U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Effective Date: JUN 17 2011

SUBJ: Unmanned Aircraft Systems Aviation Rulemaking Committee

1. **Purpose of This Charter**. This charter establishes the Unmanned Aircraft Systems Aviation Rulemaking Committee (UASARC) according to the Administrator's authority under Title 49 of the United States Code (U.S.C.), section 106(p)(5).

2. **Audience**. This charter applies to members of the UASARC, including members of aviation industry, employees within the Office of the Associate Administrator for Aviation Safety: Aircraft Certification Service, Flight Standards Service, and the Office of Rulemaking; and, employees within the Air Traffic Organization's (ATO) Operations Business Unit: Mission Support Services.

3. **Where You Can Find This Charter**. You can find this charter on the Federal Aviation Administration (FAA) Web site at http://www.faa.gov/about/committees/rulemaking.

4. **Background**. The FAA has committed to integrating unmanned aircraft systems (UAS) operations as part of the implementation of the Next Generation Air Transportation System (NextGen). Given this commitment, significant issues exist with industry dynamics; new technologies; new aircraft types/capabilities and configurations as well as current operations; airspace use; airports; infrastructure; economics; and the environment. These complex issues mandate a comprehensive review of existing regulatory criteria and guidance materials. Where existing criteria and guidance are inadequate or nonexistent, there will be a requirement to develop and implement new regulatory criteria and the guidance material needed by all stakeholders. Issues under review include:

a. Expeditious development of UAS criteria and standards (as required).

b. Implementation of non-rulemaking UAS National Airspace System (NAS) access and procedure improvements.

c. Facilitating the maximum or ideal use of modern technologies including communication, navigation, and surveillance capabilities in use by today's manned aircraft.

d. Integrating UAS into the NAS while supporting the reduction of risks identified by the Commercial Aviation Safety Team.

e. Evolving technologies and potential equipment upgrades to provide increased operational and safety benefits that may not be realized unless a practical means is established to prioritize, direct, and facilitate new criteria and implementation.

f. In concert with the International Civil Aviation Organization (ICAO) UAS Study Group and other international organizations, harmonizing certification, operations, procedures, and standards to support and facilitate the global aspects of aviation operations and unmanned aircraft production.

5. **Objectives and Scope of the Committee**. This committee will provide a forum for the U.S. aviation community to discuss, prioritize, and resolve issues, provide direction for U.S. UAS operational criteria, support the NextGen Implementation Plan, and produce U.S. consensus positions for global harmonization. The general objectives and scope are to:

a. Develop the means to continue integration of UAS with manned NAS operations that address safety, capacity, and efficiency objectives consistent with global aviation.

b. Coordinate the resolution of any comments on related proposed rulemaking.

c. Develop and recommend to the FAA draft advisory circular language and a strategy, process, and schedule for the integration of UAS into the NAS.

d. Develop and recommend to the FAA updated guidance material, notices, handbooks, and other relevant materials for UAS operations.

e. Make recommendations, including rulemaking and additional tasking, to the Administrator through the Associate Administrator for Aviation Safety and the ATO Chief Operating Officer.

6. **Committee Procedures**.

a. The committee provides advice and recommendations to the Associate Administrator for Aviation Safety and the ATO Chief Operating Officer. The committee acts solely in an advisory capacity.

b. The committee will discuss and present information, guidance, and recommendations that the committee considers relevant to disposition issues. Discussion will include, but is not limited to, the following:

(1) Operational objectives, recommendations, and requirements.

(2) Airworthiness criteria and means of compliance to meet the operational objectives.

(3) Recommendations for rulemaking necessary to meet objectives.

(4) Guidance material and the implementation processes.

(5) Global harmonization issues and recommendations.

(6) Documentation and technical information to support recommendations.

(7) Formation and oversight of specialized work groups to research, document, and make recommendations on specific, assigned topics.

c. The committee's task will focus on the operational approval standards, operating procedures, complete aircraft system capability, and guidance material required for UAS operations. Attention will be given to position, navigation and timing, control link/data communication and operations, surveillance issues, and air traffic management. The committee will develop a work plan for each task or issue and an implementation plan for each recommendation, considering related activities being undertaken by other committees. The committee will recommend timelines based on the complexity and priority of its recommendations. Recommendations should take the form of documented issue resolutions, recommended policy decisions, draft guidance material, or proposed rulemaking, as needed. The committee will develop and propose specific implementation planning and processes to ensure that recommendations meet these objectives. The committee will provide reports with written recommendations to the Administrator through the Associate Administrator for Aviation Safety and the ATO Chief Operating Officer, as appropriate.

7. **Organization and Administration.**

a. The FAA will set up a committee representing the various parts of industry and Government. The committee may set up specialized work groups that will include at least one committee member and invited subject matter experts from industry and Government, where necessary.

b. The Associate Administrator for Aviation Safety will have the sole discretion to appoint members or organizations to the committee. The committee will consist of members of the aviation community, including the public and/or other Federal Government entities representative of various viewpoints. The FAA will provide participation and support from all affected lines of business.

c. The Associate Administrator for Aviation Safety and the ATO Chief Operating Officer will receive all committee recommendations and reports. The Associate Administrator for Aviation Safety, at her discretion, determines when and how the committee recommendations and reports of the ARC are released to the public. The Associate Administrator for Aviation Safety, through the Flight Standards Service, will be responsible for providing administrative support for the committee.

d. The Associate Administrator for Aviation Safety is the sponsor of the committee and will select an industry chair from the membership of the committee. Also, the Associate Administrator will select the FAA-designated representative for the committee. Once appointed, the chair will:

(1) Determine, in coordination with the other members of the committee, when a meeting is required. Although a quorum is desirable at committee meetings, it is not required.

(2) Arrange notification to all committee members of the time and place for each meeting.

(3) Draft an agenda for each meeting and conduct the meeting.

(4) Arrange for minutes of committee meetings to be taken.

8. **Committee Membership.**

a. The committee will consist of approximately 15 members, selected by the FAA, representing aviation associations, industry operators, manufacturers, employee groups or unions, other Government entities, and other aviation industry participants.

b. The membership will be balanced in points of view, interests, and knowledge of the objectives and scope of the committee. Each member or participant on the committee should represent an identified part of the aviation community and have the authority to speak for that part. Membership on the committee will be limited to promote discussions. Active participation and commitment by members will be essential for achieving the committee objectives and for continued membership on the committee. The committee may invite additional participants as subject matter experts to support specialized work groups.

9. **Cost and Compensation.** The estimated cost to the Federal Government for the UASARC is $500,000 annually. Non-Government representatives serve without Government compensation and bear all costs related to their participation on the committee.

10. **Public Participation.** Persons or organizations that are not members of this committee and are interested in attending a meeting must request and receive approval in advance of the meeting from the committee chairperson or the designated Federal representative.

11. **Availability of Records.** Consistent with the Freedom of Information Act, Title 5, U.S.C., section 522, records, reports, agendas, working papers, and other documents that are made available to or prepared for or by the committee will be available for public inspection and copying at the FAA Flight Standards Service, 800 Independence Avenue, SW, Washington, DC 20591. Fees will be charged for information furnished to the public according to the fee schedule published in Title 49 of the Code of Federal Regulations, part 7.

12. **Public Interest**. Forming the UASARC is determined to be in the public interest to fulfill the performance of duties imposed on the FAA by law.

13. **Effective Date and Duration**. This committee is effective upon issuance. The committee will remain in existence for a term of 36 months, unless sooner terminated or extended by the Administrator.

14. **Distribution**. This charter is distributed to the director level in the Office of the Associate Administrator for Aviation Safety; the Office of the Chief Counsel; the Office of the Associate Administrator for Airports; the Air Traffic Organization; and the Office of the Assistant Administrator for Policy, International Affairs, and Environment.

JUN 17 2011

J. Randolph Babbitt
Administrator

Date

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Aviation Rulemaking Committee Charter

Effective Date: June 17, 2011
Extended Date: June 11, 2014

SUBJECT: Unmanned Aircraft Systems Aviation Rulemaking Committee

1. **PURPOSE.** This charter extends the Unmanned Aircraft Systems (UAS) Aviation Rulemaking Committee (ARC), originally issued on June 17, 2011, according to the Administrator's authority under Title 49 of the United States Code (49 U.S.C.) 106(p)(5).

2. **BACKGROUND.** The FAA has committed to integrating unmanned aircraft systems (UAS) operations as part of the implementation of the Next Generation Air Transportation System (NextGen). Given this commitment, significant issues exist with industry dynamics; new technologies; new aircraft types/capabilities and configurations as well as current operations; airspace use; airports; infrastructure; economics; and the environment. These complex issues mandate a comprehensive review of existing regulatory criteria and guidance materials. Where existing criteria and guidance are inadequate or nonexistent, there will be a requirement to develop and implement new regulatory criteria and the guidance material needed by all stakeholders. Issues under review include:

   a. Expeditious development of UAS criteria and standards (as required).

   b. Implementation of non-rulemaking UAS National Airspace System (NAS) access and procedure improvements.

   c. Facilitating the maximum or ideal use of modern technologies including communication, navigation, and surveillance capabilities in use by today's manned aircraft.

   d. Integrating UAS into the NAS while supporting the reduction of risks identified by the Commercial Aviation Safety Team.

   e. Evolving technologies and potential equipment upgrades to provide increased operational and safety benefits that may not be realized unless a practical means is established to prioritize, direct, and facilitate new criteria and implementation.

   f. In concert with the International Civil Aviation Organization (ICAO) UAS Study Group and other international organizations, harmonize certification, operations, procedures, and standards to support and facilitate the global aspects of aviation operations and unmanned aircraft production.

3. **OBJECTIVES AND TASKS OF THE ARC.** This committee will continue to provide a forum for the U.S. aviation community to discuss, prioritize, and resolve issues, provide direction for U.S. UAS operational criteria, support the NextGen Implementation Plan, and produce U.S. consensus positions for global harmonization. The general objectives and scope are to:

a. Develop the means to continue integration of UAS with manned NAS operations that address safety, capacity, and efficiency objectives consistent with global aviation.

b. Develop and recommend to the FAA draft advisory circular language and a strategy, process, and schedule for the integration of UAS into the NAS.

c. Develop and recommend to the FAA updated guidance material, notices, handbooks, and other relevant materials for UAS operations.

d. Make recommendations, including rulemaking and additional tasking, to the Administrator through the Associate Administrator for Aviation Safety and the ATO Chief Operating Officer.

Recommendation Report. In accordance with the original charter, the ARC will continue to provide recommendations, as appropriate, for each tasking.

4. ARC PROCEDURES.

a. The committee provides advice and recommendations to the Associate Administrator for Aviation Safety and the ATO Chief Operating Officer. The committee acts solely in an advisory capacity.

b. The committee will discuss and present information, guidance, and recommendations that the committee considers relevant to disposition issues. Discussion will include, but is not limited to, the following:

(1) Operational objectives, recommendations, and requirements.

(2) Airworthiness criteria and means of compliance to meet the operational objectives.

(3) Recommendations for rulemaking necessary to meet objectives.

(4) Guidance material and the implementation processes.

(5) Global harmonization issues and recommendations.

(6) Documentation and technical information to support recommendations.

(7) The formation and committee oversight of specialized work groups to research, document, and make recommendations on specific, assigned topics.

c. The committee's task will focus on the applicability, operational approval standards, operating procedures, complete aircraft system capability, and guidance material required for UAS operations. Attention will be given to position, navigation and timing, control link/data communication and operations, surveillance issues, and air traffic management. The committee will develop a work plan for each task or issue and an implementation plan

for each recommendation, considering related activities being undertaken by other committees. The committee will recommend timelines based on the complexity and priority of its recommendations. Recommendations should take the form of documented issue resolutions, recommended policy decisions, draft guidance material, or proposed rulemaking, as needed. The committee will develop and propose specific implementation planning and processes to ensure that recommendations meet these objectives. The committee will provide reports with written recommendations to the Administrator through the Associate Administrator for Aviation Safety and the ATO Chief Operating Officer, as appropriate.

a. **Status Reports**. The ARC will provide a status update to the Associate Administrator for Aviation Safety and the ATO Chief Operating Officer every three months.

b. **Recommendation Report.** The ARC will submit a final report detailing recommendations by April 18, 2016.
    i. The Industry Co-Chair will send the recommendation report to the Associate Administrator for Aviation Safety, the ATO Chief Operating Officer, and the Director of the Office of Rulemaking.
    ii. The Associate Administrator for Aviation Safety determines when the recommendation report is released to the public.

c. The ARC may reconvene following the submission of the final recommendation report for the purposes of providing advice and assistance to the FAA, at the discretion of the Associate Administrator for Aviation Safety, provided the charter is still in effect.

5. **ARC ORGANIZATION, MEMBERSHIP, AND ADMINISTRATION.** In accordance with the original charter, the organization and administration remain unchanged. Members have been selected based on their familiarity with unmanned aircraft analysis and regulatory compliance. Membership is balanced in viewpoints, interests, and knowledge of the committee's objectives and scope.

The June 18, 2010 memorandum "Lobbyists on Agency Boards and Commissions," states that a member must not be a federally registered lobbyist, who is subject to the registration and reporting requirements of the Lobbying Disclosure Act of 1995 (LDA) as amended, 2 U.S.C 1603, 1604, and 1605, at the time of appointment or reappointment to an advisory committee, and has not served in such a role for three consecutive quarters prior to appointment. Therefore, the FAA will not select any person that is a registered lobbyist. (For further information see the Office of Management and Budget final guidance on appointment of lobbyists to federal boards and commissions (76 FR 61756, October 5, 2011).

ARC membership is limited to promote discussion. Active participation and commitment by members will be essential for achieving the ARC objectives and tasks. Attendance is essential for continued membership on the committee. Attendance at ARC meetings is limited to ARC members and FAA representatives. ARC members are not permitted to name alternates or designees to attend a meeting on behalf of a member. However, in the event a member is no longer able to serve on the ARC, his or her organization may select a new representative. When

necessary, the ARC may set up specialized and temporary work groups that include at least one ARC member and invited subject matter experts from industry and government. When appropriate, the co-chairs may invite non-member subject matter experts to an ARC meeting.

The committee consists of approximately 30 members, selected by the FAA, representing aviation associations, industry operators, manufacturers, employee groups or unions, other Government entities, and other aviation industry participants. See Appendix for member organizations.

The ARC sponsor is the Associate Administrator for Aviation Safety and will select an Industry Co-Chair from the membership of the ARC. The FAA participation and support will come from all affected lines-of-business.

a. The ARC sponsor will:
   1) Select and appoints industry and FAA members to the ARC, at the sponsor's sole discretion;
   2) Provide administrative support for the ARC, through the Office of Flight Standards Service; and
   3) Receive all status reports and the recommendations report.

b. The Industry Co-Chair will:
   1) Coordinate required committee (and work group, if any) meetings in order to meet the ARC's objectives and timelines;
   2) Provide notification to all ARC members of the time and place for each meeting;
   3) Ensure meeting agendas are established and provided to the committee members in a timely manner;
   4) Keep meeting minutes, if deemed necessary;
   5) Perform other responsibilities as required to ensure the ARC's objectives are met;
   6) Provide status reports in writing to the Associate Administrator for Aviation Safety and the ATO Chief Operating Officer; and
   7) Submit the recommendation report to the Associate Administrator for Aviation Safety and the ATO Chief Operating Officer.

6. **COST AND COMPENSATION.** The estimated cost to the Federal Government for the UAS ARC is $500,000 annually. All travel costs for government employees are the responsibility of the government employee's organization. Non-Government representatives serve without Government compensation and bear all costs related to their participation on the committee.

7. **PUBLIC PARTICIPATION.** ARC meetings are not open to the public. Persons or organizations outside the ARC who wish to attend a meeting must get approval in advance of the meeting from either the Industry Co-Chair and the FAA Co-Chair.

8. **AVAILABILITY OF RECORDS.** Consistent with the Freedom of Information Act, Title 5, U.S.C., section 522, records, reports, agendas, working papers, and other documents that are made available to or prepared for or by the committee will be available for public inspection and copying at the FAA Flight Standards Service, 800 Independence Avenue, SW, Washington, DC

20591. Fees will be charged for information furnished to the public according to the fee schedule published in Title 49 of the Code of Federal Regulations, part 7.

