

AU/ACSC/SCHOENBEIN/AY09

AIR COMMAND AND STAFF COLLEGE

AIR UNIVERSITY

UNMANNED AIRCRAFT SYSTEMS (UAS):
ADDRESSING THE REGULATORY ISSUES FOR NATIONAL
AIRSPACE SYSTEM (NAS) INTEGRATION

by

Michael C. Schoenbein, Maj, USAF

A Research Report Submitted to the Faculty

In Partial Fulfillment of the Graduation Requirements

Instructors: Lt Col Lance E. Mathews and Maj Joseph F. Dene

Maxwell Air Force Base, Alabama

April 2009

Distribution A: Approved for public release; distribution unlimited.

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE APR 2009		2. REPORT TYPE N/A		3. DATES COVERED -	
4. TITLE AND SUBTITLE Unmanned Aircraft Systems (UAS): Addressing the Regulatory Issues for National Airspace System (NAS) Integration				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Air Command And Staff College Air University Maxwell Air Force Base, Alabama				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES The original document contains color images.					
14. ABSTRACT Routine unmanned aircraft systems (UAS) access to the national airspace system (NAS) poses a variety of technological, regulatory, workload, and coordination challenges. This paper will focus on the ongoing effort in the United States (U.S.) to draft and implement regulatory guidance to integrate safe, routine, and efficient UAS operations in the NAS. The current Code of Federal Regulations governing unmanned aircraft operations does not adequately address the operation of this new type of aircraft. Specifically, the Federal Aviation Administration (FAA) does not allow unrestricted UAS operations in all classifications of airspace. A lack of regulatory guidance for UASs limits their operational potential and leads to a lack of airspace for UAS testing, evaluation, and real world operations. Evolving technological advancements and increased military and civilian demand have proven the need to fully integrate and capture all the regulatory requirements for UASs to meet their full potential. The end goal is to have UASs operating in the NAS transparently. Thus, UASs must be able to function seamlessly in the current air traffic system with other general, civilian, and military aircraft and comply with all the regulatory requirements that manned aircraft must meet. A detailed assessment of the current FAA regulatory guidance was performed with the intent to examine their applicability to UAS operations.					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT SAR	18. NUMBER OF PAGES 38	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

Disclaimer

The views expressed in this academic research paper are those of the author and do not reflect the official policy or position of the US government or the Department of Defense. In accordance with Air Force Instruction 51-303, it is not copyrighted, but is the property of the United States government.

Table of Contents

Disclaimer	ii
Table of Contents	iii
List of Figures	iv
List of Tables	v
Abstract	vi
Introduction.....	1
What is a Unmanned Aircraft System (UAS)?	3
Why UASs are in Demand.....	7
National Airspace System (NAS) Infrastructure	9
National Airspace Classifications.....	10
Air Traffic System (ATS).....	13
Regulatory Guidance for UAS Integration	14
Department of Transportation	14
Federal Aviation Administration	16
Title 14 Code of Federal Aviation Regulations.....	17
Current Guidance for Unmanned Operations	18
Model Aircraft	18
Moored Balloons, Kites, Unmanned Rockets, and Unmanned Free Balloons.....	20
UAS Certificate of Authorization.....	21
Conclusion	23
Notes	27
Bibliography.....	27

List of Figures

Figure 1: Conceptual UAS.....	4
Figure 2: FAA Airspace Classes.....	11
Figure 3: UASs and Airspace Classes	13

List of Tables

Table 1: Examples of UAS Classes	6
Table 2: Desired UAS Applications	8
Table 3: Airspace Classification Definitions	12

Abstract

Routine unmanned aircraft system's (UAS) access to the national airspace system (NAS) poses a variety of technological, regulatory, workload, and coordination challenges. This paper will focus on the ongoing effort in the United States (U.S.) to draft and implement regulatory guidance to integrate safe, routine, and efficient UAS operations in the NAS. The current Code of Federal Regulations governing unmanned aircraft operations does not adequately address the operation of this new type of aircraft. Specifically, the Federal Aviation Administration (FAA) does not allow unrestricted UAS operations in all classifications of airspace. A lack of regulatory guidance for UASs limits their operational potential and leads to a lack of airspace for UAS testing, evaluation, and real world operations. Evolving technological advancements and increased military and civilian demand have proven the need to fully integrate and capture all the regulatory requirements for UASs to meet their full potential. The end goal is to have UASs operating in the NAS transparently. Thus, UASs must be able to function seamlessly in the current air traffic system with other general, civilian, and military aircraft and comply with all the regulatory requirements that manned aircraft must meet. A detailed assessment of the current FAA regulatory guidance was performed with the intent to examine their applicability to UAS operations.

Introduction

“The trouble with the future is that it usually arrives before we’re ready for it.”

—Arnold H. Glasow

Aviation finds itself at another pioneering point in its evolution. On 17 December 1903, the Wright brothers, Orville and Wilbur, were generally credited with flying the first successful *manned*, controlled, powered, and sustained heavier-than-air flight.¹ During the second century of aviation, man has removed the human pilot from the aircraft and is attempting to transparently integrate UASs with manned aircraft operations in the U.S.’s complex NAS. Some experts have compared the routine use of unmanned aircraft systems (UASs) in the national airspace system (NAS) to the early days of manned aviation, where the excitement of advancing aviation rejuvenated man’s quest for exploration and created new markets, technologies, and permanently changed the transportation system of the world.

Unmanned aircraft systems are relatively new to the NAS. “The FAA uses the term UAS because it includes the unmanned aircraft and associated data links and control.”² These aerial platforms are not operated like typical general, commercial, or military aircraft with the pilot actually onboard the aircraft; pilots who operate UASs are physically separated from them. UASs can be remotely controlled or flown autonomously based on pre-programmed flight plans or through more complex air-ground stations. They range from hand-launched models weighing several-ounces, to the size of a commercial jet aircraft while encompassing a broad span of speed, altitude, and endurance capabilities.³ UASs are launched by land, air, and ship.

Historically, military UASs operate only in certain approved sections of airspace in the NAS. Specifically, the Department of Defense (DoD) operates UASs primarily in airspace known as Restricted airspace, Warning areas, and within combat zones. Restricted airspace is

set aside for dangerous military operations such as air-to-air, air-to-ground shooting, bombing, artillery fires, and military exercises involving a large volume of military aircraft with live weapons. Due to flight safety concerns, military authority schedules restricted airspace and does not allow routine access to general and commercial aviation operations.

UASs recently have received great attention for their military application of Intelligence, Surveillance, and Reconnaissance (ISR) capabilities while operating in Operation ENDURING FREEDOM and IRAQI FREEDOM combat theaters. The recent and rapid development of the military UAS industry has increased their capabilities and potential use across the civil and commercial sectors as well. UASs are considered a perfect fit for flying activities that are monotonous, repetitive, and dangerous. Operational applications such as ISR, ordinance delivery, homeland securities (border security and war on drugs and terror), scientific studies of earth, weather, oceanic, and arctic sciences, and a vast array of other commercial purposes.⁴

Have UAS operations, the newest military transformational technology started the next evolution of aircraft operations in the NAS? According to Nick Sabatini, FAA, Associate Administrator for Aviation Safety, "UAs [Unmanned Aircraft] are part of the future of aviation, and that future is on our doorstep right now. The system is in place today to accommodate the entry of new aircraft into the National Airspace System; this is nothing new for the FAA. It is our day-to-day business ... The FAA, working closely with the aviation industry, will develop safety standards and operating procedures to ensure their safe integration into the NAS."⁵

The current problem is how to safely and efficiently integrate day-to-day UAS operations into the NAS. The FAA does not yet have specific regulatory guidance to allow UASs operations in all classifications of airspace. However, UASs do meet the FAA definition of an "aircraft," which is any contrivance invented, used, or designed to navigate, or fly in, the air.⁶

Evolving technological advancements and increased military and civilian demand have proven the need to fully integrate and capture all the regulatory requirements and operational procedures to safely, routinely, and efficiently integrate UASs in the NAS. The end goal is to have UASs operating in the NAS transparently with manned aircraft. They must be able to function seamlessly in the current air traffic system with other general, civilian, and military aircraft and comply with all the regulatory requirements that manned aircraft must meet. The FAA has identified the need to develop policies and establish procedures and standards to enable the future operation of UASs in the NAS.

What is a UAS?

The extremely broad range of UASs makes their successful integration into the national airspace system (NAS) a challenge, but certainly one worth meeting.

