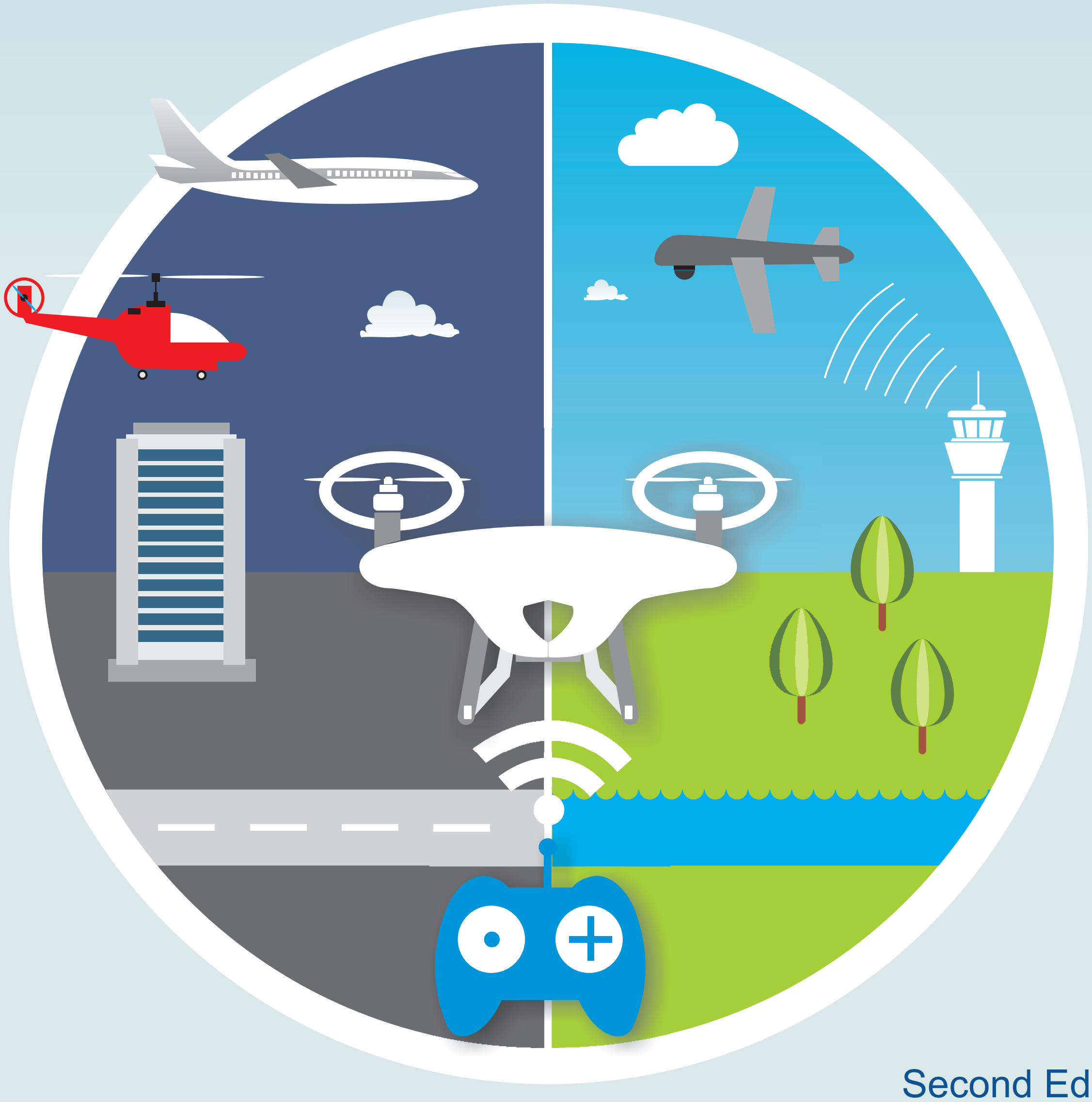
Federal Aviation Administration

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

A Five-year roadmap for the introduction of civil UAS into the NAS



Second Edition
July 2018

Final
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Executive Summary

Unmanned aircraft system (UAS) operations are rapidly increasing in number, technical complexity, and sophistication. The growth in popularity of these new aircraft has presented the U.S. Department of Transportation (the Department) and the Federal Aviation Administration (FAA) with a number of regulatory and technical challenges. This roadmap is intended to meet the requirement in Section 332 of the FAA Modernization and Reform Act of 2012 (FMRA). It provides an update on the progress to date in achieving UAS integration, the challenges we continue to face, and near-term strategies for addressing these challenges.

The Department's vision for fully integrating UAS into the National Airspace System (NAS) entails UAS operating harmoniously, side-by-side with manned aircraft, occupying the same airspace and using many of the same air traffic management (ATM) systems and procedures. This vision goes beyond accommodation practices, which largely rely on operational segregation to maintain systemic safety. As we work to realize this vision, UAS must be introduced to the NAS incrementally to ensure the safety of people and property both in the air and on the ground.

The first section of this Roadmap outlines the great strides that have been made in the early stages of integration. The Department took a significant regulatory step forward with the publication of the first two UAS rules. In December 2015, an Interim Final Rule on Registration and Marking Requirements for Small Unmanned Aircraft was published, which applies to UAS weighing more than 0.55 pounds (250 grams) and less than 55 pounds. In June 2016, the small UAS rule (Title 14 Code of Federal Regulations (CFR) part 107) was published, becoming effective in August 2016. This rule enables routine small UAS operations conducted within visual line-of-sight (VLOS). Prior to the finalization of the small UAS rule, the FAA had only authorized UAS operations on a case-by-case basis, allowing commercial UAS operations in specific, low-risk situations.

The second section of this Roadmap outlines the crucial relationships across government and industry that the Department relies on to ensure its UAS integration efforts are harmonized and consistent. The Drone Advisory Committee (DAC) and the Unmanned Aircraft Safety Team (UAST), as well as recommendations from several Aviation Rulemaking Committees (ARC), provide essential input to inform the FAA's UAS integration activities. All the work needed to resolve our collective challenges requires collaboration between partners at local, tribal State, national, and international levels, as well as partners across the UAS industry and stakeholder community.

The Department's commitment to the safe and efficient integration of UAS also requires resolving several key challenges, as described in the third section of this Roadmap, to enable this emerging technology to safely achieve its full potential. Technical issues to ensure an unmanned aircraft (UA) maintains a safe distance from other aircraft and that the pilot retains control of the UAS and know its location at all times must be addressed before UAS operations beyond visual line-of-sight (BVLOS) can become routine. Much work must also be done to develop the standards necessary to support UAS certification processes. In addition to the technological and operational challenges posed by UAS integration, there are additional policy questions raised by UAS use, including security — both physical and cyber — and privacy.

Finally, the fourth section details the strategy for near-term UAS integration efforts over the next several years. The FAA's rulemaking strategy and research priorities are crucial components to achieving a more enhanced UAS regulatory framework by 2020, which includes more complex UAS operations, such as over people and BVLOS. The safe integration of drones into the NAS will also require creating new partnerships across the federal government as well as among local governments and industry. In late 2017, the Secretary of Transportation announced the Integration Pilot Program (IPP) to streamline collaboration. The IPP allows state, local and tribal governments to partner with private sector entities (e.g., operators as well as manufacturers), to accelerate the safe integration of UAS operations. In May 2018, the Secretary announced 10 Lead Participants from amongst a competitive group of 149 applicants.

While significant UAS integration progress has been made, the Department recognizes there is still work to do. UAS must be integrated into the NAS while maintaining existing operational capacity and safety and without introducing excessive risk to airspace users or persons and property on the ground. We are committed to striking the appropriate regulatory and oversight balance to ensure that American innovation is able to thrive without compromising the safest, most efficient aerospace system in the world.

Section 1: UAS Integration Accomplishments

UAS integration has progressed significantly since the first edition of this Roadmap published in 2013. This section describes integration accomplishments to date to set the stage for subsequent discussion of challenges and next steps.

UAS Operations in the Arctic

Section 332(d) of the 2012 FMRA tasked the Secretary of Transportation with developing a plan to designate permanent areas in the Arctic where small UA could perform research and commercial operations. In 2012, the Department published the UAS Arctic Implementation Plan to inform interested parties, operators, Federal agencies, and international communities of its plans to establish permanent operational areas and corridor routes in the Arctic for the operation of small UAS.

From 2013 to 2015, several UAS operations took place in the Arctic, carrying out surveys, environmental assessments, and infrastructure inspections. These operations were made possible through authorizations from the FAA and cooperation among other U.S. Government agencies, and the academic and private sectors. Highlights include:

- The National Aeronautics and Space Administration (NASA) funded the Marginal Ice Zone Observations and Ocean Experiment in the summer 2013. NASA's Sensor Integrated Environmental Remote Research Aircraft, the ScanEagle UAS (University of Alaska), and the Data Hawk UAS (University of Colorado) flew under the first civilian Certificate of Waiver or Authorization (COA). The COA permitted ground-based radar in lieu of ground or air observers for BVLOS operations.
- ConocoPhillips began using Boeing/Insitu's ScanEagle in September 2013 to perform marine mammal and ice surveys. The FAA issued a restricted category type certificate to the ScanEagle X200, and signed an Other Transaction Agreement (OTA) with ConocoPhillips that authorized flights in the late summer under ideal weather conditions.
- In 2014 the FAA issued a restricted category type certificate[1] allowing commercial operations for AeroVironment's Puma AE to perform pipeline and infrastructure surveys for BP — the first commercial UAS operation over land. The Puma was also used to conduct an oil spill exercise in the Beaufort Sea.
- Also in 2014, the FAA issued a COA to Boeing/Insitu for commercial BVLOS operations in the Chukchi Sea flown on behalf of ConocoPhillips.
- In 2015, the U.S. Coast Guard and ConocoPhillips executed a multi-year Cooperative Research and Development Agreement (CRDA), facilitated by the FAA. Initial operations included an oil spill exercise and a search and rescue demonstration north of Alaska. The National Oceanic and Atmospheric Administration (NOAA) and the U.S. Department of Energy (DOE) also participated in the simulated search and rescue exercise, which was the first joint manned/unmanned aircraft exercise.

[1] The FAA issues type certificates to restricted category aircraft under 14 CFR part 21 for use only in those special-purpose operations identified in the applicable type design. More information is available in FAA Order 8110.56.

- Also in 2015, the FAA established 10 UAS Coastal Launch Sites and the Arctic UAS Permanent Areas were published in the Alaska Supplement, an FAA Airport Facilities Directory (now called FAA Chart Supplements). The FAA has also developed and published communication procedures for flying UAS BVLOS in the Arctic.

UAS Test Sites

In December 2013, the FAA Administrator announced the selection of six UAS test sites — University of Alaska-Fairbanks, State of Nevada, New York's Griffiss International Airport, North Dakota Department of Commerce, Texas A&M University-Corpus Christi, and Virginia Polytechnic Institute and State University. These test sites were established in accordance with the FMRA to support safe integration of UAS into the NAS. The test sites provide access to UAS flight testing opportunities for interested parties in a safe testing environment. The FAA provides oversight to guarantee each site operates according to safety standards. The partnership between the FAA and the test sites was formalized via OTAs in December 2013.[2] All six test sites were approved to conduct flight operations within nine months of selection.

The FAA has given the test sites several capabilities to support UAS integration activities. In September 2014, the FAA issued an Order allowing Designated Airworthiness Representatives (DAR) to be onsite to facilitate UAS Certification at the UAS test sites. This Order sets policy and provides training requirements limited to the issuance of special airworthiness certificates in the experimental category at UAS test sites. In December 2014, the State of Nevada was the first test site to use a DAR to issue an experimental certificate.

In May 2015, the FAA authorized test sites via COAs to conduct public aircraft operations throughout the NAS at or below 200 feet above ground level (AGL). In September 2015, this authority was expanded to 400 feet AGL. These new COAs allow small UAS (under 55 pounds) operated by the test sites to fly public aircraft operations anywhere in the country, except restricted airspace and areas close to airports and heliports. Operators must fly during daytime Visual Flight Rules (VFR) conditions and within VLOS of the pilot. These authorizations also allow the test sites to fly various types of UAS, making it easier for them to conduct research missions.

The FAA Extension, Safety, and Security Act (FESSA) of 2016 directed the FAA to include test ranges established prior to 2009 in its Test Site Program, which enabled the inclusion of the New Mexico State University UAS Flight Test Center as the seventh test site. It also extends the program to September 30, 2019.

UAS Test Site Privacy Policy

As privacy concerns have become part of the discourse on UAS operations, the FAA with public input established a requirement for each test site to develop a privacy policy. Among other

[2] OTAs enable entities to work with the Federal Government that would otherwise not wish to due to the complexity of the laws and regulations that cover contracts, grants, and cooperative agreements. The Department has used OTAs for projects ranging from construction of air traffic control towers to management of demonstration activities for emerging technologies.

requirements, test site operators must attest that they have: complied with Federal, State, and other laws protecting an individual's privacy; established publicly available privacy policies and a written plan for data use and retention; and conducted an annual review of privacy practices that allows for public comment.

These practices are expected to help facilitate dialogue among policymakers, privacy advocates, and the UAS industry. The end result should address broader questions concerning the use of UAS technologies and how privacy law, public policy, and industry practices should respond to those issues. Each test site agreed to comply with all requirements prior to conducting their first test flights.

For more information about the UAS test sites, contact the test sites directly.

Section 333 Exemption Process

By law, civil aircraft operations require a certified and registered aircraft, a certified pilot, and operational approval for certain types of commercial operations. Section 333 of the FMRA grants the Secretary of Transportation the authority to determine whether an airworthiness certificate is required for a UAS to operate safely in the NAS. Starting in September 2014, this authority was leveraged to grant case-by-case authorization for certain unmanned aircraft to perform commercial operations prior to the finalization of the small UAS rule, which is now the primary regulatory framework for small UAS operations.

The Section 333 exemption process provided operators who wished to pursue safe and legal entry into the NAS a competitive advantage in the UAS marketplace, thus discouraging illegal operations and improving safety. Since the first Section 333 exemptions were granted in 2014, the FAA issued more than 5,500 exemptions for commercial UAS operations such as closed-set filmmaking, aerial data collection, real estate photography, precision agriculture, and infrastructure inspections.

To further facilitate civil UAS integration via Section 333, in March 2015 the FAA began issuing COAs to civil operators concurrently when granting Section 333 exemptions. These COAs authorize exemption holders to conduct nationwide UAS operations below 200 feet AGL and certain distances away from airports, and also alleviated the need to apply for a separate COA for each operating location, provided an operator complies with the parameters of the issued COA. In March 2016, the FAA raised the altitude to 400 feet AGL for all "blanket" COAs issued to Section 333 exemption holders.

With the final small UAS rule (part 107) in effect as discussed below, moving forward, the FAA will only consider Section 333 exemptions for operations that cannot be conducted under part 107.

Small UAS Registration

Aircraft registration is a foundational statutory requirement that applies to all civil aircraft. Industry estimates for small UAS sales over the past several years made it clear that the FAA's existing paper-based process put forth in 14 CFR part 47 was not feasible given the rapid proliferation of new small UAS owners. Additionally, growing concern about reports of UAS flying near airports and manned aircraft highlighted the need to educate these users before they begin operating small UAS in the NAS.

The Secretary of Transportation and the FAA Administrator announced the creation of a UAS Registration Task Force in October 2015. The Task Force, comprised of industry representatives with a range of stakeholder viewpoints, interests, and knowledge, submitted its final recommendations in November 2015. The Department evaluated recommendations and published an Interim Final Rule on Registration and Marking Requirements for Small Unmanned Aircraft the following month. The rule, which establishes an alternative, web-based process for small UA registration, took effect in December 2015.

This registration process serves two critical functions that foster a culture of safety and accountability in the emerging UAS community. First, it provides a means to associate an unmanned aircraft with its owner. Owners must register their unmanned aircraft online if it weighs more than 0.55 pounds and less than 55 pounds and is flown outdoors. Registrants must provide their name and address (mailing, physical and email), and are then given a certificate of registration containing a unique number to mark on each small UA they own and fly. The registration fee is $5 and registration is valid for three years. To date, more than one million small UAS owners have registered using the online system.

Second, the registration process provides an opportunity to educate users about how to safely operate UAS in the NAS. Prior to completing the process, registrants must read and acknowledge safety guidelines, which include instructions to not fly near manned aircraft and always fly within VLOS. This acknowledgement emphasizes the fact that using the nation's airspace comes with certain responsibilities and expectations. Registration also helps law enforcement and regulators identify an operator more quickly in the event of an incident.

