and FAA, DoD publications . . . refer to the FAA Order as an approved source."[68] Now that UAS use has grown significantly over the past ten years and requests for COAs have increased annually, the COA process is slow to catch up. The question has arisen, what can the FAA do to improve the COA process to reduce turn-around time for COA requests until UAS are able to access the NAS on a regular file-and-fly basis?

Current Process

In order to determine whether the current COA process can be improved, the process itself must first be examined. In order to fly UAS in the NAS the DoD must first consult FAA Order JO 7610.4N *Special Operations*, chapter 12 that outlines the rules and procedures to be followed for requesting a COA. Within this order, sections of 14 CFR, Parts 23 and 91 are referenced for specific guidance pertaining to equipment and operations, respectively.[69] Then,

> The *Application for COA* should be submitted at least 60 days prior to the intended operation and contain:
>
> - Detailed description of the planned operation.
> - Platform physical and operational characteristics.
> - Coordination and communication procedures.
> - Contingency procedures.
> - Method that will be used to avoid other aircraft that provides an ELOS, comparable to the see-and-avoid requirements for manned aircraft.[70]

The FAA's Unmanned Aircraft Program Office (UAPO) then processes the COA and determines whether any updates or changes are needed and either grants the request for a specified period of time, up to a year, or denies it. The FAA established the UAPO with the "expressed purpose of ensuring a safe integration of UAs into the NAS" and "to ensure they do not jeopardize the safety of other aviation operations."[71]

The FAA created the COA process, along with Temporary Flight Restrictions (TFRs) that the CBP is using to operate UAS along the border, in order to allow public and government operations of UAS in the NAS. These "processes are designed to allow a sufficiently restricted operation to ensure a safe environment, while allowing for research and development until such time as pertinent standards are developed."[72] Consequently, the DoD argued that because UAS lack the ability to meet the same regulations as manned aircraft, UAS "are frequently segregated from manned aviation rather than integrated with it."[73] In addition, many private and commercial companies have requested access to the NAS, for at least an experimental certification, but have been denied since the FAA is not allowing civil UAS into the NAS at this time.[74]

Problems

The current problem the UAPO is facing with the COA process is the number of requests they receive and a lack of manpower to process them. The UAPO stated in its own policy guidance that outlines the COA process, *Interim Operational Approval Guidance 08-01*, "the proliferation of UAS into the NAS has resulted in an increased demand for the FAA to process a large number of applications to review for operational approvals."[75] The GAO also stated in a May 2008 report that, "Increased workload would stem from FAA's expectation of increased demand for UAS operations in the national

airspace system without a regulatory framework in place."[76] Within the same report, the GAO posted a chart detailing the number of applications the FAA received by year from 2004-2007, and projected it through 2010, as shown in figure 2.

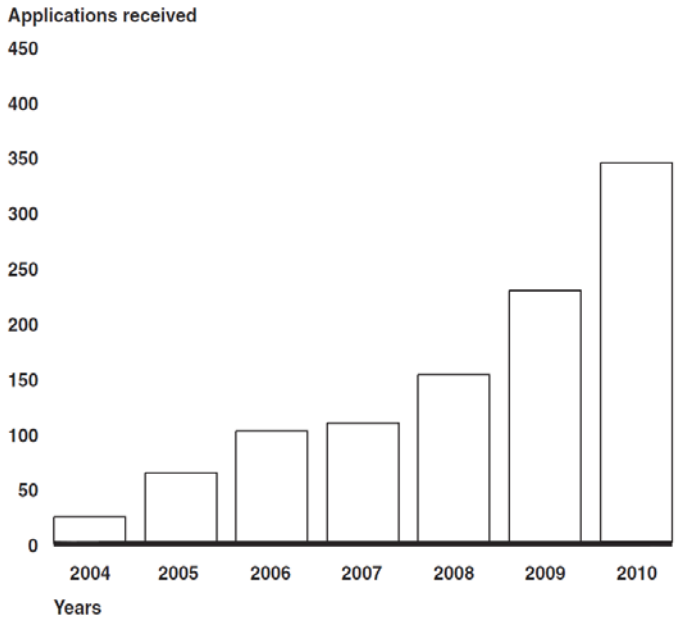

Figure 2. FAA COA Applications Received
Source: Government Accounting Office (GAO), *Unmanned Aircraft Systems: Federal Actions Needed to Ensure Safety and Expand Their Potential Uses within the National Airspace System* (Washington, DC: Government Printing Office, 15 May 2008), 27.

The FAA, on its website, posted the number of COAs it issued from 2006 through October of 2009, but they may not take into account the number of COAs it denied during this same period.[77] In a speech to the AIA late last year, Mr. Babbitt stated, "In FY-09, there were about 20,000 flights in civilian airspace for a total of over 2,500 hours. And the number of operations that have been granted has more than tripled since 2007."[78]

As a result, the UAPO office has been overwhelmed with the number of requests received in relation to the number of personnel it has to process these requests.

A second problem, from the DoD's point of view is, not only the time it takes for the FAA to process its requests, but also the need to forecast its operations beyond 60 days, as well as unforeseen operations. Under the guidelines stated previously, all COAs should be requested at least 60 days prior to flight operations, a timeline the FAA has had trouble meeting, according to GAO report 08-511.[79] The same report stated, "From December 2006 through January 2008, FAA's COA processing time averaged 66 calendar days."[80] Six days may not seem like a significant amount of time, but when operations conducted by the military have to be scheduled at least 60 days out and are scheduled down to the hour, six days can cause a significant change in the schedule. The DoD agreed that the COA process works well when they can plan for operations well past the 60-day point; however, the DoD stated, "it is insufficient to support operations of an unplanned nature, such as disaster operations or homeland defense."[81] Although the military can ask for and receive special permission to fly over restricted airspace, it is not always granted. For example, the DoD's request to fly a Predator UAS over New Orleans after Hurricane Katrina was denied.[82]

A problem the FAA has faced as the authority for regulating the safe integration of UAS into the NAS is the need to review each COA. Mentioned in the previous chapters pertaining to acquisition and categorization, UAS are not a single type of aircraft and range in size from something that weighs a few pounds and fits in your hand to something with the equivalent wingspan of a Boeing 737 and weighing thousands of pounds. The DoD and other UAS companies have complained that because of a lack of

standardization in the process, "The COAs for each user tend to be different, even though the aircraft are flying from the same location."[83] Until such time that UAS can enter the NAS on a file-and-fly basis, the COA process will have to suffice. The FAA has taken steps to improve the process somewhat, while the DoD, UAS industry leaders, and other academia work toward proposed interim solutions to the COA process.

