U.S. House of Representatives
Committee on Science, Space, and Technology
Subcommittee on Space

Unmanned Aircraft Systems Research and Development
CHARTER

Wednesday, January 21, 2015
2:30 p.m. – 4:30 p.m.
2318 Rayburn House Office Building

Purpose

On January 21, 2015, the Committee on Science, Space, and Technology will hold a hearing titled *Unmanned Aircraft Systems Research and Development*. The hearing will review research and development (R&D) performed by the Federal Aviation Administration (FAA) and the National Aeronautics and Space Administration (NASA) in the area of Unmanned Aircraft Systems (UAS) and their integration into the National Airspace System (NAS). This hearing will inform FAA and NASA reauthorizations. The Science, Space, and Technology Committee has jurisdiction over civil aviation research and development.[1]

Witnesses

- **Dr. Ed Waggoner**, Director, Integrated Systems Research Program, Aeronautics Research Mission Directorate, NASA
- **Mr. James Williams**, Manager, UAS Integration Office, Aviation Safety Organization, FAA
- **Dr. John Lauber**, Co-Chair, Committee on Autonomy Research for Civil Aviation, National Research Council
- **Mr. Brian Wynne**, CEO and President, Association for Unmanned Vehicle Systems International (AUVSI)
- **Mr. Colin Guinn**, Chief Revenue Officer, 3D Robotics, Small UAV Coalition Member
- **Dr. John R. Hansman,** T. Wilson Professor of Aeronautics and Astronautics, Massachusetts Institute of Technology (MIT)

Background

Unmanned aircraft systems (UAS) is a general and complete term which includes aircraft as well as supporting ground, air, and communications infrastructure. UAS come in a variety of shapes and sizes and are viable for a broad range of civilian, commercial, and military applications. Current domestic use of UAS is limited to academic institutions, federal, state, and

[1] House Rules for the 113th Congress, http://www.gpo.gov/fdsys/pkg/HMAN-113/pdf/HMAN-113-houserules.pdf

local government organizations that receive a Certificate of Waiver or Authorization (COA) and private sector entities that receive special airworthiness certificates by the FAA, and hobbyists who may only operate under tight restrictions.[2] Typical domestic applications of UAS include border patrol, scientific research, and environmental monitoring. For example, NASA has made extensive use of a myriad of advanced UAS to conduct aeronautics, meteorological, and environmental research over the years; from the Mini-Sniffers of the 1970s to the new high-altitude X-56A Multi-Use Technology Testbed, or MUTT.[3] Also, the National Oceanic and Atmospheric Administration (NOAA) operates the RQ-4A Global Hawk platform for climate research, the Customs and Border Patrol (CBP) operates the MQ-1 Predator platform for border patrol, and public universities operate several unmanned aircraft for academic research purposes.

Though military and civil government will likely dominate large UAS operations in the near term, the UAS market is dynamic and the commercial sector is poised for significant growth, particularly in the small UAS sector. The Teal Group, an aerospace and defense industry market intelligence firm, forecasts worldwide annual spending on UAS research, development, testing, and evaluation (RDT&E) activities and procurement rising from $6.4 billion in 2014 to $11.5 billion in 2024. Total worldwide spending for the period is forecast to amount to $91 billion. Throughout the forecast period, Teal expects the U.S. share of RDT&E to account for 65 percent of worldwide spending.[4]

In 2013, the Association for Unmanned Vehicle Systems International (AUVSI) estimated that between 2015 and 2025 103,776 jobs could be created in the U.S. as a result of UAS integration into the National Airspace System (NAS).[5] This does not include the tens of thousands of secondary jobs in sensor manufacturing, software development, and other complementary industries. The report also notes that delays in integrating UAS in the NAS could cost the U.S. more than $10 billion in economic growth annually.[6]

Congress directed that federal agencies accelerate the integration of UAS into the national airspace. The FAA Modernization and Reform Act of 2012 (FMRA) contains provisions designed to promote and facilitate the use of civilian unmanned aircraft. These included mandates for:

- development of an integration plan that is to commence by the end of FY2015, if not sooner, along with a five-year roadmap for achieving integration objectives;
- selection of six test sites to study UAV integration into the NAS;

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[2] U.S. Department of Transportation, Federal Aviation Administration, "Unmanned Aircraft Systems (UAS) Operational Approval," National Policy Notice, serial N 8900.207 (Washington, DC, 2013).
[3] Gary Creech, "Introducing the X-56a Mutt: Who Let the Dog Out?" http://www.nasa.gov/topics/aeronautics/features/x-56a_mutt.html (accessed February 8, 2013).
[4] Teal Group, Press Release for *World Unmanned Aerial Vehicle Systems: Market Profile and Forecast (Fairfax, 2014),* cited in July 14, 2014.
[5] Association for Unmanned Vehicle Systems International, *Unmanned Aircraft System Integration into the United States National Airspace System: An Assessment of the Impact on Job Creation in the U.S. Aerospace Industry* (Arlington, 2013). http://qzprod.files.wordpress.com/2013/03/econ_report_full2.pdf
[6] Ibid.