– Nicholas Sabatini, FAA, Associate Administrator for Aviation Safety, 13 July 2006

The FAA's Aviation Safety Unmanned Aircraft Program Office, AIR-160, Interim Operational Approval Guidance, 08-01, simply states and defines a UAS as a *device* that is used, or is intended to be used, for flight in the air with no onboard pilot”.⁷ This definition of a UAS appears to be broad in scope, is a model aircraft a UAS? Currently, model aircraft are not considered UASs; however, they display some similar operating characteristics of UASs. While the Code of Federal Regulations, Title 14, Aeronautics and Space, defines an *aircraft* as a device that is used or intended to be used for flight in the air.⁸ This definition can have simplistic meanings as well. Does a child's paper airplane or kite qualify as an aircraft? Officially, no. Lastly, in Federal Aviation Regulation, Part 103, there is a precedent for calling ultralights (manned), “vehicles” instead of aircraft. Should UASs be considered vehicles instead of aircraft? There is confusion with the definition of what an aircraft is, now with the advent of

UAS operations, it will make it even more complicated to integrate them into the NAS.

UAS aerial platforms are unlike general, commercial, or military aircraft with a pilot onboard the aircraft. UASs are operated by pilots who are physically separated from them and operate (pilot) them via remote control. UASs have the ability to fly autonomously on pre-programmed flight plans or through more complex air-ground stations. These aircraft may be as rudimentary similar to a remote-controlled model aircraft used for recreational purposes or as complex as a military attack, intelligence, surveillance, or reconnaissance aircraft flying in combat airspace during war.⁹ “Unmanned aircraft include all classes of airplanes, helicopters, airships, and translational lift aircraft that have no onboard pilot. Unmanned aircraft include only those aircraft controllable in three axes and therefore, exclude traditional balloons”.¹⁰ Even though cruise missiles are unmanned and flown autonomously or via remote control, they are considered weapons and are not to be reused. Therefore, cruise missiles are not categorized as UASs.

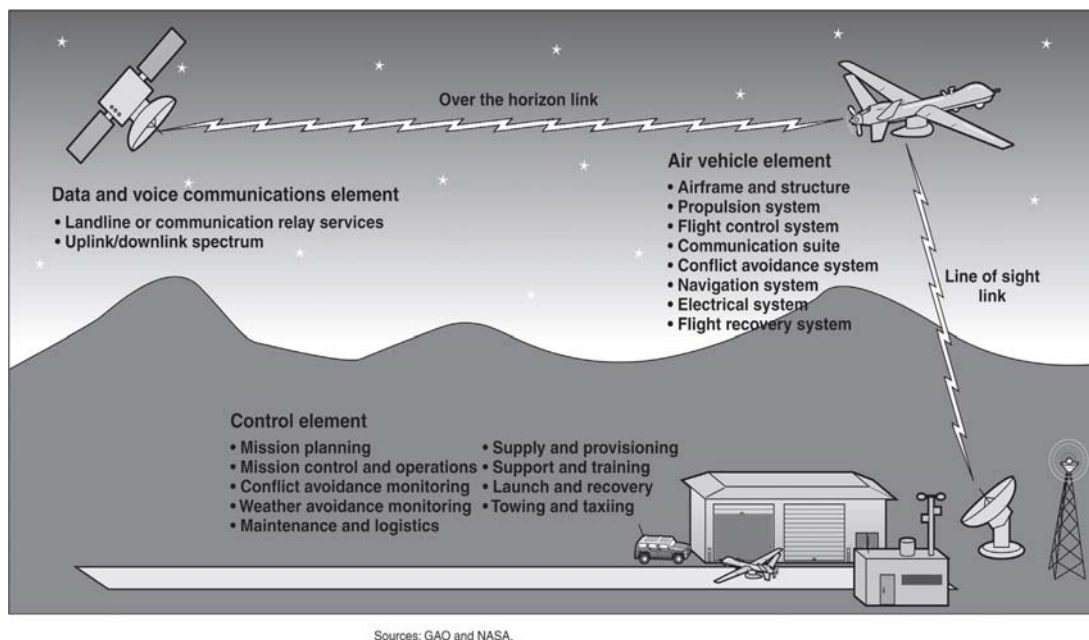


Figure 1: Conceptual UAS

The FAA has adopted the generic class, unmanned aircraft systems, originally introduced and

coined by the U.S. Navy to reflect the fact that these are not ordinary aircraft, but *systems*, including ground stations and other elements.¹¹ UAS is the newest recognized encapsulating term for unmanned aircraft; both the FAA and the U.S. Department of Defense (DoD) use this term for unmanned aircraft. However, historically, unmanned aircraft have had many names associated with their use. Unmanned aircraft have been referred to as robotic aircraft, drones, remotely piloted vehicles (RPVs), unmanned aircraft (UA), remote-controlled aircraft (RCAs), remotely operated aircraft (ROA), unmanned air vehicle systems (UAVSs), unmanned aerial vehicles (UAVs) and now UASs.¹² The official brevity code 'UAS' is relatively new to the military, civil, commerce, and educational aviation communities, but it appears to be replacing the existing term UAV. UAS is gradually becoming part of the modern-day aviation community's lexicon. "All of these unmanned aircraft and their associated terms have been a feature of aviation for much of its history, though in limited or secondary roles".¹³

Due to the diversity of UASs capabilities (just like manned aircraft), they must be individually evaluated to determine how they may be potentially classified to integrate with the NAS. UAS development comprises a diverse assortment of shapes, sizes, configurations, characteristics and capabilities. "They range in size from wingspans of six inches to 246 feet; and can weigh from approximately four ounces to over 25,600 pounds."¹⁴ Additionally UASs have diverse altitude ranges, such as the micro UASs (size of a human hand) that can operate within 10 feet of the ground surface, while high altitude UASs fly 60,000 feet above the earth's surface. UASs have a broad variance in price, they can cost as little as a couple thousand dollars to millions of dollars. Due to UAS's vast diversity in sizes and operational capabilities, it is difficult to agree upon proper regulatory aircraft (UAS) classification standards for the NAS. Each type of UAS has to be evaluated separately, with each aircraft's unique characteristics

being considered before its integration into the NAS can be accomplished.¹⁵

“When referring to UAS classes, there are numerous nomenclature used from a variety of sources, including the military, research community, manufacturers, and professional organizations. The various nomenclatures are based on a variety of parameters including mass, vehicle configuration, design, level of autonomy, operation, or military level employment.”¹⁶

Five categories of UASs seem prevalent among the FAA, commercial, civil, and military literature reviewed. The categories are Micro, Mini, Tactical, Medium Altitude (Medium Altitude Long Endurance (MALE)), and High Altitude (High Altitude Long Endurance (HALE)). A heavy UAS was included due to the potential this class could emerge in the future. Table 1 details examples of UAS’s potential classes, characteristics, and altitude parameters.

Table 1: Examples of UAS Classes

Class	Representative Aircraft	Mass In Pounds	Operating Area	Operating Altitudes
Micro		Less than 2	Local	Near surface to 500 ft
Mini		2 - 30	Local	100 - 1,000 ft
Tactical		30 - 1,000	Regional	1,500 - 18,000 ft
MALE (Medium Altitude Long Endurance)		1,000 - 30,000	Regional/National	18,000 - FL 600
HALE (High Altitude Long Endurance)		1,000 - 30,000	Regional/National International	Above FL 600
Heavy (potential)		Over 30,000	National/ International	18,000 –FL 450

Source: Hansman, J.R., and E.W. Roland, Safety Considerations for Operation of Unmanned Aerial Vehicles in the National Airspace System

Why UASs are in Demand

One aspect of our future success is the proper development and integration of unmanned aircraft systems in the Air Force. The combat contributions of unmanned aircraft systems in today's fight have surpassed all expectations and hold even greater promise for the future.