Interim Solutions

The FAA has taken steps to improve its COA process, but there is still room for improvement. A few options presented as possible solutions can help reduce the time required to process COA requests as well as reduce the number of COAs requested by the DoD. Each option may not be the ideal fit or a full replacement to the current process. However, the FAA needs to either choose from a combination of ideas presented from multiple sources or develop their own solution in order to improve the turn-around time for COA requests.

The FAA implemented changes and updates to its COA process in 2007 in an effort to reduce the time it takes to approve requests and reduce some of the backlog it had built up. The FAA designed a website on which users can fill out their COA requests for UAS operations and they automated some of the processing steps in order to decrease the human workload.[84] Additionally, the FAA is looking at incrementally allowing small UAS operations into the NAS that are requested under low risk conditions and therefore would not have to be reviewed on a case-by-case basis. The FAA anticipates releasing a rulemaking decision sometime this year, but it has not yet defined its parameters for "small UAS." In a memorandum with the DoD, the FAA reduced the number of COA

requests by allowing small UAS to operate over military installations and other specified airspace.[85]

On a larger scale, the FAA has already granted the DoD an airworthiness certificate to operate its Global Hawk UAS in the NAS on a permanent basis. The DoD is working with the FAA in hopes of getting airworthiness certificates or a national COA for its inventory of Reapers as well. The FAA also worked with the CBP on their request to use Predator UAS to conduct border surveillance along the Mexico-US border. The FAA granted the CBP a TFR along the border in Arizona and New Mexico, and more recently in North Dakota along the border with Canada.[86] Therefore, the CBP is somewhat satisfied with the current process. However, the Assistant Commissioner of the CBP stated, "each one of these COAs needs to be kind of driven, the time of it, by the risk associated with the type of aircraft that is seeking approval, the location and way in which that aircraft will be flown, and the risk both to civil aviation and the purposes on the ground."[87] This statement from the CBP highlights their desire for a faster process based on the location and operations of UAS and the risk to people on the ground.

The FAA's workload also includes issuing experimental aircraft certificates to private and civil companies to conduct UAS testing. Therefore, another interim possibility to reducing the numbers of certificates issued to these companies would be a Company COA. This would allow companies to develop and test UAS across multiple models of aircraft in restricted or remote areas.[88] The largest leap in reducing the amount of COAs would be to implement some version of the DoD's proposed categories of UAS aircraft. This process would allow specific categories of UAS to receive either a permanent airworthiness certificate or national COA in Cat III, like the Global Hawk; to

operate under specific guidelines and specific airspace with a long term COA in Cat II, like the Shadow; or be operated under the rules of the Advisory Circular in Cat I, like the Raven. This concept is not specific to the DoD and was first proposed to the FAA in 2000 and again to the House Subcommittee in 2006 by General Atomics Aeronautical Systems with a four-category classification almost identical to the one proposed by the DoD.[89] In order to better understand where these aircraft would likely be operated it is important to know how the six classes of airspace are delineated within the NAS. The DoD has defined these classes well in its *UAS Roadmap 2009-2034* and are therefore referenced here and shown in figure 3.

> Class A airspace exists from Flight Level (FL) 180 (18,000 feet MSL) to FL600 (60,000 feet MSL). Flights within Class A airspace must be under IFR and under the control of ATC at all times.
>
> Class B airspace generally surrounds major airports (generally up to 10,000 feet MSL) to reduce mid-air collision potential by requiring ATC control of IFR and Visual Flight Rules (VFR) flights in that airspace.
>
> Class C airspace surrounds busy airports (generally up to 4000 feet AGL) that do not need Class B airspace protection and requires flights to establish and maintain two-way communications with ATC while in that airspace. ATC provides radar separation service to flights in Class C airspace.
>
> Class D airspace surrounds airports (generally up to 2500 feet AGL) that have an operating control tower. Flights in Class D airspace must establish and maintain communications with ATC, but VFR flights do not receive separation service.
>
> Class E airspace is all other airspace in which IFR and VFR flights are allowed. Although Class E airspace can extend to the surface, it generally begins at 1200 feet AGL, or 14,500 feet MSL, and extends upward until it meets a higher class of airspace (A–D). It is also above FL600.
>
> Class G airspace (there is no Class F airspace in the United States) is also called "uncontrolled airspace" because ATC does not control aircraft there. (ATC will provide advisories upon request, workload dependent.) Class G airspace can extend to 14,499 feet MSL, but generally exists below 1200 feet AGL and below Class E airspace.[90]