The FAA has also used the UAS registration database to notify registrants of important safety information several times since registration took effect. In June 2016, the system reminded registrants to stay away from wildfires and wildfire suppression efforts by first responders. The agency continued to spread this message during the devastating 2018 wildfire season. In October 2016, the FAA alerted registrants to a Temporary Flight Restriction established in Florida for Hurricane Matthew, and provided instructions for UAS operators who wanted to support emergency response activities. In February 2017, Alaska-based registrants were reminded about the rules for flying UAS around the Iditarod sled dog race. Finally, UAS registrants nationwide were reminded not to interfere with emergency response efforts during the 2017 hurricane season.

On December 24, 2015, John Taylor filed a petition for review challenging the FAA's articulated good cause justification for immediate adoption of the registration and marking requirements for small unmanned aircraft and the rule's applicability to small unmanned aircraft meeting the provisions of FMRA Section 336 – The Special Rule for Model Aircraft. In May 2017, a U.S.

Circuit Court of Appeals decision vacated the FAA's unmanned aircraft registration rule to the extent that it applies to model aircraft operating in compliance with Section 336. However, in December 2017, the President signed the 2018 National Defense Authorization Act into law, which reinstated the registration requirement for model aircraft. The FAA plans to issue a final registration rule in 2018.

Small UAS Rule (Part 107)

In June 2016, the FAA issued the final small UAS rule (14 CFR part 107). The rule's provisions are designed to minimize risks to other aircraft and people and property on the ground. The regulations require pilots to keep a UA within VLOS. Operations are allowed during daylight and twilight hours if the UA has anti-collision lights. The new regulations also address operational limits such as altitude and speed restrictions as well as barring flights over people who are not operating the UAS or otherwise not protected (i.e., under structures safe from impact).

Some provisions of the rule are subject to waiver, which may be requested through the FAA's new DroneZone online portal. Applicants must demonstrate that their proposed operation can be conducted safely outside of the provisions of part 107. Additionally, the rule allows for operations in Class G airspace without prior Air Traffic Control (ATC) authorization. Operations in Class B, C, D, and surface area of E designated for an airport may be permitted with authorization from the Air Traffic Organization using the DroneZone portal.

Part 107 also created a UAS-specific airman certificate, called the Remote Pilot Certificate, which an individual can obtain by passing an aeronautical knowledge examination at an FAA-approved knowledge testing center. Alternatively, if a person holds a current non-student part 61 pilot certificate, he or she may complete an online small UAS training course in lieu of the in-person knowledge test. Remote pilots must be 16 years of age, be able to read, speak, write, and understand English, and be in an adequate physical and mental condition to operate a small UAS safely. The certificate is valid for two years, after which the remote pilot must take a recurrent knowledge test or successfully complete training if the remote pilot holds a certificate under part 61 as described above. Individuals under the age of 16 may operate a small UAS under part 107 under the direct supervision of a certificated remote pilot, provided the remote pilot has the ability to immediately retake direct control of the UA.

Part 107 provides unprecedented access to the NAS while also ensuring safe skies. However, it is only the first step in the FAA's plan to integrate UAS into the NAS; subsequent steps will facilitate UAS operations over people, BVLOS, and transporting people and property. A more detailed discussion of the FAA's rulemaking plans can be found in a later section of this document.

Research and Development

Research into gaps in current and new UAS technologies, as well as existing and future NAS automation systems, will support the development of policy and standards required to address new and novel aspects of UAS flight operations. The FAA's research needs are coordinated internally, as well as with partner agencies to provide opportunities for research collaboration and avoid duplication of effort. The research and development (R&D) work done at the UAS test sites and the UAS Center of Excellence (COE) also advances the FAA's UAS research goals.

Research, Development, Testing and Evaluation (RDT&E) at UAS Test Sites

The UAS test sites play a critical role in the safe and efficient integration of UAS into the NAS. One of the primary goals of the program is to help the FAA determine technical and operational trends that could support safety-related decision making for integration. In 2015, the FAA provided the test sites with a list of operational requirements, which they might use their diverse capabilities to help validate through research to advance integration. The FAA routinely reviews current operational and tactical matters with the test sites. Per their agreement with the FAA, all test sites participate in regular meetings and annual forums to exchange ideas among each other and the FAA on their research activities, accomplishments, and capabilities.

The test sites continue to conduct research to validate key operational requirements for UAS integration, including research and testing into technology that enables UAS to detect and avoid (DAA)[3] other aircraft and obstacles, investigation of lost link causes and resolutions, and evaluation of the adequacy of ATC and communications procedures with UAS. Test site activities have also explored industry applications of UAS, such as emergency response, utility company infrastructure inspection, wildlife census, and precision agriculture. From 2016 to 2017, the test sites also provided support for the FAA's UAS detection system evaluations conducted at four U.S. airports. Other government entities also direct research to the test sites, as NASA did in 2015 to support its UAS Traffic Management (UTM) research.

Selection of the UAS Center of Excellence (COE)

Congress mandated that the FAA establish the UAS COE under the Consolidated Appropriations Act of 2014. Like university think tank partnerships, the FAA's COEs bring together some of the best minds in the nation to conduct research to educate, train, and work with the FAA to solve aviation related challenges.

In May 2015, the FAA selected the Alliance for System Safety of UAS through Research Excellence (ASSURE), a Mississippi State University-led team, as the FAA's UAS COE. The COE is comprised of a core team of 15 of the nation's leading UAS and aviation universities,[4] as well as an affiliate team of eight domestic and international universities, that have a proven commitment to UAS R&D and the necessary resources to provide the matching contribution to the government's investment.

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[3] For the purposes of this document, the terms "see and avoid" and "detect and avoid" are synonymous.

[4] In addition to the COE lead, Mississippi State University, the other core COE members include: Drexel University, Embry-Riddle Aeronautical University, Kansas State University, Montana State University, New Mexico State University, North Carolina State University, Ohio State University, Oregon State University, University of Alabama-Huntsville, University of Alaska-Fairbanks, University of North Dakota, University of Kansas, University of California-Davis, and Wichita State University. Affiliate COE members include Louisiana Tech University, Concordia University (Canada), Auburn University, Indiana State University, Tuskegee University, University of Southampton (U.K.), Sinclair Community College, and Technion Israel Institute of Technology.

The UAS COE model encourages a cost-sharing relationship between academia, industry, and government that focuses on research areas of primary interest to the FAA and the UAS community, where the private sector matches the public funding. The UAS COE brings together public sector (FAA, NASA, the U.S. Department of Defense (DoD), State and local government, etc.), private sector, and academic institutions to create a consortium to identify solutions for existing and anticipated UAS-related issues. The COE began research in September 2015 and delivered initial research results in fall 2016.

Throughout 2017, ASSURE's research teams released findings on ground and airborne collision risks with manned aircraft. In April the research consortium identified the risks of allowing small UA to fly over people. The most significant threats to people on the ground include blunt force trauma, penetration injuries and lacerations caused by hazardous drone features like unprotected rotors. In November ASSURE'S report concluded that drones that collide with large manned aircraft can cause more structural damage than birds of the same weight for a given impact speed. The FAA will use the research results to help develop operational and collision risk mitigation requirements for UA.

Focus Area Pathfinder Program

In May 2015, to meet growing demand from the public and industry, the FAA announced the UAS Focus Area Pathfinder Program, an industry partnership program to develop and validate operational concepts for certification, operations, and safety beyond established or proposed policies and procedures. The three industry partners — CNN, PrecisionHawk, and BNSF Railways — focused their work on operational expansion of: VLOS over people; extended and beyond VLOS in rural areas; and BVLOS over right-of-ways. The goal was to develop operational concepts in manageable segments while providing the safety and validation of risk mitigation actions.

The FAA entered into Cooperative Research and Development Agreements (CRDA) with these companies to assist in the development of Concepts of Operations (ConOps) and to look at potential risks and mitigations in each of their areas of interest. By the end of 2017, the program's three focus areas (outlined below) had all met objectives spelled out at its inception, namely to: define the parameters to allow safe operation of UAS in the NAS; obtain operational approval for the Pathfinder industry stakeholder to perform routine, limited operations; and to define under what conditions and constraints similar operations may be approved for future applicants.

Focus Area One: VLOS Operations over People

CNN collaborated with the FAA to explore how UAS might be safely used for newsgathering over people. The network identified three types of operational scenarios for UAS for operations: planned event coverage, anticipated news, or breaking news. CNN acquired the UAS it planned to use, and then applied for multiple exemptions for both tethered and free flight (non-tethered) aircraft. CNN received Section 333 exemptions and conducted its first free flight UAS operations in December 2015. Since then CNN conducted multiple operations under their Section 333 exemption with contract operators. Examples include coverage of the Selma march 50th anniversary in Alabama; the Oklahoma City bombing anniversary; and the anniversary of Hurricane Katrina.

After the part 107 rule took effect in August 2016, CNN sought waivers to conduct operations over people under the new rule. For example, its Fotokite Pro tethered vehicle received approval for operations over people with restrictions (limiting flight over people to no higher than 21 feet AGL). The FAA also granted a part 107 waiver for small UAS operations over people for closed-set motion picture and television filming and production. In October 2017, the FAA granted CNN's Vantage Robotics Snap Vehicle — a lightweight small UAS designed to break apart upon collision or impact — a waiver for operations over people up to 150 feet AGL. The FAA and CNN participated in multiple public forums to raise awareness, through meetings with the DAC and the ASTM. CNN now has a UAS unit with full-time UAS operators to fully integrate aerial imagery and reporting across all CNN networks and platforms.

Focus Area Two: Extended and Beyond Visual Line-of-Sight in Rural Areas

PrecisionHawk USA Inc. entered into a partnership with the FAA in 2015 to explore Extended Visual Line of Sight (EVLOS) operations in sparsely populated rural fixed environment for application of agricultural aerial imagery. In EVLOS operations, the remote pilot in command may not have the UA in visible sight at all times, but relies on one or more remote observers to keep the UA in visual sight at all times. This focus area took on a three-phase approach to develop a repeatable approval path for EVLOS moving toward eventual localized BVLOS operations.

Throughout 2015 and 2016 (phases I and II) PrecisionHawk developed a research plan outlining the steps for EVLOS field trials, which included a safety risk management (SRM) panel to obtain a COA. With FAA authorization, early flight tests examined visual and workload capabilities of the remote pilot in command to identify encroaching aircraft while managing a routine UAS flight. This early but important step clearly defined the EVLOS concept, establishing a preliminary distance for manned aircraft visual detection capability. Subsequent tests helped to better define pilots' and observers' performance under varying traffic and environmental conditions. Under a special airworthiness certificate (experimental), PrecisionHawk operated small UAS flight tests, which provided data that used for approval of the first part 107 waiver for EVLOS.

Phase III (throughout 2017) departed from earlier operations reliant on human vision to explore operations within large areas exceeding EVLOS distances. These operations rely on technology to assist the pilot in detecting and selecting appropriate maneuvers to avoid manned aircraft. These operations used data from known traffic input (from ATC), as well as technology like LTE wireless communications networks to relay information to the remote pilot in command. PrecisionHawk's tests helped identify minimum performance and capabilities of the system and assess pilot displays, assistive features, encounter conditions, and pilot responses, and to analyze performance of LTE communications in rural environments.

Overall, Focus Area Two (FA2) provided the FAA significant knowledge to inform standards and future rules on the capabilities and limitations of human vision in aircraft detection and decision making and the effectiveness of pilot assistive technologies. The part 107 waiver enabled the first commercial use of EVLOS operations nationwide, and data collected will help inform requirements, laying the groundwork for localized BLVOS operations beyond the EVLOS range.

Focus Area Three: BVLOS in Rural /Isolated Areas

While FA2 sought to explore operations exceeding EVLOS distances within sparsely populated rural areas, BNSF Railways partnered with the FAA to take the concept even further. BNSF explored the BVLOS concept in extremely isolated areas for inspecting thousands of miles of rail infrastructure — some being hundreds of miles from any major population center.

In August 2015 BNSF presented a safety case for rural area and identified hazards, including lost link and sustained loss of GPS and command and control (C2) link; inability of manned aircraft to see the UA; and inability to comply with right-of-way rules (14 CFR 91.113) to see and avoid other aircraft. An FAA SRM panel later approved BVLOS operations around Clovis, NM in class G (uncontrolled) airspace only. In October the same year, BNSF conducted five ScanEagle flights over a 130-mile segment of BNSF rail. By November, the COA was updated and approved to include three additional areas for operations while limiting the altitude to 400 feet AGL, in Playas, NM, and Laurel and Milk River in Montana. The FAA approved multiple vehicles for the research activities using a special airworthiness certificate in the experimental category for R&D.

Test flights collected and evaluated data on C2 networks, ground based air traffic and radar capabilities to detect UAS, and onboard Automatic Dependent Surveillance-Broadcast (ADS-B).

The ability to operate well beyond the pilot's VLOS opens a wide range of commercial and other uses, for example other infrastructure inspections like electric transmission lines and pipelines, as well as emergency response and restoration. Much like the FA2 exercises, the FAA learned valuable lessons that are broadly applicable to a variety of other types of future BVLOS operations to further UAS integration into the NAS. BNSF is expanding upon its Pathfinder 3 accomplishments through the CRDA to continue BVLOS activities. Future activities include expanded testing into seven additional research areas to assess flight corridor concepts, conducting airspace risk analysis, exploring performance of airborne DAA sensors, and flying BVLOS operations in controlled airspace, among others.

UAS Detection near Airports

In October 2015, the FAA announced a research partnership with CACI International Inc. to evaluate how the company's technology can help detect UAS near airports.
Since that agreement was signed, Congress has passed legislation related to this research,[5] and the FAA has expanded efforts to evaluate certain capabilities of UAS detection technologies

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[5] In House Report 114-129 to Consolidated Appropriations Act, 2016 (Public Law No. 114-113) enacted in December 2015, the FAA was directed to:

a. Assess the feasibility of integrating proven UAS mitigation technology with airport operations to detect, identify and track both the UAS and operator.

offered by additional manufacturers — for example, Sensofusion, Liteye Systems, and Gryphon Sensors. The Interagency UAS Detection at Airports Strategy Working Group used an evaluation protocol adaptable to each system's unique detection capabilities to assess the safe and efficient integration of UAS detection technologies in airport operating environments.

The CACI UAS detection system was installed at Atlantic City International Airport in January 2016. In April 2017, the UAS Detection at Airports Strategy Working Group completed a 16-month-long series of UA detection evaluations at airports within and outside of the United States and will use the data to draft recommendations for detection systems minimum performance standards. These standards are providing guidance in selecting UA-detection systems for airports nationwide.

Education and Outreach

Unmanned aircraft have become increasingly affordable and easy to fly. Unlike the traditional model aircraft user community, people with little or no aviation experience or knowledge are beginning to fly UAS. The FAA is committed to an "education first" approach to integrating this growing community of unmanned aircraft users, which has included dedicated outreach and public service campaigns, trade show and conference participation, and collaboration with industry partners to ensure the safety message reaches the user community.

Over the past several years, significant work has been completed to upgrade the FAA's public UAS website, www.faa.gov/uas. This website is continually updated to ensure consistency and accuracy of all information provided to stakeholders and members of the public. The website also provides users an option to contact the UAS Integration Office for more information, and to subscribe for notifications and UAS news.

This commitment to consistency and accuracy also extends to the outreach the FAA does in person. Every year, UAS subject matter experts from across the FAA regularly attend trade shows, symposiums, and conferences, participate on panels and discussions, give briefings and presentations, and provide guidance to numerous organizations, associations, companies, and government agencies. The primary focus of this work is to educate and inform the UAS industry, other stakeholders, and the general public on how to fly safely and responsibly, and what the FAA is doing to safely enable UAS operations. The FAA staffs informational booths at several events to interact with the public, answer questions, and provide educational materials.

The FAA Safety Team, which is the FAA's educational outreach arm to the private pilot community, also conducts regular outreach with the public and general aviation pilots

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b. Review techniques to defeat an errant or hostile UAS without causing any collateral damage to essential navigation systems, wireless communications, the general public, or airport operations.

Additionally, Section 2206 of Public Law 114-190 directed the FAA to establish a pilot program for airspace hazard mitigation at airports and other critical infrastructure using UAS detection systems. The FAA has tested several technologies for UAS detection and is currently analyzing the results and developing a report to Congress.

regarding safe and responsible use of UAS and clarifies the FAA's authority to regulate them as aircraft within the NAS.