You can find this charter on the FAA Committee Database website at: http://www.faa.gov/regulations_policies/rulemaking/committees/documents/.

9. **DISTRIBUTION.** This charter is distributed to the director level in the Office of the Associate Administrator for Aviation Safety; the Office of the Chief Counsel; the Office of the Associate Administrator for Airports; the Air Traffic Organization; and the Office of the Assistant Administrator for Policy, International Affairs, and Environment.

10. **EFFECTIVE DATE AND DURATION.** This ARC continues to be in effect upon the issuance of this extension of the charter. The ARC will remain in existence until June 17, 2016, unless this charter is sooner suspended, terminated, or extended by the Administrator.

Issued in Washington, D.C. on June 11, 2014

Michael P. Huerta
Administrator

APPENDIX

UAS ARC MEMBER ORGANIZATIONS

- General Atomics
- MITRE
- GE
- New Mexico State University
- Raytheon
- National Business Aviation Association (NBAA)
- Northrop Grumman
- Insitu/Boeing
- Rockwell-Collins
- Honeywell
- PBFA
- DHS CBP
- ALPA
- AOPA
- AUVSI
- NASA
- AeroVironment
- Lockheed Martin

UAS ARC Recommended Changes – 8/7/12

Integration of Civil Unmanned Aircraft Systems (UAS) into the National Airspace System (NAS)

Roadmap Basis

Contents

Executive Summary
Expanding Operations of Unmanned Aircraft Systems in the NAS

Since the early 1990s, Unmanned Aircraft Systems (UAS) have operated on a limited basis in the National Airspace System (NAS). Until recently, unmanned aircraft mainly supported public operations, such as military and border security operations, with the list of potential uses rapidly expanding to include a broad range of other activities including: aerial photography, surveying land and crops, communications and broadcast, monitoring forest fires and environmental conditions, and protecting critical infrastructures. Unmanned aircraft promise new ways for commercial enterprises and public operators to increase operational efficiency, decrease costs, and enhance safety.

As stated in *Destination2025 (2011),*

> *"The Federal Aviation Administration's (FAA) mission is to provide the safest, most efficient aviation system in the world. What sets the United States apart is the size and complexity of our infrastructure, the diversity of our user groups, our commitment to safety and excellence, and a history of innovation and leadership in the world's aviation community. Now we are working to develop new systems and to enhance a culture that increases the safety, reliability, efficiency, capacity, and environmental performance of our aviation system."*

The FAA created the Unmanned Aircraft Program Office (UAPO) to facilitate integration of Unmanned Aircraft Systems (UAS) safely and efficiently into the NAS. Toward that goal, the FAA is collaborating with a broad spectrum of stakeholders, which includes manufacturers, commercial vendors, industry trade associations, technical standards organizations, academic institutions, research and development centers, governmental agencies and other regulators. Ultimately, UAS need to be integrated into the NAS without reducing existing capacity, decreasing safety or placing other airspace users or persons and property on the ground at increased risk. Great progress has been made, but significant barriers remain.

A main objective of the FAA is to develop a sound technical, regulatory and policy basis for UAS to operate safely and efficiently in the NAS. Today, unmanned aircraft are typically given access to airspace through the issuance of Certificates of Waiver or Authorization (COAs) to public operators and Special Airworthiness Certificates – Experimental Category (SAC-ECs) to civil applicants. While, the FAA has a proven certification process in place for aircraft, a key challenge will be establishing airworthiness requirements and methods of compliance unique to UAS, including control stations that are not co-located with the aircraft and datalink communications used for command and control of the aircraft.

The process of developing regulations and standards is challenging and resource-intensive. It is a significant undertaking to build the basis for the National Airspace System to first accommodate, then integrate, and finally enable unfettered access of UAS in the NAS as it evolves over time. Government and industry stakeholders must work together and apply the necessary resources to bring this task to fruition.

The FAA is committed to the safe and efficient integration of UAS into the NAS, thus enabling this emerging technology to achieve its full potential safely.

1 Purpose and Background of Civil UAS Roadmap

Unmanned aircraft systems (UAS) and operations have significantly increased in number, technical complexity and sophistication during recent years without having the same history of compliance and oversight as manned aviation. In some cases, interpretation of regulations and/or standards may be needed to address characteristics unique to UAS. The UAS community is finding it difficult to apply existing rules. Ultimately, the pace of integration will be determined by the ability of industry, the user community, and FAA to overcome technical, regulatory, and operational challenges. The purpose of this roadmap is to outline, within a broad timeline, the tasks and considerations needed to enable UAS integration into the NAS for the planning purposes of the broader UAS community.

The roadmap is intended to guide aviation stakeholders in understanding operational goals and challenges when considering future investments. It is organized into three perspectives that highlight the multiple paths used to achieve the milestones outlined, while focusing on progressive accomplishments. The three perspectives described in this roadmap transcend specific timelines, and serve as an added way of examining the complex relationship of activities necessary to integrate UAS into the NAS. In effect, the perspective approach adds a third dimension to the traditional two-dimensional approach that frames and considers time periods. Roadmap timeframes are defined in the President's National Aeronautics Research and Development Plan, which specifies less than 5 years as the near-term, 5-10 years as the mid-term, and greater than 10 years as the long-term. For this roadmap, the long-term is defined as 2022-2026, which is consistent with Joint Planning and Development Office (JPDO) *National Airspace System Concept of Operations and Vision for the Future of Aviation and NextGen Air Transportation System (NGATS) Integrated Plan*.

Integration of UAS into the NAS will require: review of current policies, regulations, standards, and procedures; identification of gaps in current UAS technologies; development of new technologies; and eventual certification of aircraft systems, propulsion systems, and airmen.

1.1 History of UAS

Historically, unmanned aircraft have been known by many names including; "drones", "remotely piloted vehicles (RPVs)", "unmanned aerial vehicles (UAVs)", "models" and "radio control (R/C) aircraft". Today, the term UAS is used to emphasize the fact that there are separate system components required to support airborne operations without a pilot onboard the aircraft. Early UAS operations received little attention from the FAA and its predecessor agencies due to the infrequency of operations, which were mostly conducted in remote locations or in special use airspace and were not deemed to impact the safety of the NAS. In the past two decades, the number of unmanned aircraft operations has been increasing dramatically, highlighting the need for a structured approach for safe and efficient integration.

1.2 Future Civil Uses

The use of UAS in commercial applications is expected to expand in a number of areas (*"Operational Services and Environment Definition (OSED) for Unmanned Aircraft Systems (UAS), RTCA DO-320, 2010).* Some of the currently proposed civil and commercial applications of UAS include:

- Security awareness
- Disaster response, including search and rescue
- Communications and broadcast, including news/sporting event coverage
- Cargo transport
- Spectral and thermal analysis
- Critical infrastructure monitoring, including power facilities, ports, and pipelines
- Commercial photography, aerial mapping and charting, and advertising

1.3 Definitions

There are several terms used in this document that are defined below as a common point of reference:

Unmanned Aircraft (UA) A device used or intended to be used for flight in the air that has no onboard pilot.

UAS Flightcrew member A person responsible for duties on unmanned aircraft that affect safe flight. This includes the pilot in command (PIC) and may include others required to ensure safe operations of the aircraft.

Unmanned Aircraft System (UAS) An unmanned aircraft and its associated elements related to safe operations, which may include control stations, control links, support equipment, payloads, flight termination systems, and launch/recovery equipment. As shown in Figure 1, it consists of three elements:

1. Unmanned Aircraft
2. Control Station
3. Data Link

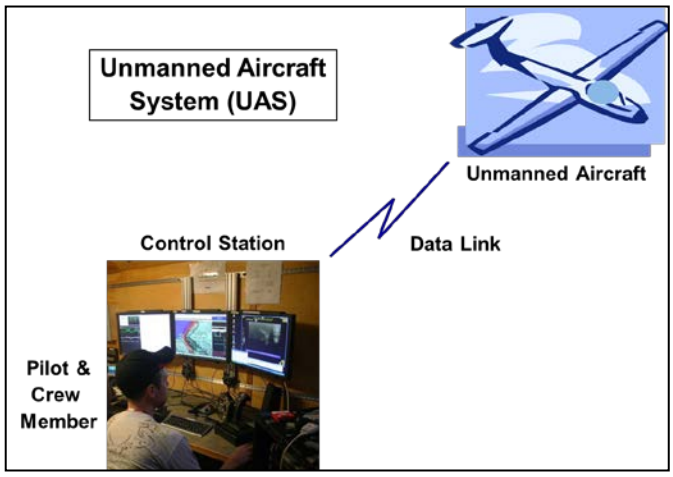

Figure 1: The UAS and Flightcrew Members

The National Airspace System (NAS) The common network of United States airspace – air navigation facilities, equipment and services, airports or landing areas; aeronautical charts, information and services; rules, regulations and procedures, technical information; and manpower and material. (see Figure 2)

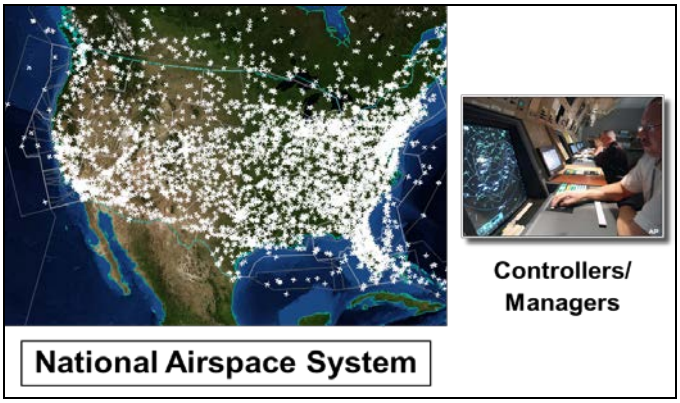

Figure 2: The NAS

NextGen An initiative focused on optimizing the operating model to best position the FAA for future success. According to the FAA *Destination 2025, 2011:*

> *NextGen is a series of inter-linked programs, systems, and policies that implement advanced technologies and capabilities to dramatically change the way the current aviation system is operated. NextGen is satellite-based and relies on a network to share information and digital communications so all users of the system are aware of other users' precise locations.*

1.4 Policy

The FAA is responsible for developing plans and policy for the safe and efficient use of the United States navigable airspace. This responsibility includes harmonizing, to the extent possible, with the international community for the mutual development of civil aviation in a safe and orderly manner. Components of existing FAA and ICAO policy are outlined below.

1.4.1 FAA UAS Policy Basis

Established FAA aviation policies support a minimum level of safety for the National Airspace System (NAS). At the core of these policies is the concept that each aircraft is flown by a pilot in accordance with required procedures and practices. This same policy applies to UAS.

Aviation policies focus on overall safety being addressed through three primary areas: equipment, personnel, and operations & procedures. Each of these areas has standards and minimum levels of safety that must be met independent of each other. As a matter of policy, for example, a new aircraft must be able to independently obtain an airworthiness certificate regardless of the airspace class where it might be flown. However, as a result or part of this certification, new procedures may be required for flightcrew members and ATC in order to maintain the minimum level of safety of the NAS while accommodating the new technology. Under special certifications and authorizations, limited operations may be authorized for equipment unable to meet current standards.

The application of these established aviation policies to UAS is summarized in this excerpt from the FAA Notice of Policy: Unmanned Aircraft Operations in the National Airspace System *(Federal Register Docket No. FAA-2006-25714, issued February 13, 2007).*

> *Regulatory standards need to be developed to enable current technology for unmanned aircraft to comply with Title 14 Code of Federal Regulations (CFR)…The operator is required to establish the UAS airworthiness and demonstrate that a collision with another aircraft or other airspace user is extremely improbable…The FAA's UAS guidance applies the pilot-in-command concept to unmanned aircraft and includes minimum qualification and currency requirements.*

These policies have enabled the accommodation of UAS into the NAS on the foundation that operations are conducted safely, present no threat to the general public, and do no harm or adversely impact other users. Until UAS possess the ability to fully integrate into the NAS, e.g. are able to obtain a standard airworthiness certificate and be flown by a certified pilot in accordance with required procedures, their access to the NAS will be limited.

1.4.2 International Civil Aviation Organization (ICAO) Policy

ICAO is responsible for facilitating the agreement among Contracting States of certain principles and arrangements in order that international civil aviation may be developed in a safe and orderly manner.

The goal of ICAO in addressing unmanned aviation is to provide the fundamental international regulatory framework to underpin routine operation of UAS throughout the world in a safe, harmonized, and seamless manner comparable to that of manned operations.
Current ICAO guidance material for UAS is published in Circular 328, which provides basic guidelines for member States to introduce and integrate UAS into airspace in a consistent manner globally. The document's guiding policy towards UAS is:

> *A number of Civil Aviation Authorities (CAA) have adopted the policy that UAS must meet the equivalent levels of safety as manned aircraft…In general, UAS should be operated in accordance with the rule governing the flight of manned aircraft and meet equipment requirements applicable to the class of airspace within which they intend to operate…To safely integrate UAS in non-segregated airspace, the UAS must act and respond as manned aircraft do. Air Traffic, Airspace and Airport standards should not be significantly changed. The UAS must be able to comply with existing provisions to the greatest extent possible. (ICAO Circular 328, AN/190 unmanned aircraft systems, 2011)*

ICAO develops standards and recommended practices (SARPs), which are generally followed by national civil aviation authorities of the member States. Although the FAA is not governed by ICAO, it plans to harmonize with international efforts and adhere to ICAO SARPs when possible.

1.4.3 Future Policy Considerations

RTCA, Inc. is a private, not-for-profit corporation that develops consensus-based recommendations regarding communications, navigation, surveillance, and air traffic management system issues. The FAA considers RTCA recommendations when making policy, program, and regulatory decisions. The RTCA Special Committee 203 (SC-203) was established in 2004, to help assure the safe, efficient and compatible operation of UAS with other aircraft operating within the NAS. This Special Committee has developed and documented guiding principles for UAS integration, which are summarized below:

- UAS must operate safely, efficiently, and compatibly with service providers and other users of the NAS, so that overall safety is not degraded
- UAS will have access to the NAS, provided they have appropriate equipage and the ability to meet the requirements for flying in various classes of airspace.
- Routine UAS operations will not require the creation of new special use airspace, or modification of existing special use airspace
- Except for some special cases, such as small UAS with very limited operational range, all UAS will require design and airworthiness certification to fly civil operations in the NAS
- UAS pilots will require certification, though some of the requirements may differ from manned aviation
- UAS will comply with ATC instructions, clearances, and procedures when receiving air traffic services
- UAS pilot (the pilot-in-command) will always have responsibility for the unmanned aircraft while it is operating

Through an FAA established UAS Aviation Rulemaking Committee (ARC), the FAA continues to collaborate with government and industry stakeholders for recommendations regarding the path toward integration of UAS into the NAS. This effort will harmonize with the work being done by international organizations working toward a universal goal of safe and efficient UAS airspace operations.

2 UAS Operations in NAS

This roadmap focuses on civil UAS access to the NAS. To this end, the FAA and UAS community are working to address the myriad challenges associated with this effort.

2.1 FAA's Dual Role for UAS Integration

For UAS, as with all aircraft, the FAA acts in a dual role. As the regulator, the FAA ensures aviation safety of persons and property in the air and on the ground. As the service provider, the FAA is responsible for the providing safe and efficient air traffic control services in the NAS and the other portions of global airspace delegated to the US by ICAO.

As part of its regulator role, the Office of Aviation Safety (AVS) efforts are led by the UAPO, AFS-407. The main focus of the UAPO is to provide within the existing AVS structure, subject matter expertise, research, and recommendations to develop UAS policy, regulations, guidance, and procedures for UAS airworthiness and operations. UAPO responsibilities span the entire scope of the UAS "system", focusing on safe integration of UAS into the NAS.

As service provider, the Air Traffic Organization (ATO) efforts are led by the UAS Group, AJV-13, which considers operational authorizations for UAS flight that are unable to meet current regulations and procedures. A Certificate of Waiver or Authorization (COA) is issued with limitations and provisions that mitigate the increased risks resulting from the use of uncertified technology. ATO is responsible for the safe and efficient handling of aircraft and the development of the airspace rules and procedures to support routine operations in the NAS.