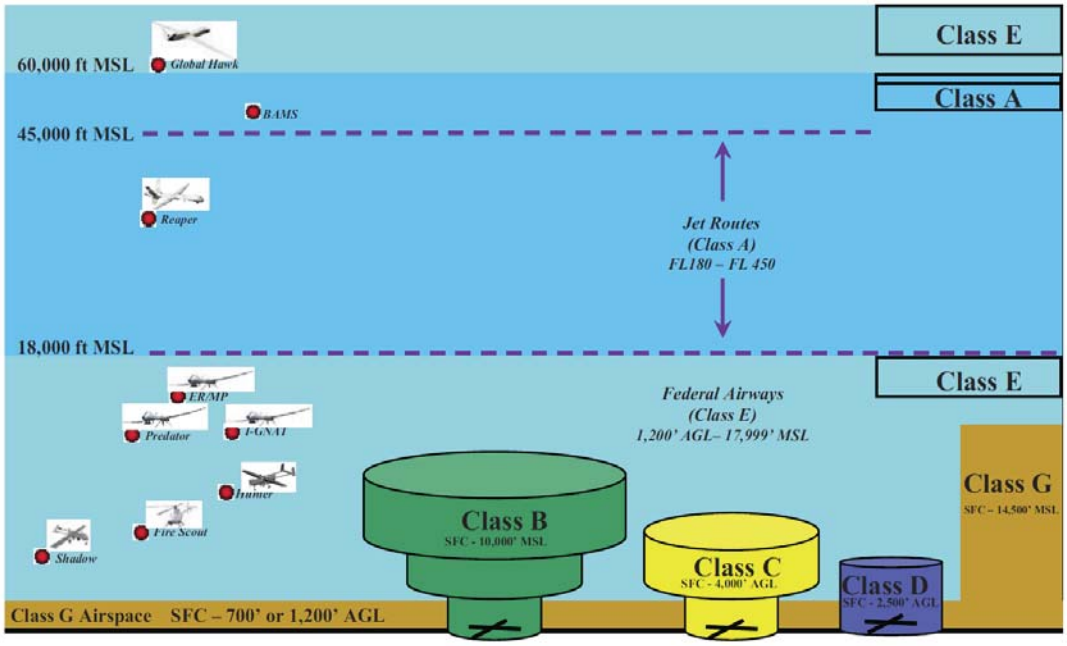

Figure 3. FAA Airspace Classification & Relative UAS Operating Areas
Source: Office of the Secretary of Defense, *Unmanned Systems Integrated Roadmap 2009-2034* (Washington, DC: Government Printing Office, 6 April 2009), 94.

The COA process, however cumbersome, time and resource consuming it may be, does work. Unfortunately, the process has not been able to keep up with the increase in UAS demand, both civilian and public. The FAA and DoD initially agreed to this process during a time when UAS operations in the NAS were minimal. Now the DoD and FAA must again work together in order to streamline the system until a solution to the integration problem can be implemented. The problems of time associated with requests, the amount of COAs being requested, and the need to process each request individually are a starting point to updating the COA process. The FAA has already taken steps in the right direction within its own organization to improve the process and relieve some of the backlog. The DoD and FAA have put together a number of organizations to address the problem of UAS integration. Along the way, these organizations offered some ideas at

improving the COA process as well. There are a number of other governmental organizations and companies that have also presented workable ideas, some of which were presented in this research. The FAA must consider implementing some of these ideas in order to prevent further delays in its own regulation process, to the detriment of the advancement of aviation.

The question of whether or not the FAA can improve the COA process is answerable by the fact that they have already made improvements. This research suggests they should continue to work on the process to streamline it even more. The FAA understands that their workload is going to increase as UAS needs and desires increase across the private, public, and civil sectors. This increase is evident by the increases each year in COA requests charted by the GAO and published on the FAA website. In order to keep up with the process the FAA must continue to work with the DoD, other government agencies, industry, aerospace companies, and academia. That cooperation is imperative in order to reach a feasible long-term solution for UAS integration.

Safe and Efficient Integration

The FAA and DoD agreed that UAS integration into the NAS is of primary importance to both organizations, as well as a host of other civilian and private ones. While all organizations agree that safety is of the upmost importance, there is also the desire to accomplish integration by the quickest and most efficient means possible. The increased numbers and capabilities of UAS and their growing operations in the near future mainly drive this desire. However, the FAA, as the overseer of safety and integration for all aerospace vehicles in the NAS for the U.S., has the responsibility for

ensuring safety is a priority. Therefore, the terms safely and efficiently may take on a different meaning for each organization based upon their given tasks and priorities.

Safe Integration

Although the FAA has the primary responsibility for ensuring the safe integration of UAS, the DoD and other organizations are also driven by the need to conform to safety standards in an effort to ease the process. In the opening statement of the House Subcommittee on Aviation in 2006, Mr. Mica, House Representative from Florida, stated, "From the early days of flight to the development of jet engines, to the introduction of helicopters and now unmanned aerial vehicles (UAVs), and also unmanned aerial systems, progress continues and the safe integration of new technologies has to be assured in our national airspace."[91] Safety has always been the primary concern of the FAA, and in part has led to the slow progression of UAS integration.

The problem the FAA must contend with regarding unmanned aircraft is the lack of an onboard pilot to make decisions and perform operations that a remote pilot cannot currently achieve. Three of these operations, two of which the FAA stated as their primary concern for UAS integration, stem from the inability to see-and-avoid according to 14 CFR, part 91.[92] The next is autonomous operations if a loss of communication occurs, and the other is a lack of safety standards.[93] Since UAS do not have pilots aboard, there have been fewer issues and concerns associated with a UAS crash as opposed to a manned aircraft crash and a loss of human life. Safety designs and standards have increased as the cost and size of UAS have increased over the years. However, the FAA made the determination that until these issues can be adequately addressed or mitigated,

UAS will not receive full file-and-fly access to the NAS and the DoD must adhere to the COA process.

In an effort to address regulatory and technical challenges, the FAA created the Unmanned Aircraft Program Office in February 2006.[94] This office contains a representative from the DoD working in coordination to address issues specific to both organizations. The UAPO is also reaching out to other government, private, civil, and international agencies to garner their expertise in solving the issue of safe integration.

The FAA must develop standards, regulations, and provide definitions for specific areas of UAS operations. This development will allow for an ELOS across all areas of UAS design and operations, which will provide direction for development and advance the process of safe integration. Therefore, the FAA tasked the RTCA to develop MASPS for the performance of UAS aircraft along with Command and Control (C2) and SAA. The RTCA created SC-203 and assigned them the task of gathering data and conducting tests to create MASPS with the hopes that, "SC-203 products will help assure the safe, efficient and compatible operations of UAS with other vehicles operating within the NAS."[95]

The FAA understands that the DoD has been flying UAS for over ten years, both inside and outside of regulated airspace. The DoD has racked up hundreds of thousands of hours across multiple UAS platforms and programs. Therefore, the FAA and DoD collaborated in an agreement to allow the FAA access to this information which will help lead to the safe integration of UAS. The Air Force incorporated this issue in its *UAS Flight Plan 2009-2047* by stating, "It is vital for the DoD and the FAA to collaborate closely to achieve progress in gaining access for UAS to the NAS to support military

requirements."[96] The GAO commented in its report to Congress in 2008, "FAA has been working to leverage DoD's decades of experience with UASs."[97] With this in mind, the FAA now has a built-in test and evaluation organization from which to pull data. Therefore, "Data from these efforts could facilitate FAA's development of a regulatory framework to allow UASs to have routine access to the national airspace system."[98] The DoD and FAA finalized the memorandum of agreement in September 2007, and the FAA has been collecting data to support safety studies by its UAPO office and other support programs.