Know Before You Fly

Faced with a growing community of new airspace users, the FAA partnered with several leading industry groups to establish *Know Before You Fly*, an educational campaign to inform UAS users about how to fly safely and responsibly. This campaign has been well received by most industry partners, and numerous UAS manufacturers now voluntarily include *Know Before You Fly* educational materials in the packaging of their products.

No Drone Zone

While *Know Before You Fly* focuses on safe and responsible operation of UAS, the objective of the FAA's *No Drone Zone* outreach campaign is specifically to inform the public where **not** to fly a UAS. Originally established in conjunction with Super Bowl XLIX in 2015, this campaign has since expanded to focus on educating the public about other flight restrictions, such as in Washington, D.C., near wildfires, and around major sporting events. The FAA has marketed the campaign with YouTube videos, and now has a dedicated *No Drone Zone* webpage, including a digital toolkit of branded imaging for government and industry use.

B4UFLY Mobile Application

The United States has the most complex airspace in the world, and many people in this growing, non-traditional model aircraft community may be unfamiliar with aviation and airspace regulations and safe operating practices. To increase situational awareness for this burgeoning community, the FAA has developed a mobile application called B4UFLY. This application is aimed at helping recreational UAS operators and model aircraft users know whether there are any restrictions or requirements in effect at the location where they want to fly using their phone's location services. The FAA released a full Apple version to the general public in January 2016, and a full Android version in March 2016.

Key features of the B4UFLY mobile application include:

- A clear "status" indicator that immediately informs operators about their current or planned location
- Information on the parameters that drive the status indicator
- A "Planner Mode" for future flights in different locations
- Informative, interactive maps with filtering options
- Links to other FAA UAS resources and regulatory information

More information about B4UFLY is available on the FAA's UAS website.

UAS Symposium

In March 2018, the FAA hosted its third annual UAS Symposium in Baltimore, MD, collaborating with the Association for Unmanned Vehicle Systems International. Building off previous years' momentum, the Symposium has become one of the nation's biggest and most prestigious UAS events. The 2018 FAA UAS Symposium boasted attendance of 942 pilots, manufacturers, and representatives of the UAS community, and millions more followed on FAA social media channels. This tally represented a nearly two-fold increase over the nearly 500 people who attended the first Symposium in 2016 with Embry-Riddle Aeronautical University in Daytona Beach, FL, and a 25 percent increase over the roughly 750 who participated in the second annual event co-hosted with AUVSI in Reston, VA in 2017.

The FAA UAS Symposiums were designed to address stakeholder issues and to provide access to FAA executives and decision makers. The agenda development considered stakeholder feedback from previous FAA UAS Symposiums and leveraged industry partnerships and experience for sessions that focused on overcoming the technical, policy, and public acceptance challenges associated with safe UAS integration. Speakers and panelists were selected from both government and industry based on their expertise in the topics that were in-demand: expanded operations, security, automation, public aircraft operations and flying for emergency response. At the 2018 Symposium the discussion with stakeholders centered on collaboration, moving away from segregated UAS operations and more toward integration — with a shared vision and building on each other's successes.

Public Meetings

The FAA-affiliated test sites and UAS COE each hosted a public meeting, supported by the FAA, during August and September 2015 to discuss innovation and research opportunities. The meetings offered opportunities for public and private sector stakeholders to better understand the value the test sites and COE provide in advancing UAS integration through research, development, and operational testing.

Drone Advisory Committee (DAC)

The DAC is a broad-based, long-term advisory committee that provides the FAA with advice on key UAS integration issues by helping to identify challenges, prioritize improvements, and create broad support for an overall integration strategy and vision. Established in 2016, the DAC's meetings are open to the public, and are generally well attended. The most recent meeting was held on July 17 in Santa Clara, CA. More on this advisory body can be found in the next section.

Security Sensitive Airspace Restrictions

From April to December 2017, the FAA announced a series of Security Sensitive Airspace Restrictions that are UAS-specific and rely on existing regulations (14 CFR part 99.7, Special Security Instructions). These included 803 restrictions over Federal sites under three categories in agreement with the following agencies:

- The DoD, prohibiting unauthorized UA operations over 133 military facilities, mostly military bases
- The Department of the Interior (DOI) against unauthorized flights over national landmarks like the Statue of Liberty, Hoover Dam, and Mt. Rushmore (10 sites in all)
- The DOE, with restrictions over six sites, mostly over nuclear facilities

In June 2018, the list was expanded to include federal prisons and U.S. Coast Guard bases. To ensure the public is aware of these restricted locations, the FAA has created an interactive map online. The link to these restrictions is also included in the FAA's B4UFLYmobile app.

Section 2: Integration through Collaboration

Integrating a new type of technology in unmanned aircraft into the NAS requires large-scale cooperation across government and industry to achieve practicable solutions. This section outlines the numerous partnerships the Department has forged as UAS integration efforts have progressed.

Cross-Government Partnerships

UAS Executive Committee

The UAS Executive Committee (ExCom) was formed in 2009 as a cross-government focal point for resolving issues on matters of policy and procedures relating to public UAS access to the NAS. The UAS ExCom comprises representatives from the FAA, DoD, U.S. Department of Homeland Security (DHS), and NASA. In February 2018, the ExCom voted to expand the charter to include the DOI, the U.S. Department of Justice (DOJ), and the U.S. Department of Commerce (DOC) and the DOE as members. This group provides leadership and direction to resolve issues and identify a path forward for cross-government UAS integration efforts. Its mission is to enable increased — and ultimately routine — access of Federal UAS engaged in public aircraft operations in the NAS. These operations are intended to support operational, training, developmental, and research requirements.

The UAS ExCom has four goals:

1. Coordinate and align efforts among key Federal Government agencies to ultimately achieve routine safe Federal public UAS operations in the NAS
2. Coordinate and prioritize technical, procedural, regulatory, and policy solutions needed to deliver incremental capabilities
3. Develop a plan to accommodate the larger stakeholder community at the appropriate time
4. Resolve conflicts among Federal Government agencies as related to the previous three goals

The UAS ExCom recognizes that a key challenge to integrating UAS into the NAS is a means for UAS to DAA other aircraft. To ensure sound technical approaches to overcome this challenge, the UAS ExCom Senior Steering Group (SSG) sponsors a Science and Research Panel (SARP) comprised of experts from organizations performing research related to safe UAS integration. One of the SARP's primary purposes is to promote partnerships between U.S. Government agencies and the broader academic and science community on UAS integration science and research initiatives.

Research efforts are aligned with each agency's capabilities, and collaboration in technical interchange meetings and standards development forums ensures an appropriate division of efforts. R&D funding prioritization is based on the availability of sufficient resources from each agency and an alignment with individual agency interests and agreed joint interests. The SARP holds quarterly forums to discuss the progress on joint research interests and to reprioritize research needs based on current progress and continuing needs of the partner agencies.

FAA R&D requirements are influenced by joint priorities discussed and agreed upon with the SARP. Researchers from the member agencies, as well as Federally-Funded Research and Development Centers (FFRDC), meet regularly to update research progress and document new research requirements for the military and civil aviation communities.

NASA

The FAA partners closely with NASA on UAS R&D activities to ensure each agency's expertise, capabilities, and research products are leveraged effectively. Since the inception of NASA's UAS in the NAS research program, the FAA has been a key partner, collaborating on UAS simulations and flight tests, as well as providing operational expertise and support from air traffic controllers, pilots, and other subject matter experts.

NASA and the FAA collaborate on research efforts through Research Transition Teams (RTT). RTTs ensure the R&D needs are identified, jointly conducted, and effectively transferred to the implementing agency. Members include key NASA and FAA stakeholders who are responsible for planning, conducting, receiving, and utilizing the research conducted by the RTT. Two RTTs have been established to ensure safe UAS access will be properly coordinated across the two organizations: The UTM RTT and the UAS Integration RTT. Generally, the RTTs respectively focus on "Low Altitude UAS Traffic Management" operations in low altitude, managed airspace, and UAS operating in higher altitude and controlled airspace.

NASA and the FAA, in concert with several business partners, are flying a series of flight tests at NASA's Ames Research Center in Moffett Field, California. This series of tests builds upon the success of similar experiments conducted in late 2014, which demonstrated a proof-of-concept DAA system. The tests engage the core air traffic infrastructure and supporting software components through live and virtual environments to demonstrate how UAS with certain DAA and C2 equipment can safely interact with air traffic controllers and other air traffic. Engineers at the Ames Research Center are developing UTM software tools, concepts, and procedures in four segments of progressively more capable levels. With continued development, the UTM system would enable UAS operators to file flight plans reserving airspace for their operations and provide situational awareness about other operations planned in the area. In June 2018, NASA flew a large UAS in the NAS without a safety chase aircraft for the first time. The FAA granted NASA a Certificate of Waiver or Authorization for the flight, which relied on airborne DAA technology to mitigate hazards and sufficiently address FAA "see and avoid" requirements.

NASA has also entered into a research technology transfer teaming agreement with the FAA, DoD, DHS, and DOC for the exploration of its UTM concept, and is partnering with many industry stakeholders to ensure the low-altitude traffic management equipment and procedures are usable in both urban and rural low-altitude airspace. These technologies will be usable by other public agencies and for the public at large.

More details on this collaborative research are in Section 4 of this document under R&D. A link to download the January 2017 UTM RTT Plan is available on the FAA's R&D online portal.

National Association of State Aviation Officials (NASAO)

NASAO is an association formed to foster and encourage cooperation and mutual support among State, Federal, and local governments to be responsive to regional, State and national needs in support of the NAS. By coordinating various State laws, regulations, policies, and programs with Federal stakeholders, NASAO seeks to develop uniformity among the states, and to preclude conflict and minimize duplication of State and Federal efforts in the development of national and state air transportation systems.

In September 2014, NASAO and the FAA established a committee on UAS to explore methods of working collaboratively to provide information on current and proposed UAS rules and authorization of UAS operations, enhance information sharing, and increase awareness of UAS activities. The partnership focuses on providing educational outreach and subject matter expertise to the aviation community regarding UAS operations, regulations, and related issues. More information can be found on NASAO's website.

Common Strategy for Law Enforcement

In response to Section 334 of the FMRA, the FAA entered into a Memorandum of Understanding (MOU) with the DOJ's National Institute of Justice to implement a streamlined training and authorization process to enable non-federal law enforcement agencies to operate UAS within the United States safely, effectively, and lawfully.

In 2018 there will be increased outreach and process improvement efforts targeted toward the public safety stakeholder community in general, and greater law enforcement engagement at the Federal, State, local and tribal levels, promoting intra-agency partnerships, and safe operation of UAS in public safety activities. Efforts for outreach will also focus on educating this large stakeholder community on the operational, legal, and regulatory issues associated with operating unmanned aircraft in the NAS, improving processes, and assisting them getting airborne quickly in emergencies. The FAA will continue to develop relationships, publish guidance and information on its website, and conduct outreach activities with the more than 80,000 Federal, State, local, and tribal agencies who are discovering the utility and effectiveness of UAS, and who desire to include UAS into their tool kit for daily operations.

Other U.S. Government Partnerships

Over the last several years, the FAA has entered into Memoranda of Agreement (MOAs) and MOUs with several Federal agencies to further enable the use of UAS. As of 2016, agreements are in place with the DoD, DOJ, DOI, NASA, DHS (Customs and Border Protection) NOAA, and the U.S. Department of Agriculture (U.S. Forest Service). These agreements generally set forth provisions to enable each agency access to certain airspace for public aircraft operations in accordance with applicable laws and government agency policy. Additional MOAs with DOI also allow the Department to train and certify its own corps of airmen, and also enable BVLOS operations to support emergency management within a temporary flight restriction, thus streamlining the issuance of emergency COAs to support first responders.

Industry Relationships

Collaboration between the FAA and UAS industry is essential to integrating UAS into the NAS safely and efficiently, as well as achieving overall support for integration priorities and solutions. The FAA has developed close working relationships with several stakeholder groups and standards development organizations to facilitate this critical engagement.

RTCA, Inc.

RTCA, Inc. (RTCA) is a private, not-for-profit association that manages the Program Management Committee as a private industry standards organization. The Program Management Committee seeks resolution of issues and challenges involving air transportation concepts, requirements, operational capabilities, and the associated use of technology and related considerations to aeronautical operations that affect the future ATM System.

RTCA supports UAS standards development through two working groups established under the Special Committee-228, "Minimum Operational Performance Standards for Unmanned Aircraft Systems." These working groups focused on UAS C2 data links and DAA equipment, which the FAA is expected to incorporate into a Technical Standard Order. In the near term, the C2 efforts are working on terrestrial communication standards and a DAA function that will enable limited operations in Class D, E, and G airspace. Longer term, the committee is responsible for UAS satellite communication standards and expanded DAA standards, which will provide greater airspace access. RTCA deliberations are open to the public and products are developed by aviation community volunteers who function in a consensus-based, collaborative, peer-reviewed environment. More information is available on RTCA's Special Committee-228 webpage.

Drone Advisory Committee (DAC)

The DAC is a broad-based, long-term advisory committee that provides the FAA with advice on key UAS integration issues by helping to identify challenges, prioritize improvements, and create broad support for an overall integration strategy and vision. Membership includes senior executives from a cross-section of stakeholders representing a wide variety of UAS interests, including UAS manufacturers, operators, advocacy groups, research and academia, retail, technology, and State and local governments.

One of the DAC's first actions in 2016 was to form the DAC Subcommittee with the ability to meet more frequently, debate initiatives, and form consensus to inform voting during full DAC meetings. The DAC also created three task groups (TG) to address three priority areas:

1. (TG1) Roles and Responsibilities. Discussed aspects of enabling State and local governments to manage certain UAS operations in low-altitude airspace.
2. (TG2) Access to Airspace. Provided recommendations concerning the safe access of a variety of UAS user groups into the NAS.
3. (TG3) UAS Funding. Provided recommendations for short and long-term funding mechanisms to pay for services required to integrate UAS operations safely into the NAS.

As of July 17, 2018, the DAC has held seven public meetings and will plan to meet three times per year. More information and a list of Committee members are available at on the FAA's website.

ASTM International

The FAA is also utilizing ASTM International, formerly known as the American Society for Testing and Materials, to develop and deliver international voluntary consensus standards for small UAS. ASTM F38 has produced several standards on UAS design, production, and operations that continue to evolve with the growing industry. Some standards prescribe technical requirements for specific pieces of equipment, such as a standard for lithium ion batteries for small UAS; others detail processes, such as the Operational Risk Assessment standard. The standards have the ability to be used in support of part 107 waiver requests, as well as in support of applicants seeking Type Certification of a UAS. The FAA is working with ASTM F38 to identify areas in which new standards could help further small UAS integration into the NAS.

Unmanned Aircraft Safety Team

The UAST is modeled after the successful Commercial Aviation Safety Team and the General Aviation Joint Steering Committee. It held its inaugural meeting in October 2016 in Washington, D.C., and continues to meet regularly. The group brings together a wide variety of stakeholders from the UAS community and uses a data-driven, consensus-based approach to analyze safety data, determine risks, and develop safety enhancements to address the increasing number of UAS entering the NAS.

The UAST has created five working groups to help develop a UAS-specific safety message based on communications, data, safety culture, loss of control, and injury prevention. Exact messaging and the best means to reach UAS operators are still under consideration. An operator credit rating program for professional operators is also in the works, and the UAST is working on a curriculum that could be wrapped into the FAA's WINGS Pilot Proficiency Program, an educational process that encourages a safer and more stress-free flying experience.

The UAST has published a report regarding the UAS sightings data, with plans to conduct further analysis and outreach on that topic. By the end of 2017, the FAA was receiving more than 100 UAS sightings per month. The UAST primary focus going forward is to analyze UAS incidents and accidents to identify common causes of accidents and develop safety enhancements to help prevent any similar events occurring in the future. The agency will continue to educate the public that operating UA around airplanes, helicopters and airports is dangerous and illegal.

International Collaboration

The integration of UAS into the existing aviation operational environment requires the development and introduction of new requirements to promote continued safety and efficiency around the world. Many countries are currently confronting the challenge of developing a regulatory framework, supported by effective program implementation and oversight, for the safe integration of UAS into their respective domestic aviation systems. Collaboration with the international aviation community supports more seamless UAS operations across national boundaries and facilitates the cross-border movement of new products. The FAA continually develops relationships with other Civil Aviation Authorities and international organizations to encourage global cooperation and information sharing. These relationships will enable the FAA to develop and implement bilateral agreements and other cooperation mechanisms, encouraging harmonization of UAS certification, airworthiness, production and operational standards and oversight.

