Integration of Civil UAS in the NAS Roadmap

Presented to: RTCA SC-228
By: Christopher Swider
Date: 5 December 2013
Overview

• Roadmap Purpose & Intent
• Roadmap Development Summary
• Roadmap Content
  – Chapter overviews and highlights
  – Explanation of appendices
Roadmap Purpose

“The purpose of the 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 also aligns proposed Agency actions with congressional mandates from Section 332 of the FAA Modernization and Reform Act of 2012.”
Roadmap Intent

“The roadmap is intended to guide aviation stakeholders in understanding FAA operational goals and Aviation Safety and Air Traffic line of business challenges when considering future investments.”
Roadmap Development

• Mar 2011 - Development starts
• Nov 2011 - UAS ARC receives copy
• Feb 2012 - FMRA requires Roadmap
• Aug 2012 - UAS ARC provides comments
• Feb 2013 - Enters LRM Review
• Sep 2013 - LRM Review Complete
• Nov 2013 - First Edition Published

ARC - Aviation Rulemaking Committee
FMRA - FAA Modernization & Reform Act of 2012
LRM - Legislative Referral Memorandum
Chapter 1 – Purpose & Background

• Purpose & Background of Civil UAS Roadmap
• History
• Proposed Civil and Commercial Applications
• Definitions
• Policy
  – FAA UAS Policy Basis
  – ICAO Policy
  – Industry Policy Recommendations
  – Privacy and Civil Liberties Considerations
  – National Security Issues
Chapter 2 - UAS Ops in the NAS

• FAA’s Dual Role in Integration
  – Regulator, through Office of Aviation Safety
  – Service provider, through Air Traffic Organization – Air Traffic Emerging Technologies Group

• Policy, Guidance and Regulatory Challenges
  – Develop minimum standards for Sense and Avoid (SAA), Control and Communications (C2), and separation assurance requirements for specified airspace
  – Understand privacy, security and environmental implications
  – Develop acceptable design standards, considering aircraft size, performance, mode of control, intended operational environment and mission criticality
  – Regulatory process designed to provide transparency to the public and an opportunity to understand and comment on proposed rules
Chapter 2 - UAS Ops in the NAS

• **Air Traffic Operational Challenges**
  – Goal: Safely integrate UAS without segregating, delaying or diverting other aircraft and users

• **Technological Challenges**
  – Research needed to understand impact of UAS operations, including equipment design and necessary technology
    • Performance considerations differ between manned and unmanned aircraft
    • Range of platforms and capabilities (size, speed, altitude, turbulence, etc.)
    • Sense and Avoid (SAA) capability
    • Control and Communications (C2) system performance requirements
Chapter 2 - UAS Ops in the NAS

• Managing Challenges
  – Focus on several interdependent topics:
    • Standards
    • Rules and Regulations
    • Certification of the UAS
    • Procedures and Airspace
    • Training
    • Research and Development (R&D) and Technology
  – Three-Perspective Approach:
    • Accommodation (Near-Term)
    • Integration (Mid- to Far-Term)
    • Evolution (Far-Term)
Chapter 2 - Roadmap Perspectives

• Perspective 1 - Accommodation
  – “Take current UAS and apply special mitigations and procedures to safely facilitate limited access…”

• Perspective 2 - Integration
  – “Establish threshold requirements…new or revised regulations, policies, procedures, guidance material, training, and understanding…to support routine NAS operations.”

• Perspective 3 - Evolution
  – “All required policy, regulations, procedures, guidance material, technologies, and training are in place and routinely updated to support UAS operations in the NAS operational environment as it evolves over time.”
Topics for Each Perspective

• Standards
• Rules and Regulations
• Certification of the UAS
• Procedures and Airspace
• Training (Pilot, Flightcrew, Mechanic, Controller)
• Research & Development and Technology
Chapter 3 - Accommodation

• **Near-Term Focus:** Safely allow for the expanded operation of UAS through accommodation
  – Special Airworthiness Certificate – Experimental
    • Research and Development, Crew Training, Market Surveys
  – Certificate of Waiver or Authorization (COA)