2.2 UAS Challenges

A number of issues that impact the integration of UAS into the NAS are being considered across the regulatory and service provider roles of the FAA. To ensure the FAA meets the goals set forth in this roadmap, these offices will be addressing the challenges of regulations, operations, and technology, as outlined in the following sub-sections.

2.2.1 Policy, Guidance, and Regulatory Challenges

To ensure the FAA has the appropriate consideration of UAS, many products will need to be reviewed and may need updated to specifically address UAS integration into the NAS. In some cases, new products will need to be created. In other cases, UAS technology and operations will need to be matured so that they can meet applicable regulations and standards. Figure 3 depicts product areas, based on the RTCA notional architecture, and primarily relates to certification of airmen and the unmanned aircraft system that will require research.

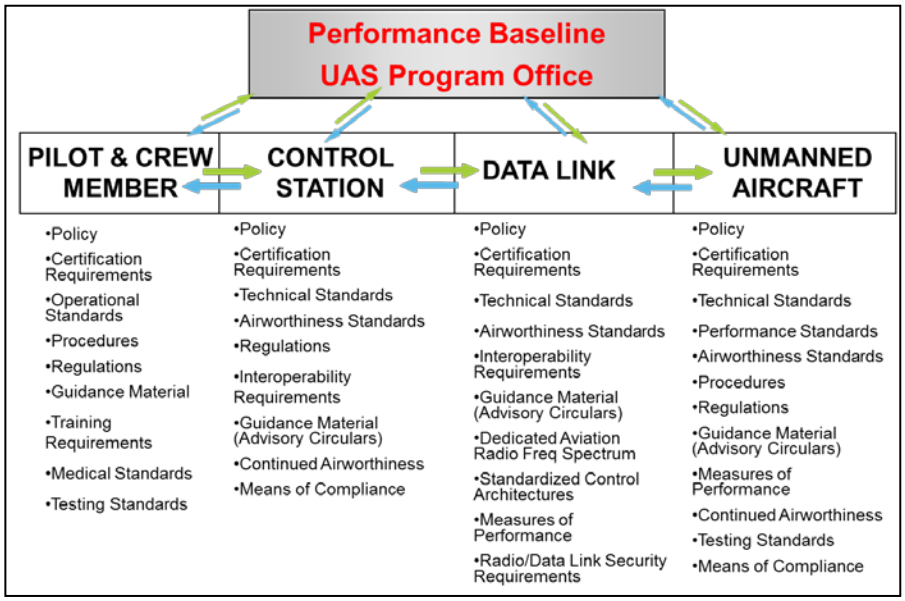

Figure 3: AVS Products Needed to Regulate

The challenge is to identify and develop the regulatory structure for UAS that encompasses areas listed in Figure 3. For the entire system there is also a requirement to:

- Develop minimum standards for Sense and Avoid (SAA), Control and Communication (C2), and Separation Assurance to meet operational requirements for specified airspace
- Understand the security and environmental implications of UAS operations

2.2.2 Air Traffic Operational Challenges

There are also numerous products that need to be reviewed and refined or developed through supporting research to permit UAS operations in the NAS. The ATO UAS Group coordinates the efforts to complete these tasks.

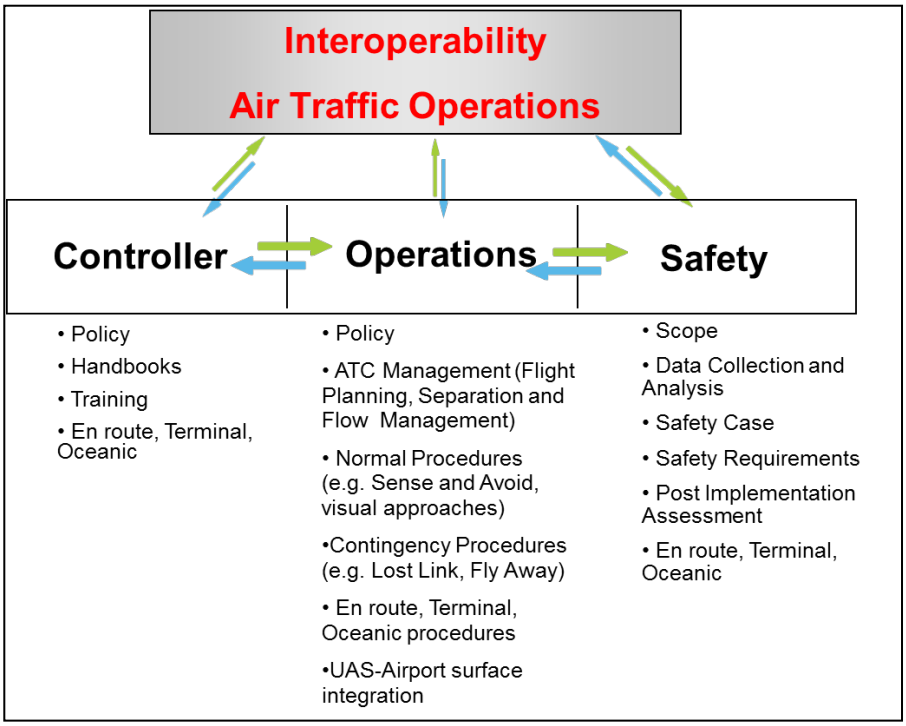

Figure 4: ATO Context to Manage the NAS

The goal of safely integrating UAS without segregating, delaying, or diverting other aircraft and other users of the system requires significant challenges in the areas outlined in Figure 4 above. For NAS integration, this also includes:

- Identifying policies and requirements for UAS to comply with ATC clearances and instructions commensurate with manned aircraft (specifically addressing the inability of UAS to comply directly with ATC visual clearances)
- Establishing procedures and techniques for safe and secure exchange of voice and data communication between UAS pilots, air traffic controllers, and other NAS users
- Establishing wake vortex and turbulence avoidance criteria needed for UAS

2.2.3 Technological Challenges

The FAA recognizes that current UAS technologies were not developed to an acceptable set of airworthiness standards. Current civil airworthiness regulations may not consider many of the unique aspects of UAS operations. Although significant technological advances have been made by the UAS community, critical research is needed to fully understand the impact of UAS operations in the NAS. There has also been little research to support the equipment design necessary for UAS airworthiness certification. In the near-to-mid-term, UAS research will need to focus on technology deemed necessary for UAS access to the NAS.

As UAS are introduced, their expected range of performance will need to be evaluated for impact on the NAS. UAS operate with widely varying performance characteristics that do not necessarily align with manned aircraft performance – some smaller, some slower, some flying much lower and higher in altitude, and for much longer durations. Similarly, the issue of

performance gap between the pilot and the avionics will impact NAS operations. One example might be the lack of a quantitative time standard for a pilot response to ATC directions (such as "turn left heading 270, maintain FL250") does not exist – there is an acceptable delay for the pilot's verbal response and physical action, but there is no documented required range of acceptable values. Avionics that perform the corresponding function cannot be designed and built without these performance requirements being established.

Existing standards ensure safe operation by pilots resident on the aircraft. These standards may not translate well to UAS designs where pilots are remotely located off the aircraft. Removing the pilot from the aircraft creates a series of performance considerations between manned and unmanned aircraft that need to be fully researched and understood to determine acceptability and potential impact on safe operations in the NAS. These include the following considerations:

- The UAS pilot is not on-board the aircraft and does not have the same sensory and environmental cues as a manned aircraft pilot
- The UAS pilot does not have the ability to directly comply with see-and-avoid responsibilities
- The UAS pilot must depend on a data link for control of the aircraft (Affect of response to revised ATC clearances, other ATC instructions, or unplanned contingencies: e.g., maneuver aircraft)
- UAS cannot comply with certain air traffic control clearances and alternate means may need to be considered (e.g. use of visual clearances)
- UAS present air traffic controllers with a different range of platform sizes and operational capabilities (such as size, speed, altitude, and wake turbulence criteria, and combinations thereof)
- Some UAS launch and recovery methods differ from manned aircraft and require manual placement and removal from runway, lead vehicle for taxi operations or dedicated launch and recovery systems

Therefore, it is necessary to develop operational concepts, formulate standards, and promote technological development that will enable manned and unmanned aircraft to operate cohesively in the same airspace. Specific technology challenges include two critical functional areas:

- "Sense and Avoid" (SAA) capability must provide for self-separation and ultimately for collision avoidance protection between UAS and other aircraft analogous to the "see and avoid" operation of manned aircraft and that meets an acceptable level of safety. SAA technology development is immature. In manned flight, see and avoid, radar, visual sighting, separation standards, proven technologies and procedures, and well-defined pilot behaviors combine to ensure safe operation. On the other hand, unmanned flight requires an alternate method to comply with "see and avoid" operational rules to detect traffic and to determine/execute avoidance maneuvers. SAA system standards must be developed to assure both self-separation and collision avoidance capability for UAS. Interoperability constraints must also be defined for safe and secure interactions between SAA-enabled UAS and other airborne and ground-based collision avoidance systems. While SAA may be an independent system, it must be designed to be compatible with

other modes of separation provision (e.g. Air Traffic Control separation services). See Sections 7.3 and 7.4 for specific goals and metrics.

- Control and Communication system performance requirements are being developed by SC-203, Working Group-2 and will specify the necessary minimum performance to achieve the necessary higher-level (UAS level) performance and safety requirements. Third party communication service providers are common today (ARINC, Harris, etc.) and the FAA has experience with setting and monitoring performance of third parties. The use of third parties is dependent on the UAS architecture chosen, but these are still being evaluated in terms of feasibility from a performance, cost, and safety perspective. See Section 7.5 for specific goals and metrics.

2.2.4 Managing the Challenges

To provide the UAS community insight into the FAA process for fostering UAS flight in the NAS, Figure 5 highlights the intended shift in focus over time. This method is consistent with the approach used for new technologies on manned aircraft.

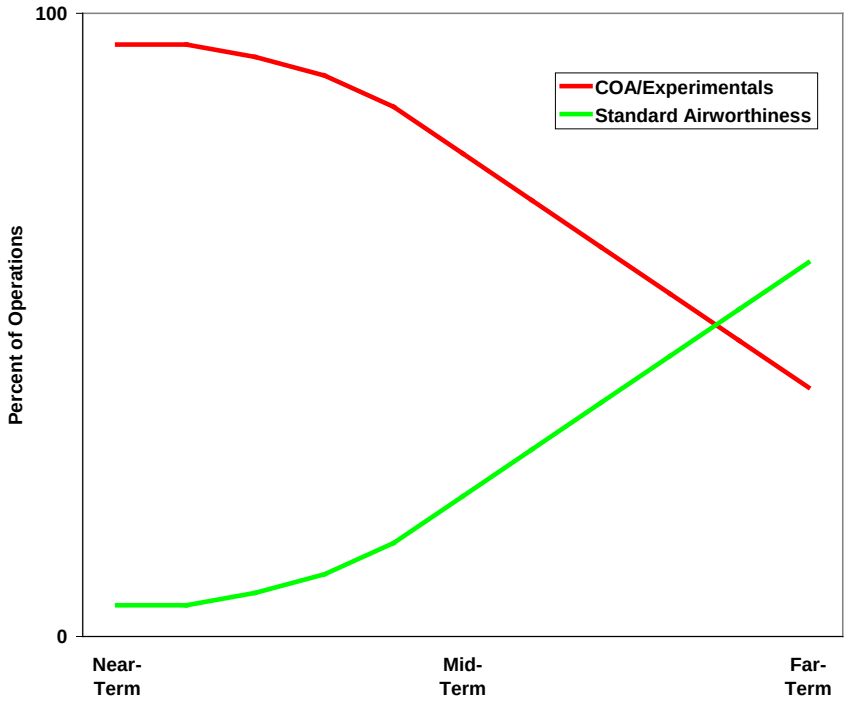

Figure 5: Transition from COA/Experimental to Standard Airworthiness

Recognizing the challenges and the complex coordination required for integration, the UAS roadmap addresses the efforts needed to move forward incrementally toward the goal of full NAS integration.

Based on this goal, the FAA identifies three key perspectives as a means for examining the way ahead. These perspectives transcend the timelines of near, mid and far term and provide additional insight into the task of integrating UAS into the NAS:

Perspective 1: Accommodation. Ability to take current UA and apply special mitigations and procedures to safely facilitate limited access to the NAS. UAS operations in the NAS are considered on a case-by-case basis. Accommodation will predominate in the near term, and while it will decline significantly as integration begins and expands in the mid term, it will continue to be a viable means for NAS access. During the near term, R&D will continue to identify challenges, validate advanced mitigation strategies, and explore opportunities to progress UAS integration into the NAS.

Perspective 2: Integration. Establishing threshold performance requirements for UAS that would increase access to the NAS, is a primary objective of integration. During the mid - far time periods, the agency will establish policy, regulations, procedures, and understanding of systems and operations to support routine NAS operations. Integration will begin in the near-to-mid-term with the implementation of the small UAS rule and will expand further over time (mid and far term) to consider wider integration of a broader field of UAS.

Perspective 3 – Evolution – All required policy, regulations, procedures, technologies, and training are in place and routinely updated to support UAS operations in the NAS operational environment as it evolves over time. It is important that the UAS community maintains the understanding that the NAS environment is not static, and that there are many improvements planned to the NAS over the next 13-15 years. To avoid the obsolescence, UAS will need to maintain a dual-focus: integration into today's NAS while maintaining cognizance of how the NAS is evolving.

Timely progress on products, decisions, research, development, test, and evaluation will be needed to successfully move from accommodation to integration and through to the evolving NAS.

The approach to addressing the challenges focuses on the following topics. They are not mutually exclusive, but instead, are highly inter-dependent.

1. Standards
2. Rules and Regulations
3. Certification of the UAS
4. Procedures and Airspace
5. Training (Pilot, Flightcrew Member, and Controller)
6. R&D and Technology

The roadmap discusses the activities and transitions for these topic areas from the vantage of the three perspectives.

3 Perspective 1: Accommodation

The FAA's focus in the near-term will be on safely allowing for the expanded operation of UAS through accommodation. Over time, increased access to the NAS through accommodation will be possible through improvements to current mitigations and introduction of advanced mitigations made possible by enhanced procedures and technology. Research and development on current and advanced mitigations is necessary as it is accepted that, while the volume of unmanned aircraft operations needing accommodation will diminish over time, the need to maintain this avenue for access will continue. The consideration and planning for integration of UAS into the NAS will continue simultaneously.

3.1 Overview

There has been a growing interest in a wide variety of civil uses for unmanned aircraft. There are a number of airworthiness paths that can be applied for airworthiness certification of UAS. Of the various methods, one method that the UAS civil community is currently using to access the NAS is the Special Airworthiness Certificate - Experimental Category (SAC-EC) process, which requires specific, proven capabilities to enable operations at a constrained level. Each application is reviewed for approval on a case-by-case basis that allows a carefully-defined level of access that is limited and dependent on risk mitigations that ensure safety and efficiency of the NAS is not diminished. The use of the experimental airworthiness certificate for UAS is similar to the use for manned aircraft.

To date, the FAA has issued over 90 experimental certificates to 13 civil operators utilizing 20 unique UAS designs, including 6 certificates for Optionally Piloted Aircraft (OPA). These experimental certificates have been useful for UAS research and development (R&D), and as R&D efforts subside, the use of SAC-EC may decrease. While the FAA continues to accommodate special access to the NAS, existing airworthiness standards are also an avenue for full type certification. The FAA is working with the ARC to gain feedback to potential changes to airworthiness standards for UAS if necessary. In the long-term, UAS that are designed to a standard and built to conform to the design can be integrated into the NAS as fully certificated aircraft.

3.2 Standards

If UAS are to operate routinely in the NAS, they must conform to an agreed upon set of standards. Requirements will vary depending on the nature and complexity of the operation, aircraft or component system limitations, pilot and other crewmember qualifications, and the operating environment

A technical (or operational) standard is an established norm or requirement about a technical (or operational) system which documents uniform engineering or technical criteria, methods, processes and practices. A standard may be developed privately or unilaterally, by a corporation, regulatory body, or the military. Standards can also be developed by organizations such as trade unions and associations. These organizations often have more diverse input and usually develop voluntary standards which may be adopted by the FAA as a means of compliance.