While working with the DoD and the RTCA to collect data and develop standards, the FAA has been working to address issues with the COA process. The FAA realized the increase in UAS activity increased its workload, but also allowed it a chance to gather more data and information to help speed up the integration process. Therefore, "the FAA has undertaken a safety review that will examine the feasibility of creating a different category of unmanned 'vehicles' that may be defined by the operator's visual line of sight and are also small and slow enough to adequately mitigate hazards to other aircraft and persons on the ground."[99] "The FAA hopes to publish the proposed rule in spring 2011, and the final rule in early 2012."[100] The FAA has also shown that if an ELOS can be demonstrated and compliance with current 14 CFR safely maintained, then they are willing to grant access to the NAS, as demonstrated when the FAA granted the DoD an airworthiness certificate for its Global Hawk UAS.

Safety is the FAA's primary concern when determining whether operations may be conducted by UAS in the NAS. The DoD is working closely with the FAA and within its own organization to increase the safety of its products and operations. The FAA has

stood firm in the face of mounting pressure from all sides of the aerospace industry and government in its efforts to integrate UAS. During this time, the FAA has allowed increased operations and developed new methods and operations to safely allow increasing numbers of UAS into the NAS. The question now remains, are the FAA and the DoD working efficiently to develop a solution for UAS integration?

Efficient Integration

Efficiency may be difficult to quantify when trying to determine how the DoD and FAA have been working together. However, it has been thirteen years since the COA process was first put in place by the FAA and DoD and could likely be five to ten more years before UAS integration. Although not originally designed to be a permanent framework for granting UAS access to the NAS, it has definitely been both an asset and hindrance to moving forward with integration. In order to answer the question of whether or not the DoD and FAA are working efficiently for a solution to the NAS problem, the research looked at how each organization was taking on the problem as well as how they were collaborating to solve it.

The DoD is the primary organization pushing for the integration of UAS. There are other public, private, and commercial organizations that would like to see integration as well, but the DoD is currently the largest owner and operator of UAS and therefore has the biggest stake in the process. In a report presented to the House Subcommittee on Air and Land Forces Committee on Armed Services, the GAO reported, "The department [DoD] plans to invest more than $16 billion from 2008 through 2013 to develop and produce additional unmanned aircraft systems."[101] While more collaboration and

coordination are needed to help draw attention to the challenges that result from this increase in UAS and provide recommendations, it has not led to efficiency in effort.

In 2001, the DoD began the process of consolidating its efforts with respect to UAS planning when it established the UAS Planning Task Force (PTF) under the office of the Under Secretary of Defense (OUSD) (Acquisition Technology and Logistics [AT&L]). "The UAS PTF provides oversight on all DoD UAS acquisition programs."[102] The USAF's Air Combat Command (ACC) then created its own joint working group responsible for establishing and quantifying capabilities for SAA systems for submission to the FAA.[103] Also in 2003, the DoD created the UAV Interoperability Working Group in order to facilitate joint and international cooperation on systems development.[104] The Joint Staff then chartered its own organization in 2005 called the Joint UAS Center of Excellence (JUAS COE), "to pursue solutions to optimize UAS capabilities and utilization (including concepts of operation)."[105] The separate Services of the Air Force, Army, and Navy then joined the process in 2005 and created the Tri-Service UAS Airspace Integration Joint Integrated Product Team (JIPT) to coordinate related technology and standards development.[106]

Each of these organizations is working on a specific problem when it comes to UAS operations and that seems like an efficient process. However, with respect to oversight and coordination, there is no single organization or Service that is responsible for those functions. The PTF is only responsible for answering to the OUSD while the JUAS COE answers to the Joint Staff, and the JIPT answers to their respective Service branches. These committees may generate and develop great ideas and procedures for UAS systems, capabilities and operations, but if the other organizations do not approve of

it, or never hear about it, then there is no real advancement toward combined integration. A Congressional Research Service report presented to Congress in 2005 stated, "In spite of the creation of the UAV Task Force, Congressional concerns with UAV acquisition management, program duplication, interoperability, and other issues continue."[107] This sentiment was echoed in the Air Force's own *UAS Flight Plan 2009-2047* referenced previously in the discussion of acquisition problems. It stated, "There are numerous UAS initiatives underway in the USAF and in the DoD that are not integrated."[108] Therefore, the last five years of coordination and Tri-Service collaboration between the DoD and FAA have produced little in the advancement toward integration.

Five years ago, the FAA began to address the problems it faced with integrating UAS into the NAS. In 2005, they created the UAPO and assigned them the responsibility for "the safe integration of UAS in to the NAS by developing the procedures and regulations for certification, licensing, training, inspection, maintenance, and operations of UAS."[109] The UAPO then began assigning duties to private organizations in an attempt to collaborate efforts in hopes of a quicker response to the problem of integration. The UAPO assigned the RTCA the responsibility for developing MASPS for UAS in areas such as UAS operations, C2, and SAA. The RTCA then developed the Special Committee, SC-203 to work with the FAA and DoD on this effort.