• **Continuing need to maintain NAS access with accommodation for some UAS**
Chapter 3 - Accommodation

- **Standards**
  - Need for agreed-upon standards for 14 CFR compliance

- **Rules and Regulations**
  - New or revised rules for UAS to operate under IFR

- **Airworthiness certification**
  - Tailoring design standards to specific UAS applications

- **Procedures and Airspace**
  - Baselining and SMS to adapt UAS or procedures/regulations

- **Training**
  - Mirror manned aircraft standards and account for all UAS roles

- **Research and Development/Technology**
  - Sense and Avoid
  - Control and Communications
  - Modeling and Simulation
  - Human Factors
Chapter 3 - 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
  – Safety case validation for UAS operations in NAS – collect/analyze operation and safety data
  – Robust research, modeling and simulation for UAS Sense and Avoid, C2 and human factors
Chapter 4 - Integration

• Mid-to-Far-Term Focus:
  – Efforts provide a foundation for creating and modifying FAA policies and procedures to permit broader UAS access while developing policy, guidance and operational procedures to allow manned and unmanned aircraft to safely and efficiently co-exist

• Fourteen general requirements and assumptions that pertain to all* UAS operations that are integrated into the NAS

  * Exception for sUAS operated within visual line of sight
Chapter 4 - Integration

• Standards
  – Development of detailed MOPS

• Rules and Regulations
  – Compliant UAS access additional airspace

• Airworthiness Certification
  – Use experience to make relevant policy/rule changes

• Procedures and Airspace
  – Compliant UAS access additional airspace
Chapter 4 - Integration

• **Training**
  – Testing and certification process
  – Handbook development
  – Standards & policies synchronized with regulatory guidance

• **Research and Development**
  – Sense and Avoid
    • Development of separation algorithms
  – Control and Communications
    • Capacity, performance and security impacts

• **Test Ranges (Sites)**
  – Six sites selected in accordance with FMRA criteria
  – Goal to provide a verification mechanism for safe operations prior to integration
Chapter 4 - Integration

• Priorities:
  – New operational rules and associated standards, policies and procedures established for small and other UAS
  – FAA acceptance of MASPS (i.e. OFRSO for UAS) to enable development of detailed MOPS
  – Published FAA policy and operational guidance to define acceptable methods to comply with operational rules in accordance with an acceptable UAS certification basis for each applicant
  – Published FAA flight crew training and certification standards
Chapter 5 - Evolution

• Refinement of and updates to regulation, policy and standards, implementation of streamlined processes
  – Policy, operational guidance and standards for civil aircraft airworthiness and NAS operations, with consideration for privacy and security concerns
  – Continued airworthiness methodologies
    • Consistent with all other airworthiness and operational approval processes
    • Data analysis and trending – operations, human factors, communications links, maintenance
  – Training and certification standardization
  – Certification of key technologies to enable continued UAS operations in the NAS
    • Integration with NextGen
Chapter 5 - 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 algorithms for collision avoidance and self-separation that are interoperable with evolving NextGen ATC systems and manned collision avoidance systems
Chapter 6 - Conclusions

The basis for the FAA’s consideration of requirements to integrate civil UAS into the NAS include:

1. Government-industry collaboration is paramount to success and must focus on process, quality and timely results.
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.
4. The FAA is focused on increased access for UAS without impacting the safety or efficiency of the NAS, while managing environmental impacts.
5. Progress must be made on the development of technology to enable NAS access.
Appendices

• Appendix A - Acronyms
• Appendix B - Glossary
  – Sources and Definitions
• Appendix C - Goals, Metrics & Target Dates
Keys to Appendix C

• Goals are intended to be addressed concurrently
• Goals and metrics establish a set of strategic objectives that can guide the definition of activities, schedules and resource requirements in an implementation plan
• Target dates, unless they are required by law (e.g., FMRA) are exactly that – targets
  – Not FAA, industry, or other government commitments
  – Some are aggressive and will require additional industry or government resources if they are to be met
Keys to Appendix C