—Air Force Chief of Staff General Norton Schwartz
AFA Convention Keynote, 16 Sep 2008

In the 21st century, UAS technology and operations are greatly expanding in military and civilian applications. “The most common public use of unmanned aircraft today in the United States is by the DoD. U.S. operations in Iraq, Afghanistan and elsewhere have fueled a huge increase in unmanned aircraft demand. In Iraq alone, more than 700 unmanned aircraft are in use for surveillance and weapons delivery.”¹⁷ UASs no longer merely perform intelligence, surveillance, reconnaissance, and attack functions, although these remain their predominant missions. “In addition to the Departments of Defense (DoD) and Homeland Security (DHS), the Department of the Interior (DOI), the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA) and state and local governments are all interested in increasing their use of UAS for a range of very different purposes.”¹⁸ UASs have civil sector applications as well, to include policing activities, firefighting operations, and reconnaissance support in natural disasters when a human observer’s safety would be jeopardized. “The one thing they have in common is that their numbers and uses are growing dramatically. In the United States alone, approximately 50 companies, universities, and government organizations are developing and producing some 155 unmanned aircraft designs”.¹⁹ As UAS’s technology evolves, there appear to be countless other applications for UASs, including crop dusting, monitoring, patrolling borders, and collecting various data. Table 2 details proposed or demonstrated UAS applications.

Table 2: Desired UAV Applications

UAS APPLICATION		
MILITARY	CIVIL	COMMERCIAL
ISR	Border Management	Fisheries/Agriculture Mngt
C2/Communications	Maritime Patrol	Freight
Force Protection	Critical Infrastructure Protection	Pipeline Monitoring
Remote Sensors (EO/IR)	Domestic Counter Terrorism	Powerline Monitoring
Ordinance Delivery Systems (Hunter/Killer)	Explosive Detection Systems	Private Infrastructure Surveillance/Security
SIGINT	NBC Terrorism Response	Agriculture
Theater Air Missile Defense	Transportation Security	Aerial Photography
Combat Search and Rescue	Search & Rescue	Telecommunications Services
Psychological Ops	Crime Prevention/ Drug Interdiction	Satellite Augmentation Systems
Weather/Oceanography	Geology, Meteorology	ATC Support
Counter Narcotics (CN)	Forest Fire Monitoring	Broadcasting

UASs have advantages over manned aircraft in certain niche applications. Technology has rapidly advanced the evolution of UASs making them an important aviation platform for the U.S.'s military, civil and commercial sectors. "UAS's have the potential capability to operate far beyond manned aircraft in terms of costs and endurance and offers certain important military and commercial advantages over traditional piloted aircraft."²⁰ As the technology evolves, UASs will be cheaper to operate, their operators (human ground pilots) will be less affected by the stress and fatigue compared to onboard airborne pilots, and UASs do not put human pilots at risk. UASs are preferred for missions that are coined too "dull, dirty, or dangerous" for manned aircraft.²¹

The military and civilian application of UASs have a substantial growth potential in the next decade. "The Teal Group's 2008 market study estimates that UAV spending will more than double over the next decade from current worldwide UAV expenditures of \$3.4 billion annually to \$7.3 billion within a decade, totaling close to \$55 billion in the next ten years."²² Philip

Finnegan, third author of the new 2008 UAV [UAS] study that targeted the worldwide UAV market indicated the UAV market was "as one of the hottest areas of growth for defense and aerospace companies."²³

NAS Airspace Infrastructure

AOPA is concerned that unless these aircraft meet certification standards established by the FAA, large airspace restrictions may be necessary to segregate piloted aircraft from UAs.

—Aircraft Owners and Pilot Association

The NAS is one of the most advanced and efficient aviation systems in the world, enabling safe, orderly, and efficient air commerce in the United States. Due to the U.S.'s reliance on the NAS's infrastructure, it is considered a vital national resource. The NAS supports commerce, military operations, economic development, law enforcement, emergency response, and personal travel and leisure. "The purpose of the system is to safely facilitate air transportation and provide equitable access to both air and ground-side aviation resources."²⁴ Until recently, the infrastructure of the NAS has evolved to predominately support navigation and air commerce of "manned" aircraft operations.

"The NAS consists of a intricate network of United States' (U.S.) airspace, air navigation facilities, equipment, services, airports or landing areas, aeronautical charts, information/services, rules, regulations, procedures, technical information, manpower, and material. The NAS includes and shares jointly both civilian and military system components."²⁵ "The system is governed by United States law and the federal aviation regulations, which govern both the design and operation of aircraft within the system, as well as structures on the ground that affect air navigation."²⁶ "The system's present configuration is a reflection of the

technological advances concerning the speed and altitude capability of jet aircraft, as well as the complexity of microchip and satellite-based navigation equipment.”²⁷

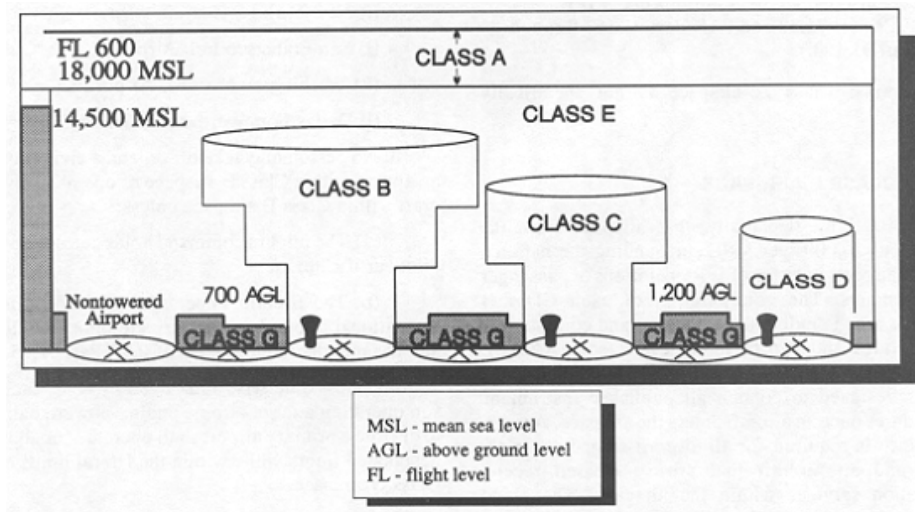
NAS workforce and infrastructure requirements are quite extensive. According to the FAA, the “NAS requires 14,500 air traffic controllers, 4,500 aviation safety inspectors, and 5,800 technicians to operate and maintain services. It has more than 19,000 airports and 600 air traffic control facilities. In all, there are 41,000 NAS operational facilities. In addition, there are over 71,000 pieces of equipment, ranging from radar systems to communication relay stations. On average, the U.S.’s dynamic NAS services about 50,000 flights each day.”²⁸

One of the foundational issues facing UAS integration is the ability to have UASs fly alongside general and commercial aviation aircraft in the dynamic and extremely complex NAS, in contrast to where they operate now, special use airspace, which includes Restricted and Warning airspaces where airliners and private pilots are not allowed to fly. The U.S. military was one of the early proponents for UAV operations in the NAS, for the purpose of repositioning aircraft between bases. To accomplish this task, the NAS infrastructure must be explored to understand the complexity of integrating UASs with manned aircraft.

National Airspace Classifications

Listed in the FAA, *Aeronautical Information Manual*, there are two categories of airspace or airspace areas that a wide variety of aircraft operates. “Regulatory (Class A, B, C, D and E airspace areas, restricted and prohibited areas); and Nonregulatory (military operations areas (MOAs), warning areas, alert areas, and controlled firing areas). Within these two categories, there are four types: Controlled, Uncontrolled, Special use, and Other airspace. The categories and types of airspace are dictated by the complexity or density of aircraft movements, nature of the operations within the airspace, level of safety required, and national and public interest.”²⁹

Figure 2 is a visual chart of the FAA airspace classes defined in Table 2.



Source: Source: FAA, Aeronautical Information Manual

Figure 2: FAA Airspace Classes

Airspace classes A, B, C, D, and E are referred to as regulated or “controlled” airspace and Class G is “uncontrolled” airspace. In controlled airspace aircraft are generally required to operate and comply with air traffic control clearances in order to assure safe, orderly, and expeditious air traffic movements. Air traffic control services, including air-to-ground communications and navigation aids are provided in controlled airspace. Uncontrolled airspace is airspace not designated as controlled, air traffic control may not be available in such airspace.

The FAA, *Aeronautical Information Manual*, defines the boundaries and weather minimums for these airspace classes.³⁰ The important aspects of airspace classification relevant to UAS operations are the general restrictiveness of each airspace class, communications and entry requirements, and separation services provided by air traffic control.³¹ Again, UASs are restricted, with exception, from operating in all classes of controlled airspace. Presently most UASs operate in Restricted airspace or within combat zones.