To operate an aircraft safely and efficiently in today's NAS, a means of complying with Title 14 of the Code of Federal Regulation (14 CFR) must be developed. Aircraft certification standards govern the design, construction, manufacturing, and continued airworthiness of aircraft used in private and commercial operations. These standards were developed with an underlying assumption that a person would be onboard the aircraft and manipulating the controls. This has led to numerous requirements that make aircraft highly reliable and safe for their intended operations.

While UAS share many of the same design considerations as manned aircraft, such as structural integrity and performance, most existing unmanned aircraft and control stations have not been designed to comply with civil airworthiness standards. Beyond the problem of meeting existing aircraft certification standards, other components of the UAS, such as the equipment and software associated with the data link (control and communication) and the launch and recovery mechanisms, are not currently addressed in 14 CFR.

Since 2004, the FAA has developed close working relationships with several standards development organizations. Most of these organizations plan to complete their UAS standards development efforts in the near-to-mid-term timeframe. When accepted, these standards development products will provide a means of compliance for rules established in the mid-term. The FAA has also been either the lead (or an important participant) in cross-agency efforts that influence standards development and has coordinated and harmonized these activities with international efforts.

Standardization efforts have already produced a number of useful definitions, guidance documents, and considerations that provide common understanding and add insight and data to UAS integration efforts.

- SC-203's Guidance Material (DO-304) and numerous position papers
- SC-203's Operational Services and Environment Definition For Unmanned Aircraft Systems (OSED, DO-320) which documented definitions and operating scenarios for different UAS operations in the NAS
- RTCA Air Traffic Management Advisory Committee, Requirements and Planning Work Group Report "Airspace Considerations for UAS Integration in the National Airspace System," March 26, 2008
- SAA Workshop Reports which have documented SAA timelines and definitions

Standards development will continue with the goal of producing Minimum Performance Standards (MPS) by the end of the near-term. RTCA/SC-203 products will be taken under consideration by the FAA in the development of policy and guidance products such as Advisory Circulars. The MPS may be used to define Technical Standard Orders (TSOs) in the mid-to-long-term.

Additional coordination and input from the stakeholder community (industry and trade associations, manufacturers, academia and research organizations, and public agencies) is being provided with the recent establishment of the FAA-UAS ARC.

Although the need to develop standards cannot be overstated, detailed policy, guidance, technical performance requirements, and operational procedures are also needed to enable manned and unmanned aircraft to fly safely and efficiently in the NAS. See Section 7 for specific goals and metrics.

3.3 Rules and Regulations

Unmanned aircraft operations have significantly increased in number, technical complexity and sophistication during recent years without specific regulations to address their unique characteristics. For a person wishing to design, manufacture, market or operate an unmanned aircraft system (UAS) for a commercial mission and is seeking FAA approval for that aircraft, its pilot and the operations, existing rules have not been fully-tailored to the unique features of UAS.

The FAA is in the process of publishing a Notice that will replace the current Interim Operational Guidance Material 08-01 which is used to support UAS accommodation. Since accommodation is not envisioned to be eliminated entirely, this guidance material will need to be updated periodically even as progress continues simultaneously on development of UAS rules and regulations for integration.

The appropriate regulations are being reviewed for applicability to UAS operations by the FAA, industry groups, and an ARC. The results of this review will determine any regulatory gaps that need to be addressed in the development of specific UAS guidance. Based on the findings of this review, a determination will be made regarding the need to modify, supplement, or create new regulations to support UAS beyond the near term. UAS rulemaking will follow these steps.

3.4 Airworthiness Certification of the UAS

Airworthiness certification is a process that the FAA uses to ensure that an aircraft design complies with Airworthiness Regulations codified in 14 CFR and that an aircraft conforms with its approved design.

Airworthiness standards for aircraft are codified in 14 CFR, with processes defined for FAA type certification in FAA Order 8110.4 and airworthiness certification in FAA Order 8130.2. Civil UAS are currently accommodated with SAC-EC under FAA Order 8130.34.

Consideration of UAS in the certification process will be limited in number until such time as a broad and significant consideration is given to existing standards, regulations, and policy. UAS operators must employ certified systems that enable compliance with standardized air traffic operations and contingency/emergency procedures for UAS.

The FAA believes that the UAS community will be best served by their use of an incremental stepwise approach as opposed to a “jump” to a civil type certification. As additional UAS airworthiness options are considered and UAS airworthiness standards are developed, type certification may be more efficiently and effectively achieved, as shown in Figure 8. The UAS Industry will continue to build capabilities into the mid- and long-term time frames. See Section 7.1 for specific goals and metrics.

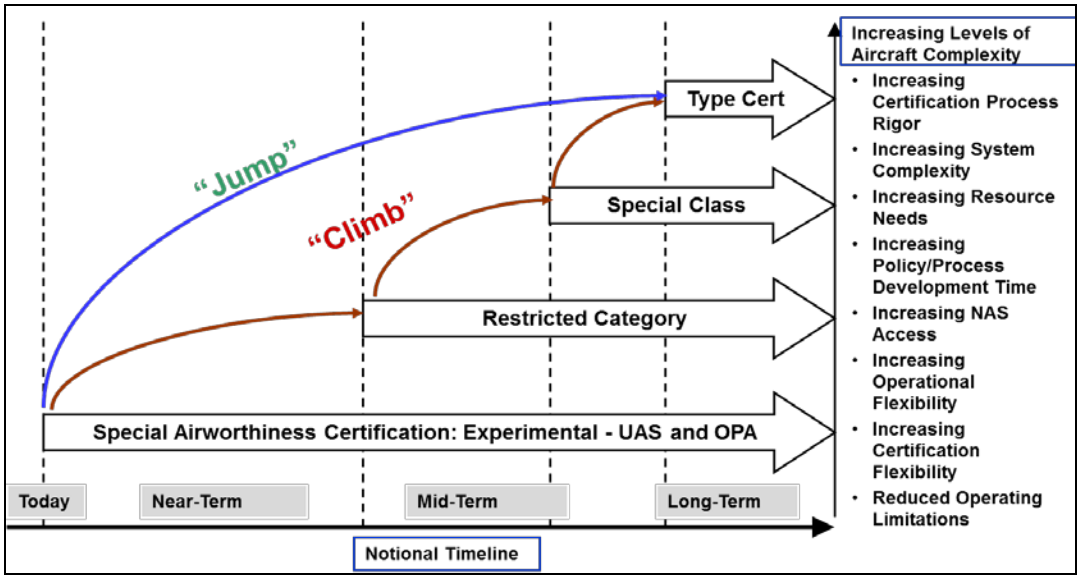

Figure 8: Potential Airworthiness Path for UAS Industry

3.5 Procedures and Airspace

A procedure is a series of actions or operations which have to be executed in the same manner in order to always obtain the same result under the same circumstances (for example, emergency procedures). The NAS depends on the structure of its airspace and the use of standard procedures to enable safe and efficient operations. ATO Policy N JO 7210.766 (titled "Unmanned Aircraft Operations in the National Airspace System (NAS)", March 28, 2011), defines how UAS are permitted to operate in the NAS today:

- COAs: for Public access to the NAS – interim regulatory guidance is being updated and will be released as a Notice
- SAC-EC: for civil access to the NAS
- AC 91-57: for Modelers (recreation) access to the NAS (June 1981)

SAC-EC and COAs will always be viable methods for accessing the NAS, but typically come with undesirable constraints and limitations. Expanded, easier access to the NAS will occur after the UAS certification criteria is defined and the FAA develops specific methods for appropriately integrating UAS into NAS operations.

Another requirement is the base-lining activity to assess UAS applicability to existing air traffic control regulations and orders. The resultant list of gaps will need to be analyzed, and decisions on accommodation or changes to UAS or regulations will be completed. Some sample differences that affect the air traffic system are:

- UAS Interoperability Issues:
  - En route – current UAS are not RVSM capable; and they do not fly traditional trajectory-based flight paths and require non-traditional handling in emergency situations

    - Terminal – UAS cannot comply with ATC visual separation clearances and cannot execute published instrument approach procedures
- Facilities – The introduction of UAS at existing airports represents a complex operational challenge. For the near term, it is expected that UAS will require deconfliction from mainstream air traffic, possibly accommodated with UAS launch windows, special airports, or off-airport locations where UAS can easily launch and recover. The sUAS Rule will not address the requirements for UAS at airport facilities, since these UAS will not use airports for take-off and landing. However, as civil UAS are developed that require airport access, airport integration requirements will need to be developed

ICAO has issued guidance requiring States to implement Safety Management Systems (SMS) programs. These programs are essential to manage risk in the aviation system, and the FAA fully supports this and is a leader in the design and implementation of SMS. Technical challenges abound, including the ability to analyze massive amounts of data to provide useful information for oversight and assessment of risk.

3.6 Training (Pilot, Flightcrew Member, and Air Traffic Controller)

UAS training standards will mirror manned aircraft training standards to the maximum extent possible and will account for all roles involved in UAS operation; specifically, the pilot, required crew members (such as a visual observer, or launch and recovery specialist), instructors, inspectors, maintainers, as well as the air traffic controllers. See Section 7.2 for specific goals and metrics.

Accident investigation policies, processes, procedures, and training will be developed near-term, and will be provided to Flight Standards District Office (FSDO) for implementation. Existing manned procedures will be leveraged as much as possible, though differences will need to be highlighted and resolved (e.g. when an unmanned aircraft accident occurs, there may be a need to impound the control station as well as the aircraft).

3.7 R&D / Technology

Research in the areas of gaps in current technology and new UAS technologies and operations will support and enable the development of airworthiness and operational guidance required to address new and novel aspects of UAS and associated flight operations. The FAA will continue to articulate requirements for flight in the NAS so R&D efforts are not duplicative and make the best use of limited resources. Additionally, the FAA UAS R&D plan is considered within the JPDO RD&D roadmap to prevent overlap and provide opportunities for research collaboration.

R&D efforts with industry support the establishment of acceptable performance limits in the NAS and enable the development of performance parameters for today's NAS, while evaluating future concepts, technologies, and procedures for NextGen. The Technical Community Representative Group (TCRG) is sponsoring broad-based UAS research (SAA, C2, and control station studies) aimed at integration with NextGen and validation of concepts. Near-term expected progress is described here:

<u>Sense and Avoid:</u>

Significant research into SAA methods is underway by both government and industry through a variety of approaches and sensor modes. Specifically the FAA is researching:

1. Establishment of Sense and Avoid system definitions and performance levels
2. Assessment of Sense and Avoid system multi-sensor use and other technologies
3. Minimum Sense and Avoid information set required for collision avoidance maneuvering.

Some public agencies and commercial companies are seeking to develop advanced mitigations, such as Ground Based Sense and Avoid (GBSAA) systems, as a strategy for increased access. Concept-of-use demonstrations are under way at several locations to use GBSAA as a mitigation to see and avoid requirements for public UAS COA proponents in limited operational areas. GBSAA research and the test evaluations will help develop the sensor, link, and algorithm requirements that could allow GBSAA to function as a partial solution set for meeting the SAA requirement and will help build the overall SAA requirements in the long-term. Additionally, as GBSAA technology matures, GBSAA could be utilized to provide "localized" UAS NAS integration in addition to being used as an advanced accommodation tool. See Section 7.3 for specific goals and metrics

Research is underway on Airborne SAA (ABSAA) concepts. Due to complexity, significant progress in ABSAA is not expected until the mid-term. Research goals for the near-term include a flight demonstration of various sensor modes (electro-optic/infrared, radar, TCAS and ADS-B). Actual fielding of a standardized SAA system is a long-term objective. See Sections 7.4 for specific goals and metrics

Control and Communications:
A primary goal of C2 research is the development of an appropriate C2 link between the unmanned aircraft and the control station to support the required performance of the unmanned aircraft in the NAS and to ensure that the pilot always maintains a threshold level of control of the aircraft. Research will be conducted for UAS control data link communications to determine values for latency, availability, integrity, continuity and other performance measures.

UAS contingency and emergency scenarios also require research (e.g. how will a UAS in the NAS respond when the command link is lost either through equipment malfunction or malicious jamming, etc.). This research will drive standards that are being established:

- Development and validation of UAS control link prototype
- Vulnerability analysis of UAS safety critical communications
- Completion of large-scale simulations and flight testing of initial performance requirements

Spectrum and civil radio frequency (RF) allocation are issues that require global coordination. The World Radionavigation Conference (WRC) will allocate UAS civil spectrum for C2 in the near-term. Link security requirements, such as protection against intended and unintended jamming, RF interference, unauthorized link takeover, and spoofing, will also be investigated. See Section 7.5 for specific goals and metrics

Modeling and Simulation:
The FAA is working with other government agencies and industry to develop a collaborative UAS modeling and simulation environment to explore key challenges to UAS integration. The near-term modeling goals are to:

- Validate current mitigation proposals
- Establish a baseline of end-to-end UAS performance measures
- Establish thresholds for safe and efficient introduction of UAS into the NAS
- Develop NextGen concepts, including 4-dimensional trajectory utilizing UAS technology

These modeling and simulation efforts will address NAS integration topics, such as ATC clearance, UAS inability to accept ATC visual clearances, lost link, and flyaway scenarios.

Human Factors:
With the pilot controlling the aircraft from beyond the aircraft, there emerges several human factors issues related to both the pilot and ATC, and how they will interact to safely operate unmanned aircraft in the NAS. Human factors issues in manned aviation are well known, but there needs to be further analyses, specifically regarding integration of UAS into the NAS. In the near-term, data will be collected to permit analysis of how pilots fly UAS, how controllers provide service involving a mix of manned aircraft and UAS, and how pilots and controllers interact with each other, with the goal of developing pilot, ATC, and automation roles and responsibilities concepts. A JPDO workshop, with collaboration of Government, Academia, and Industry researchers, identified several interrelated research challenges (Joint Planning and Development Office, 2011):

- Effective Human-Automation Interaction (level; trust; and mode awareness)
- Pilot-Centric GCS Design (displays; sensory deficit and remediation; and sterile cockpit)
- Display of Traffic / Airspace Information (separation assurance interface)
- Predictability and Contingency Management (lost link status; lost ATC communication; and ATC workload)
- Definition of Roles and Responsibilities (communication flow among crew, ATC, and flight dispatcher)
- System-Level Issues (NAS-wide human performance requirements)
- Airspace Users and Providers Qualification and Training (crew/ATC skill set, training, certification, and currency)

Other research in this phase includes activities to support safety case validation and the associated mitigations. This includes case-by-case assessments to determine the likelihood that a system/operation can achieve an acceptable safety level. The research will consider UAS operational and technical risks including:

- Inability to avoid a collision
- Inability to maintain positive control
- Inability to meet operational environment's expected behavior
- Inability to safeguard the public

Summary of "Accommodation" Priorities
Accommodation of UAS in the NAS through evaluation and improvement of safety mitigations
Work with industry and the ARC to review the operational, pilot, and airworthiness regulations
Development of required standards to support technological solutions to identified operational gaps. (MOPS)
Safety Case Validation for UAS operations in NAS—collect/analyze operational and safety data
Robust research, modeling, and simulation for UAS Sense and Avoid, C2, and Human Factors

3.8 Test Ranges

The FAA will coordinate with and leverage the resources of NASA and the DoD to establish six test ranges no later than 180 days from the enactment (February 14, 2012) of the FAA Modernization and Authorization Act of 2012. The test ranges will take into consideration climate and geographic diversity, the location of ground infrastructure and research needs. A project at a test range will be operational no later than 180 days after the date on which a project is established. See Section 7.7 for specific goals and metrics.

The test range program will address and account for:

- Manned-unmanned operations,
- Certification standards and air traffic requirements at test ranges,
- Coordinate and leverage NASA and DoD resources
- Civil and public unmanned aircraft systems,
- Coordination with the Next Generation Air Transportation System
- Provide a verification mechanism for safe operations before unmanned aircraft are integrated into the national airspace system.