• **Guide to target dates**
  - Dates prior to October 2015 are identified by the calendar quarter and year when they are targeted for completion
    • Example: “3rd Quarter of 2014”
  - Other metrics within the 5 year planning horizon of the Roadmap may only have a year or year range specified for their targeted completion
    • Example: “2016” or “2016 – 2017”
  - Target dates shown as “from 201x to 201y” indicate related activity is expected throughout this time period
    • Example: “2013 to 2020”
  - Target dates related to FMRA are stated as such
    • FMRA Subtitle B (Unmanned Aircraft Systems) is included as Appendix D
Final Key to Appendix C

• FAA will update the specific implementation details (goals, metrics, target dates) as we:
  – “learn from our current UAS operations,
  – leverage ongoing research, and
  – incorporate the work of our government and industry partners in all related areas.”
Comments?
Questions?
Compliments?
Supplementary Material (Backup Slides)
Acronyms and Terminology
### Acronyms

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<th>Acronym</th>
<th>Description</th>
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<th>Description</th>
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<tbody>
<tr>
<td>ABSAA</td>
<td>Airborne Sense and Avoid</td>
<td>DoD</td>
<td>Department of Defense</td>
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<td>ACAS X</td>
<td>Airborne Collision Avoidance System</td>
<td>DOJ</td>
<td>Department of Justice</td>
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<td>ADS-B</td>
<td>Automatic Dependent Surveillance-Broadcast</td>
<td>DPE</td>
<td>Designated Pilot Examiner</td>
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<td>AIM</td>
<td>Aeronautical Information Manual</td>
<td>FAA</td>
<td>Federal Aviation Administration</td>
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<td>AMA</td>
<td>Academy of Model Aeronautics</td>
<td>FCC</td>
<td>Federal Communications Commission</td>
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<td>ARC</td>
<td>Aviation Rulemaking Committee</td>
<td>FRMA</td>
<td>FAA Modernization and Reform Act of 2012</td>
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<td>ASI</td>
<td>Aviation Safety Inspector</td>
<td>FSDO</td>
<td>Flight Standards District Office</td>
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<td>ASTM</td>
<td>American Society for Testing and Materials</td>
<td>GBSAA</td>
<td>Ground Based Sense and Avoid</td>
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<tr>
<td>ATC</td>
<td>Air Traffic Control</td>
<td>GSE</td>
<td>Ground Support Equipment</td>
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<td>ATO</td>
<td>Air Traffic Organization</td>
<td>IFR</td>
<td>Instrument Flight Rules</td>
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<td>AVS</td>
<td>Office of Aviation Safety</td>
<td>ICAO</td>
<td>International Civil Aviation Organization</td>
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<td>BLOS</td>
<td>Beyond-Line-of-Site</td>
<td>IPC</td>
<td>Interagency Planning Committee</td>
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<td>C2</td>
<td>Control and Communications</td>
<td>ITU</td>
<td>International Telecommunication Union</td>
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<tr>
<td>COA</td>
<td>Certificate of Wavier or Authorization</td>
<td>JPDO</td>
<td>Joint Planning and Development Office</td>
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<td>DAA</td>
<td>Detect and Avoid</td>
<td>LOS</td>
<td>Line-of-Sight</td>
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<td>DHA</td>
<td>Department of Homeland Security</td>
<td>MASPS</td>
<td>Minimum Aviation System Performance Standard</td>
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## Acronyms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tr>
<td>MOPS</td>
<td>Minimum Operational Performance Standard</td>
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<td>NAS</td>
<td>National Airspace System</td>
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<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
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<td>NextGen</td>
<td>Next Generation Air Transport System</td>
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<td>NIJ</td>
<td>National Institute of Justice</td>
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<td>NOAA</td>
<td>National Oceanic and Atmospheric Administration</td>
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<td>NPRM</td>
<td>Notice of Proposed Rulemaking</td>
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<td>NTIA</td>
<td>National Telecommunications and Information Administration</td>
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<td>OPA</td>
<td>Optionally Piloted Aircraft</td>
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<td>OSED</td>
<td>Operational Services and Environmental Definition</td>
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<tr>
<td>PIC</td>
<td>Pilot-in-Command</td>
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<td>PTS</td>
<td>Practical Test Standards</td>
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<td>R/C</td>
<td>Radio Control</td>
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<td>R&amp;D</td>
<td>Research and Development</td>
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<td>RF</td>
<td>Radio Frequency</td>
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<td>RPV</td>
<td>Remotely Piloted Vehicle</td>
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<td>RVSM</td>
<td>Reduced Vertical Separation Minimum</td>
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<td>SAA</td>
<td>Sense and Avoid</td>
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<td>SARP</td>
<td>Standards and Recommended Practices</td>
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<td>SMS</td>
<td>Safety Management System</td>
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<td>S&amp;T</td>
<td>Science and Technology</td>
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<td>sUAS</td>
<td>Small Unmanned Aircraft Systems</td>
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<tr>
<td>TC</td>
<td>Type Certificate</td>
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<td>TCAS</td>
<td>Traffic Alert and Collision Avoidance System</td>
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<td>TCRG</td>
<td>Technical Community Representative Group</td>
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<td>TSO</td>
<td>Technical Standard Order</td>
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<td>UAS</td>
<td>Unmanned Aircraft System</td>
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<td>UAV</td>
<td>Unmanned Aerial Vehicle</td>
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<td>VO</td>
<td>Visual Observer</td>
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<tr>
<td>WRC</td>
<td>World Radiocommunication Conference</td>
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<tr>
<td>14 CFR</td>
<td>Title 14 of the Code of Federal Regulations</td>
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<tr>
<td>RF</td>
<td>Radio Frequency</td>
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<tr>
<td>RPV</td>
<td>Remotely Piloted Vehicle</td>
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## Terminology