Table 3: Airspace Classification Definitions

Class A Airspace	Generally, that airspace from 18,000 feet MSL up to and including FL 600, including the airspace overlying the waters within 12 nautical miles of the coast of the 48 contiguous States and Alaska; and designated international airspace beyond 12 nautical miles of the coast of the 48 contiguous States and Alaska within areas of domestic radio navigational signal or ATC radar coverage, and within which domestic procedures are applied.
Class B Airspace	Generally, that airspace from the surface to 10,000 feet MSL surrounding the nation's busiest airports in terms of IFR operations or passenger enplanements. The configuration of each Class B airspace area is individually tailored and consists of a surface area and two or more layers (some Class B airspace areas resemble upside-down wedding cakes), and is designed to contain all published instrument procedures once an aircraft enters the airspace. An ATC clearance is required for all aircraft to operate in the area, and all aircraft that are so cleared receive separation services within the airspace. The cloud clearance requirement for VFR operations is "clear of clouds."
Class C Airspace	Generally, that airspace from the surface to 4,000 feet above the airport elevation (charted in MSL) surrounding those airports that have an operational control tower, are serviced by a radar approach control, and that have a certain number of IFR operations or passenger enplanements. Although the configuration of each Class C airspace area is individually tailored, the airspace usually consists of a 5 NM radius core surface area that extends from the surface up to 4,000 feet above the airport elevation, and a 10 NM radius shelf area that extends no lower than 1,200 feet up to 4,000 feet above the airport elevation.
Class D Airspace	Generally, that airspace from the surface to 2,500 feet above the airport elevation (charted in MSL) surrounding those airports that have an operational control tower. The configuration of each Class D airspace area is individually tailored and when instrument procedures are published, the airspace will normally be designed to contain the procedures.
Class E Airspace	Generally, if the airspace is not Class A, Class B, Class C, or Class D, and it is controlled airspace, it is Class E airspace.
Class G Airspace	Class G airspace (uncontrolled) is that portion of airspace that has not been designated as Class A, Class B, Class C, Class D, or Class E airspace.

Source: FAA, *Aeronautical Information Manual*

Large segments of controlled and uncontrolled airspace have been designated as special use Airspace (SUA). Operations in SUA are considered hazardous to civil aircraft. SUA is divided into prohibited, restricted, warning, military operations, and alert areas as described in Table 4.

Table 4: Airspace Classification Definitions

Type	Description
Prohibited	Areas where, for reasons of national security, the flight of an aircraft is not permitted are designated as prohibited areas. Prohibited areas are depicted on aeronautical charts. For example, a prohibited area (P-56) exists over the White House and U.S. Capitol.
Restricted	In certain areas, the flight of aircraft, while not wholly prohibited is subject to restrictions. These designated often have invisible hazards to aircraft, such as artillery firing, aerial gunnery, or guided missiles. Aircraft operations in these areas are prohibited during times when it is "active."
Warning	A warning area contains many of the same hazards as a restricted area, but because it occurs outside of U.S. airspace, aircraft operations cannot be legally restricted within the area. Warning areas are typically established over international waters along the coastline of the United States.
Alert	Alert areas are shown on aeronautical charts to provide information of unusual types of aerial activities such as parachute jumping areas or high concentrations of student pilot training.
Military Operations Area	Military operations areas (MOA) are blocks of airspace in which military training and other military maneuvers are conducted. MOA's have specified floors and ceilings for containing military activities. VFR aircraft are not restricted from flying through MOAs while they are in operation, but are encouraged to remain outside of the area.

Source: FAA, *Aeronautical Information Manual*

Figure 3 depicts DoD UASs operating in their respective NAS classifications:

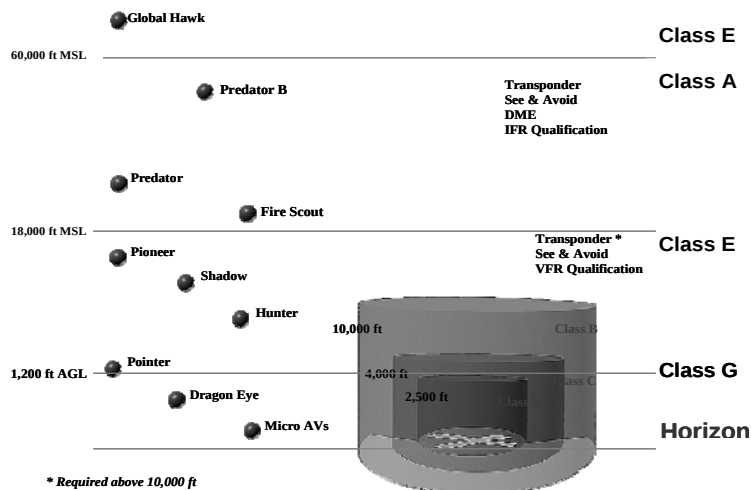


Figure 3: UASs and Airspace Classes

Source: DoD 2005 UAS Roadmap, 2005-2030

Air Traffic System (ATS)

The FAA, an agency under the U.S. Department of Transportation is responsible for and manages the air traffic control (ATC) system. The ATC system's primary purpose is to prevent a collision between aircraft operating in the NAS and to organize and expedite the flow of traffic, and to provide support for National Security and Homeland Defense. ATC handles aircraft operating in the NAS by partitioning the airspace and delegating individual airspace sectors to various ATC facilities. All of the ATC facilities provide separation or informational services to all users of the ATS to varying degrees. ATC towers (most familiar to the traveling public), enroute radar centers, terminal radar approach control facilities and flight service centers are responsible for separating over 50,000 manned aircraft flights each day.

When considering integrating UAS operations into the NAS and ATS, there are two technology areas that require addressing, UAS vehicle control and traffic surveillance and avoidance. By removing the pilot from direct operation of the vehicle, UASs must provide reliable and accurate

control and traffic surveillance methods that still provide the equivalent level of safety of manned aircraft.

Regulatory Guidance for UAS Integration

“Because of the extraordinarily broad range of unmanned aircraft types and performance, the challenges of integrating them safely into the NAS continue to evolve. The certification and operational issues described herein highlight the fact that there is a missing link in terms of technology today that prevents these aircraft from getting unrestricted access to the NAS.”

– Nicholas Sabatini, FAA, Associate Administrator for Aviation Safety, September 2006

This section outlines the statutory basis for the Department of Transportation and FAA’s authority for the effective administration of the transportation and aviation programs of the United States Government. The FAA, under the Department of Transportation, has taken initial steps to regulate UAS operations and ensure the safety of all users of the NAS and the general public. However, guidance is still limited in scope and lacks the specific regulatory procedures for all the different UAS types and capabilities to function seamlessly in the current air traffic system with other general, civilian, and military aircraft.

Department of Transportation

“The Department of Transportation is an executive department of the United States Government at the seat of government. The head of the Department is the Secretary of Transportation. The President appoints the Secretary, by and with the advice and consent of the Senate.”³² The part of federal law that addresses regulating the U.S. transportation is Title 49 of the United States Code, referred to as 49 U.S.C. Title 49, Subtitle I, governs the Department of Transportation. The FAA’s authority resides in 49 U.S.C. Subtitle I-Department of Transportation, Subtitle VII-Aviation Programs. 49 U.S.C. titled-Transportation, Subtitle I-Department of Transportation-Chapter 1, Organization, contains the purpose and organizational structure of the Department of Transportation. Under Chapter 1, Subtitle I- *Purpose*, outlines the

strategic transportation objectives of the U.S and states: “The national objectives of general welfare, economic growth and stability, and security of the United States require the development of transportation policies and programs that contribute to providing fast, safe, efficient, and convenient transportation at the lowest cost consistent with those and other national objectives, including the efficient use and conservation of the resources of the United States.”³³

49 U.S.C. Transportation, Subtitle I-Department of Transportation-Chapter 1, Organization, § 101, *Purpose*, details the authority and responsibility for the Department of Transportation:

Department of Transportation is necessary in the public interest and to—

1. ensure the coordinated and effective administration of the transportation programs of the United States Government
2. make easier the development and improvement of coordinated transportation service to be provided by private enterprise to the greatest extent feasible;
3. encourage cooperation of Federal, State, and local governments, carriers, labor, and other interested persons to achieve transportation objectives;
4. stimulate technological advances in transportation, through research and development or otherwise;
5. provide general leadership in identifying and solving transportation problems; and
6. develop and recommend to the President and Congress transportation policies and programs to achieve transportation objectives considering the needs of the public, users, carriers, industry, labor, and national defense.”³⁴

49 U.S.C. titled-Transportation, Subtitle VII-Aviation Programs, Part A-Air Commerce and Safety, subpart i-General, Chapter 401-General Provisions, § 40101. Policy, contains the economic regulatory guidance the secretary of transportation is charged with considering:

The **Secretary of Transportation shall** consider the following matters, among others, as being in the public interest and consistent with public convenience and necessity:

- (1) assigning and maintaining safety as the highest priority in air commerce.
- (2) before authorizing new air transportation services, evaluating the safety implications of those services.
- (3) preventing deterioration in established safety procedures, recognizing the clear intent, encouragement, and dedication of Congress to further the highest degree of safety in air transportation and air commerce, and to maintain the safety vigilance that has evolved in air transportation and air commerce and has come to be expected by the traveling and shipping public.
- (7) developing and maintaining a sound regulatory system that is responsive to the needs of the public and in which decisions are reached promptly to make it easier to adapt the air transportation system to the present and future needs of—
 - (A) the commerce of the United States;
 - (B) the United States Postal Service; and
 - (C) the national defense³⁵

Clearly, integrating UAS operations into the NAS is within the scope of the Department of Transportation's authority and responsibilities. As noted in U.S.C. 49, Subtitle I-Transportation and VII-Aviation Programs, the Secretary of Transportation is charged with leadership, regulatory development, research and development, national defense efforts, and to maintain safety as the highest priority in air commerce.