4 Perspective 2: Integration

4.1 Overview

In the mid-term, emphasis will shift significantly from accommodation to integration. For the residual accommodation requirements, it is expected that operational lessons learned and technological advances will lead to more sophisticated mitigations with increased safety margins. Thus, COAs and SAC-ECs will remain avenues for accessing the NAS, but emphasis will shift toward integration of UAS through the implementation of civil standards for unmanned aircraft pilots and UAS certification, together with necessary policy guidance and operational procedures.

Integration efforts will focus on sequentially developing and implementing the UAS system requirements established by the FAA:

- Finalize the integrated set of FAA policy, operational guidance, procedures, and standards
- Define continued airworthiness methodologies
- Complete training and certification standardization
- Continue the technology development and assessment work that underpins the ability of UAS to operate safely and efficiently in the NAS

Research is needed to help define the UAS certification basis that supports necessary equipment design for the approval of technology development intended to receive civil certification under existing or adapted/expanded regulations, guidance, and standards. While current regulations, guidance, and standards assure safe operation of aircraft with pilots in the cockpit, these may not represent the necessary and sufficient basis for the design and operation of UAS.

Integration efforts will provide a foundation for creating and modifying FAA policies and procedures to permit more routine forms of UAS access and bridge the gap to the long-term goal of developing the policy, guidance, and operational procedures required to enable manned and unmanned aircraft to fly together in an environment that meets or exceeds today's level of safety and efficiency. As new UAS evolve, more specific training will be developed for UAS Pilot, Crew Member, and Certified Flight Instructor (CFI). See Section 7.2 for specific goals and metrics.

UAS operations comingled at airports with manned aircraft is one of the more significant challenges to NAS integration. The UAS must be able to operate within airport parameters and comply with the existing provisions for aircraft. As with airspace operational requirements, the airport standards are not expected to change with the introduction of UAS, and their operation must be harmonized in the provision of air traffic services.

4.2 Standards

After MASPS are completed, the emphasis of standards activities will be geared towards the development of MOPS, which will contribute to the basis for regulatory changes and the equipment standards for UAS-specific systems and equipment. The development of MOPS may

provide the necessary and sufficient requirement for invocation as Technical Standard Orders for airworthiness approval on certificated unmanned aircraft and may lead to the development of improved systems, potentially applicable to all civil aircraft. See Section 7 for specific goals and metrics.

4.3 Rules and Regulations

Recognizing that the UAS community might be better served by specific rules, the FAA is proposing to amend its regulations to adopt specific rules for the operation of small unmanned aircraft systems (sUAS) in the NAS. These changes will address the classification of sUAS, certification of sUAS pilots, registration of sUAS, approval of sUAS operations, and sUAS operational limits.

The establishment of the sUAS Rule will provide experience for pilots and additional data to determine an "operational" case for UAS flying safely and efficiently in the NAS. Although the sUAS airspace and performance requirements are constrained, there will be an opportunity to adapt and improve the sUAS rule and to leverage or expand its application to other UAS based on data analysis and lessons learned. As the first rule for UAS, it will establish a separate regulatory framework for sUAS operated in visual line-of-sight of the pilot. It will enable commercial operations by civil operators and establish an initial basis for sUAS crew certification and requirements.

Once adopted, the proposed regulation will alleviate the need for sUAS operators to conduct operations under either a COA or an SAC-EC. This will result in a reduction of workload and backlog to both the operators and the FAA, which will allow each to shift the focus of resources to other solutions that will better enable UAS integration. See Section 7.6 for specific goals and metrics.

4.4 Certification of the UAS

The UAPO will work with the UAS community in defining an acceptable UAS certification basis. This may involve the development of new policy, guidance, special conditions and methods of compliance. See Section 7.1 for specific goals and metrics.

4.5 Procedures and Airspace

There will be incremental increases in NAS access based on rigorous safety mitigations of current UAS which were previously developed and built without approved industry or governmental standards, other than the current 14 CFR. As integration begins, there will be approved airspace and procedures for small UAS, which will provide a basis for developing plans for increased NAS access as UAS are certified. To support this, ATO goals will be:

- Develop airport facility integration plans, this will require research and the development of procedures that address critical issues such as low visibility, taxi spacing, light gun signals and compatibility with NextGen operations.
- Establish UAS operating requirements with associated ATC procedures for airport conditions

4.6 Training (Pilot, Flightcrew Member, and Air Traffic Controller)

The FAA's role in training is to establish policy, guidance and standards. Flight instructor, pilot, and crew member training standards are under development. These standards will be synchronized with the regulatory guidance. Civil operators normally develop training regimen that allows pilots and flight support to meet regulatory standards.

Flightcrew performance standards for small UAS will be determined before the sUAS rule becomes effective and the FAA begins issuing UAS pilot certificates. Activities needed to enable the rule include:

- Training of ASIs at the FSDO level to provide practical test oversight
- Designation of Pilot Examiners (DPE) to assist the FSDOs
- Development of a UAS handbook for pilot and instructors
- Development of Practical Test Standards (PTS) and UAS pilot knowledge test question bank

Pilot endorsements will be developed for specific UAS make and model to permit commercial operations. Pilot qualifications by make and model will be built into training and will be expanded based on pilot experience.

Training standards development will be more complex for UAS with unique operating parameters and will continue into the long-term, as these UAS are certified.

Regardless of the UAS platform, similar types of training regimens are expected; consisting of a written test, practical exam, and evaluations or check-rides. There will be a requirement for currency and proficiency; qualified ASIs will be fielded to regional offices across the country.

With the introduction of UAS into the NAS, additional training requirements specific to different types of UAS characteristics may be required for ATC personnel, including UAS performance, behavior, communications, unique flight profiles, ATC standardized procedures, lost link/fly away profiles, operating limitations and emergency procedures. Controller training will include differences in interoperability between manned and UAS flights, with a focus on specific handling issues of the aircraft. This training must be administered to ATC facilities throughout the NAS. Controllers will handle UAS just as manned aircraft; therefore, no special ATC certification will be required. See Section 7.2 for specific goals and metrics.

4.7 R&D / Technology

Sense and Avoid:

Research on SAA sensor performance, data communication, and algorithms must provide solutions for safe separation for integration of UAS into the NAS. Research to develop separation algorithms will be accomplished with JPDO R&D Plan goals of:

- Flight demonstration of Self-Separation (SS) and Collision Avoidance (CA) algorithms, with multiple sensors and intruders

- Assessment of the performance of various SS concepts as a function of surveillance data configurations, and evaluation of risk-based SS algorithms and policy issues
- Assessment of the performance of various Separation Assurance (SA) concepts, and flight demonstration of SA algorithms, with criteria-based separation

Although research will continue, fully certified UA-based collision avoidance solutions may not be feasible until the long-term and are deemed to be a necessary component for full UAS NAS integration. This will include research on safe and efficient terminal airspace and ground operations, followed by ground demonstrations of autonomous airfield navigation and ATC interaction. See Section 7.4 for specific goals and metrics.

Control and Communications:
Advanced research is required in data link management, spectrum analysis, and frequency management. Efforts will focus on completing development of C2 link assurance and mitigation technologies and methods for incorporating them into the development of certification of the UAS. This will include:

- Allocation of satellite communication spectrum from the International Telecommunications Union through its World Radio Telecommunication Conference
- Verification and validation of control communication final performance requirements
- Establishment of UAS control link national/international standards
- Development and validation of technologies to mitigate vulnerabilities

Complete characterization of the capacity and performance impact of UAS on ATC communication systems will be completed. See Section 7.5 for specific goals and metrics.

Human Factors:
Human Factors research will continue in the areas of human-machine interface (both control station displays and ATC displays), automation, and migration of control. Human factors data collected in the near-term and mid-term will be analyzed to determine the safest technologies and best procedures for pilots and ATC controllers to interact with each other and with the aircraft; these results will influence technology and operations research. For separation and collision avoidance capability, the contribution of human decision-making versus automation must be identified.

Summary of "Integration" Priorities
"Equivalent visual" flight operations standards defined
Public Issuance of sUAS rule
C2 link standards defined for integrity, latency, and continuity
FAA acceptance of MASPS to enable development of detailed MOPS
Published FAA policy, operational guidance, and define an acceptable UAS certification basis
Published FAA flightcrew training and certification standards

5 Perspective 3: Evolution

5.1 Overview

Overlaying the integration of UAS is the need to remain aware of the changing characteristics and requirements of the evolving NAS. The long-term focus for UAS operations is the refinement and updating of regulation, policy, and standards. The end-state is to implement streamlined processes for the continued integration of UAS into the NAS.

These efforts will include:

- Policy, operational guidance, and standards for civil aircraft airworthiness and NAS operations
- Continued airworthiness methodologies
- Training and certification standardization
- Certification of key technologies to enable continued operations of UAS in the NAS

5.2 Standards

A UAS certification basis will have been determined. MASPS, MOPS and TSOs will support the regulations and certification of key systems for each UAS. Additionally, all standards will be evaluated and modified, as needed. See Section 7 for specific goals and metrics.

5.3 Rules and Regulations

Lessons learned from developing and implementing previous rules are directly applicable to the development of various UAS rules and regulations. The process will accelerate as UAS experience is gained and data analysis proves safety cases more quickly. Rulemaking activities will enter a phase of evolution rather than creation of new UAS-based rules.

5.4 Certification of the UAS

Certification of UAS will evolve as future technologies evolve and will be consistent with all other aircraft airworthiness and operational approval processes, adding more capability to the UAS through data analyses, and trending which will identify areas for change and improvement in operations, human factors, communication links, and maintenance. See Section 7.1 for specific goals and metrics.

5.5 Procedures and Airspace

Certified pilots and UAS will be permitted access into the NAS under seamless operating procedures. The need to accommodate special NAS access will be dramatically reduced, and will be limited to research and development or test operations.

UAS operations will continue to evolve based on NextGen requirements.

5.6 Training (Pilot, Flightcrew Member, and Air Traffic Controller)

As new UAS evolve, more specific training will be developed for UAS Pilot, Crew Member, and Certified Flight Instructor (CFI) based on lessons learned and data collection. See Section 7.2 for specific goals and metrics.

5.7 R&D / Technology

Identified limitations and gaps will be closed via research and development of required technologies that meet standards established by the FAA. Planned activities include:

- Sense and Avoid research that focuses on algorithm development and compatibility with current and future manned aircraft collision avoidance systems such as TCAS and ADS-B, as well as compatibility with ATC separation management procedures and tools
- Research on UAS system safety and levels of autonomy for the improvement of UAS into the future
- Examination of potential concepts for the wide-spread integration of UAS into the future NextGen environment
- Research on new tools and techniques to support avionics and control software development and certification, to ensure their safety and reliability.

Organized studies will continue to investigate the evolution of UAS operations into the NextGen environment. Detailed research on "equivalent visual" flight operations, using certified sensor systems, could allow aircraft to maintain safe distances from other aircraft during flight conditions that would not be appropriate for visual flight in a manned aircraft. This capability would rely heavily on net-enabled information, precision navigation, and cooperative surveillance, and would require the development and integration of NextGen-representative technologies for traffic, weather, and terrain avoidance. This conceptual model will be enlarged with sensors that expand the ability to maintain separation from other aircraft past the current visual spectrum and flight conditions restrictions.

Summary of "Evolution" Priorities
Seamless operations of certified UAS and crew members in the evolving NAS
Published FAA TSOs based on system level MOPS
Certified Sense and Avoid algorithm for collision avoidance

6 Key Messages

6.1 Summary

The safe integration of unmanned aircraft into the NAS is a significant challenge. The FAA is dedicated to pursuing the resources required to develop the technical and regulatory standards, policy guidance, and operational procedures on which successful UAS integration depends.

The application of financial and human resources by academia and industry to support critical FAA initiatives will shorten the time required to develop technical and regulatory standards. Together, all stakeholders can overcome the challenge of integrating UAS into the NAS and to better utilize UAS and associated technologies for the greater benefit of society.

6.2 List of Key Messages

Based on the FAA Policy and the challenges that need to be addressed, this roadmap has focused on the activities required to achieve full integration of UAS into the evolving NAS. Throughout the process, these key messages reflect the basis for the FAA's consideration of requirements to integrate civil UAS into the NAS.

1) **Government-industry collaboration is paramount to success and must focus on process, quality, and timely results.**
   The FAA expects to gain experience with applying the existing airworthiness regulations during the type certification process with early UAS adopters. We also expect to get input from industry and the ARC. Taking into account industry and ARC inputs, and future experience with UAS type certification projects, the FAA will review and revise as necessary the existing airworthiness regulations to ensure UAS safety.

2) **The FAA must remain committed to the development of technical and regulatory standards, policy guidance, and operations procedures on which successful UAS integration depends.**
   With this Roadmap, the FAA has outlined a series of sequenced initiatives that must be accomplished. Because unmanned aircraft are considered aircraft that are flown by pilots, existing regulations and procedures are largely applicable. However, the complete integration of UAS at airports and in the various airspace classes may necessitate the development of UAS-specific regulations and supplemental procedures, while complying with the guiding principles addressed in this document.

3) **Global standards encourage harmonization and yield cost-effective development.**
   The FAA is not bound by international policies and standards. However, harmonizing efforts with the international aviation community will allow for more seamless operations of UAS across national boundaries. Synchronizing efforts within the aviation community will also permit better utilization of limited human and fiscal resources, thereby reducing the time required to produce regulatory guidance, policy, and standards.

4) **FAA is focused on increased access for UAS without impacting the safety or efficiency of the NAS.**

The FAA has placed a high priority on delivery of a small UAS rule in the near term that will allow increased UAS access to the NAS and the initial opportunity for commercial operations. In the long term, the principle objective of the aviation regulatory framework is to achieve and maintain the highest possible uniform level of safety while maintaining or increasing the efficiency of the NAS. In the case of UAS, this means ensuring the safety of all airspace users as well as the safety of persons and property on the ground.

5) **Progress must be made on the development of technology to enable NAS access.** *Because of many distinct differences from manned aircraft, there are required technologies that must be matured to enable the safe and seamless integration of UAS into non-segregated airspace. Research will be focused in the areas of sense and avoid, control and communications, and human factors.*

7 Goals and Metrics

This section identifies the key goals to be accomplished in accommodating, integrating, and evolving UAS operations in the NAS. The goals are, for the most part, intended to be addressed concurrently. For each goal, a set of metrics (i.e., well-defined milestones with target completion dates) are defined. The metrics help establish and maintain common government and industry expectations, and enable objective assessments of the progress made toward the accomplishment of each goal. The goals and metrics reflect the incremental approach to UAS certification and integration described in this roadmap.

The goals and metrics in and of themselves do not constitute a UAS integration roadmap implementation plan; however, they do establish a set of set of strategic objectives that can guide the definition of activities, schedules, and resource requirements in such a plan. Many of the goals and metrics are not under the FAA's direct control and are dependent upon industry efforts such as participation in civil UAS standards development activities and execution of Pathfinder programs to aid in the establishment of certification requirements.

The goals and metrics are summarized in Appendix C. Near-term metrics (i.e., those with target dates between 2012 and 2015, inclusive) are identified by month and year. Mid-term metrics (between 2016 and 2020, inclusive) and far-term metrics (beyond 2020) typically only have a target year specified, and some have no target year specified. All the target dates are exactly that – targets. They are not commitments, either by the FAA, other government organizations, or industry. The target dates were established with full awareness and consideration of on-going and planned government and industry activities and schedules; however, they were not constrained by these activities and schedules. Many of the target dates are aggressive and likely will require additional resources and activities if they are to be met. The specific requirements for meeting the target dates can only be determined through establishment of a roadmap implementation plan.

Although this roadmap is focused on the integration of civil UAS in the NAS, some of the goals and metrics address public UAS integration activities – primarily those of the DoD. Public entities establish their own certification requirements and processes, which typically build upon the requirements and processes established by the FAA for civil aviation. Since the DoD has significant experience with UAS development and operation and since it has an urgent and rapidly growing need to operate a wide variety of UAS in the NAS, the DoD's significant activities to develop certification bases for public UAS can and should be leveraged in the FAA's establishment of civil UAS certification requirements.