The FAA also solicited the help of aerospace industry companies like UNITE, AIA, and Lockheed Martin. In 2006, the FAA selected Lockheed Martin to support the UAPO in the development of a roadmap for introducing UAS into the NAS. The roadmap is supposed to help the UAPO refine its efforts by laying out a five-year plan for requirements and milestones.[110] Although the DoD and the Services have continually

produced a UAS roadmap for the future planning and organization of its UAS fleet, the FAA has yet to publish a UAS roadmap unifying the efforts of everyone involved with NAS integration. Companies like UNITE and AIA support the MASPS being developed by SC-203 and consequently provide subject matter experts to subcommittees addressing UAS initiatives, operations, and legislation.[111]

While the FAA and DoD are working to develop standards and procedures for UAS integration, the lack of an overarching committee is slowing the process. The DoD has incorporated a liaison representative within most of the FAA's committees, specifically the UAPO office, and the FAA has done the same within the DoD. However, as reiterated in the GAO's report from 2008, "Although FAA's UAPO serves as a focal point within FAA, the office has no authority over other agencies' efforts."[112] In the *Unmanned Systems Integrated Roadmap 2009-2034* the DoD stated, "The JIPT ensures subject matter experts are engaged in the work activities of SC-203 and conducts critical planning activities with SC-203 leadership to ensure synergy of effort."[113] That, along with the private industry companies such as UNITE and AIA, has helped in developing the standards that are required for the FAA to make regulations. However, without a focal point for all the different committees listed above to answer to, from the OUSD, Joint Staff, Services, UAPO, and aerospace companies, the combined efforts may be delayed beyond the expectations of the DoD and FAA. The DoD pointed out, concerning the same committee cooperation above, "the current SC-203 schedule does not meet the timelines of many DoD UAS programs."[114]

The efficiency with which the DoD and FAA have worked to develop standards, procedures, and capabilities for UAS is lacking due to no overarching regulatory

organization. This is partly due to a lack of standardization among UAS and the speed with which technology and capabilities are increasing. It has become a vicious cycle for the FAA since a lack of UAS regulations and standards leads to very diverse designs and capabilities that do not lend themselves to easy classification from which to develop these standards. The FAA has only recently (within the last three years) begun to collect data from the DoD on its UAS operations and has been slow to process the information due to manpower issues. Until some form of an integrated UAS roadmap is developed that incorporates the work and initiatives of all the organizations involved with UAS integration and lays out milestones for specific coordinated efforts, the way ahead will continue to be inefficient with regards to extended deadlines and lack of a single source to collaborate efforts.

Conclusion

This research looked into three specific areas between the DoD and FAA to provide analysis for the primary question addressed in chapter 1. The study first described the equivalent level of safety availability to supplant the regulation of see-and-avoid and the availability of SAA technology and the DoD's operations and organizations attempting to achieve it. It then described the current acquisition and categorization process in use by the DoD and how those processes are going to affect the FAA's mission of UAS integration. Next, the study determined whether the FAA can improve its COA process and provided recommendations from the DoD, as well as from private and civil sources. Finally, the primary question of whether or not the DoD and FAA are working together efficiently to safely integrate UAS into the NAS was analyzed based on a compilation of research from the three secondary questions.

The research noted that the FAA needed to define and standardize ELOS and SAA so that the DoD can design and develop to those standards. The DoD's acquisition process, although not considered a factor to the FAA, could be better integrated, while its categorization based on years of UAS experience will help the FAA's job of regulation. The FAA has already improved its COA process, but the research suggests there is still more room for improvement and the DoD and other UAS industry leaders have suggested ways to move ahead. Overall, the FAA and DoD have been working together to safely integrate UAS into the NAS, despite a lack of efficiency of cooperation.

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[1]FAA Docket No. FAA-2006-25714, 2.

[2]Due to the lack of a definition or acronym published by the FAA, the term sense-and-avoid is abbreviated many different ways by different organizations. The DoD abbreviates it S&A, while some test and research companies use DS&A for detect, sense-and-avoid and other, such as the Radio Technical Commission for Aeronautics (RTCA) use SAA. The will use SAA as the reference for sense-and-avoid and will maintain it throughout the paper.

[3]CFR *Title 14*, Part 91-113, "Right of Way Rules," 91.113(b) General.

[4]U.S. Congress, *Hearing on Unmanned Aerial Vehicles and the National Airspace System*, 71.

[5]Office of the Secretary of Defense, *Unmanned Systems Integrated Roadmap (2009-2034)*.

[6]Federal Aviation Administration (FAA), Order JO7610.4N, *Special Operations* (Washington, DC: Government Printing Office, 27 August 2009), 12-9-1.

[7]U.S. Congress, House, *Hearing on Unmanned Aerial Vehicles and the National Airspace System.* 109th Cong, 2nd Sess., 29 March 2006, 144.

[8]Ibid., 45.

[9]Headquarters, Air Combat Command/Director-Unmanned Aerial Vehicle Special Mission Office, "Sense-and-Avoid Requirement for Remotely Operated Aircraft (ROA)" (White Paper, Langley AFB, VA, 25 June 2004), http://www.amtech-usa.org/a5/news/SAAWP_signed.pdf (accessed 15 April 2010), 4.

[10]American Institute of Aeronautics and Astronautics (AIAA), "Development of a Sense and Avoid System" (Infotech@Aerospace 26-29 September 2005, Arlington, VA), http://www.colorado.edu/ASEN/asen5519_arg/papers/2005_7177_194.pdf. (accessed 15 April 2010), 1.

[11]Office of the Secretary of Defense, *Unmanned Systems Integrated Roadmap (2009-2034)*, 99.

[12]Ibid., 99.

[13]Radio Technical Commission for Aeronautics, "RTCA Paper No. 232-09/SC203-037" (Summary of the Fifteenth Plenary Special Committee 203, 15 October 2009, Washington DC), http://www.rtca.org/CMS_DOC/SC%20203%20Oct2009%20Plenary%20Minutes.pdf (accessed 15 April 2010). MITRE is not an acronym; it is the name of the research company based out of Massachusetts Institute of Technology and is spelled with all capital letters.

[14]Ibid., 3.

[15]Federal Aviation Administration, "Safety Must Come First" (Speech to the Aviation Instrument Association, 18 November 2009, Scottsdale, AZ), http://www.faa.gov/news/speeches/news_story.cfm?newsId=10964. (accessed 15 April 2010).