- designation of certain permanent areas in the Arctic where small unmanned aircraft may operate 24 hours per day for commercial and research purposes, including flights conducted beyond line-of-sight;
- a simplified process for issuing authorizations for entities seeking to operate public UAS in the NAS;
- incrementally expanding airspace access as technology matures and safety data and analysis become available and to facilitate public agency access to UAS test ranges;
- developing and implementing operational and certification requirements for public UAS by December 31, 2015; and
- an exemption from rules and regulations pertaining to the operation of unmanned aircraft for model aircraft weighing 55 pounds or less that are flown within visual line-of-sight strictly for hobby or recreation.[7]

Department of Transportation Inspector General Report

In June 2014, the Department of Transportation Office of Inspector General issued an audit report criticizing FAA for being significantly behind its efforts to integrate UAS into the National Airspace System. The report indicated that while the agency has made some progress in implementing the Congressionally mandated requirements from the FAA Modernization and Reform Act of 2012, they missed all their major milestones in doing so. Also, in November 2013, the FAA completed the first required roadmap for integrating UAS into the NAS. The IG audit concluded that it was not likely that FAA would reach the September 2015 deadline of integrating UAS into the NAS.[8]

National Academies Study

In August 2014, the National Research Council's Committee on Autonomy Research for Civil Aviation, Aeronautics and Space Engineering Board released a report titled *Autonomous Research for Civil Aviation: Toward a New Era of Flight*.[9] The report outlined concern about the technological readiness to safely integrate into the National Airspace System. It also recommended creation of a national UAS research agenda developed by FAA, NASA, and the Department of Defense (DOD), that include eight high-priority research projects:

- Behavior of Adaptive/Nondeterministic Systems
- Operation Without Continuous Human Oversight
- Modeling and Simulation
- Verification, Validation, and Certification
- Roles of Personnel and Systems

[7] FAA Modernization and Reform Act of 2012 (PL 112-95). https://www.congress.gov/bill/112th-congress/house-bill/658
[8] Department of Transportation Office of Inspector General, *FAA Faces Significant Barriers to Safely Integrate Unmanned Aircraft Systems into the National Airspace System*, AV-2014-061 (Washington, DC, 2014). https://www.oig.dot.gov/sites/default/files/FAA%20Oversight%20of%20Unmanned%20Aircraft%20Systems%5E6-26-14.pdf
[9] *sites.nationalacademies.org/cs/groups/depssite/.../deps_144680.pdf*

- Safety and Efficiency
- Stakeholder Trust

Issues

UAS stakeholders have made progress toward completing the above requirements, but the GAO and Department of Transportation's Office of Inspector General have both assessed that significant technical obstacles and research gaps still exist.[10] Also, *The Washington Post* recently reported that at least nine U.S. UAS crashes occurred near civilian airports overseas as a result of pilot error, mechanical failure, software bugs, or poor coordination with air-traffic controllers.[11] While the operational environment for military UAS overseas is vastly different from UAS use domestically, these incidents are instructive. As UAS are integrated or accommodated into the NAS, several R&D challenges must be addressed.

Vulnerabilities in command and control of UAS operations – Ensuring uninterrupted command and control is critically important to safe integration of UAS into the national airspace.

Unprotected data links can be hacked, spoofed or jammed to disrupt or gain control of the aircraft. For example, last summer a University of Texas (UT) at Austin research team demonstrated for the first time that it is possible to electronically hijack a UAV through Global Positioning System (GPS) spoofing. The team created false GPS signals to commandeer a small but sophisticated UAV about one kilometer away.[12] Redundant systems or encrypted communications would mitigate risks, but the costs, weight, and encryption issues make such additional equipage unfeasible for smaller UAS. NASA's five-year UAS Integration in the National Airspace System Project aims to: develop data and rationale to obtain appropriate frequency spectrum allocations to enable safe and efficient operation of UAS in the NAS; develop and validate candidate secure safety-critical command and control system/subsystem test equipment for UAS that complies with UAS international/national frequency regulations, recommended practices and minimum operational and aviation system performance standards for UAS; and perform analysis to support recommendations for integration of safety-critical command and control systems and air traffic control communications to ensure safe and efficient operation of UAS in the NAS.[13]

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[10] U.S. Government Accountability Office, *Unmanned Aircraft Systems: Measuring Progress and Addressing Potential Privacy Concerns Would Facilitate Integration into the National Airspace System,* GAO-12-981 (Washington, DC, 2012).