7.1 Certification Requirements (Airworthiness, Production, Operator)

Note: The term "Operator" is used here as defined by the FAA for passenger/cargo carrying and other "for hire and compensation" operations. Not all UAS operations conducted for hire and compensation will require an Operator Certificate. One outcome of this effort will be to establish which UAS operations will or will not require an Operator Certificate.

Goal 1: FAA's classification and draft basis of certification established for all types of UAS in 2012.

A. FAA's UAS classification strategy finalized and communicated by Dec 2012.
   - Explanation. A baseline classification is a required first step in developing regulations or consensus standards.

B. FAA's draft basis of certification established by Dec 2012.
   - Explanation. This will most likely be modifications to existing requirements and/or consensus-based standards established for manned aircraft.

C. Pathfinder certification programs defined through government-industry partnerships by Dec 2012.
   - Explanation. Industry is willing to participate in supporting UAS platform certification under appropriate, existing certification regulations to establish a basis for modifying existing rules or establishing new rules specific to UAS. This will act as a catalyst to establish the process to be used for UAS certification. It has the potential to significantly reduce the time/effort required by future UAS certification applicants.

Goal 2: FAA's draft certification requirements are available in 2013.

D. FAA's initial certification requirements defined for UAS ground station, airframe, control system, propulsion system, ground support equipment (GSE), etc. by Dec 2013.
   - Explanation. Requirements for all UAS system components must be established. Requirements can be identified and refined as a result of previous Pathfinder efforts, publication of ASTM consensus standards, and related ongoing efforts of RTCA. Timely establishment of requirements will advance and expedite industry technology investment and development in UAS design and function.

E. Pathfinder certification programs underway by Jan 2013.
   - Explanation. See explanation above for Pathfinder programs.

F. Other UAS certification programs defined by Dec 2013.
   - Explanation. The basis for certification requirements will be driven by early establishment of Small UAS (sUAS) Rule (Part 107). As certification rules begin evolving in 2012-2013, lessons learned can be applied to larger platforms.

Goal 3: FAA's minimum certification requirements established by 2015.

G. FAA's minimum certification requirements for UAS ground station, airframe, control system, propulsion system, GSE, etc. published by Dec 2015.
   - Explanation. Lessons learned from certification of Pathfinder systems, publication of consensus standards, and additional operational experience gained as a result of sUAS Rule publication will provide the necessary data to finalize

full system certification requirements.

H. Other UAS certification programs underway by Dec 2014.
- Explanation. Once the Pathfinder programs are underway, other certification programs should be able to be started based on results of the Pathfinder programs.

I. Pathfinder certification programs completed by Dec 2015.
- Explanation. It is expected that some certifications will be granted under existing rules and requirements by this date.

J. Other certification programs completed by Dec 2015.
- Explanation. Lessons learned from certification of Pathfinder systems, publication of consensus standards, and additional operational experience gained as a result of the sUAS Rule will provide the necessary data to finalize certification requirements. It is expected that some system certifications will be granted under these new requirements by this date.

Goal 4. FAA certification requirements updated and systems certified as necessary.

K Certification requirements updated as necessary.
- Explanation. Self-explanatory.

L. UAS certified as necessary.
- Explanation. Self-explanatory.

7.2 Certification Requirements (Pilot/Crew)

Goal 1: FAA certification requirements for pilots and crew members for all UAS classes (including medical requirements, training standards, etc.) published by 2013 and updated as necessary.

A. FAA decision to develop draft requirements itself.
- Explanation. The certification and medical requirements included in the FAA's sUAS rule should form the basis for all classes of UAS. Existing CFR 14 Part 61 pilot certificate regulations and some logical adaptation of CFR 14 Part 67 Medical Requirements should be readily applicable to UAS. The FAA already has decided to develop these draft requirements itself, and is working on them now.

B. Draft requirements developed by Dec 2013.
- Explanation. Adaptation of existing regulations regarding record keeping, logging of flight time, recent experience, etc. found in CFR 14 Parts 61, 91, 141, and 142 provide a ready baseline to establish requirements.

C. FAA publishes final requirements by Jun 2014.
   - Explanation. Once the draft requirements are established, final requirements should be made available within six months.

D. Requirements updated as necessary.
   - Explanation. Self-explanatory.

Goal 2: Necessary changes to record keeping systems established.

E. Changes to FAA and industry record keeping systems completed by Dec 2014.
   - Explanation. Once the final requirements are established, some changes to existing record keeping systems likely will be necessary.

7.3 Ground-Based Sense and Avoid (GBSAA)

Goal 1: GBSAA operations fully approved by FAA for routine use by DoD and other public entities by 2013.

A. FAA approvals for use of GBSAA at all DoD GBSAA test sites granted by Dec 2012.
   - Explanation. Utilize US Army and US Air Force-developed solutions at DoD UAS test sites. (Note: These are existing DoD GBSAA test sites, not the new test ranges discussed in Sections 3.8 and 7.7.) Gain FAA approval for use of GBSAA to provide sense-and-avoid (SAA) functionality and meet SAA requirement for operation of UAS at these test sites.

B. FAA approvals for use of GBSAA for educational and other public applications granted by Dec 2013.
   - Explanation. As above, but expanded beyond DoD to include public use and at any locations equipped with GBSAA.

Goal 2: GBSAA operations fully approved by the FAA for routine use by all aviation, including both public and civil entities (if needed), by 2015.

C. FAA approvals for use of GBSAA for limited civil applications granted by Jan 2014.
   - Explanation. As with FAA operational approvals for use of GBSAA at all DoD GBSAA test sites and operational approvals for use of GBSAA for educational and other public applications, expanded approvals are expected to be granted for limited civil use at select locations.

D. FAA's initial GBSAA certification standards for civil operations established by Jan 2014.
   - Explanation. Assimilate prior deployment experience for DoD, public, and limited civil use, and develop MASPS for GBSAA.

E. FAA approvals for use of GBSAA for civil applications granted by Dec 2014.

- Explanation. Self-explanatory.

F. FAA's final GBSAA certification standards for civil operations established by Dec 2014.
- Explanation. Self-explanatory.

G. GBSAA certification standards updated as necessary.
- Explanation. Self-explanatory.

7.4 Airborne-Based Sense and Avoid (ABSAA)

Goal 1: Initial FAA certification of ABSAA that facilitates UAS operations without the requirement for a visual observer by 2014.

A. Initial proposal for SAA implementation, integration, and operation in an industry Pathfinder program released by Apr 2014. (See Section 7.1 for the Pathfinder program goals and metrics.)
- Explanation. This industry proposal will address: a) UAS operations requirements, b) specific UAS sense-and-avoid requirements at the proposed operating site(s), c) UAS ABSAA equipage requirements, including ADS-B, TCAS, and non-cooperative sensors, and d) installation and integration of the initial, proposed SAA system(s). ("System" includes both hardware and software.)

B. FAA "Issue Paper(s)" on UAS SAA implementation in one or more Pathfinder programs released by Dec 2014.
- Explanation. The FAA "Issue Paper(s)" will document the special considerations for certification of initial UAS airborne systems that include SAA functions. They also will document special considerations for operating UAS that employ the initial ABSAA systems, and special considerations (including avionics equipage requirements) for manned aircraft operating simultaneously in the same airspace.

Goal 2: Installation and certification of ABSAA for use by DoD, other public, and civil entities that provide the SAA functions required in the NAS for Classes A, E, and G airspace, and operations approved without the requirement for a visual observer or a COA.

C. RTCA UAS MASPS Part I (operational and functional requirements) released by Dec 2012.
- Explanation. This includes the overall, end-to-end civil UAS performance requirements, including the necessary portion of avionics onboard the unmanned aircraft and off aircraft subsystems that will enable operations in the NAS.

D. RTCA UAS MASPS Part II (safety and interoperability requirements) released by Dec 2013.
   - Explanation. This document includes the overall, end-to-end civil UAS performance requirements, including the necessary portion of avionics onboard the unmanned aircraft and off aircraft subsystems that will enable operations in the NAS.

E. RTCA SAA MASPS released by Jun 2014.
   - Explanation. This document includes the requirements basis to develop Minimum Operational Performance Standards (MOPS) for SAA subsystems, including the SAA avionics onboard the unmanned aircraft and required elements of ground control systems.

F. RTCA SAA MOPS released by Dec 2015.
   - Explanation. This document includes the avionics onboard the UAS and required elements of ground control systems.

G. FAA SAA TSO issued by 2016.
   - Explanation. This document includes the avionics onboard the UAS and required elements of ground control systems.

H. FAA SAA TSO'd equipment used operationally in 2016.
   - Explanation. Self-explanatory.

Goal 3: DoD or other public entity certification of initial ABSAA systems that enable the DoD and other public entities to safely operate ABSAA-equipped UAS in all NAS airspace classes without the need for a COA.

I. Initial proposal for ABSAA implementation, integration, and operation in one or more programs released by 2017.
   - Explanation. This proposal will address the requirements for ABSAA system(s), including ADS-B, TCAS and non-cooperative sensing. ("System" includes both hardware and software.)

J. FAA "Issue Paper(s)" on UAS SAA implementation in one or more programs for UAS operations in all NAS airspace classes released by 2018.
   - Explanation. The FAA "Issue Paper(s)" will document the special considerations for certification of UAS airborne systems that include SAA functions. They also will document special considerations for operating UAS that employ these ABSAA systems, and special considerations (including avionics equipage requirements) for manned aircraft operating in the same airspace.

Goal 4: Installation and certification of ABSAA systems for use by DoD, other public, and civil entities that provide the SAA functions that facilitate integrated operation of manned and unmanned aircraft in all NAS airspace classes by 2020.

K. Initial RTCA UAS MASPS released by 2016.
- Explanation. This document includes requirements for the overall, end-to-end civil UAS, including the necessary portion of avionics onboard the aircraft and off aircraft subsystems that will enable operations in the NAS.

L. RTCA SAA MASPS released by 2017.
- Explanation. This document includes the SAA avionics onboard the aircraft and required elements of ground control systems.

M. RTCA SAA MOPS for all UAS subsystems released by 2019. The elements will include the avionics onboard the UAS and required elements of ground control systems.
- Explanation. Self-explanatory.

N. FAA SAA TSO released by 2020.
- Explanation. This document will include the avionics onboard the aircraft and required elements of ground control systems.

O. FAA SAA TSO'd equipment used operationally in 2020 and beyond.
- Explanation. Self-explanatory.

P. RTCA UAS MASPS and SAA MASPS and MOPS updated as necessary.
- Explanation. Self-explanatory.

Q. FAA SAA TSOs updated as necessary.
- Explanation. Self-explanatory.

7.5 Command and Control (C2)

Note: For purposes of this section, Line of Sight (LOS) means radio LOS - not visual LOS.

Goal 1: International agreements, industry standards, and FAA regulations and guidance material are established by 2015 for civil UAS command and control (C2) capabilities such that C2 subsystems can be certified by the FAA for use in FAA-approved UAS operations.

Note: C2 includes communications internal to the UAS for pilots to operate unmanned aircraft from ground control stations. C2 also includes communications external to the UAS for pilots of unmanned aircraft to interact with air traffic controllers and pilots of nearby aircraft, both manned and unmanned.

A. International agreement was reached in Feb 2012 at the International Telecommunications Union's (ITU) World Radiocommunication Conference (WRC) on spectrum allocations for radio line-of-sight (LOS) UAS C2 links (or in ITU terminology, Control and Non-Payload Communications [CNPC] links).

- Explanation. Internationally harmonized radio spectrum allocations are needed for UAS C2 links to help ensure their protection from unintentional radio frequency interference, to help ensure adequate spectral bandwidth is available for meeting the projected C2 link capacity demands, and to facilitate operation of UAS across international borders. While spectrum allocations also are needed for beyond-line-of-sight (BLOS) C2 links, the initial focus is on radio line-of-sight allocations for which agreements can be reached more easily and quickly, and for which the civil UAS demand is expected to be greater.

B. RTCA's initial Minimum Aviation System Performance Standards (MASPS) for the overall, end-to-end C2 capability for civil UAS, including the necessary portion of avionics onboard the unmanned aircraft, the voice and data links, and the necessary portion of ground control systems published by Dec 2012. Note: In this context, "necessary portion" means the UAS elements involved in providing or enabling the C2 capability.
   - Explanation. Before C2 subsystem standards (including functional and performance requirements) can be developed, the minimum overall C2 performance standards must be established. The MASPS must address all aspects of UAS C2, including all "internal" and "external" communications needed pre-flight, in-flight, and post-flight.

C. RTCA's final MASPS for civil UAS C2 capabilities published by Jun 2013.
   - Explanation. The civil UAS C2 MASPS are needed as a basis for RTCA to develop Minimum Operational Performance Standards (MOPS) for the C2 subsystems, including the necessary portion of avionics onboard the unmanned aircraft, the voice and data links, and the necessary portion of ground control systems.

D. RTCA's initial MOPS for all the UAS subsystems involved in providing or enabling radio line-of-sight C2 capabilities for civil UAS published by Jun 2014. These elements will include the necessary portion of avionics onboard the unmanned aircraft, the voice and data links, and the necessary portion of ground control systems.
   - Explanation. The MOPS are needed for the FAA to incorporate in its regulations and guidance material. They form the basis upon which the FAA can certify systems and services used in providing C2 capabilities for civil UAS.

E. FAA's initial regulations and guidance material (such as TSOs and Advisory Circulars) to enable the production, sale, installation, and maintenance of FAA-certified systems and services used in providing radio line-of-sight C2 capabilities for civil UAS published by Dec 2014.
   - Explanation. For the commercial marketplace to offer FAA-certified systems and services for use in providing C2 capabilities for civil UAS, the FAA must establish the necessary regulations and guidance material. These are expected to be based on and largely incorporate the consensus industry standards defined in the RTCA MOPS.

F. International agreement reached at the ITU's WRC 15 on radio spectrum allocations for beyond-line-of-sight (BLOS) UAS C2 links (or in ITU terminology, Control and Non-Payload Communications [CNPC] links) by Dec 2015.
   - Explanation. Internationally harmonized radio spectrum allocations are needed for UAS C2 links to help ensure their protection from unintentional radio frequency interference, to help ensure adequate spectral bandwidth is available for meeting the projected C2 link capacity demands, and to facilitate operation of UAS across international borders. In the far term, some civil UAS operations are expected to require beyond line-of-sight C2 links, hence the need for this ITU agreement.

G. RTCA's final MOPS for all the UAS subsystems involved in providing or enabling radio line-of-sight C2 capabilities for civil UAS published by Jun 2015. These elements will include the necessary portion of avionics onboard the unmanned aircraft, the voice and data links, and the necessary portion of ground control systems.
   - Explanation. Revised MOPS likely will be needed based on lessons learned from industry application of the initial MOPS during product development and FAA certification activities.

H. FAA's final regulations and guidance material to enable the production, installation, and maintenance of FAA-certified systems and services used in providing radio line-of-sight C2 capabilities for civil UAS published by Dec 2015.
   - Explanation. A revised set of FAA regulations and guidance material likely will be needed based on lessons learned from application of the initial set.

I. Initial FAA-certified C2 subsystems intended for civil UAS operations are available commercially by 2016.
   - Explanation. FAA-certified C2 subsystems for civil UAS are needed for operators to manufacturers to incorporate in their UASs, and for operators to obtain FAA approval for their UAS operations.

Goal 2: Beyond-line-of-sight (BLOS) C2 links and capabilities are addressed in the international agreements, industry standards, and FAA regulations and guidance material.

J. RTCA's MOPS for all the UAS subsystems involved in providing or enabling beyond-line-of-sight (BLOS) C2 capabilities for civil UAS published. Initial publication is in 2016 and final publication is in 2017. These elements include the necessary portion of avionics onboard the unmanned aircraft, the voice and data links, and the necessary portion of ground control systems.
   - Explanation. Self-explanatory.

K. FAA's regulations and guidance material amended as necessary to address BLOS C2 capabilities for civil UAS.
   - Explanation. Self-explanatory.

L. FAA-certified C2 subsystems intended for civil UAS operations are available commercially.
- Explanation. Self-explanatory.