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tr>
<td>Air Traffic Control</td>
<td>A service operated by appropriate authority to promote the safe, orderly and expeditious flow of air traffic.</td>
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<td>Aircraft</td>
<td>A device that is used or intended to be used for flight in the air.</td>
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<td>Airspace</td>
<td>Any portion of the atmosphere sustaining aircraft flight and which has defined boundaries and specified dimensions. Any airspace may be classified as to the specific types of flight allowed, rules of operation and regulations in accordance with International Civil Aviation Organization standards or state regulations.</td>
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<tr>
<td>Airworthiness Certificate</td>
<td>An FAA grant of approval for a specific flight operation. The authorization to operate a UAS in the NAS as a public aircraft outside of Restricted, Warning or Prohibited areas approved for aviation activities.</td>
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<tr>
<td>Civil Aircraft</td>
<td>Aircraft other than public aircraft.</td>
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<td>Collision Avoidance</td>
<td>The Sense and Avoid system function where the UAS takes appropriate action to prevent an intruder from penetrating the collision volume. Action is expected to be initiated within a relatively short time horizon before the closest point of approach. The collision avoidance function engages when all other modes of separation fail.</td>
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<tr>
<td>Communication Link</td>
<td>The voice or data relay of instructions or information between the UAS pilot and the air traffic controller and other NAS users.</td>
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<tr>
<td>Control Station</td>
<td>The equipment used to maintain control, communicate with, guide or otherwise pilot an unmanned aircraft.</td>
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<td>Crewmember</td>
<td>In addition to the crewmembers identified in 14 CFR Part 1, a UAS flight crewmember includes pilots, sensor/payload operators and visual observers, but may include other persons as appropriate or required to ensure safe operation of the aircraft.</td>
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<tr>
<td>Data Link</td>
<td>A ground-to-air communications system which transmits information via digital coded pulses.</td>
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<td>Detect and Avoid</td>
<td>Term used instead of Sense and Avoid in the Terms of Reference for RTCA Special Committee 228. This new term has not been defined by RTCA and may be considered to have the same definition as Sense and Avoid.</td>
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## Terminology