International Civil Aviation Organization

The International Civil Aviation Organization (ICAO) promotes global harmonization and interoperability for aviation through the publication of international standards and recommended practices and procedures for Air Navigation Services. Through active participation in ICAO panels and technical groups, the FAA works collaboratively with other ICAO Member States and industry representatives to identify and address emerging topics, and create a common global framework comprising both new SARPs and guidance material, as well as modifications to existing requirements, in support of UAS integration.

Joint Authorities for Rulemaking of Unmanned Systems (JARUS)

Sponsored by the FAA, the European Aviation Safety Agency, and the European Organisation for the Safety of Air Navigation (EUROCONTROL), JARUS represents a group of regulatory experts from more than 50 countries worldwide, as well as industry representatives from communities of interest. JARUS activities focus on recommendations for a single set of technical, safety, and operational requirements encompassing all aspects linked to the safe operation of UAS. Aviation authorities may use the JARUS material to develop their own regulatory policies from a harmonized perspective.

Canada-United States Regulatory Cooperation Council

In February 2011, the United States and Canada launched the Canada-United States Regulatory Cooperation Council (RCC) to facilitate closer cooperation between the two countries to develop smarter and more effective approaches to regulation. The goal of this Council is to make the U.S. and Canadian economies stronger and more competitive, while meeting the fundamental responsibilities to protect the safety and welfare of citizens. Both countries recognized that regulatory differences and duplicative procedures might impose unnecessary requirements and costs to citizens, businesses, and economies. Through the RCC, the FAA and Transport Canada Civil Aviation collaborate in the area of aviation safety with a specific focus on UAS. Copies of work plans and partnership statements are available for review at the RCC website.

As a rapidly growing sub-sector of the aviation industry, UAS provide unique opportunities in technology and innovation, but also introduce new safety challenges to the aviation system. Going forward, the FAA will continue to identify opportunities to promote international collaboration and harmonization in the safe integration of UAS.

Section 3: UAS Integration Challenges

To preserve the current level of NAS safety, integration of new and novel technologies, such as UAS, must be done incrementally. Each step provides the Department with new perspectives and approaches to accomplishing the overall goal, while further defining the obstacles ahead. This section outlines the primary challenges — from both technological and public policy standpoints — that the Department and other stakeholders face in working toward UAS integration.

Technology Challenges

Advancing UAS integration into the NAS requires the FAA to address key technological challenges to enable routine UAS operations, including those required to interact with ATC and others that do not.

Detect and Avoid (DAA)

One of the key challenges to integrating UAS into the NAS is the development of DAA operating requirements applicable to UAS. These requirements are intended to ensure UAS maintain a safe distance from other aircraft, both manned and unmanned, and prevent mid-air collisions. While manned aircraft accomplish see and avoid through visual means, UAS are unable to rely on the vision of the pilot. In order to develop such requirements, minimum performance standards must be developed for UAS operating BVLOS of the pilot to ensure that they maintain a safe distance from all other aircraft and avoid mid-air collisions.

Both government and industry are conducting significant research into DAA methods through a variety of approaches and sensor modes. Airborne Sense and Avoid (ABSAA) concepts are a particular focus. Research goals for the near-term include a flight demonstration of various sensor modes, including electro-optic/infrared, radar, Traffic Alert and Collision Avoidance System and ADS-B. Fielding a standardized ABSAA system is a long-term objective. Specific challenges the FAA is researching include:

- Establishment of DAA system definitions and performance levels
- Assessment of DAA system multi-sensor use and other technologies
- A minimum DAA information set required for collision avoidance maneuvering

Command and Control (C2)

The C2 link between a UAS and its pilot is critical to ensure the pilot can safely control the UAS during normal and emergency situations. The C2 link typically provides telemetry information, such as altitude, airspeed, and position. This enables the pilot to maintain control of the UAS during various operational scenarios, such as complying with ATC instructions, avoiding bad weather, or avoiding nearby air traffic. Because the C2 link is critical to the safety of a UAS operation, minimum performance standards are needed to ensure the link performs safely and reliably. For large UAS, the FAA has identified an additional safety need for UAS to use protected spectrum for the C2 link. Protected spectrum includes spectrum with aeronautical mobile (route) service, and aeronautical mobile satellite (route) service allocations (desired), or other appropriate primary allocations where an acceptable level of performance, preemption, and protection can be demonstrated. In order for these large UAS to share the limited amount of protected spectrum available, a standard is necessary to coordinate spectrum sharing while ensuring safe and predictable UAS operations.

Some of the challenges associated with establishing UAS C2 include the following:

- UAS operational demand can vary significantly across geographical areas. As a result, C2 demands and system requirements are very difficult to project with confidence.
- Growth projections for locations, aircraft types, and flight types are largely unknown, as are projections for daily, weekly, monthly, and seasonal flight activities.
- Developing C2 requirements involve trade-offs across available radio spectrum, additional spectrum needs, and highly variable operational performance features such as system integrity, availability, and security, among others.
- Engineering the most efficient use of UAS C2 radio spectrum allocations being made by international agreement(s) requires making difficult technical decisions about critical performance areas such as channel separations, compatibility, interoperability, and security. All of these areas affect current and future radio design.
- Coordination, rulemaking, and agreements are needed across the government to make way for a safe and efficient control system that can be accessed by qualified UAS operators.
- Determining which of many possible approaches should be used to fund and sustain the UAS C2 system, consistent with the overall goals of safe UAS flight in the NAS, must account for significant safety, financial, and business risks.

UAS contingency and emergency scenarios — for example, how a UAS in the NAS will respond when the command link is lost — also require research. This research will drive standards that are being established through:

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

Spectrum Management

Appropriate management of radio frequency spectrum for UAS operations is crucial to the safe integration of UAS into the NAS. Without it, growth of the UAS industry could be significantly constrained. Spectrum reserved for aviation safety communications is already a scarce commodity, so the allocation of spectrum to the UAS user community for Control and Non-Payload Communications must be weighed against the needs of the rest of the aviation community, including civil manned aviation and the military.[6] During the World Radio Conference in 2012, the 5030-5091 MHz band was repurposed to better enable sharing between UAS safety services and existing safety services. While this was a first step, an assignment function for specific frequency use by individual UAS operators is the subject of on-going technical and policy discussion, and much work is needed in this area to enable safe

[6] A Control and Non-Payload Communications link supports safety critical functions only. ICAO has determined that the link must operate over protected aviation spectrum.

integration of UAS. Specifically, the FAA is investigating a mechanism to get the maximum capacity (UAS density in the NAS) by efficient management of allocated spectrum. Additionally, as commercial applications for UAS grow, suitable frequency bands for real-time communication of payload data collected by UAS operations must also be allocated.

Standards Development

For UAS to operate routinely in the NAS beyond what is currently allowed, they must conform to an agreed-upon set of minimum performance-based standards to ensure safety, efficiency, and reliability. These standards will vary depending on the nature and complexity of the operation, aircraft or component system limitations, pilot and other crewmember qualifications, as well as the operating environment.

Most UAS have not been designed to comply with existing civil airworthiness or operational 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 (C2), and the takeoff and recovery mechanisms, are not currently addressed in civil airworthiness or operational standards.

The FAA is undertaking certification activities using 14 CFR part 21 to gain certification experience to inform future rulemaking.[7] Additional guidance outlining the Agency's risk-based approach to UAS certification is also under development. The FAA is also working to develop requirements for UAS that do not need to meet the stringent requirements of a type certificate or to be produced under a production certificate. This would allow operations not currently allowed under part 107 based on a finding that these operations can be conducted safely.

Additionally, since there are no specifications for size, weight, use, or other configurations that preclude UAS from qualifying as aircraft for airworthiness certification purposes, UAS that are type-certificated are required to comply with the noise certification requirements of 14 CFR part 36.[8] Compliance with these procedures is difficult or impossible for some UAS, so the FAA is working to develop noise certification requirements and procedures that are appropriate for UAS.

Airspace Management

The FAA continues to develop and mature operational concepts associated with ATM of UAS operations in the NAS. Efforts are currently underway to develop air traffic procedures and operational requirements for ATC/ATM automation systems and identify related policy issues that must be resolved to enable UAS integration. These concept development, maturation, and

[7] 14 CFR part 21 contains the certification procedures for products and articles. It identifies the procedures for obtaining type certificates, supplemental type certificates, production certificates, airworthiness certificates, and import and export approvals. UAS do not need to gain airworthiness certification to be operated under the Small UAS Rule (part 107); however, more advanced UAS operations, such as those operated BVLOS, may require a level of airworthiness certification that requires the FAA to update rules related to the airworthiness requirements for aircraft.

[8] 14 CFR part 36 prescribes noise standards for aircraft with type certificates issued under 14 CFR part 21.

validation efforts will ensure that NAS systems and stakeholders are sufficiently prepared to safely handle the expected increase of UAS operations in the NAS.

In low altitude airspace where FAA air traffic services are not provided, the FAA and NASA, along with industry, are collaboratively exploring concepts of operation for enabling routine civil small UAS operations at low altitudes and BVLOS. UTM is a "traffic management" ecosystem for UAS operations not under the control of ATC, and is separate but complementary to the FAA's ATM system. UTM development will ultimately identify services, roles/responsibilities, information architecture, data exchange protocols, software functions, infrastructure, and performance requirements for enabling the management of low-altitude UAS operations where ATC does not typically provide separation services. NASA's UTM concept specifically addresses small UAS operations primarily below 400 feet AGL, in airspace that contains low-density manned aircraft operations. NASA has developed a phased approach for its UTM platform, building from rural to urban and from low-density airspace to high-density airspace, through the previously mentioned RTTs.

In addition to NASA's research, the UAS industry more broadly is grappling with the traffic management challenges presented by a high volume of low-altitude UAS operations. This work also presents challenges with UAS operating in proximity to airports, which the FAA is working with airport industry stakeholders to address. Further discussion of the RTTs can be found later in this Roadmap under Section 4, under the R&D discussion.

Public Policy Challenges

In addition to technological challenges, there are a number of public policy challenges the UAS community must address to foster the expansion of safe UAS operations. The policy challenges described below are being addressed in a number of national and international committees and working groups, all of which are developing recommendations for UAS requirements and policy, as described under International Collaboration, Section 2.

Safety and Education

In the past few years, UAS have become increasingly affordable and available to the general public. Sophisticated unmanned aircraft, capable of flying as high as some manned aircraft, are ready to use right out of the box with little or no instruction required of their operators. The possibilities for, and applications of, this technology are infinite, but the dynamics of access to airspace present a fundamental shift in the unmanned and model aircraft community. An unmanned aircraft operated by someone with little or no aviation knowledge is now capable of occupying the same airspace as a manned aircraft that requires a certified pilot and airworthiness certificate to fly.

The potential for conflicts between manned and unmanned aircraft has become a very real challenge in integrating these new technologies into the NAS. The FAA has received increasing numbers UAS sightings from pilots — many at higher altitudes than authorized for commercial operations, and those recommended for recreational aircraft flights. As a result, some of these operations may pose an increased risk to the NAS.

As the Federal agency responsible for the safety of the flying community, the increasing number of these reports is of great concern to the FAA. As a result, the FAA has actively engaged in public education and outreach efforts, such as the aforementioned *Know Before You Fly* campaign. The goal of the FAA's partnership with industry through this initiative is to educate unmanned aircraft users about flying safely and responsibly. The FAA's numerous public service announcements and social media campaigns have all sought to extend the reach of this safety message into the expanding UAS community.

While the FAA is committed to educating the UAS community first and foremost, the FAA's Compliance Philosophy, FAA Order 8000.373, notes that intentional or reckless deviations from regulatory standards that pose a hazard to the NAS require strong enforcement. Additionally, the FMRA made clear that the FAA can take enforcement action against anyone who endangers the safety of the NAS, which includes flying carelessly or recklessly. The line between education and enforcement has been outlined in the FAA's "Interpretation of the Special Rule for Model Aircraft," FAA Order 8900.1, Volume 14 – "Compliance and Enforcement," and FAA Order 2150.3B, Change 6.

However, the FAA's resources for actively pursuing UAS operators who endanger the safety of others are limited, and identifying operators is challenging. While UAS registration is a critical step forward, engagement with the law enforcement community is paramount to ensuring our airspace remains the safest in the world. In January 2015, the FAA published guidance for the law enforcement community on the UAS website, and has been actively engaging with law enforcement agencies at local, State, and Federal levels through a variety of channels. The goal of these efforts is to reduce confusion in the law enforcement community about how to respond to UAS events. The FAA encourages citizens to call local law enforcement if they feel someone is endangering people or property on the ground or in the sky. Local law enforcement will then work with local FAA field offices to ensure these safety issues are addressed.

Physical Security

As technology continues to improve and new uses for small UAS are identified, the FAA anticipates an increased demand for flexibility in operational restrictions under part 107. However, aviation security communities have expressed growing concerns that new or expanded operations may have public safety and national security risks that were not anticipated or envisioned. These concerns involve two general scenarios: individuals operating without ill intent, but whose careless or reckless operation creates a physical security or safety risk; and individuals operating with the intent to cause harm, inflict damage, or otherwise disrupt lives of everyday Americans.

The FAA is working extensively with our Federal partners to address these concerns. For example, in December 2015, the DHS and the FAA signed an MOU. The purpose of this MOU is to set forth terms by which DHS and the FAA will cooperate on various activities that support UAS integration into the NAS with an emphasis on enhancing both aviation safety and security through broad research and concept exploration projects. The FAA and DHS currently co-lead the Interagency UAS Detection at Airports Strategy Working Group, which includes the DoD, FBI, U.S. Secret Service, DOE, DOI, Federal Communications Commission, U.S. Army, NASA, and the U.S. Capitol Police. The group's focus is on the implementation of the FAA Extension, Safety, and Security Act (FESSA) Section 2206, and it is currently analyzing and summarizing the results of the evaluation of several UAS detection technologies for potential use at airports for a report to Congress.

Cyber Security

Concerns about cyber security are also becoming increasingly prevalent in conversations about UAS. UAS-specific cyber security vulnerabilities are a subset of overall aviation cyber security threat concern. The FAA is working with industry partners and Federal stakeholders to identify and address the cyber security risks associated with the overall NAS and highly networked avionics onboard aircraft. These efforts include identifying the security issues, defining the security requirements, and determining security mitigations for risks associated with systems specific to UAS, for example C2 links between unmanned aircraft and their control stations. The FAA and its partners will draw guidance from the Aviation Rulemaking Advisory Committee's (ARAC) Aircraft Systems Information Security Protection Working Group and RTCA Special Committee 228 recommendations to implement cyber security measures for UAS avionics.

Privacy

In February 2015, then-President Obama signed a Presidential Memorandum entitled "Promoting Economic Competitiveness while Safeguarding Privacy, Civil Rights, and Civil Liberties in Domestic Use of Unmanned Aircraft Systems." This memorandum directed the DOC's National Telecommunications and Information Administration (NTIA) to initiate a multi-stakeholder engagement process to develop a framework for privacy, accountability, and transparency for commercial and private UAS use. The Presidential Memorandum also directed Federal agencies that use UAS to develop privacy policies and take necessary action to ensure that their use of UAS takes into account the privacy, civil rights, and civil liberties concerns these systems may raise.

In March 2015, the NTIA initiated its stakeholder engagement with an announcement published in the *Federal Register* inviting public comments on the structure of the multi-stakeholder engagement and the substantive issues stakeholders will discuss. In August 2015, NTIA initiated a series of public meetings as part of that process, and in May 2016, the NTIA published voluntary best practices for UAS operations. The guidance can be found on the NTIA website. The FAA has supported this initiative by including privacy guidance on its UAS registration website and in its B4UFLY mobile app.

Funding

Integration of UAS into the NAS will require significant resources. The needs of this new user will compete with existing NAS resources for funding. UAS resource needs are expected to continue to grow.

Section 4: Ongoing Work and Next Steps

The previous sections of this Roadmap have outlined the integration progress already made by the Department and its partners, the importance of relationships across government and industry to ensure its UAS integration efforts are harmonized and consistent, and the challenges that lie ahead. This section describes the FAA's ongoing and forthcoming regulatory, operational, and R&D activities, which represent the Agency's near-term strategy for UAS integration.

The Department Names Integration Pilot Program (IPP) Participants

Directed by Presidential Memorandum, the Secretary of Transportation unveiled the IPP in November 2017, providing State, local, and tribal governments an opportunity to collaborate with private sector entities to conduct more advanced UAS operations.