Federal Aviation Administration

The Federal Aviation Act of 1958, Pub.L. 85–726, §§ 301(a), (b), 302(a), (b), 72 Stat, created the Federal Aviation Agency, later renamed the Federal Aviation Administration and aligned it as an administrative agency within the Department of Transportation. The Federal Aviation Act of 1958 gave the FAA the authority and responsibility to regulate the air transportation system.

The FAA Administrator acts as the “single manager” of the NAS to develop, operate, and regulate a common system of air traffic control, navigation, and airspace for both civil and military aircraft in the interest of safety and efficiency. U.S.C. 49, 40101. *Policy* charges the FAA administrator with the same responsibilities as the Secretary of Transportation with the added task of “enhancing safety.” U.S.C. 49, 40101. *Policy* states:

(d) Safety Considerations in Public Interest.— In carrying out subpart III of this part and those provisions of subpart IV applicable in carrying out subpart III, **the Administrator shall** consider the following matters, among others, as being in the public interest:

- (1) assigning, maintaining, and enhancing safety and security as the highest priorities in **air commerce**.
- (2) regulating air commerce in a way that best promotes safety and fulfills national defense requirements.
- (3) encouraging and developing civil aeronautics, including new aviation technology.
- (4) controlling the use of the navigable airspace and regulating civil and military operations in that airspace in the interest of the safety and efficiency of both of those operations.
- (5) consolidating research and development for air navigation facilities and the installation and operation of those facilities.
- (6) developing and operating a common system of air traffic control and navigation for military and civil aircraft.
- (7) providing assistance to law enforcement agencies in the enforcement of laws related to regulation of controlled substances, to the extent consistent with aviation safety.³⁶

It is important to note the FAA is charged to maintain safety *in air commerce*, not merely in aviation. “Air commerce means foreign air commerce, interstate air commerce, the transportation of mail by aircraft, the operation of aircraft within the limits of a Federal airway, or the operation of aircraft that directly affects, or may endanger safety in, foreign or interstate air commerce.”³⁷ Future UASs will operate within the limits of a federal airway and could potentially affect or endanger safety in foreign or interstate air commerce. Operators of UASs want them to be able to fly simultaneously among all users of the NAS.

Title 49-Transportation, Subtitle VII-Aviation Programs, Part A-Air Commerce, subpart iii-Safety, Chapter 447-Safety Regulation, § 44701. Promoting Safety directs the FAA Administrator to promote safe flight of civil aircraft in air commerce by prescribing—

(d) Considerations and Classification of Regulations and Standards—When prescribing a regulation or standard under subsection (a) or (b) of this section or any of sections 44702–44716 of this title, the Administrator shall—

(1) consider—

(A) the duty of an air carrier to provide service with the highest possible degree of safety in the public interest; and

(B) differences between air transportation and other air commerce; and

(2) classify a regulation or standard appropriate to the differences between air transportation and other air commerce.³⁸

Since the military and civilian application of UASs have a substantial growth potential in the next decade, the FAA will need to apply the same rigorous regulatory standards codified in federal law applicable to manned aircraft to UAS operations as well.

Title 14 Code of Federal Aviation Regulations

The Code of Federal Regulation, Title 14-Space and Aeronautics, Chapter 1—Federal Aviation Administration, Department of Transportation contain Federal Aviation Rules (FARs) detailing the governing rules for aviation in the U.S. FARs are designed to promote and regulate aviation safety for users of the NAS and the general public. Chapter 1, Subchapter F-Air Traffic and General Operating Rules, Part 101 prescribes the applicability, waivers, operating

limitations, notice requirements and special provisions for moored balloons and kites, unmanned rockets and unmanned free balloons in the NAS.³⁹ These unmanned operations will be discussed later. UASs presently cannot operate in all classes of airspace controlled by ATC. UASs are not compliant with various sections of Title 14, Code of Federal Regulations (14 CFR) and are required to meet these regulatory standards. Since UASs do not have an on-board pilot and are required to meet “see-and-avoid” provisions of 14 CFR 91.113, *Right-of-Way Rules: Except Water Operations*, UASs must have comparable “sense-and avoid” capabilities.

Current Guidance for Unmanned Operations

There are already unmanned aircraft operating in the NAS flanking manned operations. The FAA has regulated or crafted guidance for model aircraft, unmanned kites, rockets, and balloons so they can safely co-exist with manned aircraft operations. Unmanned kites, rockets, and balloons are regulated by FARs, while model aircraft are operated under FAA advisory circular guidelines and private recreational organizational guidelines. Important to note, model aircraft have some of the same flight characteristics as micro and mini military and civilian UASs; however, they are not formally regulated. Lastly, other UAS operations (like military UASs) must be approved by a Certificate of Authorization (COA) authorizing an exemption to FAA regulations. The regulatory and advisory guidance for these unmanned operations will be analyzed to provide insight for possible recommendations for overarching UAS regulatory standards.

Model Aircraft

Modeling enthusiasts (modelers) fly model aircraft, also known as radio-controlled (RC) aircraft within visual line-of-sight of the operator. Model aircraft consist of many different types of aircraft models to include fixed wing and helicopters and may use a wide variety of propulsion

methods. “A model aircraft shall be defined as a non-human-carrying device capable of sustained flight in the atmosphere...and is intended to be used exclusively for recreational or competition activity.”⁴⁰ Even though model aircraft fly within the NAS, model aircraft’s flight activities in the NAS have not been formally regulated by directives. The FAA attempts to regulate model aircraft activities through advisory circular guidance and voluntary compliance with private model aircraft organizations due to the lack of risk to NAS aviation. The Academy of Model Aeronautics (AMA) is the world’s largest model aviation organization and the official body for model aviation in the U.S.⁴¹ This private organization has prompted voluntary flight safety compliance through their guidelines for AMA membership, directives, and competition rules.

To gain voluntary aviation compliance or to distribute key important aviation information, the FAA uses the Advisory Circular (AC) System. “The AC provides guidance such as methods, procedures, and practices acceptable to the FAA Administrator for complying with regulations and grant requirements. ACs may also contain explanations of regulations, other guidance material, best practices, or information useful to the aviation community. They do not create or change a regulatory requirement.”⁴²

FAA Advisory Circular 91-57, dated 9 June 1981, outlines, and encourages voluntary compliance with, safety standards for model aircraft operators. “Modelers, generally, are concerned about safety and do exercise good judgement when flying model aircraft. However, model aircraft can at times pose a hazard to full-scale aircraft in flight and to persons and property on the surface.”⁴³ The advisory circular states that the aircraft should be operated at an altitude less than 400 ft, away from populated and noise sensitive areas, and not within 3 miles of an airport without notifying the airport operator, air traffic control tower or flight service

station.⁴⁴ It also states that model aircraft should give the right-of-way to and avoid flying in the vicinity of full-scale aircraft.⁴⁵

The AMA has an Academy of Model Aeronautics, National Model Aircraft Safety Code that incorporates the provisions in AC 91-57 for its members to follow. However, this code only is required to be adhered to, if you are a member of AMA or are operating your model aircraft at an AMA sponsored event. If you are not a member of the AMA, there is no FAA mandatory regulation for modelers to follow, only voluntary FAA advisory circular guidance. Since there are no FAA directives to regulate model aircraft activities, this identifies a lack of regulatory directives for model aircraft, thus creating a potential flight safety breach for these type of operations in the NAS.