| **International Civil Aviation Organization** | A specialized agency of the United Nations whose objective is to develop the principles and techniques of international air navigation and to foster planning and development of international civil air transport. |
| **Manned Aircraft** | Aircraft piloted by a human onboard. |
| **Model Aircraft** | An unmanned aircraft that is capable of sustained flight in the atmosphere; flown within visual line-of-sight of the person operating the aircraft and flown for hobby or recreational purposes. |
| **National Airspace System** | The common network of U.S. airspace; air navigation facilities, equipment and services, airports or landing areas; aeronautical charts, information and services; rules, regulation and procedures, technical information, and manpower and material. Included in the system components shared jointly with the military. |
| **Optionally Piloted Aircraft** | An aircraft that is integrated with UAS technology and still retains the capability of being flown by an onboard pilot using conventional control methods. |
| **Pathfinder** | An initial UAS airworthiness certification program that will aid the FAA in the establishment of certification requirements. |
| **Pilot-in-Command** | The person who:  
1. Has final authority and responsibility for the operation and safety of the flight;  
2. Has been designated as pilot-in-command before or during the flight; and  
3. Holds the appropriate category, class and type rating, if appropriate, for the conduct of the flight. |
| **Public Aircraft** | An aircraft operated by a governmental entity (including federal, state or local governments, and the U.S. Department of Defense and its military branches) for certain purposes as described in 49 U.S.C. §§ 40102(a)(41) and 40125. Public aircraft status is determined on an operation by operation basis. See 14 CFR Part 1, § 1.1 for a complete definition on public aircraft. |
# Terminology

| **RTCA** | RTCA, Inc. is a private, not-for-profit corporation that develops consensus-based recommendations regarding communications, navigation, surveillance, and air traffic management system issues. RTCA functions as the Federal Advisory Committee. Its recommendations are used by the FAA as the basis for policy, program and regulatory decisions and by the private sector as the basis for development, investment and other business decisions. (www.rtca.org) |
| **See and Avoid** | When weather conditions permit, pilots operating instrument flight rules or visual flight rules are required to observe and maneuver to avoid another aircraft. Right-of-war rules are contained in 14 CFR Part 91. |
| **Self-Separation** | Sense and Avoid system function where the UAS maneuvers within a sufficient timeframe to remain well clear of other airborne traffic. |
| **Sense and Avoid** | The capability of a UAS to remain well clear from and avoid collisions with other airborne traffic. Sense and Avoid provides the functions of self-separation and collision avoidance to establish an analogous capability to “see and avoid” required by manned aircraft. |
| **Small Unmanned Aircraft** | An unmanned aircraft weighing less than 55 pounds. |
| **Special Airworthiness Certificate – Experimental Category (UAS)** | Airworthiness certification for experimental UAS and optionally piloted aircraft. |
| **Test Range** | A defined geographic area where research and development are conducted in accordance with Sections 332 and 334 of the FMRA. Test ranges are also known as test sites in related documents such as the FAA’s Screening Information Request. |
## Terminology

<table>
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<th>Term</th>
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| **Unmanned Aircraft**                     | 1. A device used or intended to be used for flight in the air that has no onboard pilot. This devise excludes missiles, weapons or exploding warheads, but includes all classes of airplanes, helicopters, airships and powered-lift aircraft without an onboard pilot. UA do not include traditional balloons (see 14 CFR Part 101), rockets, tethered aircraft and non-powered gliders.  
  2. An aircraft that is operated without the possibility of direct human intervention from within or on the aircraft. |
| **Unmanned Aircraft System**              | An unmanned aircraft and its associated elements related to safe operations, which may include control stations (ground, ship or air-based), control links, support equipment, payloads, flight termination systems and launch/recovery equipment.                                                                                   |
| **Visual Line-of-Sight**                  | Unaided (corrective lenses and/or sunglasses exempted) visual contact between a pilot-in-command or a visual observer and a UAS sufficient to maintain safe operational control of the aircraft, know its location, and be able to scan the airspace in which it is operation to see and avoid other air traffic or objects aloft or on the ground. |