The application process for Lead applicants for IPP closed in early January 2018, and the FAA counted more than 2,800 interested parties that submitted proposals. Following a thorough review of a competitive group of 149 State, local, and tribal entities, the Secretary named the 10 Lead Participants for the UAS IPP on May 9, 2018 at Department headquarters in Washington:

- Choctaw Nation of Oklahoma (Durant, Oklahoma)
- City of San Diego (San Diego, California)
- Virginia Tech – Center for Innovative Technology (Herndon, Virginia)
- Kansas Department of Transportation (Topeka, Kansas)
- Lee County Mosquito Control District (Ft. Myers, Florida)
- Memphis-Shelby County Airport Authority (Memphis, Tennessee)
- North Carolina Department of Transportation (Raleigh, North Carolina)
- North Dakota Department of Transportation (Bismarck, North Dakota)
- City of Reno (Reno, Nevada)
- University of Alaska-Fairbanks (Fairbanks, Alaska)

The Lead Participants will serve as the primary point of contact with the FAA, and will partner with private sector companies and organizations to carry out their operations. Marking a new milestone for unmanned aviation in the United States, the IPP will test and evaluate various models of involvement in the development and enforcement of Federal regulations for UAS operations. It will inform the development of future Federal guidelines and regulatory decisions on UAS operations nationwide.

The IPP will also foster a meaningful dialogue on the balance between local and national interests related to UAS integration.

The IPP will address ongoing concerns regarding the potential security and safety risks associated with UAS operating near people and critical infrastructure by ensuring that operators communicate more effectively with Federal, State, local and tribal authorities to enable law enforcement to determine if a UAS operation poses any risks. These operations will focus on DAA technologies, C2 links, navigation, weather and human factors. Examples for uses in the program include agriculture, commerce, emergency management, human transportation, and other sectors. Part of the FAA's role will be to emphasize a balance among the benefits of innovation, and the need to protect national security, public safety, critical infrastructure and the NAS.

The Department Spurs Economic Innovation

In April 2018, the Department of Transportation published a Federal Register Notice announcing procedures that streamline economic authorization for drone delivery operations. The Notice stated that companies proposing to engage in certain air transportation operations with UAS may obtain economic authority using the existing air taxi registration process.

Companies proposing to operate UAS to engage in air transportation, including the delivery of goods for compensation, must obtain economic authority from the Department prior to engaging in the air transportation, in addition to meeting all applicable aviation regulatory requirements. The Department will use its existing regulatory procedures — specifically related to exemptions to air taxi operators from the certificate requirements — as the basis to grant UAS operators' requests for economic authority.

UAS operators seeking air taxi authority must:

- Be a citizen of the United States as defined in 49 USC 40102(a)(15);
- maintains liability insurance required by Department rules in 14 CFR Part 205; and
- register with the Department.

The exemption authority conferred by 14 CFR part 298 is not available to air carriers that operate "large" aircraft. For UAS operators looking to transport goods for compensation, an exemption under part 298 is an appropriate form of economic authority. The Department will consider whether granting the exemption is appropriate based on the specific facts and circumstances of each proposed operation.

To become an air taxi operator, UAS operators must submit a registration application and a current aircraft liability insurance certificate. Additional instruction material concerning air taxi registration can also be found in the FAA's air taxi guidance handbook, "How to Become an On-Demand Air Carrier Operator."

Rulemaking

The FAA is taking a risk-based approach to UAS integration by setting a framework for safety that opens the skies to the majority of UAS operations without unduly impeding innovation. The FAA will incrementally expand existing regulations allowing small UAS operations, concentrating initially on enabling operations with the least complexity. The FAA will gradually take actions and develop regulations to enable operations of greater complexity while fully maintaining critical safeguards for UAS and manned aircraft separation among existing users of the NAS. This approach will ultimately allow most UAS to conduct routine and safe operations under newly established rules and regulations, and reserve the need for case-by-case evaluations for UAS activities that fall outside the scope of current regulations. Building on part 107, which is the foundational operating rule for small UAS operations in the NAS, the FAA will use this phased approach to expand UAS operational access.

Beyond the small UAS rule, the FAA will focus on a regulatory framework to address UAS operations at night and over non-participating people. Regarding operations of small UAS at night, the FAA has issued certificates of waiver under part 107 to permit operations at night. Based on the information received in waiver applications, research concerning human vision and observation of small UAS, and Focus Area Pathfinder Program participants, the FAA will develop an update to part 107 to permit operations of small UAS at night. As for operations of small UA over people, the FAA received recommendations from an ARC in April 2016 that included a proposed regulatory framework that would allow certain small UA operations over people not directly involved in the operation of the aircraft. Specifically, the ARC recommended the FAA adopt performance-based standards to which manufacturers would adhere, in addition to operational restrictions when the operations of UA aircraft over people would entail the highest level of risk. In addition to the ARC's recommendations, the FAA will also leverage lessons learned from the Focus Area Pathfinder Program (detailed in the Accomplishments section) as it develops standards for safe operation of small UA over people. Lastly, the FAA will continue to derive valuable information from waivers issued for part 107 operations, as well as the documents and applications on which such waivers are based.

More long-term rulemaking will explore opportunities for full integration of UAS operations into the NAS, including issues such as certification of UAS operations to accommodate future business models involving the widespread transportation of property and delivery of packages and supplies. This may entail operations in controlled and uncontrolled airspace with UAS that contain appropriate equipage and are determined to be airworthy in accordance with an updated process that employs appropriate standards.

Parallel, phased efforts in research, outreach, rulemaking, standards development, and planning will be necessary to achieve the FAA's strategic plan for UAS. In addition, the FAA will continue to consider environmental regulations and laws, such as the National Environmental Policy Act, and engage in tribal consultation during each rulemaking effort. The pace of UAS integration will be determined by the combined ability of industry, the operator community, and the FAA to overcome technical, regulatory, and operational challenges.

Authorization and Notification

Communicating with ATC is a normal occurrence for manned aircraft pilots, and policies and procedures for doing so are well-documented. However, the growing community of UAS users makes the authorization request and Section 336 notification processes far more burdensome for both ATC and UAS pilots. The small UAS rule requires remote pilots to get authorization from ATC prior to operating in controlled airspace; meanwhile, the Special Rule for Model Aircraft (Public Law 112-95, Section 336) requires model aircraft operators to notify local ATC facilities prior to operating within 5 miles of an airport.

Future legislative, industry, FAA and interagency activities could mitigate a high percentage of errant or delinquent UAS operations. As a result, the FAA established processes to explore an identification system and a low altitude authorization and notification capability (LAANC) for UA and operators. By the end of 2017, the FAA created the UAS Identification and Tracking ARC to identify and recommend available and emerging technologies for the remote identification and tracking of UAS, and began to roll out LAANC in a phased approach.

Low-Altitude Authorization and Notification Capability (LAANC)

The FAA partnered with external service providers on developing LAANC. Beginning with a 2016 Request for Information (RFI), the agency sought industry feedback on ways to replace a cumbersome authorization process with an automated one that was scalable to industry demand and leverages industry innovation. Specifically, the RFI intended to:

- Engage private entities (PEs) to lead the establishment of a practical approach to information and data sharing
- Develop practical demonstrations of data sharing techniques for Notification and Authorization (N&A), beginning with basic initial N&A functionality and continuing to evolve the demonstrations over time through expanding capabilities and users
- Apply collaborative problem solving among the FAA and PEs (for example, virtual and in-person workshops) to identify small UAS information sharing needs, assess experience data collected from demonstrations, and recommend system enhancements

The RFI identified 12 participating vendors and service providers with the ability to develop near term capabilities. In October 2017, the FAA deployed a prototype LAANC system[9] for UA operators at several air traffic facilities during an evaluation period to last through January 2018. A nationwide beta test of LAANC started April 30, 2018. LAANC will be deployed incrementally at nearly 300 air traffic facilities covering approximately 500 airports throughout 2018.

Once fully developed, LAANC should foster equitable access for all users and service providers while ensuring critical ATC technical and safety requirements are met for NAS operations. Ultimately, this will enable a smoother transition to an eventual UTM capability.

UAS Identification and Tracking Aviation Rulemaking Committee

In 2017, the FAA formed the UAS Identification and Tracking ARC, comprised of members representing a diverse array of stakeholders that included the aviation community and industry member organizations, law enforcement agencies and public safety organizations, manufacturers, researchers, and standards entities involved with UAS. The ARC held its first meeting that June and considered existing regulations applicable to drone identification and tracking, UTM, concerns and authorities of local law enforcement, and potential legal considerations.

[9] By the end of December 2017, these participating LAANC facilities had processed more than 1,500 airspace authorizations.

In December, the committee issued its final report and recommendations, covering issues related to existing and emerging technologies, law enforcement and security, and implementation of remote identification and tracking. Highlights of the recommendations include:

- Consider two methods for remote ID and tracking UA: 1) direct broadcast (transmitting data in one direction only with no specific destination or recipient) and (2) network publishing (transmitting data to an internet service or group of services). Both methods would send the data to an FAA-approved internet-based database.
- Ensure that data collected must include a unique identifier for UA, tracking information, and drone owner and remote pilot identification.
- Promote fast-tracked development of industry standards while a final remote ID and tracking rule is developed.
- Implement a rule in three stages, with an ultimate goal that all drones manufactured or sold within the United States that comply with the rule must be so-labeled.
- Coordinate any ID and tracking system with the existing ATC system.

The FAA will use the data and recommendations in the ARC report to draft a proposed rule for public comment.

R&D

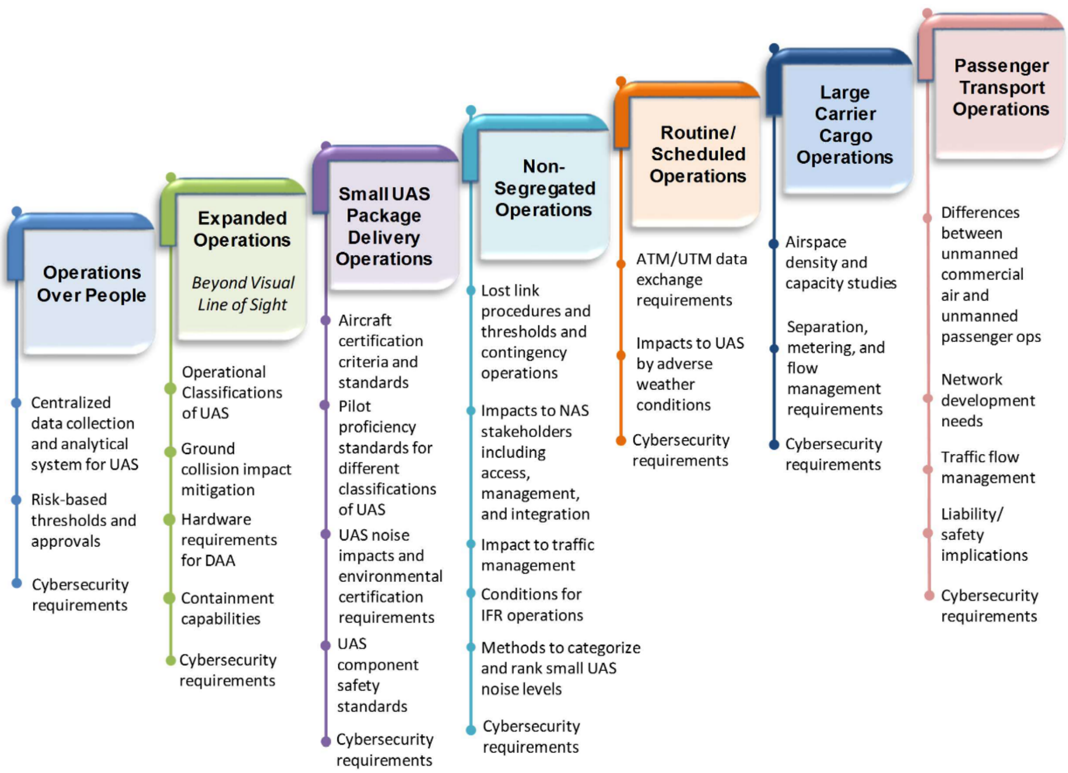
With the exponential growth of UAS technologies and market applications over the past few years, it is necessary for research to keep pace to support full integration. The FAA conducts applied research and priorities R&D activities in support of its regulatory integration path, which is intended to enable increasingly more complex UAS operations over time:

- Operations Over People: Expansion of the part 107 rule to enable small UAS to operate over people not directly participating in the operation.
- Expanded Operations: Builds upon part 107 small UAS operations over people while expanding to BVLOS operations (such as infrastructure or agriculture inspection), swarms, and on-airport operations.
- Small UAS Package Delivery Operations: Enables small UAS fleet operators to conduct external load and agricultural operations that involve multiple launches and landings for transporting materials.
- Non-Segregated Operations: Enables restricted UAS operations to coexist in controlled airspace with manned aircraft. Includes UAS operations with large, properly equipped UAS at varying altitudes and on instrument flight rules flight plans. Includes interstate delivery and small cargo operations.
- Routine or Scheduled Operations: Enables regularly scheduled UAS arrivals and departures at Class B, C, and D airports and permits optionally piloted aircraft for large cargo operations. ATC services will be available to UAS operators filing instrument flight rules flight plans, and routine or scheduled operations will occur as the equipment and automation on the UAS and in the ATC infrastructure can accommodate them.
- Large Carrier Cargo Operations: Enables cargo transport by remote pilots in U.S. domestic airspace, and arrivals of remotely piloted cargo flights.

- Passenger Transport Operations: Enables air taxi services conducted by remote pilot, based on vehicle performance requirements and type certification of the aircraft, its equipment, and the automation technology that replaces pilot functions on board the aircraft.

Operational capabilities associated with each step forward are defined to help prioritize R&D activities and funding (see Table 1 below). Safety remains the FAA's first priority, and continued support for UAS research initiatives will ensure that UA are integrated into the NAS in a safe, secure, and efficient manner. The FAA's safety-related work focuses on understanding the hazard severity from a UAS collision with other aircraft or people on the ground, as well as ways to mitigate the severity. Longer-term operations with increasing levels of automation for BVLOS flights will need to be validated and tested. Much like the driverless cars that are being tested today under specific conditions, UAS operational concepts where a pilot is not readily available to intervene will have to be carefully considered and developed so as not to increase risk to the aviation system or to people and property on the ground.

Table 1: Summary of Identified Needs for Operational Capabilities



Research activities are coordinated across many different types of entities, including internal FAA organizations, different U.S. Government agencies, and nongovernmental entities that perform collaborative research to support the FAA's overall UAS integration objectives. Coordination with each type of entity includes the identification of research needs and current research, governance for continuous coordination, and mechanisms for realizing the guidance generated as a result of the coordination. Issues and considerations being addressed include DAA standards and technologies, "well clear" definition and visual compliance, collision avoidance standards, C2 standards and technologies, human factors, severity thresholds (for example, impact effects), automation/autonomy, wake turbulence effects, and detection and tracking. The table above summarizes ongoing priorities for each of the operational capabilities outlined in the UAS IRP.

The FAA's Next Generation Air Transportation System (NextGen) has appointed a UAS portfolio manager to unify and manage all UAS R&D execution. The UAS R&D portfolio includes UAS research being conducted at the FAA's William J. Hughes Technical Center, the UAS COE, interagency UAS partnerships (NASA, DoD, DHS, DOC, etc.), UAS flight demonstrations, and all aviation safety research defined by the FAA's UAS Integration Office and funded by the FAA's UAS Research, Engineering and Development budget line item. Additionally, the FAA's Air Traffic Organization is developing concepts and requirements to address FAA challenges associated with the provision of air traffic services to UAS airspace users.

UAS Traffic Management (UTM) Research Transition Team (RTT)

NASA's efforts to overcome challenges of integrating low-altitude UAS operations into both controlled and uncontrolled airspace are coordinated with the FAA through the UTM RTT established in 2015. This UAS Integration RTT will ensure that FAA/NASA collaborative efforts to enable safe UAS access will be properly coordinated across the two organizations. For this RTT, NASA is leading two research programs: "UAS in the National Airspace System," which is focused on UAS operating in higher altitude and controlled airspace, and "Low Altitude UAS Traffic Management" research, which focuses on operations in low altitude, managed airspace.

The FAA is actively working with NASA, DoD, and DHS to enable safe and efficient low-altitude UAS operations under the UTM paradigm. The RTT was established to enable the seamless transfer of all UTM research products from NASA. NASA's role — in collaboration with industry, academia, FAA, and other Federal agencies — is to conduct UTM research and develop technologies and concepts of use for each of UTM's incremental functional builds (more recently referred to as Technical Capability Levels). From a technical standpoint, capabilities must be developed to depict available airspace and airspace constraints, show where all aircraft are operating, depict relevant weather information, and provide continuous flight tracking. Geo-fencing, collision avoidance, and communication technologies must also be developed to support UTM operations.