Moored Balloons, Kites, Unmanned Rockets, and Unmanned Free Balloons

FAR, Part 101 prescribes rules that govern the operation of moored balloons, kites, unmanned rockets, and unmanned free balloons. Subpart A lists general requirements, Subpart B governs unmanned balloons and kites, Subpart C, unmanned rockets, and Subpart D, unmanned free balloons. FAR, Part 101 sets prescribed guidance for these three types of unmanned aircraft focusing on risk mitigation. By addressing these unmanned aircraft's primary applicability and notification standards, and hazardous operational guidance, the FAA enhances flight safety for all users of the NAS and provides protection of personnel on the ground. Subpart A, § 101.7, Hazardous operations states, "(a) No person may operate any moored balloon, kite, unmanned rocket, or unmanned free balloon in a manner that creates a hazard to other persons, or their property, and (b) No person operating any moored balloon, kite, unmanned rocket, or unmanned free balloon may allow an object to be dropped therefrom, if such action creates a hazard to other persons or their property."⁴⁶

The FAA's regulatory requirements for moored balloons, kites, unmanned rockets, and unmanned free balloons achieve the appropriate level of safety by restricting the following: (1) classifications of airspace they are allowed to operate, (2) ensuring their operations are not conducted in the vicinity of densely populated areas, (3) setting specific meteorological conditions and day and night visibility requirements, (4) operational notification timelines to airport operators, air traffic control facilities, or flight service stations, (5) construction and materials used to make these unmanned aircraft, and (6) increased airborne visibility requirements so manned aircraft can avoid these unmanned objects, without requiring the objects to avoid manned aircraft. All these FAA requirements are in place so these aircraft can safely operate with other manned aircraft operations in the NAS.

UAS Certificate of Authorization

On March 2008, the FAA's Aviation Safety Unmanned Aircraft Program Office (UAPO) published Interim Operational Approval Guidance 08-01, *Unmanned Aircraft Systems Operations in the U. S. National Airspace System*. This document provides guidance to determine if unmanned aircraft systems (UAS) may be allowed to conduct flight operations in the NAS. "These procedures are applicable for operations in the contiguous United States, Alaska, Hawaii, and the Flight Information Regions delegated to the United States and areas where the FAA is the air traffic control service provider."⁴⁷

If operators of UASs desire to conduct operations outside of active Restricted, Prohibited, Warning Area airspace, or inside buildings or structures (not considered part of the NAS), the applicant must obtain specific authorization through the UAPO to conduct UAS operations in the NAS.⁴⁸ These UAS operators are obligated to obtain a Certificate of Waiver or Authorization (COA) or the issuance of a special airworthiness certificate (normally issued in an experimental category). "The applicability and process to be used in a UAS operational approval is dependent on

whether the applicant is a civil user or a public user. A public user is one that is intrinsically governmental in nature (i.e., federal, state, and local agencies). Public applicants should utilize the COA application process. Civil applicants (private industry) must apply for an airworthiness certificate.”⁴⁹

For civil UAS operations, applicants may obtain a Special Airworthiness Certificate, Experimental Category. The applicant must demonstrate their UAS can operate safely within an assigned flight test area and cause no harm to the public.⁵⁰ The applicants must be able to describe how their system is designed, constructed and manufactured; including engineering processes, software development and control, configuration management, and quality assurance procedures used, along with how and where they intend to fly.⁵¹ If the FAA determines the UAS design, construction, and capabilities do not present an unreasonable safety risk, the FAA will issue a Special Airworthiness Certificate in the Experimental Category with operating limitations applicable to the particular UAS.⁵²

“For public UAS operations, the FAA issues a COA permitting public agencies and organizations to operate a particular UAS, for a particular purpose, in a particular area. The FAA works with these organizations to develop conditions and limitations for UA operations to ensure they do not jeopardize the safety of other aviation operations. The objective is to issue a COA with terms that ensure an equivalent level of safety as manned aircraft.”⁵³ By a review instead of regulation process, the same mechanisms for safety that are enforced for manned aircraft are also enforced for UASs. Sample COA application requirements:

1. Proponent information, point of contact
2. Operational description of the intended flight operation including the classification of the airspace to be utilized
3. UAS description
4. Flight performance characteristics
5. Airworthiness
6. Communications procedures, i.e., lost link, lost comm., emergency, frequency

7. Avionics equipment, lightning
8. Spectrum analysis approval
9. Electronic and visual surveillance/detection capability
10. Location, destination, routing information
11. Flight crew qualifications
12. Special circumstances, UAS COA status history

Currently, UAS operations in the NAS are considered on a case-by-case basis and COA evaluation may take months to gain approval. COAs are typically issued for a period of up to 1 year, but may be issued for a lesser duration if requested or deemed appropriate. This process is established to ensure a conformist approach towards safety for unmanned flight operations, personnel and property on the ground until regulatory directives are in place.

Conclusion

Due to the demand for UAS integration of the NAS, the broad diversity of UAS's sizes, configurations, characteristics, and performance and equipment capabilities generates a tremendous challenge for the FAA and the aviation community to accomplish.⁵⁴ This assimilation will truly be an evolutionary process that will most likely span over the next decade or longer. Multiple efforts must be simultaneously accomplished and in lockstep phases to integrate UASs. A three-pronged approach consisting of regulatory guidance, technology advancement, and certification criteria will foster the unrestricted access to the NAS. Until then, the FAA, must ensure flight safety by separating UASs from manned aircraft operations.

Current Approach

The one major competing approach to integrating UASs into the NAS is through creating large restricted areas or blocked off airspace segments to partition and separate UASs from other air traffic. To date, this has been a viable approach to ensure safety among manned and unmanned aircraft considering the limited number of UAS operations within the system. However, the FAA must anticipate and plan for the future expansion and demand for UASs.

If they do not, creating large amounts of restricted airspace or blocked off airspace could have potential severe operational and economic consequences for commercial airline routes, locally based and transient aircraft , as well as for underlying airports and the businesses.⁵⁵

“Creating large restricted areas to segregate unmanned aircraft systems (UAS) from other air traffic will have negative operational and economic consequences, and it is not the best way to ensure safety, Aircraft Owners and Pilot Association (AOPA) told the Air Force in formal comments. The comments, filed Nov. 11, were written in response to a plan to create a large complex of restricted areas in northern North Dakota. The plan marks the first time the FAA will consider creating a restricted area solely for the use of UAS.”⁵⁶

“We have concerns about any plan that would close airspace to civilian traffic so UAS can fly,” said Pete Lehmann, AOPA manager of air traffic services. “Surveys have shown that 77 percent of our members, or more than half the U.S. pilot population, would rather fly with certified unmanned aircraft rather than be subject to flight restrictions.”⁵⁷

“In its comments, AOPA recommended alternative means of ensuring safety for both piloted and unmanned aircraft, including using ground spotters or chase aircraft, and allowing operations in positively controlled airspace above Flight Level 180—all of which could be enacted immediately, without the long wait required to establish a restricted area.”⁵⁸

Regulatory Considerations

One of the first steps to reach this goal is to begin crafting regulatory directives addressing current and future UAS classification. With the varied sizes, weights and performance and equipment capabilities it is obvious a “one size fits all” policy for classification standards will not adequately or accurately address the integration of all public and civil UAS models. As mentioned previously in this paper, there are suggestions for UAS classification considerations

based on current UAS models, i.e., Micro, Mini, Tactical, MALE, HALE and Heavy. These UAS potential classifications would require them to be harmonized with existing FAA classification standards--Class, Category, and Type. An example would be a tactical UAS that complies with the existing classification of a small airplane (Class, less than 12,500 pounds defined under Part 23) categorized as Primary, Normal, Utility, Aerobatic, Limited, Restricted, or Transport. Another potential example would be public or civil Micro or Mini UASs that require airspace access outside Restricted Areas and Warning Areas. Remote-controlled (RC) model airplanes presently operate without a COA in this same airspace. The FAA could evaluate rewriting and re-titling AC 91-57, *Model Aircraft Operating Standards* to meet both UAS and RC requirements.