[16]Government Accounting Office (GAO), *Unmanned Aircraft Systems: Federal Actions Needed to Ensure Safety and Expand Their Potential Uses within the National Airspace System* (Washington, DC: Government Printing Office, 15 May 2008).

[17]House, *Hearing on Unmanned Aerial Vehicles and the National Airspace System*, 77.

[18]Ibid., 127.

[19]Ibid.

[20]Federal Aviation Administration, "Safety Must Come First."

[21]Ibid., 131.

[22]GAO, *Unmanned Aircraft Systems*, 16.

[23]Ibid.

[24]Office of the Secretary of Defense, *Unmanned Systems Integrated Roadmap (2009-2034)*, 99.

[25]Headquarters, Air Combat Command/Director-Unmanned Aerial Vehicle Special Mission Office.

[26]House, *Hearing on Unmanned Aerial Vehicles and the National Airspace System*, 144.

[27]Headquarters, Air Combat Command/Director-Unmanned Aerial Vehicle Special Mission Office, 4-5. Federal Aviation Regulations (FAR) are the precursors to the Code of Federal Regulations (CFR).

[28]Ibid., 6.

[29]David Grilley, "Resolution Requirements for Passive Sense and Avoid" (Paper, Alion Science and Technology, Morgantown, WV, 26 January 2005), abstract.

[30]Federal Aviation Administration (FAA), Flight Standards Service AFS-400 UAS Policy 05-01, Definitions.

[31]Headquarters, Air Combat Command/Director-Unmanned Aerial Vehicle Special Mission Office, 8.

[32]Ibid., 8.

[33]Defense Research Associates, Inc., "Sense and Avoid," *Innovative Technologies Today* https://dra-inc.net/index.php?option=com_content&view=article&id=58&Itemid=72 (accessed 15 April 2010).

[34]Ibid., Summary.

[35]Ibid.

[36]Ibid., paragraph 3.

[37]GAO, *Unmanned Aircraft Systems*.

[38]Ibid., 40.

[39]GAO, GAO-09-520, *Defense Acquisitions*.

[40]Ibid.

[41]Office of the Secretary of the Air Force, *Unmanned Aircraft Systems Flight Plan (2009-2047)*.

[42]GAO, GAO-09-520, *Defense Acquisition,* 6.

[43]Ibid., 22.

[44]U.S. Congress, House, Committee on Appropriations, Department of Defense Appropriations Bill for Fiscal Year 2003, 2d sess., 207.

[45]Congressional Research Service, *Unmanned Aerial Vehicles: Background and Issues for Congress* (Washington, DC: Government Printing Office, Library of Congress, 21 November 2005).

[46]Ibid.

[47]Ibid., 18.

[48]GAO, GAO-09-520, *Defense Acquisition*.

[49]Office of the Secretary of the Air Force, *Unmanned Aircraft Systems Flight Plan (2009-2047)*, 63.

[50]U.S. Congress, House, *Hearing on FY2006 Defense Budget*." 9 March 2005.

[51]Office of the Secretary of the Air Force, *Unmanned Aircraft Systems Flight Plan (2009-2047)*, 66.

[52]Ibid., 67.

[53]GAO, GAO-09-520, *Defense Acquisition,* Introduction.

[54]Code of Federal Regulation (CFR). *Title 14*, Part 1, Definitions and Abbreviations, *Category.*

[55]Ibid.

[56]House, *Hearing on Unmanned Aerial Vehicles and the National Airspace System*, 6.

[57]Office of the Secretary of Defense. *Unmanned Systems Integrated Roadmap (2009-2034)*.

[58]House, *Hearing on Unmanned Aerial Vehicles and the National Airspace System*.

[59]Office of the Secretary of Defense, *Unmanned Systems Integrated Roadmap (2009-2034)*, 96.

[60]House, *Hearing on Unmanned Aerial Vehicles and the National Airspace System*.

[61]Office of the Secretary of Defense, *Unmanned Systems Integrated Roadmap (2009-2034)*.

[62]Ibid.

[63]Ibid., 98.

[64]House, *Hearing on Unmanned Aerial Vehicles and the National Airspace System*, 46.

[65]Ibid., 6.

[66]GAO, *Unmanned Aircraft Systems*, 16.

[67]Headquarters, Air Combat Command/Director-Unmanned Aerial Vehicle Special Mission Office, 4. The term ROA, meaning remotely operated aircraft is the predecessor to the terms UAV and UAS or what the Air Force currently calls RPA. ROA supplanted the term RPV, remotely piloted vehicle, during the mid-1990s.

[68]Ibid., 4.

[69]FAA Order JO7610.4N, 12-9-1.

[70]Headquarters, Air Combat Command/Director-Unmanned Aerial Vehicle Special Mission Office, 5.

[71]House, *Hearing on Unmanned Aerial Vehicles and the National Airspace System*, 6.

[72]Ibid., 7.

[73]Office of the Secretary of Defense, *Unmanned Systems Integrated Roadmap (2009-2034)*, 91.

[74]House, *Hearing on Unmanned Aerial Vehicles and the National Airspace System*.

[75]Federal Aviation Administration (FAA), Unmanned Aircraft Program Office AIR-160, 2.

[76]GAO, *Unmanned Aircraft Systems*, 16.

[77]Federal Aviation Administration, Fact Sheets, *Unmanned Aircraft Systems (UAS)*, 12 November 2009. http://www.faa.gov/news/fact_sheets/news_story.cfm?newsId= 6287 (accessed 15 March 2010).

[78]Federal Aviation Administration, "Safety Must Come First."

[79]GAO, *Unmanned Aircraft Systems*.

[80]Ibid., 26.

[81]House, *Hearing on Unmanned Aerial Vehicles and the National Airspace System*, 11.

[82]Ibid., 32.

[83]Ibid., 28.

[84]GAO, *Unmanned Aircraft Systems*.

[85]Ibid.

[86]Graham Warwick and John Doyle, "Predator UAV Set for U.S.-Canada Patrol," *Aviation Week,* 5 December 2008, http://www.aviationweek.com/aw/generic/story_channel.jsp?channel=defense&id=news/PRED12058.xml&headline=Predator%20UAV%20Set%20for%20U.S.-Canada%20Patrol (accessed 5 February 2010).