[11] Craig Witlock, "Drone crashes mount at civilian airports," *The Washington Post,* November 30, 2012, http://www.washingtonpost.com/world/national-security/drone-crashes-mount-at-civilian-airports-overseas/2012/11/30/e75a13e4-3a39-11e2-83f9-fb7ac9b29fad_story.html (accessed February 6, 2013).

[12] Melissa Mixon, "Todd Humphreys' Research Team Demonstrates First Successful Gps Spoofing of Uav," http://www.ae.utexas.edu/news/archive/2012/todd-humphreys-research-team-demonstrates-first-successful-gps-spoofing-of-uav (accessed February 6, 2013).

[13] "Unmanned Aircraft Systems Integration in the National Airspace System," National Aeronautics and Space Administration, http://www.nasa.gov/centers/dryden/news/FactSheets/FS-075-DFRC.html (accessed February 7, 2013).

Spectrum – The 2012 World Radiocommunication Conference allocated two bands of protected spectrum for UAS command and control.[14] UAS stakeholders continue to develop hardware and standards to operate safely in allocated spectrum, while also working with the National Telecommunications and Information Administration and International Telecommunication Union to identify additional UAS-dedicated spectrum, particularly satellite spectrum, needed to assure continuous communication.

Inability to detect, sense, and avoid other aircraft – No suitable technology exists that would provide UAS with the capability to "sense and avoid" other aircraft and airborne objects in compliance with FAA regulations.[15,16] Most UAS, particularly small UAS, do not carry onboard systems to transmit and receive electronic identification signals. Solutions such as ground-based sense and avoid (GBSAA)[17] may offer a technical alternative to maintaining a human line-of-sight in the near-term before ultimately transitioning to Automatic Dependent Surveillance-Broadcast (ADS-B) and the satellite-based Next Generation Air Transportation System (NextGen). NextGen is due for implementation across the United States in stages between 2012 and 2025.

Human Factors – Unmanned aircraft systems is a misnomer. Skilled human operators are critical to safe UAS operations. FAA defines human factors as the examination of interactions between people, machines, and the environment for the purpose of improving performance and reducing error.[18] UAS stakeholders are examining ways to incorporate additional technical safeguards and regulations to mitigate the risks associated with remotely piloted aircraft, but according to a September GAO report, several issues remain: how pilots or air traffic controllers respond to the lag in communication of information from the UAS; the skill set and medical qualifications required for UAS operators; and UAS operator training requirements.[19] NASA is working to develop a research test bed and database to provide data and proof of concept for ground control station (GCS) and will coordinate with standards organizations, such as RTCA SC-203,[20] to develop human-factors guidelines for GCS operation in the NAS.[21]

Lack of technological standards – Minimum aviation system performance standards (MASPS) and minimum operational performance standards (MOPS) are needed in the areas of: operational and navigational performance; command and control communications; and sense and avoid capabilities. The complexity of the issues and the lack of data have hindered

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[14] Julie Zoller, "NTIA Spotlight: Meeting Spectrum Needs At Home Takes Work Abroad," http://www.ntia.doc.gov/blog/2012/ntia-spotlight-meeting-spectrum-needs-home-takes-work-abroad (accessed February 7, 2013).
[15] Ibid.
[16] The FAA regulations include 14 C.F.R. § 91.111, "Operating near other aircraft," with reference to "create a collision hazard," and 14 C.F.R. § 91.113, "Right of way rules."
[17] GBSAA is an air surveillance radar that provides positional information via a display of traffic information to the UAS flight crew.
[18] GAO-12-981, *Unmanned Aircraft Systems*
[19] Ibid.
[20] RTCA is a private, not-for-profit organization consisting of industry experts. SC 203 is responsible for developing consensus-based recommendations and standards regarding UAS communications, navigation, surveillance and air traffic management system issues.
[21] "Unmanned Aircraft Systems Integration in the National Airspace System," NASA

the standards development process. That said, according to the GAO, the FAA had not made the most of the data it possessed to develop such standards, according to a report issued in September 2012.[22] For instance, the FAA had not analyzed information collected as part of the COA process, nor had it used the seven years of operational and safety data provided by the Department of Defense because it lacked sufficient detail to be of much value. FAA officials have since more clearly defined and communicated data requirements, and the agency contracted with MITRE to address remaining data challenges. However, it remains to be seen if this will result in useful information.[23]