Technology Advancement

The primary regulatory challenge for routine UAS integration foundationally lies within the future advancement of technology. UASs having a lack of a “sense and avoid” capability that has the same equivalent level of safety that “see and avoid” provides for manned aircraft operations. The UAS requirement for routine access to the NAS is UAS compliance with 14 CFR 91.113, Right-of-Way Rules: Except Water Operations. This contains the regulatory requirement for the capability of “see-and-avoid,” and is the principal constraint for routine UAS operations in the majority of airspace classes. Pilots are required to avoid other aircraft and yield the right-of way in accordance with 14 CFR 91.113. Pilots comply with this requirement by visually scanning the horizon with their eyes and other equipment sensors to comply with “see-and-avoid” requirements to avoid a potential ground or air conflict. The technological efforts should be focused on how UAS can “sense-and avoid” traffic on the ground and in the air.

Certification

To ensure flight and public safety, all UASs need to meet certification or regulatory criteria, just as manned aircraft. By regulating UAS certification, the FAA Administrator fosters the development of civil and military aeronautics through embracing and advancing new UAS technology. UAS certification also will ensure UASs do not negatively impact the NAS by causing undue flight restrictions or large segments of airspace being blocked from civil and commercial aviation. Certification of UASs is in the best interest of safety and efficiency of both military and civil aircraft operations.

The NAS, is a vital resource to the nation and must be able to simultaneously support both manned and unmanned aircraft operations to meet our national transportation system and defense objectives. From federal law, it is clear that the FAA Administrator has the authority and responsibility to act to ensure the safe integration of UASs with manned aircraft into the NAS. FAA Associate Administrator for Aviation Safety, Mr. Nick Sabatini, said, “that UAS should do no harm,” when referring to their potential integration into the NAS. The standards for design, construction, maintenance and operation of UAS must be developed to the point where they operate with the same high level of safety we all expect of aviation before they are allowed unrestricted access to the NAS. Several methods are currently used to ensure the safety of unmanned aircraft depending upon the nature of risk posed by UAS operations and their associated systems. The current established rules governing UAS operations are limited in scope and to achieve routine and transparent UAS operations in the NAS, it is compulsory to push beyond the initial COA process and regulate UAS operations based on current manned aircraft regulatory directives. UAS regulation will ensure the FAA’s highest priority in air commerce—safety!

Notes

- ¹ Smithsonian Institution, *The Wright Brothers, The Invention of the Aerial Age*
- ² FAA Home page, UAS, FAA.gov Home
- ³ FAA, *Meeting the Challenge, Unmanned Aircraft Systems*,8
- ⁴ FAA, *Meeting the Challenge, Unmanned Aircraft Systems*,8
- ⁵ FAA Home page, Unmanned Aircraft Program Office (UAPO)
- ⁶ Code of Federal Regulation, Title 14, Part 1, Definitions
- ⁷ FAA, *Unmanned Aircraft Systems Operations in the U. S. National Airspace System*, 3
- ⁸ Code of Federal Regulation, Title 14, Part 1, Definitions
- ⁹ FAA, Department of Transportation, Docket No. FAA-2006-25714
- ¹⁰ FAA, *Unmanned Aircraft Systems Operations in the U. S. National Airspace System*, 4
- ¹¹ FAA, UAS, FAA.gov Home
- ¹² G. Goebel, *Unmanned Aerial Vehicles*, Introduction
- ¹³ G. Goebel, *Unmanned Aerial Vehicles*, Introduction
- ¹⁴ FAA, DOT, *Unmanned Aircraft Operations in the National Airspace System*, 1
- ¹⁵ N. Sabatini, Unmanned Aircraft Systems in Alaska and the Pacific Region: A Framework for the Nation,1
- ¹⁶ Hansman, J.R., and E.W. Roland, *Safety Considerations For Operation Of Unmanned Aerial Vehicles In The National Airspace System*, 36-37
- ¹⁷ FAA, DOT, *Unmanned Aircraft Operations in the National Airspace System*, 2
- ¹⁸ N. Sabatini, Unmanned Aircraft Systems in Alaska and the Pacific Region: A Framework for the Nation, 2
- ¹⁹ FAA, DOT, *Unmanned Aircraft Operations in the National Airspace System*, 2
- ²⁰ FAA, *Meeting the Challenge, Unmanned Aircraft Systems*,8
- ²¹ Briefing, *Unmanned Aircraft Systems – UAS Enabling America’s Next Generation of Aviation Vehicles*, slide 5
- ²² Teal Group Corporation, *Teal Group Predicts Worldwide UAV Market Will Reach Nearly \$55Billion*
- ²³ Teal Group Corporation, *Teal Group Predicts Worldwide UAV Market Will Reach Nearly \$55Billion*
- ²⁴ Hansman, J.R., and E.W. Roland, *Safety Considerations For Operation Of Unmanned Aerial Vehicles In The National Airspace System*, 23
- ²⁵ FAA-Handbook 8083-15A, *Instrument Flying Handbook*,8-1
- ²⁶ Hansman, J.R., and E.W. Roland, *Safety Considerations For Operation Of Unmanned Aerial Vehicles In The National Airspace System*, 23
- ²⁷ FAA-Handbook 8083-15A, *Instrument Flying Handbook*,8-1
- ²⁸ FAA. NAS 6 Toolset
- ²⁹ FAA, *Aeronautical Information Manual*, Chapter 3-1-1
- ³⁰ FAA, *Aeronautical Information Manual*, Chapter 3
- ³¹ Hansman, J.R., and E.W. Roland, *Safety Considerations For Operation Of Unmanned Aerial Vehicles In The National Airspace System*, 25
- ³² 49 U.S.C. §102 (a) (b) (c)
- ³³ 49 U.S.C. §101 (a)
- ³⁴ 49 U.S.C. §101 (b) (1)-(6)
- ³⁵ 49 U.S.C. §40101 (a) (1)-(7)
- ³⁶ 49 U.S.C. §101 (d) (1)-(7)
- ³⁷ 49 U.S.C. §40102 (a) (3)
- ³⁸ [49 U.S.C. §40102](#)
- ³⁹ Title 14 of the Code of FARs, Part 101
- ⁴⁰ Academy of Model Aeronautics, publication page, National Model Safety Code, 1
- ⁴¹ Academy of Model Aeronautics, publication page
- ⁴² FAA, Advisory Circular System, 1
- ⁴³ FAA, Advisory Circular, 91-57
- ⁴⁴ FAA, Advisory Circular, 91-57
- ⁴⁵ FAA, Advisory Circular, 91-57
- ⁴⁶ Title 14 of the Code of FAR, Part 101

- ⁴⁷ FAA, *Unmanned Aircraft Systems Operations in the U. S. National Airspace System*, 4
- ⁴⁸ FAA, *Unmanned Aircraft Systems Operations in the U. S. National Airspace System*, 4
- ⁴⁹ FAA, *Unmanned Aircraft Systems Operations in the U. S. National Airspace System*, 5
- ⁵⁰ FAA, Home, Aircraft, Design Approvals. *Unmanned Aircraft Systems (UAS) Certifications and Authorizations*
- ⁵¹ FAA, Home, Aircraft, Design Approvals. *Unmanned Aircraft Systems (UAS) Certifications and Authorizations*
- ⁵² FAA, Home, Aircraft, Design Approvals. *Unmanned Aircraft Systems (UAS) Certifications and Authorizations*
- ⁵³ FAA, Home, Aircraft, Design Approvals. *Unmanned Aircraft Systems (UAS) Certifications and Authorizations*
- ⁵⁴ AOPA, *Regulatory Brief: Unmanned Aircraft Systems*
- ⁵⁵ AOPA, *Airspace restrictions for UAS a concern*
- ⁵⁶ AOPA, *Airspace restrictions for UAS a concern*
- ⁵⁷ AOPA, *Airspace restrictions for UAS a concern*
- ⁵⁸ AOPA, *Airspace restrictions for UAS a concern*