[87]House, *Hearing on Unmanned Aerial Vehicles and the National Airspace System*, 15.

[88]Ibid., 131.

[89]Ibid., 47.

[90]Office of the Secretary of Defense, *Unmanned Systems Integrated Roadmap (2009-2034)*, 93-94. In a footnote on page 95, the Roadmap explains the move toward a two-class structure for aviation, "The FAA is moving toward a two-class structure for the NAS, 'terminal' and 'en route.' Terminal will subsume Class B, C, and D airspace, and en route will include Class A, E, and G airspace".

[91]House, *Hearing on Unmanned Aerial Vehicles and the National Airspace System*, 1.

[92]Ibid., 2.

[93]Ibid.

[94]GAO, *Unmanned Aircraft Systems*.

[95]Radio Technical Commission for Aeronautics (RTCA), SC-203, "*Unmanned Aircraft Systems*," http://www.rtca.org/comm/Committee.cfm?id=45 (accessed 15 February 2010).

[96]Office of the Secretary of the Air Force, *Unmanned Aircraft Systems Flight Plan (2009-2047)*, 71.

[97]GAO, *Unmanned Aircraft Systems*, 35.

[98]Ibid.

[99]Federal Register, *Rules and Regulations* 72, no. 29 (13 February 2007), policy statement, http://edocket.access.gpo.gov/2007/pdf/E7-2402.pdf (accessed 18 February 2010).

[100]Federal Aviation Administration, Fact Sheets, paragraph 9.

[101]GAO, Defense Acquisition, 1.

[102]Office of the Secretary of Defense, *Unmanned Systems Integrated Roadmap (2009-2034)*, 103.

[103]Ibid.

[104]Congressional Research Service, *Unmanned Aerial Vehicles: Background and Issues for Congress,* 11.

[105]Ibid.

[106]Ibid.

[107]Congressional Research Service, *Unmanned Aerial Vehicles: Background and Issues for Congress*, 11.

[108]Office of the Secretary of the Air Force, *Unmanned Aircraft Systems Flight Plan (2009-2047)*, 66.

[109]National Transportation Safety Board, *"NTSB Safety Forum: Unmanned Aircraft Systems*," 29-30 April 2008, http://ntsb.gov/events/symp_UAS/PDFs/ UASForum1.pdf (accessed 19 February 2010), 14.

[110]Space War: Your World At War, "*LM Selected To Develop FAA Road Map For Unmanned Aircraft Systems*," 28 September 2006, http://www.spacewar.com/ reports/LM_Selected_To_Develop_FAA_Road_Map_For_Unmanned_Aircraft_Systems _999.html (accessed 15 February 2010).

[111]UNITE, "*Initiative: SC-203*," http://www.uniteaero.com/Archives/UNITE% 20v2/html/Initiatives_SC-203.html (accessed 16 February 2010).

[112]GAO, *Unmanned Aircraft Systems*, 40.

[113]Office of the Secretary of Defense, *Unmanned Systems Integrated Roadmap (2009-2034)*, 106.

[114]Ibid.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Chapter 4 provided analysis and comparison of DoD and FAA regulations, publications, and cooperation to answer the primary research question, "Are the DoD and FAA working together in an efficient manner to develop a safe way to integrate UAS into the NAS?" This chapter will expand on the initial results from chapter 4 and recommend changes and additional research into the issue of safe and efficient cooperation for UAS integration.

The question of whether current technology is available to allow the FAA to develop procedures to replace the see-and-avoid requirement with SAA is still in progress. The FAA and DoD have both developed teams to address the problems of ELOS and SAA capabilities within this topic. However, the FAA, with the amount of information available, needs to define the terms ELOS and SAA and develop standards for their operations. Until this is accomplished, the teams working under the DoD and FAA have no basis from which to coordinate their efforts.

The FAA assigned the responsibility to the RTCA to develop these standards in the form of MASPS. However, RTCA's work has been slow to proceed, due to a lack of data to formulate definitions and standards as a result of the restriction of UAS operations in NAS airspace. The DoD has demonstrated advances on the key pieces to the ELOS and SAA question and has implemented the next stage in the process. Unfortunately, as the GAO described, there has been a lack of coordination between the DoD, FAA, and other government agencies in moving forward to meet safety requirements. The FAA

established the UAPO office and assigned it responsibility for developing policies and regulations for UAS operations. However, until the FAA and DoD coordinate and consolidate under one committee with the authority over both these issues, progress will remain slow on ELOS and SAA requirements and definitions.

The acquisition and categorization methods of the DoD help and hurt the COA process. The acquisition process increases the FAA's COA workload, but this increase could be alleviated, or mitigated, if the FAA adopted the DoD's categorization method. The GAO and DoD itself noted that the DoD acquisition process is inefficient and stove-piped due to Service-specific needs and requests. The DoD created the JCIDS process in an effort to reduce overlapping design issues and integrate operational efforts from a joint perspective. However, the separate Services can bypass this process through other avenues, specifically the Planning, Programming, Budgeting and Execution (PPBE) Process. The effect this has had on the FAA is an increased number of UAS designs, which led to an increase in COA requests because of a lack of standardization.

The DoD is the largest owner and operator of UAS in the United States. Therefore, its experience with UAS operations and the amount of flight hours logged led the DoD to classify its UAS into three categories. This categorization system is consistent with specific CFR manned and AC 91-57 model aircraft regulations. Due to a current lack of industry standards for manufacturing and operating UAS as a class of aircraft, the FAA should adopt or incorporate the DoD categorization model as a basis for developing a UAS regulatory category for all UAS owners, operators, and developers. An agreement between the FAA and DoD to share data and the DoD classification system will help the FAA and other committees by speeding up the integration process.