Goal 3: Adequate spectrum is allocated and available for both radio line-of-sight and beyond-line-of-sight C2 links to meet the current and projected demand generated by civil UAS operations in the NAS.

M. International spectrum allocations for both LOS and BLOS UAS C2 links are reviewed at the WRC 2020 and revised as necessary and possible.
- Explanation. Self-explanatory.

7.6 Small UAS (sUAS) Rules

Goal 1: sUAS rule adopted for public operations.

A. Agreements (MOU, MOA, COA, etc.) among the FAA and DoD, DHS, NASA, NOAA, DOJ and other public entities finalized and signed in conjunction with the release of the sUAS Notice of Proposed Rulemaking (NPRM). (Currently, the NPRM is expected to be released by Dec 2012, but this is subject to change).
- Explanation. The sUAS proposed rule has undergone a risk assessment by FAA through is Safety Management System (SMS) process. Adopting the provisions of the proposed rule for public operations may not constitute an additional safety risk, will accelerate NAS integration of small systems, and will facilitate a greater opportunity for data collection in support of the final rule. It will also reduce the number of COAs the FAA will need to process and free up FAA resources to address other time critical UAS in the NAS integration issues.

B. sUAS night operations experiments and final report completed by Sep 2012.
- Explanation. Night operations may be deemed as safe as or safer than daylight operations from a collision avoidance perspective with proper aircraft lighting. In addition to these focused experiments early consideration of operational data gathered by DoD and offshore entities should be immediately considered as relevant.

C. If night operations are deemed as safe or safer by the FAA, increased night operations for public entities are allowed by Dec 2012.
- Explanation. Public entities are requesting night operations as a means to fully exploit the capability of sUAS.

D. Drafts of all required consensus standards necessary for the implementation of 14CFR107 available to the public in conjunction with the release of the sUAS NPRM (which currently is expected to occur by Dec 2012, but this is subject to change).
- Explanation. Over three years of consensus standard development have occurred. When completed, these standards will provide meaningful guidance to

manufacturers and end users for the design, construction, and operation of small UAS. The timely release of the standards will permit industry an opportunity to fully prepare for publication of a final rule, and provide useful guidance to public entities desiring UAS deployment prior to final rule release. Having these drafts available to entities reviewing the proposed sUAS rule will also allow for a more complete and thorough review of the rule since. Without these draft standards being available, it will be difficult to provide meaningful and constructive comments.

Goal 2: sUAS rule adoption for public and civil operations.

E. 14CFR107 published, consensus-based standards accepted by the FAA, and the FAA able to issue permits to operate by August 2014.
   - Explanation. In order for operations to be conducted under 14CFR107, the FAA must issue a Notice of Applicability of referenced consensus-basedstandards and it must have in place a process to issue permits to operate.

F. Update sUAS rules, guidance, and/or consensus-based standards after sufficient data have been gathered and analyzed by Dec 2015.
   - Explanation. Assuming a final rule implementation s, the FAA will have over 1.5 years of data for sUAS operating under 14CFR107. Advancements in technology and analysis of operational and safety data will provide the catalyst for refinement and improvement of Part 107 guidance and/or standards by this date.

G. Update sUAS rules, guidance, and/or consensus-based standards as necessary.
   - Explanation. As more operational and safety data is accumulated it will provide a catalyst for refinement and improvement of 14CFR107 guidance and/or standards as necessary.

7.7 Test Ranges

Goal 1: FAA program to integrate UAS into the NAS at six test ranges established by Aug 2012.
   - Explanation. In order to establish this program selection criteria and procedures must be developed and communicated to prospective site operators. Test areas should then be evaluated by the FAA in collaboration with NASA and the DoD. Test areas criteria should take into consideration geographic and climate diversity, the location of ground infrastructure, and research needs.

Goal 2: Test ranges selected by FAA by Dec 2012.
   - Explanation. Any test range selected should provide the FAA, NASA, DoD, Industry and Academia with the opportunity for UAS prototype development and deployment. Test range policy and procedures should enable manned-unmanned cooperation.

Goal 3. Selected test ranges operational by Jun 2013.

- Explanation. The FAA Reauthorization Act requires that "the test range shall be operational no later than 180 days after the date on which a project is established." This is assumed to be 180 days after the selection of the test ranges is made.

Goal 4. Test range program operational until Feb 2017, unless extended.

- Explanation. The FAA Reauthorization Act requires that the test range program be terminated by Feb 2017. However, if this program is successful then termination may not be desired or necessary.

7.8 Miscellaneous

Goal 1: Update the FAA UAS Integration Roadmap annually through 2015.

A. Updated FAA UAS Integration Roadmap published annually.
   - Explanation. Self-explanatory.

Goal 2: Develop a comprehensive plan by 2013 for safely integrating UAS operations in the NAS by 2015.

B. The 2006 Airspace Integration Plan is reviewed and updated by the FAA's UAS ARC by Nov 2012.
   - Explanation. The 2006 Airspace Integration Plan is a modified version of the Airspace Integration plan developed under the government-industry Access 5 program. The original plan was restructured to more directly address the 8 major challenges with UAS integration in the NAS as the FAA envisioned at that time. The purpose of this activity is to review and update that plan to ensure it is up to date, reflects current thinking about what is required to integrate UASs into the NAS, and addresses the goals and metrics documented in this roadmap. The plan also will be updated to include what has happened since 2006 and what is currently being accomplished or planned by various government organizations (including FAA, DoD, NASA, and DHS). Once this is done, the plan will be used to identify gaps where a requirement has been identified but no organization is working on satisfying that requirement. It will also identify any duplication of effort discovered during this review. Once these gaps/duplications of effort are identified, the resources required to address the gaps and recommended organizations to perform the work will be provided. If any duplications of effort are identified, the ARC will provide recommendations for addressing them.

C. UAS ARC recommendations for changes to FAA, DoD, DHS, NASA, and industry programs are provided to the FAA by Dec 2012.
   - Explanation. Once the UAS ARC has completed its review and update of the 2006 Airspace Integration Plan, it will provide recommendations to the FAA for addressing the gaps/duplication of efforts identified. These recommendations will include proposed changes to existing and planned programs.

Goal 3: Identify air traffic management system changes required to be implemented in NextGen.

D. UAS are addressed in the FAA's 2012 NextGen Implementation Plan by Dec 2012.
   - Explanation. This will require explicitly addressing the operation of UAS in the NAS, and the evolution of enabling system capabilities in the various NextGen Segment Implementation Plans (NSIP)Although no significant changes to the current NAS and future NextGen are expected to be necessary for the integration of UAS operations in unrestricted airspace, some system and procedure changes will be necessary. Identifying these changes is necessary to incorporate them in the NextGen Implementation Plan as soon as possible, so that appropriate adjustments to program baselines can be made.

E. UAS are addressed in FAA's NextGen Enterprise Architecture by Dec 2012.
   - Explanation. This will require explicitly addressing the integration of UAS operations in the NAS, including the necessary operational concepts and system capabilities. The NextGen Enterprise Architecture defines the operational and technical aspects of NextGen. Currently, it does not explicitly identify whatever is needed to integrate UAS operations in unrestricted airspace. It must do so such that the necessary changes can be incorporated into the appropriate NextGen program implementation plans.

Goal 4: Develop UAS operational scenarios.

F. RTCA and FAA-defined operational scenarios are provided to the UAS ARC by Aug 2012.
   - Explanation. A rich set of operational scenarios is needed to develop a complete set of operational requirements, from which system functional and performance requirements can be derived. While nominal operations are important to define, it is essential that off-nominal operations are defined for conceivable contingency situations. The latter are what truly drive system requirements.

G. UAS ARC completes its review of draft UAS operational scenarios, and provides its comments to the FAA by Sep 2012.
   - Explanation. The UAS ARC was established, in part, to review key FAA products, such as the UAS operational scenarios. The ARC is well positioned to critically assess the FAA's draft operational scenarios.

Appendix C
Goals and Metrics Summary

7.1 Certification Requirements (Airworthiness, Production, Operator) Goals and Metrics Summary						
Time Frame	**Near Term**				**Mid Term**	**Far Term**
	2012	**2013**	**2014**	**2015**	**2016-2020**	**2020+**
Goals	*1. FAA's classification and draft basis of certification established for all types of UAS*	*2. FAA's draft certification requirements are available*	*3. FAA's minimum certification requirements established*		*4. FAA certification requirements updated and systems certified as necessary*	
Regulations & Guidance Metrics	A. FAA's UAS classification strategy finalized and communicated by Dec 2012 B. FAA's draft basis of certification established by Dec 2012	D. FAA's initial certification requirements defined for UAS ground station, airframe, control system, propulsion system, ground support equipment (GSE), etc. by Dec 2013		G. FAA's minimum certification requirements for UAS ground station, airframe, control system, propulsion system, GSE, etc. published by Dec 2015	K. Certification requirements updated as necessary	
Product Metrics	C. Pathfinder certification programs defined through government-industry partnerships by Dec 2012	E. Pathfinder certification programs underway by Jan 2013 F. Other certification programs defined by Dec 2013	H. Other certification programs underway by Dec 2014	I. Pathfinder certification programs completed by Dec 2015 J. Other certification programs completed by Dec 2015	L. UAS certified as necessary	

7.2 Certification Requirements (Pilot/Crew) Goals and Metrics Summary						
Time Frame	**Near Term**				**Mid Term**	**Far Term**
	2012	**2013**	**2014**	**2015**	**2016-2020**	**2020+**
Goals	*1. Pilot and crew member FAA certification requirements for pilots and crews for all UAS classes (including medical requirements, training standards, etc.) published by 2013 and updated as necessary* *2. Necessary changes to record keeping systems established*					
Regulations & Guidance Metrics	A. FAA decision to develop draft requirements itself [Decision made.]	B. Draft requirements developed by Dec 2013	C. FAA publishes final requirements by Jun 2014 E. Changes to FAA and industry record keeping systems completed by Dec 2014	D. Requirements updated as necessary		

7.3 Ground-Based Sense and Avoid (GBSAA) Goals and Metrics Summary						
Time Frame	**Near Term**				**Mid Term**	**Far Term**
	2012	**2013**	**2014**	**2015**	**2016-2020**	**2020+**
Goals	*1. GBSAA operations fully approved by FAA for routine use by DoD and other public entities by 2013*		*2. GBSAA operations fully approved by the FAA for routine use by all aviation, including both public and civil entities (if needed), by 2015*			
Standards Metrics			D. FAA's initial GBSAA certification standards for civil operations established by Jan 2014 F. FAA's final GBSAA certification standards for civil operations established by Dec 2014		G. GBSAA certification standards updated as necessary	
Regulations & Guidance Metrics	A. FAA approvals for use of GBSAA at all DoD GBSAA test sites granted by Dec 2012	B. FAA approvals for use of GBSAA for educational and other public applications granted by Dec 2013	C. FAA approvals for use of GBSAA for limited civil applications granted by Jan 2014 E. FAA approvals for use of GBSAA for civil applications granted by Dec 2014			

7.4 Airborne-Based Sense and Avoid (ABSAA) Goals and Metrics Summary

Time Frame	Near Term				Mid Term	Far Term
	2012	2013	2014	2015	2016-2020	2020+
Goal	*1. Initial FAA certification of ABSAA that facilitates UAS operations without the requirement for a visual observer by 2014*					
Regulations & Guidance Metrics			A. Initial proposal for SAA implementation, integration, and operation in an industry Pathfinder program released by Apr 2014 B. FAA "Issue Paper(s)" on UAS SAA implementation in one or more Pathfinder programs released by Dec 2014			
Goal	*2. Installation and certification of ABSAA for use by DoD, other public, and civil entities that provide the SAA functions required in the NAS for Classes A, E, and G airspace, and operations approved without the requirement for a visual observer or a COA*					
Standards Metrics	C. RTCA UAS MASPS Part I (operational and functional requirements) released by Dec 2012	D. RTCA UAS MASPS Part II (safety and interoperability requirements) released by Dec 2013	E. RTCA SAA MASPS released by Dec 2014	F. RTCA SAA MOPS released by Dec 2015		
Regulations & Guidance Metrics					G. FAA SAA TSO issued by 2016	
Product Metrics					H. FAA SAA TSO'd equipment used operationally in 2016	

7.4 Airborne-Based Sense and Avoid (ABSAA) Goals and Metrics Summary						
Time Frame	**Near Term**				**Mid Term**	**Far Term**
	2012	**2013**	**2014**	**2015**	**2016-2020**	**2020+**
Goal					*3. DoD or other public entity certification of initial ABSAA systems that enable the DoD and other public entities to safely operate ABSAA-equipped UAS in al NAS airspace classes without the need for a COA*	
Regulations & Guidance Metrics					I. Initial proposal for ABSAA implement-tation, integration, and operation in one or more programs released by 2017	
Product Metrics					J. FAA "Issue Paper(s)" on UAS SAA implement-tation in one or more programs for UAS operations in all NAS airspace classes released by 2018	

7.4 Airborne-Based Sense and Avoid (ABSAA) Goals and Metrics Summary						
Time Frame	**Near Term**				**Mid Term**	**Far Term**
	2012	**2013**	**2014**	**2015**	**2016-2020**	**2020+**
Goal					*4. Installation and certification of ABSAA for use by DoD, other public, and civil entities that provide the SAA functions that facilitate integrated operation of manned and unmanned aircraft in all NAS airspace classes by 2020*	
Standards Metrics					K. Initial RTCA UAS MASPS released by 2016 L. RTCA SAA MASPS released by 2017 M. RTCA UAS SAA MOPS for all UAS subsystems released by 2019	P. RTCA UAS MASPS and SAA MASPS and MOPS updated as necessary
Regulations & Guidance Metrics					N. FAA SAA TSO released by 2020	Q. FAA SAA TSOs updated as necessary
Product Metrics					O. FAA SAA TSO'd equipment used operationally in 2020 and beyond	

7.5 Command and Control (C2) Goals and Metrics Summary

Time Frame	Near Term				Mid Term	Far Term
	2012	2013	2014	2015	2016-2020	2020+
Goals	*1. International agreements, industry standards, and FAA regulations and guidance material are established by 2015 for civil UAS command and control (C2) capabilities such that C2 subsystems can be certified by the FAA for use in FAA-approved UAS operations*				*2. BLOS C2 links and capabilities are addressed in the international agreements, industry standards, and FAA regulations and guidance material*	*3. Adequate spectrum is allocated and available for both radio LOS and BLOS C2 links to meet the current and projected demand generated by civil UAS operations in the NAS*
Spectrum Metrics	A. International agreement was reached in Feb 2012 at the ITU's WRC on spectrum allocations for radio LOS UAS C2 links			F. International reached at ITU's WRC 15 on radio spectrum allocations for BLOS UAS C2 links by Dec 2015		M. International spectrum allocations for both LOS and BLOS UAS C2 links reviewed at WRC 2020 and revised as necessary and possible
Standards Metrics	B. RTCA's initial MASPS for the overall C2 capability for civil UAS published by Dec 2012	C. RTCA's final MASPS for civil UAS C2 capabilities published by Jun 2013	D. RTCA's initial MOPS for all UAS subsystems involved in radio line-of-sight C2 capabilities for civil UAS published by Jun 2014	G. RTCA's final MOPS for all UAS subsystems involved in radio line-of-sight C2 capabilities for civil UAS published by Jun 2015	J. RTCA's MOPS for all UAS subsystems involved in BLOS C2 capabilities for civil UAS published Initial – 2016 Final – 2017	

7.5 Command and Control (C2) Goals and Metrics Summary						
Time Frame	**Near Term**				**Mid Term**	**Far Term**
	2012	**2013**	**2014**	**2015**	**2016-2020**	**2020+**
Regulations & Guidance Metrics			E. FAA's initial regulations and guidance material to enable production, sale, installation, and maintenance of FAA-certified systems and services for radio line-of-sight C2 capabilities for civil UAS published by Dec 2014	H. FAA's final regulations and guidance material to enable production, sale, installation, and maintenance of FAA-certified systems and services used in providing radio line-of-sight C2 capabilities for civil UAS published by Dec 2015	K. FAA's regulations and guidance material amended as necessary to address BLOS C2 capabilities for civil UAS	
Product Metrics					I. Initial FAA-certified UAS C2 subsystems intended for civil UAS operations are available commercially by 2016 L. FAA-certified C2 subsystems intended for civil UAS operations are available commercially	