Bibliography

- Academy of Model Aeronautics website. <http://www.modelaircraft.org/>. Accessed: (15 November 2008).
- Aircraft Owners and Pilots Association, Government Advocacy, *Airspace restrictions for UAS a concern*. <http://www.aopa.org/whatsnew/region/2008/081113nd.html>. Access: (9 February 2009)
- Aircraft Owners and Pilots Association, *Regulatory Brief: Unmanned Aircraft Systems*. <http://www.aopa.org/whatsnew/regulatory/unmanned.html>. Accessed: (9 February 2009).
- Briefing. 30th Annual FAA Aviation Forecast Conference, Washington, DC. Subject: *Unmanned Aircraft Systems – UAS Enabling America’s Next Generation of Aviation Vehicles*, 18 March 2005.
- Briefing. Cabanya, Robert (Bob), President & CEO, Unmanned Aerial System, Inc. Subject: *FAA Forecast Conference*, 11 March 2008.
- Briefing. Pitts, Michael J., Director, UAS Program Office, U.S. Customs and Border Protection Office of CBP Air and Marine. Subject: *CBP Air and Marine, FAA UAS Tech Conference, January 2007*.
- Briefing. Tarbert, Bruce, NAS Integration Team Lead Unmanned Aircraft Program Office, AIR-160. Subject: *Unmanned Aircraft Systems, Charting the path to the Future*, 11 January, 2007.
- Code of Federal Regulations (CFR), The Federal Register. <http://www.archives.gov/federal-register/cfr/> (accessed 15 Nov 2008).
- Code of Federal Regulations, Title 14, Part 1, Definitions, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=0d6e206778d1319f5dadbb895b27c4852&rgn=div8&view=text&node=14:1.0.1.1.1.0.1.1&idno=14> Accessed: (26 January 2009)
- Federal Aviation Administration. <http://www.faa.gov>. Accessed: (15 November 2008).
- Federal Aviation Administration Advisory Circular, “*Model Aircraft Operating Standards*” AC 91-57, June 9, 1981.
- Federal Aviation Administration, Aeronautical Information Manual, *Official Guide to Basic Flight Information and ATC Procedures*, http://www.faa.gov/airports_airtraffic/air_traffic/publications/ATpubs/AIM/, 14 Feb 2008. Accessed: (28 January 2008).

Federal Aviation Administration. Aviation Safety Unmanned Aircraft Program Office, AIR-160, Interim Operational Approval Guidance, 08-01, *Unmanned Aircraft Systems Operations in the U. S. National Airspace System*, March 13, 2008. Accessed: (26 November 2008).

Federal Aviation Administration, Department of Transportation, *Advisory Circular System*, 31 May 2002. [http://www.airweb.faa.gov/regulatory_and_guidance_library/rgorders.nsf/0/19bdd0e37bd5717c86256bcf006c4b7f/\\$FILE/1320.46c.pdf](http://www.airweb.faa.gov/regulatory_and_guidance_library/rgorders.nsf/0/19bdd0e37bd5717c86256bcf006c4b7f/$FILE/1320.46c.pdf). Accessed: (28 January 2009).

Federal Aviation Administration, Department of Transportation, Docket No. FAA-2006-25714, *Unmanned Aircraft Operations in the National Airspace System*, 7 February 2007.

Federal Aviation Administration. “*FAA Flight Plan 2008-2012*.” <http://www.faa.gov/AboutFAA/Plans.cfm>. Accessed: (15 November 2008).

Federal Aviation Administration. Home, Aircraft, Design Approvals. *Unmanned Aircraft Systems (UAS) Certifications and Authorizations*. http://www.faa.gov/aircraft/air_cert/design_approvals/uas/cert/. Accessed: (26 January 2009).

Federal Aviation Administration. Notice N 8700.25. “*Inquiries Related to Unmanned Aerospace Vehicle Operations*.” October 10, 2003. (<http://www.ihsaviation.com/FAA/N8700.25.pdf>)

Federal Aviation Administration. NAS 6 Toolset. <http://www.nas-architecture.faa.gov/nas/Search/home.cfm>. Accessed: (27 January 2009).

Federal Aviation Administration. Order 7610.4K. *Special Military Operations*. February 19 2004.

Federal Aviation Administration. Order 8040.4. *Safety Risk Management*. June 26 1998.

Federal Aviation Administration . Order JO 7110.65S. *Air Traffic Control*. February 14, 2008.

Federal Aviation Administration. *R and D Review*, 2006, Issue 4., Meeting the Challenge, Unmanned Aircraft Systems. http://www.airtech.tc.faa.gov/RD/2006_winter.pdf . Accessed: (15 January 2009).

Federal Aviation Administration. *System Safety Handbook*. 30 December, 2000.

Federal Aviation Administration. UAS, FAA.gov Home, http://faa.custhelp.com/cgi-bin/faa.cfg/php/enduser/std_adp.php?pfaqid=108&p_created=1071245802&p_sid=VCOGBWoj&p_accessibility=&p_lva=&p_sp=cF9zcmNoPSZwX3NvcnRfYnk9JnBfZ3JpZHNvcnQ9JnBfcm93X2NudD0mcF9wcm9kc0mcF9jYXRzPSZwX3B2PSZwX2N2PSZwX3BhZ2U9MQ**&p_li=&p_topview=1. Accessed: (26 November 08)

- Federal Aviation Administration. Unmanned Aircraft Program Office (UAPO), Our Mission. http://www.faa.gov/about/office_org/headquarters_offices/avs/offices/air/hq/engineering/uapo/. (Accessed: 20 November 2008).
- Federal Aviation Administration. “U.S. Airspace Classes at a Glance Card.” <http://www.asy.faa.gov/safetyproducts/airspacecard.html>. Accessed: (15 Nov 2008).
- Fulgham, D. A. and R. Wall. “Baghdad Confidential.” *Aviation Week and Space Technology*. Vol. 158, No. 17, April 28, 2003. pp. 32.
- G. Goebel, “Unmanned Aerial Vehicles,” <http://www.vectorsite.net/twuav.html>. Accessed: (1 Dec 2008).
- Hansman, J.R., and E.W. Roland. “Safety Considerations For Operation Of Unmanned Aerial Vehicles In The National Airspace System.” Report No. ICAT-2005-1. MIT International Center for Air Transportation, Department of Aeronautics & Astronautics, Massachusetts Institute of Technology, March 2005. <http://dspace.mit.edu/handle/1721.1/30364> (accessed 15 November 2008)
- Morris, J. “Standards Committee Releases UAV Sense-and-Avoid Standard.” *Aerospace Daily and Defense Report*. Vol. 211, No. 3, July 6, 2004. pp. 3.
- Northrop Grumman News. “Northrop Grumman Hunter Unmanned Aerial Reconnaissance System Surpasses 30,000 Flight Hours.” Press Release. July 12, 2004.
- Office of the Secretary of Defense, *Airspace Integration Plan for Unmanned Aviation*. November 2004.
- Official Academy of Model Aeronautics National Model Aircraft Safety Code. January 1, 2005. <http://www.modelaircraft.org/PDF-files/105.pdf>. Accessed: (17 December 2008).
- Sabatini, N. Remarks Prepared for Delivery, Special Committee 203: Unmanned Aircraft Systems, RTCA. RTCA Paper No. 214-04/SC203-002. November 30, 2004.
- Sabatini, N. RTCA Paper No. 214-04/SC203-002. Remarks Prepared for Delivery. RTCA Special Committee 203: Unmanned Aircraft Systems. Washington, DC. November 30, 2004.
- Smithsonian Institution, The Wright Brothers, *The Invention of the Aerial Age*. http://www.nasm.si.edu/wrightbrothers/index_full.cfm. Accessed: (27 January 2009).
- Teal Group Corporation, *Teal Group Predicts Worldwide UAV Market Will Reach Nearly \$55 Billion*, 2008 UAV Market Profile and Forecast Now Available. <http://www.tealgroup.com/content/view/31/>. Accessed: (26 Jan 09).

Title 49-Transportation, Subtitle I-Department of Transportation, Chapter 1-Organization,
§ 102. Department of Transportation. [http://www.law.cornell.edu/uscode/html/uscode49/
usc_sec_49_00000102----000-.html](http://www.law.cornell.edu/uscode/html/uscode49/usc_sec_49_00000102----000-.html). Accessed: (26 Jan 2009)

Title 49-Transportation, Subtitle I-Department of Transportation, Chapter 1-Organization,
§ 101. Purpose. [http://www4.law.cornell.edu/uscode/html/uscode49/usc_sec_49_00000101--
--000-.html](http://www4.law.cornell.edu/uscode/html/uscode49/usc_sec_49_00000101--000-.html). Accessed: (26 Jan 2009)

Title 49-Transportation, Subtitle VII-Aviation Programs, Part A-Air Commerce and Safety,
subpart i, Chapter 101-General Provisions, § 40101. Policy.
http://www4.law.cornell.edu/uscode/html/uscode49/usc_sec_49_00040101----000-.html.
Accessed: (26 January 2009).

Tuttle, R. "Meetings to spur routine use of UAVs, official says." *Aerospace Daily & Defense Report*. Vol. 213, No. 13, January 21, 2005. pp. 5.