For example, work is underway to research, develop, and implement a comprehensive flight notification system for low altitude UAS operations. This system will allow UAS operators to submit their flight intent, and will allow other airspace users to access that information to support trajectory de-confliction through knowledge of flight intent. The system will initially focus on small UAS operations at or below 400 feet AGL. As the notification system evolves, it may extend to larger UAS, higher altitudes, controlled airspace, and possibly urban areas.

While NASA's role is focused on UTM research and technology development, the FAA will focus on airspace management and operational implementation. Part of this effort includes the development of a UAS flight information management system. Under the UTM RTT, work groups have been established to address concepts and use cases, data and information exchange, information architecture, performance requirements for communications and navigation, and DAA. More information is available at the FAA's R&D online portal, as well as a link to download the UTM RTT Plan published in January 2017.

Research Partnerships

The FAA has increased its efforts to define requirements for UAS integration in the NAS and is using research, policy-making, analyses, and system engineering to satisfy these requirements. FAA partners in government, industry (e.g. through the UAS test sites, as previously discussed), and academia (i.e. the UAS COE) have also increased their efforts in these areas and offer additional research and analysis to support joint needs. The FAA's ability to define and use specific concept level requirements to validate UAS integration into the NAS is key to effective interaction with partners. These partnerships are necessary to maximize opportunities for transfer of technology.

UAS Center of Excellence

The UAS COE focuses on research, education, and training in areas critical to safe and successful integration of UAS into the nation's airspace. The COE research areas are expected to evolve over time, but include:

- Evaluating the sufficiency of existing airborne surveillance equipment for manned aircraft (for example, transponders and/or ADS-B) in providing separation and collision avoidance functions for UAS.
- Supporting the establishment of maintenance data requirements for UAS to include the collection and analysis of maintenance and repair data from multiple UAS platforms.
- Supporting the development of a BVLOS operation framework, minimum performance standards for DAA systems, and the proposed operating rules, limitations, and guidelines for small UAS.
- Informing airworthiness requirements for UAS by using analytical computer modelling to examine hazard severity thresholds for UAS collisions with property and people on the ground as well as UAS collisions with other aircraft in the NAS.
- Supporting the development of small UAS industry consensus standards for UAS airworthiness, maintenance, and flight proficiency requirements.
- Examining human factors considerations for UAS control station design, pilot training/certification requirements, and visual observer requirements to inform the development of standards.
- Supporting the collection of noise measurements of UAS using current noise standards, to begin the initial assessment of whether noise certification procedures designed for manned aircraft are appropriate for UA.

Per the 2017 Appropriations Act (H.R. 224 omnibus), the ASSURE alliance is establishing a UAS Safety Research Center (SRC), to serve as the COE's operational testing and validation arm. The SRC will provide a unique ability to:

- Incrementally build specific, tailored RDT&E capability to support FAA goals.

- Purchase specialized test/measurement equipment, develop tailored models and simulations, and to integrate capabilities into an on-demand, multi-discipline RDT&E facility.
- Accomplish additional RDT&E capability growth (equipment and staffing) resourced from industry and other government agencies through the ASSURE Research & Development Corporation.

The aim of the SRC is to conduct laboratory-based research modeling, simulation and testing in a controlled, repeatable, high fidelity and reliable environment. Additionally, flight tests of appropriate scale will be coordinated with FAA UAS test sites.

MITRE/CAASD

The FAA has partnered with the MITRE Corporation — an FFRDC — and its Center for Advanced Aviation System Development (CAASD) to produce many UAS integration-aligned outcomes. Fiscal year (FY) 2017 outcomes and products were delivered in September 2017. Outcomes and products scheduled to be delivered throughout FY18 include a multitude of R&D activities. These products include a multitude of R&D activities. Objectives of these outcomes include:

- Supporting the implementation of standards for safe operation of UAS without compromising safety or efficiency of the NAS.
- Ensuring safety assurance and cyber security processes as an integral part of normal operations.
- Using metrics to proactively detect issues prior to incidents or accidents.
- Collecting and analyzing the FAA's UAS evolving operational, functional, and roadmap products and detailed planning information from FAA lines of business (LOB) to ensure alignment with the overarching UAS Integration Strategy.
- Developing a test plan that identifies goals, milestones, and metrics for this feasibility study and that helps ensure alignment with the Air Traffic Organization's evolving UAS Roadmap and the FAA's UAS Implementation Plan.

MITRE/CAASD will analyze and maintain currency with UAS research internal and external to the FAA to identify research gaps and the mapping of these research gaps and their requirements as milestones for UAS integration. MITRE CAASD must conduct analysis and coordinate the alignment and integrations of UAS research conducted internal and external to the FAA to support the UAS Implementation Plan to meet FAA's rulemaking and operational policy objectives. The scope of MITRE/CAASD's analyses may include NASA UTM and High Altitude research transition teams, EXCOM SSG Science and Research Panel, ASSURE UAS COE research and other efforts as identified.

In 2018, MITRE/CAASD continued to coordinate with the FAA to identify advances in research efforts, new initiatives, and the continued evolution of the small UAS Industry. This updated effort includes the coordination and the integration of small UAS research advancements and development activities, across the FAA LOBs, NASA, industry, and academia for the incorporation into the UAS IRP, and the analysis for the update and management of the UAS R&D efforts.

MITRE/CAASD will provide the FAA an interactive planning, management, and analysis capability to identify the R&D critical path for implementing the UAS integration regulatory 2020 framework. It will serve as a centralized source for managing the research that supports the implementation and rulemaking activities for UAS integration into the NAS. The UAS R&D management capability must support the FAA in defining dependencies and critical path timelines, identifying research and policy gaps, and contingency analysis to identify cost and schedule risks.

NextGen and NAS Enterprise Architecture

NextGen Implementation

NextGen proposes to transform the United States' NAS from a radar-based system with radio communication to a satellite-based system, shortening routes, saving time and fuel, reducing traffic delays, increasing system capacity, and enabling better and safer ATM. NextGen improvements in technology and procedures represent a widespread, transformative change in the management and operation of air transportation. As the FAA continues to deploy NextGen programs and capabilities, apply lessons learned, and establish best practices, NextGen is delivering tangible benefits to users. The FAA has completed implementation of the majority of NextGen's foundational infrastructure, including its En Route Automation Modernization (ERAM) and much of the Terminal Automation Modernization and Replacement (TAMR). While the automation and technology support FAA internal advancements, the upgrades were also necessary to deploy enhancements that provide direct benefits to external aviation stakeholders.

Currently, work is underway in several areas that are changing the way the NAS operates:

- ADS-B
- Data Communications (Data Comm)
- NAS Voice System (NVS)
- System Wide Information Management (SWIM)

These programs will be key to integrating UAS into the NextGen Air Transportation System. For more information on NextGen implementation, visit www.faa.gov/nextgen.

National Airspace System Enterprise Architecture (NAS EA)

The NAS EA is the comprehensive, multiyear strategic plan and framework for improving and evolving the NAS from the current portfolio of fielded ATM services and capabilities through 2025 and beyond.

The FAA communicates integration efforts such as these through the NAS EA's Infrastructure Roadmaps. These roadmaps articulate a 15-year transition strategy that depict key acquisition and strategic milestones, system availability and enhancements, and associated supporting activities such as standards development, rulemaking, prototyping and demonstrations, and technical validation. The roadmaps highlight changes to the NAS through the perspective of various infrastructure domains, such as automation, communication, navigation, surveillance, weather, facilities, aircraft, and others.

The January 2015 edition of the NAS EA Infrastructure Roadmaps captured part of the UAS-NAS integration strategy, focusing only on basic UAS rulemaking and standards development, as part of the aircraft domain. To enhance the representation of the full UAS-NAS integration efforts, the FAA established a new domain within the NAS EA Infrastructure Roadmaps called "New Entrants." The purpose of this domain is to provide a single, consolidated view of all supporting infrastructure, investments funding additional development, and a visual representation of how schedule deviations may impact the timeline for assimilating these new entrants into the current airspace.

Conclusion

The FAA has made significant progress in integrating UAS into the NAS since the last Roadmap was published. However, much more must still be accomplished to achieve the FAA's vision for full integration. Tremendous growth has occurred in the UAS sector over the past several years, and the growing interest in using UAS for business applications will continue with the implementation of the small UAS rule.

The path to UAS integration must be step-by-step and take into consideration that each novel aspect of an operation must be folded into routine operations. Lessons learned from each new stage must be continuously applied to make informed decisions for subsequent steps. UAS integration must consider risk and mitigations, and above all, must ensure the safety of the current airspace system and its users is maintained as progress is made.

While finalizing the small UAS rule was an important first step, the FAA will gain valuable experience from issuing waivers to the rule, as well as from continued work performed through the Focus Area Pathfinder Program, the UAS Test Site Program, and the FAA's R&D portfolio, as well as interagency coordination. The newly launched IPP sets the stage to move even closer to expanded operations through enhanced partnerships among industry and State, local and tribal authorities. This experience will inform the next round of rulemaking, which will expand UAS operations BVLOS for new purposes and services. Recommendations made by the DAC will help the FAA focus and prioritize its integration activities.

The near-term challenges of UAS integration are significant. As a result, the FAA's strategic goals and activities are increasingly focused on bridging the knowledge and technological gaps. Establishing performance and design standards to inform rulemaking and policy development, as well as ensuring network, cyber and other security concerns are addressed, will be areas of intense focus over the coming years. The FAA will also continue to educate the general public, many of whom have little to no aviation experience, about how to safely operate UAS in the NAS.

Solving these challenges requires flexibility and a willingness to consider new and novel approaches to shared challenges. The pace of UAS integration will require the FAA to be nimble and amenable to non-traditional thinking, while its commitment to safety remains steadfast. This burgeoning industry brings tremendous potential economic benefits, and as the global trailblazer in aviation innovation, the FAA is committed to ensuring that the U.S. paves the way in addressing the challenges of UAS integration without compromising our worldwide leadership role in aviation safety.

Appendices

Appendix A: Commonly Used Acronyms and Glossary

ADS-B	Automatic Dependent Surveillance–Broadcast
ARC	Aviation Rulemaking Committee
ATC	Air Traffic Control
BVLOS	Beyond Visual Line-of-Sight
C2	Command and Control
COA	Certificate of Waiver or Authorization
ConOps	Concept of Operations
DAA	Detect and Avoid
DHS	Department of Homeland Security
DoD	Department of Defense
DOE	Department of Energy
DOJ	Department of Justice
EVLOS	Extended Visual Line-of-Sight
FAA	Federal Aviation Administration
FMRA	FAA Modernization and Reform Act of 2012
ICAO	International Civil Aviation Organization
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NextGen	Next Generation Air Transportation System
NOAA	National Oceanic and Atmospheric Administration
NTIA	National Telecommunications and Information Administration
R&D	Research and Development
RTT	Research Transition Team
SARP	Science and Research Panel
UAS	Unmanned Aircraft System
UTM	UAS Traffic Management
VLOS	Visual Line-of-Sight
14 CFR	Title 14 of the Code of Federal Regulations

The following definitions were obtained from several sources, including:

1. Title 14 of the Code of Federal Regulations, Part 1.1
2. FAA Pilot/Controller Glossary
3. RTCA DO-320: *Operational Services and Environmental Definition for Unmanned Aircraft Systems*
4. FAA Order 8900.1, *Flight Standards Information Management System, Volume 16 - Unmanned Aircraft Systems,* July 30, 2014
5. *FAA Modernization and Reform Act of 2012, Section 336*
6. *Sense and Avoid (SAA) for Unmanned Aircraft Systems (UAS)* – Second Caucus Workshop Report 2013
7. Detect and Avoid (DAA) White Paper RTCA Paper No. 074-14/PMC-1200
8. FAA Order 8130.34C, *Airworthiness Certification of Unmanned Aircraft Systems and Optionally Piloted Aircraft*

Note: Applicable sources are shown at the end of each definition in parentheses ((1), (2), etc.). Terms without a specific source definition are defined in this Roadmap.

Terminology	**Definition**
Air Traffic Control	A service operated by appropriate authority to promote the safe, orderly, and expeditious flow of air traffic. (1)
Aircraft	A device that is used or intended to be used for flight in the air. (1)
Airspace	Any portion of the atmosphere sustaining aircraft flight and which has defined boundaries and specified dimensions. Airspace may be classified as to the specific types of flight allowed, rules of operation, and restrictions in accordance with International Civil Aviation Organization standards or State regulation. (3)
Airworthy	An unmanned aircraft system (UAS) is airworthy if the aircraft and all of the other associated support equipment of the UAS are in condition for safe operation. Special emphasis must be placed on the integrity of the data link. If any element of the systems is not in condition for safe operation, then the UA would not be considered airworthy. (8)
Airworthiness Certification	A process that the FAA uses to ensure that an aircraft design complies with the appropriate safety standards in the applicable airworthiness regulations.
Certificate of Waiver or Authorization	An FAA grant of approval for a specific flight operation.(4)
Civil Aircraft	Aircraft other than public aircraft. (4)
Collision Avoidance	The Detect (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 closest point of approach. The collision avoidance function engages when all other modes of separation fail. (6)
Communication Link	The voice or data relay of instructions or information between the UAS pilot and the air traffic controller and other NAS users. (3)
Control Station	The equipment used to maintain control, communicate with, guide, or otherwise pilot an unmanned aircraft. (3)
Data Link	A ground-to-air communications system which transmits information via digital coded pulses. (3)
Detect and Avoid	Per the RTCA SC-228 DAA Working Group, the term/phrase “Detect and Avoid” will be synonymous with “Sense and Avoid,” as defined below. It is further

	recognized that ICAO makes a distinction between these two terms/phrases.
Ground Control Station	A ground control station is a control center that provides the facilities for human control of unmanned vehicles. Note: For this document, the term is used for all control stations, regardless of location.
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. (2)
Manned Aircraft	Aircraft piloted by a human onboard. (3)
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. (5)
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, regulations and procedures; technical information; and manpower and material. Included are system components shared jointly with the military. (2)
Optionally Piloted Aircraft	A manned aircraft that can be flown by a remote pilot from a location not onboard the aircraft. (8)
Pathfinder	Pathfinder is a framework for the agency to work closely with industry to develop and validate operational concepts for certification, operations, and safety beyond those contained in established or proposed policies and procedures.
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. (1)
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 USC §§ 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 of a public aircraft. (4)

RTCA, Inc.	RTCA, Inc. is a private, not-for-profit association that develops consensus-based recommendations regarding communications, navigation, surveillance, and air traffic management system issues. RTCA functions as a 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 VFR are required to observe and maneuver to avoid other aircraft. Right-of-way rules are contained in 14 CFR part 91. (2)
Sense and Avoid	The capability of a UAS to remain well clear from and avoid collisions with other airborne traffic. Detect and avoid provides the functions of self-separation and collision avoidance to establish an analogous capability to "see and avoid" required by manned aircraft. (3)
Small Unmanned Aircraft	An unmanned aircraft weighing less than 55 pounds. (5)
Special Airworthiness Certificate – Experimental Category (UAS)	Airworthiness certificate issued to UAS and optionally piloted aircraft for the purposes of R&D, crew training, and market survey.
Unmanned Aircraft	An aircraft that is operated without the possibility of direct human intervention from within or on the aircraft. (5)
Unmanned Aircraft System	An unmanned aircraft and associated elements (including communications 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. (5)
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 operating to see and avoid other air traffic or objects aloft or on the ground. (4)

Appendix B: FAA Modernization and Reform Act of 2012, Sections 331-336

SEC. 331. DEFINITIONS.

In this subtitle, the following definitions apply:

(1) Arctic.--The term ``Arctic" means the United States zone of the Chukchi Sea, Beaufort Sea, and Bering Sea north of the Aleutian chain.

(2) Certificate of waiver; certificate of authorization.— The terms "certificate of waiver" and "certificate of authorization" mean a Federal Aviation Administration grant of approval for a specific flight operation.

(3) Permanent areas.—The term "permanent areas" means areas on land or water that provide for launch, recovery, and operation of small unmanned aircraft.

(4) Public unmanned aircraft system.—The term "public unmanned aircraft system" means an unmanned aircraft system that meets the qualifications and conditions required for operation of a public aircraft (as defined in section 40102 of title 49, United States Code).

(5) Sense and avoid capability.—The term "sense and avoid capability" means the capability of an unmanned aircraft to remain a safe distance from and to avoid collisions with other airborne aircraft.

(6) Small unmanned aircraft.—The term "small unmanned aircraft" means an unmanned aircraft weighing less than 55 pounds.