### References:

1. Title 14 of the Code of Federal Regulations, Part 1.1
2. FAA Pilot/Controller Glossary (P/CG)
3. RTCA DO-320: Operational Services and the Environmental Definition of Unmanned Aircraft Systems
5. FAA Modernization and Reform Act of 2012
6. “Sense and Avoid (SAA) for Unmanned Aircraft systems (UAS)" – Second Caucus Workshop Report 2013
7. FAA Order 8130.34B – Airworthiness Certification of Unmanned Aircraft Systems and Optionally Piloted Aircraft
Appendix C - Goals
C.1 - Certification Requirements (Airworthiness)

1. FAA initial certification process established for one or more civil applicants by 2014

2. FAA’s initial issue papers for one or more standard airworthiness certification projects are available by 2014

3. FAA’s unique certification requirements identified through issue papers that have matured for one or more standard airworthiness certification projects by 2015

4. FAA certification requirements updated and systems certified as necessary
C.2 - Certification Requirements (Pilot/Crew)

1. FAA certification requirements for pilots and crew members for sUAS classes published as part of a sUAS rule by 2014 in accordance with the FMRA
   - Includes coordination with government agencies on security/vetting requirements

2. Necessary changes to record keeping systems established as part of the sUAS rule and in accordance with the FMRA

3. FAA certification requirements for pilots and crew members for UAS classes other than those addressed under the sUAS rule published by 2014 - 2017
C.3 - Ground Based Sense and Avoid (GBSAA)

1. FAA draft Advisory Circular on GBSAA systems and requirements released by 2015

2. GBSAA operations fully approved by the FAA for routine use by all aviation, including both public and civil entities
C.4 - Airborne Sense and Avoid (ABSAA)

1. Initial FAA certification of ABSAA that facilitates UAS operations without the requirement for visual observer by 2016-2020

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

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

4. Installation and certification of ABSAA systems for use by the DoD and other public and civil entities that provide the SAA functions that facilitate integrated operation of manned and unmanned aircraft in all NAS airspace classes
C.5 - Control and Communications (C2)

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

2. Beyond-Line-of-Sight C2 links and capabilities are addressed in international agreements, industry standards and FAA regulations and guidance material.

3. Adequate spectrum is available for both radio LOS and BLOS C2 links to meet the current and projected demand generated by civil operations in the NAS.
C.6 - Small UAS (sUAS) and Other Rules

1. sUAS rule adopted to allow for both civil and public operations

2. sUAS rule adoption for public and civil operations

3. sUAS rule supports ATC interoperability to ensure safe and efficient NAS operations

4. Other Rulemaking per the FMRA
C.7 - Test Ranges

1. FAA program to integrate UAS into the NAS at six test ranges established in accordance with the FMRA

2. Test ranges selected by FAA in accordance with the FMRA

3. Selected test ranges operation in accordance with the FMRA

4. Test range program operational until February 2017

5. Report findings and conclusions concerning projects in accordance with the FMRA
C.8 - Air Traffic Interoperability

1. Safety and Interoperability – the overall level of safety in the NAS is preserved through NAS integration, which requires adherence to rigorous airworthiness standards and airspace regulations
   – Apply equally to manned aircraft; also recognize the distinguishing characteristics of UAS

2. Procedures and training
C.9 - Miscellaneous

1. Develop more detailed plans for safely integrating UAS operations in the NAS by 2015

2. Identify air traffic management system changes required to be implemented in NextGen

3. Review and revise and/or develop new UAS operational scenarios to mature UAS operational concept elements, update operational requirements and validate key concept elements for UAS integration in the NAS

4. Develop UAS integration in the Arctic Region in accordance with the FMRA
C.9 - Miscellaneous

5. Develop implementation of Common Strategy for DOJ and associated law enforcement, fire and first responder agency use of sUAS in the NAS in accordance with the FMRA

6. Develop policies to ensure “the Administrator of the FAA may not promulgate any rule or regulation regarding a model aircraft, or an aircraft being developed as a model aircraft”
   – Per FMRA

7. Requirements for the operation of “public unmanned aircraft systems” in the NAS in accordance with the FRMA
UAS ARC Membership

- DoD PBFA
- NASA
- Honeywell
- Northrop Grumman
- General Electric
- AeroVironment
- Boeing/Insitu
- A4A, ALPA, and AOPA
- MITRE