The FAA created the COA process in coordination with the DoD to allow UAS access to the NAS. This process has become overwhelmed with the number of UAS requests and the lack of manpower within the UAPO to process them. The stated 60-day turn-around has, at times, taken longer than expected, in part due to the FAA's requirement to review every request as a separate entity. Therefore, the FAA has taken steps to streamline the process by allowing website COA requests and automating some of the processing steps. The FAA has also worked with the CBP and developed a TFR in lieu of the COA process to accommodate its needs. The research revealed that the FAA could still improve on the COA process and should take steps to implement some of the proposed solutions from the DoD, other government agencies, civil and private UAS companies, and UAS manufacturers. The COA process does currently provide limited public UAS access, as it has for 13 years, but the system has been overwhelmed and the FAA needs to take more steps to increase efficiency.

The safe and efficient integration of UAS into the NAS is the primary concern and question of this research. Safety is also a primary concern of the FAA and UAPO office and is a factor in all FAA decisions. In conjunction with its other duties, the FAA created the UAPO office to ensure the safe integration of UAS into the NAS. However, before any UAS can safely integrate on a file-and-fly basis, the UAPO must develop standards and regulations, and provide definitions across all levels of UAS operations. The FAA and DoD agreement to share data concerning UAS operations has been a step forward in effecting regulations, standards, and definitions; however, the FAA has been hindered from processing the information in a timely manner due to a lack of manpower. In the meantime, in order to reduce the number of COA requests, the FAA has

undertaken a safety review for smaller UAS. The intention of this review is to look at allowing smaller UAS access to the NAS on a regular basis without going through the COA process. This will relieve some of the burden from the UAPO office and allow the FAA and its committees to focus on the larger integration effort.

Although the FAA and DoD are working together to integrate UAS into the NAS, many inefficiencies still plague the process. Over the last 10 years, the DoD developed many separate organizations to work on specific sections of UAS integration. The FAA also formed the UAPO office and subsequently delegated responsibility for standards and regulations to a separate private organization. The FAA and DoD even incorporated members from their own organizations into that of the other. However, there is no single oversight organization with the responsibility and authority to direct and coordinate all the committees' efforts from both organizations. In conjunction with a lack of oversight, there is no single collaborative UAS roadmap. The FAA said they were going to publish a roadmap, with the help of Lockheed Martin, which detailed the requirements and laid out milestones for UAS integration, but have not done so. Until the DoD and FAA address these issues, their efforts will continue to be inefficient, slowing the process for UAS integration.

Recommendations

The FAA needs to define terms and provide standards and regulations by which public, civil, and private organizations can design, test, and operate UAS in the NAS. Therefore, based on the primary and secondary questions, this research proposes four recommendations for consideration. The first recommendation is the development of an overarching body in charge of the integration of UAS into the NAS. This body would be

composed of representatives from the DoD, FAA, other government agencies, civilian and private companies, and UAS industry manufacturers. The FAA would serve as the lead agency and have the authority to delegate and integrate resources across all areas of UAS research and development. In addition, Congress needs to allocate funds to the FAA for distribution to the committees under their control responsible for all forms of UAS research and integration, regardless of affiliation.

In order to give the committees within the DoD and FAA, along with UAS designers and manufacturers a point of reference for the development of new UAS capabilities and technologies, the FAA must define ELOS and SAA. The second recommendation of this research is to adopt the following definitions:

SAA--The ability to detect and determine a possible collision with another aircraft within ± 110 degrees of the longitudinal axis and ± 15 degrees of the horizontal axis, then be able to maneuver in a timely manner so as to remain well clear of the traffic. All aircraft, regardless of type, must be equipped with, assigned, and use a position and altitude encoded transponder at all times, even when flying VFR in uncontrolled airspace.

ELOS--The ability to detect, track, and maneuver in relation to other aircraft so as not to cause a hazard to other aircraft or people, either in the air or on the ground.
The testing the DoD has already conducted with regard to SAA provides the best application of SAA technology and parameters for defining SAA. Certain exemptions will apply, such as small UAS under visual contact and control, along with model aircraft that fall under AC 91-57, or aircraft flying in restrictive or prohibitive airspace, and so forth. These definitions provide a foundation for UAS designs, capabilities, and

operations to build upon and will allow for quick and efficient integration in a safe manner.

The third recommendation is for the FAA to develop a categorization process that incorporates all UAS aircraft. The DoD developed a categorization process for its UAS based on years of development, testing, and operations. The FAA has enough information from testing by other sources, such as civil and private companies and the DoD, to develop its own categorization program. Categorization will allow for the development of standards and operating procedures specific to each category. It will also provide public, private, and civil companies and UAS manufacturers with a basis for design, development, and operation.

The fourth and final recommendation is to integrate UAS starting as soon as possible at the lower categorization levels with small UAS. Most small UAS are not going to have the technology or capabilities to integrate into the NAS on a file-and-fly basis. Therefore, by developing standards and regulations, to include updating current regulations or advisory circulars, smaller UAS can access the NAS based on restrictions within the regulations without going through the COA process. This will help to relieve some of the backlog from the FAA and focus efforts toward integrating the capabilities of larger UAS.

Summary

The DoD and the FAA are working toward UAS integration. The process has been slow due to issues raised by and affecting UAS organizations across design, manufacture, operations, and regulations development. These issues can be overcome by appointing the FAA as the overarching body and by granting them the authority to

delegate across all UAS organizational levels. The adoption of definitions and a classification system will allow designers, manufacturers, and operators a regulatory framework from which to build new UAS and adapt legacy systems. By first integrating smaller UAS that are unable to fully file-and-fly, the FAA can reduce its COA workload and concentrate its efforts on larger UAS integration. Incorporating the recommendations presented by this research will help safely and effectively integrate UAS into the NAS.

APPENDIX A

LIST OF RECOMMENDATIONS FOR FURTHER STUDY

1. How will the new airspace structure (Access 5) affect UAS integration?

2. Does the DoD UAS categorization process cover design, operational, and technical capabilities of its fleet of UAS aircraft now and for the future?

3. How well has the TFR concept worked for CBP along the border and what are the impacts on civil and commercial flight?

4. How can the FAA start incorporating small UAS into the NAS based on current information?

5. How have other countries already started to incorporate UAS into their systems?

6. How will efforts in integration in the U.S. affect operations in ICAO?

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