(7) Test range.—The term "test range" means a defined geographic area where research and development are conducted.

(8) Unmanned aircraft.—The term `"unmanned aircraft" means an aircraft that is operated without the possibility of direct human intervention from within or on the aircraft.

(9) Unmanned aircraft system.—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.

SEC. 332. INTEGRATION OF CIVIL UNMANNED AIRCRAFT SYSTEMS INTO NATIONAL AIRSPACE SYSTEM.

(a) Required Planning for Integration.—

(1) Comprehensive plan. –Not later than 270 days after the date of enactment of this Act, the Secretary of Transportation, in consultation with representatives of the aviation industry, Federal agencies that employ unmanned aircraft systems technology in the national airspace system, and the unmanned aircraft systems industry, shall develop a comprehensive plan to safely accelerate the integration of civil unmanned aircraft systems into the national airspace system.

(2) Contents of plan.—The plan required under paragraph (1) shall contain, at a minimum, recommendations or projections on—

(A) the rulemaking to be conducted under subsection (b), with specific recommendations on how the rulemaking will—

(i) define the acceptable standards for operation and certification of civil unmanned aircraft systems;

(ii) ensure that any civil unmanned aircraft system includes a sense and avoid capability; and

(iii) establish standards and requirements for the operator and pilot of a civil unmanned aircraft system, including standards and requirements for registration and licensing;

(B) the best methods to enhance the technologies and subsystems necessary to achieve the safe and routine operation of civil unmanned aircraft systems in the national airspace system;

(C) a phased-in approach to the integration of civil unmanned aircraft systems into the national airspace system;

(D) a timeline for the phased-in approach described under subparagraph (C);

(E) creation of a safe

(F) airspace designation for cooperative manned and unmanned flight operations in the national airspace system;

(G) establishment of a process to develop certification, flight standards, and air traffic requirements for civil unmanned aircraft systems at test ranges where such systems are subject to testing;

(H) the best methods to ensure the safe operation of civil unmanned aircraft systems and public unmanned aircraft systems simultaneously in the national airspace system; and

(I) incorporation of the plan into the annual NextGen Implementation Plan document (or any successor document) of the Federal Aviation Administration.

(3) Deadline.--The plan required under paragraph (1) shall provide for the safe integration of civil unmanned aircraft systems into the national airspace system as soon as practicable, but not later than September 30, 2015.

(4) Report to congress.--Not later than 1 year after the date of enactment of this Act, the Secretary shall submit to Congress a copy of the plan required under paragraph (1).

(5) Roadmap.—Not later than 1 year after the date of enactment of this Act, the Secretary shall approve and make available in print and on the Administration's Internet website a 5-year roadmap for the introduction of civil unmanned aircraft systems into the national airspace system, as coordinated by the Unmanned Aircraft Program Office of the Administration. The Secretary shall update the roadmap annually.

(b) Rulemaking. –Not later than 18 months after the date on which the plan required under subsection (a)(1) is submitted to Congress under subsection (a)(4), the Secretary shall publish in the Federal Register--

(1) a final rule on small unmanned aircraft systems that will allow for civil operation of such systems in the national airspace system, to the extent the systems do not meet the requirements for expedited operational authorization under section 333 of this Act;

(2) a notice of proposed rulemaking to implement the recommendations of the plan required under subsection (a)(1), with the final rule to be published not later than 16 months after the date of publication of the notice; and

(3) an update to the Administration's most recent policy statement on unmanned aircraft systems, contained in Docket No. FAA-2006-25714.

(c) Pilot Projects.—

(1) Establishment. –Not later than 180 days after the date of enactment of this Act, the Administrator shall establish a program to integrate unmanned aircraft systems into the national airspace system at 6 test ranges. The program shall terminate 5 years after the date of enactment of this Act.

(2) Program requirements.--In establishing the program under paragraph (1), the Administrator shall—

(A) safely designate airspace for integrated manned and unmanned flight operations in the national airspace system;

(B) develop certification standards and air traffic requirements for unmanned flight operations at test ranges;
(C) coordinate with and leverage the resources of the National Aeronautics and Space Administration and the Department of Defense;
(D) address both civil and public unmanned aircraft systems;
(E) ensure that the program is coordinated with the Next Generation Air Transportation System; and
(F) provide for verification of the safety of unmanned aircraft systems and related navigation procedures before integration into the national airspace system.
(3) Test range locations.—In determining the location of the 6 test ranges of the program under paragraph (1), the Administrator shall—
(A) take into consideration geographic and climatic diversity;
(B) take into consideration the location of ground infrastructure and research needs; and
(C) consult with the National Aeronautics and Space Administration and the Department of Defense.
(4) Test range operation.—A project at a test range shall be operational not later than 180 days after the date on which the project is established.
(5) Report to congress.—
(A) In general.--Not later than 90 days after the date of the termination of the program under paragraph (1), the Administrator shall submit to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Transportation and Infrastructure and the Committee on Science, Space, and Technology of the House of Representatives a report setting forth the Administrator's findings and conclusions concerning the projects.
(B) Additional contents.--The report under subparagraph (A) shall include a description and assessment of the progress being made in establishing special use airspace to fill the immediate need of the Department of Defense—
(i) to develop detection techniques for small unmanned aircraft systems; and
(ii) to validate the sense and avoid capability and operation of unmanned aircraft systems.
(d) Expanding Use of Unmanned Aircraft Systems in Arctic.—
(1) In general. <<NOTE: Deadline. Plans.>> --Not later than 180 days after the date of enactment of this Act, the Secretary shall develop a plan and initiate a process to work with relevant Federal agencies and national and international communities to designate permanent areas in the Arctic where small unmanned aircraft may operate 24 hours per day for research and commercial purposes. The plan for operations in these permanent areas shall include the development of processes to facilitate the safe operation of unmanned aircraft beyond line-of-sight. Such areas shall enable over-water flights from the surface to at least 2,000 feet in altitude, with ingress and egress routes from selected coastal launch sites.
(2) Agreements.—To implement the plan under paragraph (1), the Secretary may enter into an agreement with relevant national and international communities.
(3) Aircraft approval.—Not later than 1 year after the entry into force of an agreement necessary to effectuate the purposes of this subsection, the Secretary shall work with relevant national and international communities to establish and implement a process, or may apply an applicable process already established, for approving the use of unmanned aircraft in the designated permanent areas in the Arctic without regard to whether an unmanned aircraft is used as a public aircraft, a civil aircraft, or a model aircraft.

SEC. 333. SPECIAL RULES FOR CERTAIN UNMANNED AIRCRAFT SYSTEMS.

(a) In General.—Notwithstanding any other requirement of this subtitle, and not later than 180 days after the date of enactment of this Act, the Secretary of Transportation shall determine if certain unmanned aircraft systems may operate safely in the national airspace system before completion of the plan and rulemaking required by section 332 of this Act or the guidance required by section 334 of this Act.

(b) Assessment of Unmanned Aircraft Systems.—In making the determination under subsection (a), the Secretary shall determine, at a minimum—

(1) which types of unmanned aircraft systems, if any, as a result of their size, weight, speed, operational capability, proximity to airports and populated areas, and operation within visual line-of-sight do not create a hazard to users of the national airspace system or the public or pose a threat to national security; and

(2) whether a certificate of waiver, certificate of authorization, or airworthiness certification under section 44704 of title 49, United States Code, is required for the operation of unmanned aircraft systems identified under paragraph (1).

(c) Requirements for Safe Operation.—If the Secretary determines under this section that certain unmanned aircraft systems may operate safely in the national airspace system, the Secretary shall establish requirements for the safe operation of such aircraft systems in the national airspace system.

SEC. 334. PUBLIC UNMANNED AIRCRAFT SYSTEMS.

(a) Guidance.—Not later than 270 days after the date of enactment of this Act, the Secretary of Transportation shall issue guidance regarding the operation of public unmanned aircraft systems to—

(1) expedite the issuance of a certificate of authorization process;

(2) provide for a collaborative process with public agencies to allow for an incremental expansion of access to the national airspace system as technology matures and the necessary safety analysis and data become available, and until standards are completed and technology issues are resolved;

(3) facilitate the capability of public agencies to develop and use test ranges, subject to operating restrictions required by the Federal Aviation Administration, to test and operate unmanned aircraft systems; and

(4) provide guidance on a public entity's responsibility when operating an unmanned aircraft without a civil airworthiness certificate issued by the Administration.

(b) Standards for Operation and Certification.—Not later than December 31, 2015, the Administrator shall develop and implement operational and certification requirements for the operation of public unmanned aircraft systems in the national airspace system.

(c) Agreements With Government Agencies.—

(1) In general.—Not later than 90 days after the date of enactment of this Act, the Secretary shall enter into agreements with appropriate government agencies to simplify the process for issuing certificates of waiver or authorization with respect to applications seeking authorization to operate public unmanned aircraft systems in the national airspace system.

(2) Contents.—The agreements shall—

(A) with respect to an application described in paragraph (1)—

(i) provide for an expedited review of the application;

(ii) require a decision by the Administrator on approval or disapproval within 60 business days of the date of submission of the application; and
(iii) allow for an expedited appeal if the application is disapproved;
(B) allow for a one-time approval of similar operations carried out during a fixed period of time; and
(C) allow a government public safety agency to operate unmanned aircraft weighing 4.4 pounds or less, if operated—
(i) within the line-of-sight of the operator;
(ii) less than 400 feet above the ground;
(iii) during daylight conditions;
(iv) within Class G airspace; and
(v) outside of 5 statute miles from any airport, heliport, seaplane base, spaceport, or other location with aviation activities.

SEC. 335. SAFETY STUDIES.

The Administrator of the Federal Aviation Administration shall carry out all safety studies necessary to support the integration of unmanned aircraft systems into the national airspace system.

SEC. 336. SPECIAL RULE FOR MODEL AIRCRAFT.

(a) In General.—Notwithstanding any other provision of law relating to the incorporation of unmanned aircraft systems into Federal Aviation Administration plans and policies, including this subtitle, the Administrator of the Federal Aviation Administration may not promulgate any rule or regulation regarding a model aircraft, or an aircraft being developed as a model aircraft, if—
(1) the aircraft is flown strictly for hobby or recreational use;
(2) the aircraft is operated in accordance with a community-based set of safety guidelines and within the programming of a nationwide community-based organization;
(3) the aircraft is limited to not more than 55 pounds unless otherwise certified through a design, construction, inspection, flight test, and operational safety program administered by a community-based organization;
(4) the aircraft is operated in a manner that does not interfere with and gives way to any manned aircraft; and
(5) when flown within 5 miles of an airport, the operator of the aircraft provides the airport operator and the airport air traffic control tower (when an air traffic facility is located at the airport) with prior notice of the operation (model aircraft operators flying from a permanent location within 5 miles of an airport should establish a mutually-agreed upon operating procedure with the airport operator and the airport air traffic control tower (when an air traffic facility is located at the airport)).
(b) Statutory Construction.—Nothing in this section shall be construed to limit the authority of the Administrator to pursue enforcement action against persons operating model aircraft who endanger the safety of the national airspace system.
(c) Model Aircraft Defined.—In this section, the term “model aircraft” means an unmanned aircraft that is—
(1) capable of sustained flight in the atmosphere;
(2) flown within visual line-of-sight of the person operating the aircraft; and
(3) flown for hobby or recreational purposes.

Appendix C: FAA Extension, Safety, and Security Act (FESSA) of 2016, Subtitle B – UAS Safety

SEC. 2201. DEFINITIONS.

(a) DEFINITIONS APPLIED.—In this subtitle, the terms ''unmanned aircraft'', ''unmanned aircraft system'', and ''small unmanned aircraft'' have the meanings given those terms in section 331 of the FAA Modernization and Reform Act of 2012 (49 U.S.C. 40101 note), as amended by this Act.

(b) FAA MODERNIZATION AND REFORM ACT.—Section 331 of the FAA Modernization and Reform Act of 2012 (49 U.S.C. 40101 note) is amended—

(1) in paragraph (6) by inserting '', including everything that is on board or otherwise attached to the aircraft'' after ''55 pounds''; and

(2) by striking paragraph (7) and inserting the following:

''(7) TEST RANGE.—

''(A) IN GENERAL.—The term 'test range' means a defined geographic area where research and development are conducted as authorized by the Administrator of the Federal Aviation Administration.

''(B) INCLUSIONS.—The term 'test range' includes any of the 6 test ranges established by the Administrator of the Federal Aviation Administration under section 332(c), as in effect on the day before the date of enactment of this subparagraph, and any public entity authorized by the Federal Aviation Administration as an unmanned aircraft system flight test center before January 1, 2009.''.

SEC. 2202. IDENTIFICATION STANDARDS.

(a) IN GENERAL.—The Administrator of the Federal Aviation Administration, in consultation with the Secretary of Transportation, the President of RTCA, Inc., and the Director of the National Institute of Standards and Technology, shall convene industry stakeholders to facilitate the development of consensus standards for remotely identifying operators and owners of unmanned aircraft systems and associated unmanned aircraft.

(b) CONSIDERATIONS.—As part of any standards developed under subsection (a), the Administrator shall ensure the consideration of—

(1) requirements for remote identification of unmanned aircraft systems;

(2) appropriate requirements for different classifications of unmanned aircraft systems operations, including public and civil; and

(3) the feasibility of the development and operation of a publicly accessible online database of unmanned aircraft and the operators thereof, and any criteria for exclusion from the database.

(c) DEADLINE.—Not later than 1 year after the date of enactment of this Act, the Administrator shall submit to the appropriate committees of Congress a report on any standards developed under subsection (a).

(d) GUIDANCE.—Not later than 1 year after the date on which the Administrator submits the report under subsection (c), the Administrator shall issue regulations or guidance, as appropriate, based on any standards developed under subsection (a).

SEC. 2203. SAFETY STATEMENTS.

(a) REQUIRED INFORMATION.—Beginning on the date that is 1 year after the date of publication of the guidance under subsection (b)(1), a manufacturer of a small unmanned aircraft shall make available to the owner at the time of delivery of the small unmanned aircraft the safety statement described in subsection (b)(2).

(b) SAFETY STATEMENT.—

(1) IN GENERAL.—Not later than 1 year after the date of enactment of this Act, the Administrator of the Federal Aviation Administration shall issue guidance for implementing this section.

(2) REQUIREMENTS.—A safety statement required under subsection (a) shall include—

(A) information about, and sources of, laws and regulations applicable to small unmanned aircraft;

(B) recommendations for using small unmanned aircraft in a manner that promotes the safety of persons and property;

(C) the date that the safety statement was created or last modified; and

(D) language approved by the Administrator regarding the following:

(i) A person may operate the small unmanned aircraft as a model aircraft (as defined in section 336 of the FAA Modernization and Reform Act of 2012 (49 U.S.C. 40101 note)) or otherwise in accordance with Federal Aviation Administration authorization or regulation, including requirements for the completion of any applicable airman test.

(ii) The definition of a model aircraft under section 336 of the FAA Modernization and Reform Act of 2012 (49 U.S.C. 40101 note).

(iii) The requirements regarding the operation of a model aircraft under section 336 of the FAA Modernization and Reform Act of 2012 (49 U.S.C. 40101 note).

(iv) The Administrator may pursue enforcement action against a person operating model aircraft who endangers the safety of the national airspace system.

(c) CIVIL PENALTY.—A person who violates subsection (a) shall be liable for each violation to the United States Government for a civil penalty described in section 46301(a) of title 49, United States Code.

SEC. 2204. FACILITATING INTERAGENCY COOPERATION FOR UNMANNED AIRCRAFT AUTHORIZATION IN SUPPORT OF FIREFIGHTING OPERATIONS AND UTILITY RESTORATION.

(a) FIREFIGHTING OPERATIONS.—The Administrator of the Federal Aviation Administration shall enter into agreements with the Secretary of the Interior and the Secretary of Agriculture, as necessary, to continue the expeditious authorization of safe unmanned aircraft system operations in support of firefighting operations consistent with the requirements of section 334(c) of the FAA Modernization and Reform Act of 2012 (49 U.S.C. 40101 note).

(b) UTILITY RESTORATION.—The Administrator shall enter into agreements with the Secretary of Energy and with such other agencies or parties, including the Federal Emergency Management Agency, as are necessary to facilitate the expeditious authorization of safe unmanned aircraft system operations in support of service restoration efforts of utilities.

(c) DEFINITION OF UTILITY.—In this section, the term ‘‘utility’’ shall at a minimum include the definition in section 3(4) of the Public Utility Regulatory Policies Act of 1978 (16 U.S.C. 2602(4)).