Test Sites - Section 332 of the FAA Modernization and Reform Act of 2012 directs the FAA Administrator to establish six test sites for UAS. [24] Researchers use the sites to test UAS technologies, and the data collected through their research is given to FAA to aid the Administration in developing rules that ensure public safety throughout integration of UAS into the NAS.

In late 2013, FAA announced six teams to host the test sites including the University of Alaska, the state of Nevada, New York's Griffiss International Airport, North Dakota Department of Commerce, Texas A&M University in Corpus Christi, and Virginia Polytechnic Institute and State University. These teams then established test ranges in Hawaii, Oregon, Alaska, Nevada, Texas, North Dakota, New York, Massachusetts, Virginia, New Jersey and Maryland. The sites became operational in mid-2014.

Test site operators and researchers alike have been frustrated by their inability to test UAS at the test sites as researchers still need experimental certification from FAA to use the test sites, and the FAA certification process is slow. [25] For example, Nevada's test site opened in June 2014, but was only able to conduct its first UAS test last December.

Test sites are currently the most common means for the private sector to test UAS (other means include an FAA exemption under FMRA Section 333 or a Cooperative Research and Development Agreement). However, due to funding challenges, FAA indecision about the specific data test sites need to obtain from users, and private sector concerns about protecting intellectual property, the test sites are not being fully utilized. The long approval process to use a UAS test site has led some researchers to take their testing abroad, where rules on UAS testing are less restrictive.

Potential Loss of Jobs and Industry Growth to Lagging International Competitiveness– The FAA Modernization and Reform Act of 2012 allows companies to apply for an exemption of current regulations prohibiting commercial drones from flying in US airspace. However, the FAA's Sec 333 exemption application process, combined with the delay in its publication of new regulations for small UAVs, is impacting the pace of research,

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[22] Ibid.
[23] Ibid.
[24] H.R. 658
[25] http://motherboard.vice.com/read/the-faa-wont-tell-its-drone-test-sites-what-to-test

development, and testing of UAS technology.[26] It also may drive U.S.-based companies to move their R&D testing, resources, and high paying jobs to other countries, where UAS regulations are not as stringent as the United States.[27]

In July 2014, Amazon petitioned the FAA for an exemption under Sec. 333. Included in their petition was a request to use its own test facilities in Washington state, instead of taking the time and paying the expense to use one of the six test facilities in other parts of the country.[28]

Last September, the FAA began issuing exemptions under Section 333 of the FMRA. A few permits were granted to film companies, but Amazon's petition has yet to be addressed. In response to their inability to test their technology outdoors, Amazon has stated that more of its UAS research and development will have to be moved overseas. They have already begun flight testing in the United Kingdom, where regulations for UAS R&D and flight testing are less stringent.[29]

U.S. companies have UAS products that are in demand, but they are selling their products to customers in countries**.** For instance, one start up UAV company, based in Grand Forks, North Dakota, not far from one of FAA's UAS testing sites, sells most of their products to customers in Canada, South American countries, South Africa, the Czech Republic, and France. This is not a single case, and contributes to concern that the U.S. is losing its competitiveness in the growing UAS market.[30]

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[26] U.S. Government Accountability Office, *Unmanned Aerial Systems: Efforts Made toward Integration into the National Airspace Continue, but Many Actions Still Required*, Testimony before the Subcommittee on Aviation, Committee on Transportation and Infrastructure, House of Representatives, GAO-15-254T, (Washington, DC 2014) http://www.gao.gov/assets/670/667346.pdf

[27] http://www.wsj.com/articles/amazon-warns-it-will-move-drone-research-abroad-1418076981

[28] http://www.washingtonpost.com/blogs/the-switch/wp/2014/07/11/amazon-wants-an-exemption-from-the-faas-drone-restrictions/

[29] http://www.wsj.com/articles/amazon-warns-it-will-move-drone-research-abroad-1418076981

[30] http://www.theguardian.com/world/2014/sep/29/drone-testers-faa-aviation-frustration-grows