7.6 Small UAS (sUAS) Goals and Metrics Summary

Time Frame	Near Term				Mid Term	Far Term
	2012	2013	2014	2015	2016-2020	2020+
Goals	*1. sUAS rule adopted for public operations*		*2. sUAS rule adoption for public and civil operations*			
Standards Metrics	D. Drafts of all required consensus standards necessary for imple-mentation of 14CFR107 available to the public in conjunction with the release of the sUAS NPRM		E. Consensus-based standards accepted by the FAA by August 2014	F. Consensus-based standards updated by Dec 2015	G. Consensus-based standards updated as necessary	
Regulations & Guidance Metrics	A. Agreements among the FAA, DoD, DHS, NASA, NOAA, DOJ and other public entities finalized and signed in conjunction with the release of the sUAS NPRM by Dec 2012		E. 14CFR107 published by August 2014	F. 14CFR107 and/or guidance material updated by Dec 2015	G. 14CFR107 updated as necessary	
Product Metrics	B. sUAS night operations experiments and final report completed by Sep 2012 C. If night operations are deemed as safe or safer by the FAA, increased night operations for public entities are allowed by Dec 2012		E. FAA process for issuing permits to operate is functional by August 2014	F. FAA process for issuing permits to operate updated by Dec 2015	G. FAA process for issuing permits to operate updated as necessary	

7.7 Test Ranges Goals and Metrics Summary						
Time Frame	**Near Term**				**Mid Term**	**Far Term**
	2012	**2013**	**2014**	**2015**	**2016-2020**	**2020+**
Goals and Metrics	*1. FAA program to integrate UAS into NAS at six test ranges established by Aug 2012* *2. Test ranges selected by FAA by Dec 2012*	*3.Selected test ranges operational by Jun 2013*	*4. Test range program operational until Feb 2017, unless extended*			

7.8 Miscellaneous Goals and Metrics Summary						
Time Frame	**Near Term**				**Mid Term**	**Far Term**
	2012	**2013**	**2014**	**2015**	**2016-2020**	**2020+**
Goals	*1. Update the FAA UAS Integration Roadmap annually through 2015*					
	2. Develop a comprehensive plan by 2013 for safely integrating UAS operations in the NAS by 2015 *3. Identify air traffic management system changes required to be implemented in NextGen* *4. Develop UAS operational scenarios*					
Product Metrics	A. Updated FAA UAS Integration Roadmap published annually B. 2006 Airspace Integration Plan reviewed and update by the FAA's UAS ARC by Nov 2012 C. UAS ARC recommendations for changes to FAA, DoD, DHS, NASA and industry programs are provided to the FAA by Dec 2012 D. UAS are addressed in the FAA's 2012 NextGen Implementation Plan by Dec 2012 E. UAS are addressed in FAA's NextGen Enterprise Architecture by Dec 2012	A. Updated FAA UAS Integration Roadmap published annually				

7.8 Miscellaneous Goals and Metrics Summary						
Time Frame	Near Term				Mid Term	Far Term
	2012	2013	2014	2015	2016-2020	2020+
	F. RTCA and FAA-defined operational scenarios are provided to the UAS ARC by Aug 2012 G. UAS ARC completes its review of draft UAS operational scenarios, and provides its comments to the FAA by Sep 2012					

Ms. Margaret Gilligan
Associate Administrator for Aviation Safety
Federal Aviation Administration
800 Independence Avenue
Washington, DC 20591

October 24, 2013

Mr. David Grizzle
Chief Operating Officer for Air Traffic Organization
Federal Aviation Administration
800 Independence Avenue
Washington, DC 20591

Dear Ms. Gilligan and Mr. Grizzle

The Unmanned Aircraft Systems Aviation Rulemaking Committee (UAS ARC) is pleased to submit the enclosed recommendations for inclusion of UAS language into 14 CFR § 91.113 (b) for your consideration. This body of work represents the UAS ARC's 91.113 Working Group evaluation and review process. This team is made up of subject matter experts from within both the UAS community and the greater aviation community at large.

The 91.113 Working Group assessed terminology currently published in 14 CFR as well as other FAA and ICAO publications for inclusions in this work. They also leveraged the UAS ARC's Terminology and Classification Action Team's (TCAT) recommendations. Whenever possible, they reviewed and updated existing terminology to better represent the current state of the UAS terminology nationally and internationally.

The UAS industry will benefit from the FAA's formal recognition of the UAS ARC's 91.113 recommendations for UAS Detect and Avoid language. This recognition will facilitate the operational use of UAS in the NAS and be the cornerstone for regulatory work on Detect and Avoid.

The UAS ARC appreciates your continued support of its activities and invites you to discuss any aspects of these recommendations at your earliest convenience. The UAS ARC respectfully requests the FAA to provide us with a formal response. The members and constituents of UAS ARC will support FAA actions to develop and implement this recommendation.

Sincerely,

Robert Scott Dann
Chairman
Unmanned Aircraft Systems
Aviation Rulemaking Committee

Unmanned Aircraft System (UAS)
Aviation Rulemaking Committee (ARC)
Part 91 Working Group

Recommendations for 14 CFR 91.113 on Right of Way Rules for Unmanned Aircraft

August 2013

Table of Contents

1. Overview

The Federal Aviation Administration (FAA) currently requires a Certificate of Waiver or Authorization (COA) for public, civil, or commercial Unmanned Aircraft System (UAS) operations in the National Airspace System (NAS).[1] These special authorizations are required, at least in part because 14 CFR 91 rules were written for aircraft with a pilot in the cockpit onboard the aircraft. Specifically § 91.113 discusses right-of-way rules, and requires vigilance to be maintained by each person operating an aircraft so as to "see and avoid" other aircraft. The UAS ARC Part 91 Working Group recommends the addition of a sentence under Part 91 Subpart B—Flight Rules § 91.113 (b) that specifically addresses UAS. The recommended language is (underlined language is new):

Part 91 Subpart B—Flight Rules § 91.113
(b) General. When weather conditions permit, regardless of whether an operation is conducted under instrument flight rules or visual flight rules, vigilance shall be maintained by each person operating an aircraft so as to see and avoid other aircraft, except as noted in paragraph (b)(1) of this section. When a rule of this section gives another aircraft the right-of-way, the pilot shall give way to that aircraft and may not pass over, under, or ahead of it unless well clear.
(1) For a UAS, vigilance shall be maintained so as to detect and avoid other aircraft.

2. Background

The guiding principles provided to the Part 91 WG by the UAS ARC steering group in development of this new language were to maintain the current level of safety in the NAS and to not impact the interpretation of the current language for manned aviation. The steering group acknowledged that some reference to a new exception may be required in § 91.113 (b), but directed that no other deletion, modification, or additional words to the existing § 91.113 (b) be made. Adding the reference to the end of the first sentence reduces any confusion that the exception in § 91.113 (b) (1) only applies to the first sentence, and the second sentence would apply to all aircraft including UAS. The intent of the new rule language is to enable an alternate means of compliance without requiring an exemption to the current rule. The steering group also advised the WG that the new rule must apply to all classes of airspace, and that it should enable technology expansion without requiring future rule revisions. To focus the WG on this first phase, the steering group directed attention to the portion of the paragraph that states "vigilance shall be maintained by each person operating an aircraft so as to see and avoid other aircraft" in association with both avoiding collisions and remaining well clear. The WG will look to address other portions of § 91.113 and other Part 91 rules in the second phase.

All WG members agree to this approach; however, there is some difference of opinion on the specific words and definitions to be used. The WG attempted to keep the changes simple so as to minimize addition of new terms and definitions, but to ensure the language satisfies the guiding principles provided by the steering group. The WG recognizes this is a recommendation

to the FAA and is not the final rule, so every attempt is made to capture in this paper the rationale for all options and alternatives.

3. Discussion

In the existing language of § 91.113 (b), the first part of the paragraph references "when weather conditions permit, regardless of whether an operation is conducted under instrument flight rules or visual flight rules." All WG members agreed that the new § 91.113 (b) (1) specific to UAS would omit this language with the rationale that the individual UAS operations manual would specify under what weather conditions the UAS could operate. This position was reinforced by feedback from the steering group.

For the new sentence, a term is needed to identify the type of aircraft the new rule applies to. The two terms in prevailing use today are "Unmanned Aircraft System (UAS)" and "Remotely Piloted Aircraft System (RPAS)." There was about a 50/50 split within the WG on whether to use the terms UAS/UA or RPAS/RPA. The WG's discussion of these terms and an option for avoiding both terms is summarized below. In addition, an alternative sentence in lieu of the recommended sentence is provided for each term.

a) The term "UA/UAS" is described in the FAA Modernization and Reform Act of 2012, which states, "The term 'unmanned aircraft' means an aircraft that is operated without the possibility of direct human intervention from within or on the aircraft. The term 'unmanned aircraft system' means an unmanned aircraft and associated elements (including communication links and the components that control the unmanned aircraft) that are required for the pilot in command to operate safely and efficiently in the national airspace system."[2] UAS is the more encompassing term that allows for various levels of automation. By using the term UAS in the language now, we allow for technology expansion and preclude having to re-write the rule if autonomous aircraft are accepted at some point in the future. Every UA will be under some level of automation, which must be included in the UAS definition. As automation increases, the balance of flight operation duties shifts from the pilot to the UAS. The FAA UAS Concept of Operations Version 2.0 uses the term UAS, but also states the pilot in command will have full control or override authority to assume control at all times during normal operations and that routine autonomous operations are not permitted. In addition, the UAS ARC Terminology and Classification Action Team (TCAT) recommended UAS as an over-arching term that includes both RPAS and autonomous aircraft. The recommended rule language would allow for future expansion of UAS automation. An alternative to the recommended rule language would be to add the following words: "by each person operating a UA." This alternative would focus the rule on the requirement of the pilot to remain vigilant, but may limit future expansion.

(1) For a UAS, vigilance shall be maintained by each person operating a UA so as to detect and avoid other aircraft.

b) The term "RPA/RPAS" is defined in the International Civil Aviation Organization (ICAO) Annex 2. For "RPA" the definition is: "An unmanned aircraft which is piloted from a remote pilot station."[3] The term "RPAS" is defined as: "A remotely piloted aircraft, its associated remote pilot station(s), the required command and control links and any other components as specified in the type design."[3] These definitions make clear the involvement of a pilot. This involvement may include some supervisory role even if the aircraft performs some lower-level automation which the pilot only oversees. The ICAO-defined RPAS term is now widely accepted on a global basis. Focusing the rule change on RPAS, which always involves a pilot, may expedite the FAA's rulemaking process. Broadening the scope of the rule to UAS which includes autonomous aircraft may complicate the approval process. The UAS ARC Terminology and Classification Action Team (TCAT) in August 2012 recommended the ICAO Circular 328 term RPA to make clear the involvement of the pilot and harmonize with the international community. ICAO Circular 328 defined RPA as: "An aircraft where the flying pilot is not on board the aircraft. Note: This is a subcategory of unmanned aircraft."[4] An alternative to the recommended rule language using the term RPA/RPAS would focus solely on the pilot in command and not allow for expansion to autonomous aircraft.

   (1) <u>For a RPAS, vigilance shall be maintained by each person operating a RPA so as to detect and avoid other aircraft.</u>

c) To avoid the issue of using UAS or RPAS, the WG discussed an alternative to describe the intent. The intent of the WG is that the UAS, including when possible the UAS pilot, must maintain vigilance so as to detect and avoid other aircraft.

   (1) <u>Aircraft without the pilot in command onboard shall maintain vigilance so as to detect and avoid other aircraft.</u>

No matter which term is used, the loss of the command and control (C2) link will require an automated mode for safe UAS operation. The consensus of the WG was that a significant loss of the C2 link (definition and criteria to be determined in Phase 2) is considered an emergency condition and is covered under § 91.113 (c) "In distress. An aircraft in distress has the right-of-way over all other air traffic." Subpart B of Part 91 is focused on the pilot's responsibility and Subpart C of Part 91 is focused on the equipage. Therefore, the topic of lost C2 link must be addressed in another section of Part 91, if it is not already adequately addressed in § 91.113 (c).

The other part of the paragraph that needs to be addressed is the word "see" in the phrase "see and avoid" in the existing § 91.113 (b). Several words, including "sense", "detect", and "be aware of" were considered as substitute for the word "see." The WG members all agreed on the term "detect" as the best word to use. The rationale for this word choice is summarized below in Section 4.

4. Definitions

There is additional work in Phase 2 of this WG to include definitions of the terms introduced in this paper, but we wanted to include the discussions of the WG and the intent of the terms used. Though the WG agreed on the term "detect and avoid," there was a split on how the term should be defined in the glossary (i.e., not included in § 91.113 (b)), which can then be referenced in § 91.113 (b) as well as other portions of 14 CFR Part 91.

The recommended definition is "**Detect and avoid is the capability to see, sense or detect other aircraft and take the appropriate action to remain well clear from and to avoid collisions with other aircraft.**"

The WG agreed that "see and avoid" means more than collision avoidance, so the new term must work for other functions such as maintaining situational awareness and determining right of way. The WG also agreed that the definition chosen should be harmonized with the terms used by RTCA SC-228, especially if avoiding other hazards is included in the definition. However, half the WG believes we should directly adopt the ICAO language and show alignment with the international community while the other half prefers to modify the ICAO language replacing the phrase "conflicting traffic or other hazards" with simply "other aircraft" and add specific actions.

The definition in ICAO Annex 2 is: "**The capability to see, sense or detect conflicting traffic or other hazards and take the appropriate action.**"[3]

Based on the Sense and Avoid (SAA) for UAS Workshop report, the WG agreed on the intent of the definition for SAA. The definition is: "SAA is the capability of a UA to remain well clear from and avoid collisions with other airborne traffic. SAA is the combination of UAS Self-Separation plus Collision Avoidance as a means of compliance with 14CFR Part 91, §91.111 and §91.113."[5]

This brings into discussion three topics to consider for the definition of "detect and avoid." In the general glossary definition:

a) Does all traffic need to be detected, or just the conflicting traffic? The new proposed sentence in § 91.113 (b) (1) states "to detect and avoid other aircraft" where the last two words are a direct lift from the existing language in §91.113 (b). Therefore, the current language does not limit this function to only those aircraft in conflict. The WG's recommendation is to use the term "other aircraft."

b) Should the UAS just avoid aircraft or other hazards (e.g., ground obstacles) as well? The current language in § 91.113 (b) does not specify the need to detect and avoid other hazards. The WG's recommendation is to not include "other hazards" in the definition.

c) Do we leave open to interpretation what the appropriate action for the avoidance maneuver is, or should we further define the actions to be taken? The ICAO initially

established ICAO Circular 328 in 2011 prior to the approval of the Annex 2 language that had the additional, "**and take the appropriate action to comply with the applicable rules of flight.**"[4] The WG's recommendation is to specify avoidance actions in relation to remaining well clear and avoiding collisions recognizing the definition may have to be modified later if the term "detect and avoid" is to be used elsewhere in Part 91. This also aligns with the guidance provided by the steering group.

5. References

[1] FAA NOTICE N 8900.227, 30 Jul 2013.
[2] FAA Modernization and Reform Act of 2012, 14 Feb 2012.
[3] International Standards, Annex 2 to the Convention on International Civil Aviation, Tenth Edition July 2005 Amendment 43, 15 Nov 2012.
[4] International Civil Aviation Organization Circular 328, Mar 2011.
[5] Sense and Avoid (SAA) for Unmanned Aircraft Systems (UAS) Workshop report, 9 Oct 2009.

6. Acronyms

ARC	Aviation Rulemaking Committee
COA	Certificate of Waiver or Authorization
FAA	Federal Aviation Administration
ICAO	International Civil Aviation Organization
NAS	National Airspace System
RPA	Remotely Piloted Aircraft
RPAS	Remotely Piloted Aircraft System
TCAT	Terminology and Classification Action Team
UA	Unmanned Aircraft
UAS	Unmanned Aircraft System
WG	Working Group