SEC. 2205. INTERFERENCE WITH WILDFIRE SUPPRESSION, LAW ENFORCEMENT, OR EMERGENCY RESPONSE EFFORT BY OPERATION OF UNMANNED AIRCRAFT.

(a) IN GENERAL.—Chapter 463 of title 49, United States Code, is amended by adding at the end the following:

''§ 46320. Interference with wildfire suppression, law enforcement, or emergency response effort by operation of unmanned aircraft

''(a) IN GENERAL.—Except as provided in subsection (b), an individual who operates an unmanned aircraft and in so doing knowingly or recklessly interferes with a wildfire suppression, law enforcement, or emergency response effort is liable to the United States Government for a civil penalty of not more than $20,000.

''(b) EXCEPTIONS.—This section does not apply to the operation of an unmanned aircraft conducted by a unit or agency of the United States Government or of a State, tribal, or local government (including any individual conducting such operation pursuant to a contract or other agreement entered into with the unit or agency) for the purpose of protecting the public safety and welfare, including firefighting, law enforcement, or emergency response.

''(c) COMPROMISE AND SETOFF.—

''(1) COMPROMISE.—The United States Government may compromise the amount of a civil penalty imposed under this section.

''(2) SETOFF.—The United States Government may deduct the amount of a civil penalty imposed or compromised under this section from the amounts the Government owes the person liable for the penalty.

''(d) DEFINITIONS.—In this section, the following definitions apply:

''(1) WILDFIRE.—The term 'wildfire' has the meaning given that term in section 2 of the Emergency Wildfire Suppression Act (42 U.S.C. 1856m).

''(2) WILDFIRE SUPPRESSION.—The term 'wildfire suppression' means an effort to contain, extinguish, or suppress a wildfire.''.

(b) FAA TO IMPOSE CIVIL PENALTY.—Section 46301(d)(2) of title 49, United States Code, is amended by inserting ''section 46320,'' after ''section 46319,''.

(c) CLERICAL AMENDMENT.—The analysis for chapter 463 of title 49, United States Code, is amended by adding at the end the following:

''46320. Interference with wildfire suppression, law enforcement, or emergency response effort by operation of unmanned aircraft.''.

SEC. 2206. PILOT PROJECT FOR AIRPORT SAFETY AND AIRSPACEHAZARD MITIGATION.

(a) IN GENERAL.—The Administrator of the Federal Aviation Administration shall establish a pilot program for airspace hazard mitigation at airports and other critical infrastructure using unmanned aircraft detection systems.

(b) CONSULTATION.—In carrying out the pilot program under subsection (a), the Administrator shall work with the Secretary of Defense, the Secretary of Homeland Security, and the heads of other relevant Federal departments and agencies for the purpose of ensuring that technologies that are developed, tested, or deployed by those departments and agencies to mitigate threats posed by errant or hostile unmanned aircraft system operations do not adversely impact or interfere with safe airport operations, navigation, air traffic services, or the safe and efficient operation of the national airspace system.

(c) AUTHORIZATION OF APPROPRIATIONS.—There is authorized to be appropriated from the Airport and Airway Trust Fund to carry out this section $6,000,000, to remain available until expended.

(d) AUTHORITY.—After the pilot program established under subsection (a) ceases to be effective pursuant to subsection (g), the Administrator may use unmanned aircraft detection systems to detect and mitigate the unauthorized operation of an unmanned aircraft that poses a risk to aviation safety.

(e) REPORT.—

(1) IN GENERAL.—Not later than 18 months after the date of enactment of this Act, the Administrator shall submit to the appropriate committees of Congress a report on the results of the pilot program established under subsection (a).

(2) CONTENTS.—The report required under paragraph (1) shall include the following:

(A) The number of unauthorized unmanned aircraft operations detected, together with a description of such operations.

(B) The number of instances in which unauthorized unmanned aircraft were mitigated, together with a description of such instances.

(C) The number of enforcement cases brought by the Federal Aviation Administration for unauthorized operation of unmanned aircraft detected through the pilot program, together with a description of such cases.

(D) The number of any technical failures in the pilot program, together with a description of such failures.

(E) Recommendations for safety and operational standards for unmanned aircraft detection systems.

(F) The feasibility of deployment of the systems at other airports.

(3) FORMAT.—To the extent practicable, the report prepared under paragraph (1) shall be submitted in a classified format. If appropriate, the report may include an unclassified summary.

(f) SUNSET.—The pilot program established under subsection (a) shall cease to be effective on the earlier of—

(1) the date that is 18 months after the date of enactment of this Act; and

(2) the date of the submission of the report under subsection (e).

SEC. 2207. EMERGENCY EXEMPTION PROCESS.

(a) IN GENERAL.—Not later than 90 days after the date of enactment of this Act, the Administrator of the Federal Aviation Administration shall publish guidance for applications for, and procedures for the processing of, on an emergency basis, exemptions or certificates of authorization or waiver for the use of unmanned aircraft systems by civil or public operators in response to a catastrophe, disaster, or other emergency to facilitate emergency response operations, such as firefighting, search and rescue, and utility and infrastructure restoration efforts. In processing such applications, the Administrator shall give priority to applications for public unmanned aircraft systems engaged in emergency response activities.

(b) REQUIREMENTS.—In providing guidance under subsection (a), the Administrator shall—

(1) make explicit any safety requirements that must be met for the consideration of applications that include requests for beyond visual line of sight or nighttime operations, or the suspension of otherwise applicable operating restrictions, consistent with public interest and safety; and

(2) explicitly state the procedures for coordinating with an incident commander, if any, to ensure operations granted under procedures developed under subsection (a) do not interfere with other emergency response efforts.

(c) REVIEW.—In processing applications on an emergency basis for exemptions or certificates of authorization or waiver for unmanned aircraft systems operations in response to a catastrophe, disaster, or other emergency, the Administrator shall act on such applications as expeditiously as practicable and without requiring public notice and comment.

SEC. 2208. UNMANNED AIRCRAFT SYSTEMS TRAFFIC MANAGEMENT.

(a) RESEARCH PLAN FOR UTM DEVELOPMENT AND DEPLOYMENT.—

(1) IN GENERAL.—The Administrator of the Federal Aviation Administration (in this section referred to as the ''Administrator''), in coordination with the Administrator of the National Aeronautics and Space Administration, shall continue development of a research plan for unmanned aircraft systems traffic management (in this section referred to as ''UTM'') development and deployment.

(2) REQUIREMENTS.—In developing the research plan, the Administrator shall—

(A) identify research outcomes sought; and

(B) ensure the plan is consistent with existing regulatory and operational frameworks, and considers potential future regulatory and operational frameworks, for unmanned aircraft systems in the national airspace system.

(3) ASSESSMENT.—The research plan shall include an assessment of the interoperability of a UTM system with existing and potential future air traffic management systems and processes.

(4) DEADLINES.—The Administrator shall—

(A) initiate development of the research plan not later than 60 days after the date of enactment of this Act; and

(B) not later than 180 days after the date of enactment of this Act—

(i) complete the research plan;

(ii) submit the research plan to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Science, Space, and Technology and the Committee on Transportation and Infrastructure of the House of Representatives; and

(iii) publish the research plan on the Internet website of the Federal Aviation Administration.

(b) PILOT PROGRAM.—

(1) IN GENERAL.—Not later than 90 days after the date of submission of the research plan under subsection (a)(4)(B), the Administrator, in coordination with the Administrator of the National Aeronautics and Space Administration, the Drone Advisory Committee, the research advisory committee established by section 44508(a) of title 49, United States Code, and representatives of the unmanned aircraft industry, shall establish a UTM system pilot program.

(2) SUNSET.—Not later than 2 years after the date of establishment of the pilot program, the Administrator shall conclude the pilot program.

(c) UPDATES.—Not later than 180 days after the date of establishment of the pilot program, and every 180 days thereafter until the date of conclusion of the pilot program, the Administrator shall submit to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Science, Space, and Technology and the Committee on Transportation and Infrastructure of the House of Representatives an update on the status and progress of the pilot program.

SEC. 2209. APPLICATIONS FOR DESIGNATION.

(a) APPLICATIONS FOR DESIGNATION.—Not later than 180 days after the date of enactment of this Act, the Secretary of Transportation shall establish a process to allow applicants to petition the Administrator of the Federal Aviation Administration to prohibit or restrict the operation of an unmanned aircraft in close proximity to a fixed site facility.

(b) REVIEW PROCESS.—
(1) APPLICATION PROCEDURES.—
(A) IN GENERAL.—The Administrator shall establish the procedures for the application for designation under subsection (a).
(B) REQUIREMENTS.—The procedures shall allow operators or proprietors of fixed site facilities to apply for designation individually or collectively.
(C) CONSIDERATIONS.—Only the following may be considered fixed site facilities:
(i) Critical infrastructure, such as energy production, transmission, and distribution facilities and equipment.
(ii) Oil refineries and chemical facilities.
(iii) Amusement parks.
(iv) Other locations that warrant such restrictions.
(2) DETERMINATION.—
(A) IN GENERAL.—The Secretary shall provide for a determination under the review process established under subsection (a) not later than 90 days after the date of application, unless the applicant is provided with written notice describing the reason for the delay.
(B) AFFIRMATIVE DESIGNATIONS.—An affirmative designation shall outline—
(i) the boundaries for unmanned aircraft operation near the fixed site facility; and
(ii) such other limitations that the Administrator determines may be appropriate.
(C) CONSIDERATIONS.—In making a determination whether to grant or deny an application for a designation, the Administrator may consider—
(i) aviation safety;
(ii) protection of persons and property on the ground;
(iii) national security; or
(iv) homeland security.
(D) OPPORTUNITY FOR RESUBMISSION.—If an application is denied, and the applicant can reasonably address the reason for the denial, the Administrator may allow the applicant to reapply for designation.
(c) PUBLIC INFORMATION.—Designations under subsection (a) shall be published by the Federal Aviation Administration on a publicly accessible website.
(d) SAVINGS CLAUSE.—Nothing in this section may be construed as prohibiting the Administrator from authorizing operation of an aircraft, including an unmanned aircraft system, over, under, or within a specified distance from that fixed site facility designated under subsection (b).

SEC. 2210. OPERATIONS ASSOCIATED WITH CRITICAL INFRASTRUCTURE.

(a) IN GENERAL.—Any application process established under section 333 of the FAA Modernization and Reform Act of 2012 (49 U.S.C. 40101 note) shall allow for a person to apply to the Administrator of the Federal Aviation Administration to operate an unmanned aircraft system, for purposes of conducting an activity described in subsection (b)—
(1) beyond the visual line of sight of the individual operating the unmanned aircraft system; and
(2) during the day or at night.
(b) ACTIVITIES DESCRIBED.—The activities described in this subsection are—
(1) activities for which manned aircraft may be used to comply with Federal, State, or local laws, including—
(A) activities to ensure compliance with Federal or State regulatory, permit, or other requirements, including to conduct surveys associated with applications for permits for new

pipeline or pipeline systems construction or maintenance or rehabilitation of existing pipelines or pipeline systems; and

(B) activities relating to ensuring compliance with—

(i) parts 192 and 195 of title 49, Code of Federal Regulations; and

(ii) the requirements of any Federal, State, or local governmental or regulatory body, or industry best practice, pertaining to the construction, ownership, operation, maintenance, repair, or replacement of covered facilities;

(2) activities to inspect, repair, construct, maintain, or protect covered facilities, including for the purpose of responding to a pipeline, pipeline system, or electric energy infrastructure incident; and

(3) activities in response to or in preparation for a natural disaster, manmade disaster, severe weather event, or other incident beyond the control of the applicant that may cause material damage to a covered facility.

(c) DEFINITIONS.—In this section, the following definitions apply:

(1) COVERED FACILITY.—The term ''covered facility'' means—

(A) a pipeline or pipeline system;

(B) an electric energy generation, transmission, or distribution facility (including a renewable electric energy facility);

(C) an oil or gas production, refining, or processing facility; or

(D) any other critical infrastructure facility.

(2) CRITICAL INFRASTRUCTURE.—The term ''critical infrastructure'' has the meaning given that term in section 2339D of title 18, United States Code.

(d) DEADLINES.—

(1) CERTIFICATION TO CONGRESS.—Not later than 90 days after the date of enactment of this Act, the Administrator shall submit to the appropriate committees of Congress a certification that a process has been established to facilitate applications for unmanned aircraft systems operations described in this section.

(2) FAILURE TO MEET CERTIFICATION DEADLINE.—If the Administrator cannot provide a certification under paragraph (1), the Administrator, not later than 180 days after the deadline specified in paragraph (1), shall update the process under section 333 of the FAA Modernization and Reform Act of 2012 (49 U.S.C. 40101 note) to facilitate applications for unmanned aircraft systems operations described in this section.

(e) EXEMPTIONS.—In addition to the operations described in this section, the Administrator may authorize, exempt, or otherwise allow other unmanned aircraft systems operations under section 333 of the FAA Modernization and Reform Act of 2012 (49 U.S.C. 40101 note) that are conducted beyond the visual line of sight of the individual operating the unmanned aircraft system or during the day or at night.

SEC. 2211. UNMANNED AIRCRAFT SYSTEMS RESEARCH AND DEVELOPMENT ROADMAP.

Section 332(a)(5) of the FAA Modernization and Reform Act of 2012 (49 U.S.C. 40101 note) is amended—

(1) by inserting '', in coordination with the Administrator of the National Aeronautics and Space Administration (NASA) and relevant stakeholders, including those in industry and academia,'' after ''update''; and

(2) by inserting after ''annually.'' the following: ''The roadmap shall include, at a minimum—

''(A) cost estimates, planned schedules, and performance benchmarks, including specific tasks, milestones, and timelines, for unmanned aircraft systems integration into the national airspace system, including an identification of—

''(i) the role of the unmanned aircraft systems test ranges established under subsection (c) and the
Unmanned Aircraft Systems Center of Excellence;

''(ii) performance objectives for unmanned aircraft systems that operate in the national airspace system; and

''(iii) research and development priorities for tools that could assist air traffic controllers as unmanned aircraft systems are integrated into the national airspace system, as appropriate;

''(B) a description of how the Administration plans to use research and development, including research and development conducted through NASA's Unmanned Aircraft Systems Traffic Management initiatives, to accommodate, integrate, and provide for the evolution of unmanned aircraft systems in the national airspace system;

''(C) an assessment of critical performance abilities necessary to integrate unmanned aircraft systems into the national airspace system, and how these performance abilities can be demonstrated; and

''(D) an update on the advancement of technologies needed to integrate unmanned aircraft systems into the national airspace system, including decisionmaking by adaptive systems, such as sense-and-avoid capabilities and cyber physical systems security.''.

SEC. 2212. UNMANNED AIRCRAFT SYSTEMS-MANNED AIRCRAFT COLLISION RESEARCH.

(a) RESEARCH.—The Administrator of the Federal Aviation Administration (in this section referred to as the ''Administrator''), in continuation of ongoing work, shall coordinate with the Administrator of the National Aeronautics and Space Administration to develop a program to conduct comprehensive testing or modeling of unmanned aircraft systems colliding with various sized aircraft in various operational settings, as considered appropriate by the Administrator, including—

(1) collisions between unmanned aircraft systems of various sizes, traveling at various speeds, and jet aircraft of various sizes, traveling at various speeds;

(2) collisions between unmanned aircraft systems of various sizes, traveling at various speeds, and propeller-driven aircraft of various sizes, traveling at various speeds;

(3) collisions between unmanned aircraft systems of various sizes, traveling at various speeds, and rotorcraft of various sizes, traveling at various speeds; and

(4) collisions between unmanned aircraft systems and various parts of the aforementioned aircraft, including—

(A) windshields;

(B) noses;

(C) engines;

(D) radomes;

(E) propellers; and

(F) wings.

(b) REPORT.—Not later than 1 year after the date of enactment of this Act, the Administrator shall transmit to the Committee on Science, Space, and Technology and the Committee on Transportation and Infrastructure of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate a report summarizing the costs and results of research under this section.

SEC. 2213. PROBABILISTIC METRICS RESEARCH AND DEVELOPMENT STUDY.

(a) STUDY.—Not later than 30 days after the date of enactment of this Act, the Administrator of the Federal Aviation Administration shall enter into an arrangement with the National Academies to study the potential use of probabilistic assessments of risks by the Administration to streamline the integration of unmanned aircraft systems into the national airspace system, including any research and development necessary.

(b) COMPLETION DATE.—Not later than 1 year after the date of enactment of this Act, the Administrator shall provide the results of the study to the Committee on Science, Space, and Technology and the Committee on Transportation and Infrastructure of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate.