



May 2018

# SMALL UNMANNED AIRCRAFT SYSTEMS

## FAA Should Improve Its Management of Safety Risks

Accessible Version

# GAO Highlights

Highlights of [GAO-18-110](#), a report to congressional committees

## Why GAO Did This Study

Small UAS—unmanned aircraft weighing less than 55 pounds, typically flown by remote control within sight of a ground “pilot”—are increasingly being used for commercial and recreational purposes. Congress and others have raised questions about the extent of unsafe small UAS use and FAA’s and other agencies’ efforts to address safety risks they pose.

This report examines (1) what information is available to FAA about the extent of unsafe small UAS use in the national airspace, and (2) the extent to which FAA’s management of safety risks posed by small UAS has followed key principles of risk management, among other objectives. GAO reviewed FAA and other federal data on small UAS use from 2014 to 2018, and FAA and industry documents. From FAA’s policies that apply to its safety oversight, including small UAS, GAO identified five key safety risk management principles and 15 supporting requirements, and compared them to FAA’s regulatory efforts related to small UAS. GAO also interviewed FAA officials, as well as 46 aviation stakeholders, including experts and industry groups, selected based on their knowledge of small UAS safety issues.

## What GAO Recommends

GAO recommends that FAA establish a mechanism to ensure that FAA’s management of small UAS safety risks follows all applicable principles and requirements in the agency’s policies. FAA agreed with GAO’s recommendation.

View [GAO-18-110](#). For more information, contact Heather Krause at (202) 512-2834 or [KrauseH@gao.gov](mailto:KrauseH@gao.gov).

May 2018

## SMALL UNMANNED AIRCRAFT SYSTEMS

### FAA Should Improve Its Management of Safety Risks

## What GAO Found

The Federal Aviation Administration’s (FAA) information on the extent of unsafe use of small unmanned aircraft systems (UAS) in the national airspace system is limited. Although FAA collects data on several types of safety events involving small UAS, the accuracy and completeness of the data are questionable. For example, since 2014, pilots and others have reported to FAA over 6,000 sightings of UAS, often flying near manned aircraft or airports, but FAA officials told GAO that FAA cannot verify that small UAS were involved in most of the sightings. Officials explained that small UAS are often difficult for pilots to identify definitively and typically are not picked up by radar. Such data limitations impede the agency’s ability to effectively assess the safety of small UAS operations. FAA is taking steps to improve its data. For example, it is developing a web-based system for the public to report any sightings of UAS that are perceived to be a safety concern and a survey of UAS users on their UAS operational activity. FAA did not have time frames for completing these efforts, but according to FAA, each of the efforts is underway and at varying stages of development. FAA is also evaluating technologies for detecting and remotely identifying UAS, and that could improve data on unsafe use.

#### Examples of Fixed-Wing and Multi-Rotor Small Unmanned Aircraft Systems



Sources: PrecisionHawk and DJI. | GAO-18-110

Of the five key principles of safety risk management in its policies, FAA—in its regulatory efforts related to small UAS—followed two and partially followed three. FAA followed the principles of (1) defining appropriate roles and responsibilities for safety risk management and (2) describing the aviation system under consideration. FAA partially followed the other three principles: (1) analyzing and assessing safety risks; (2) implementing controls to mitigate the risks; and (3) monitoring the effectiveness of the controls and adjusting them as needed. For example, FAA did not consistently analyze and assess safety risks in terms of their severity and likelihood; FAA officials told GAO that for some efforts, the agency did not have sufficient data to do so. However, for other efforts for which FAA did not have sufficient data, the agency made estimates based on expert judgment, as allowed under the agency’s safety risk management policy. Improved risk management practices would help FAA determine whether additional actions are needed to ensure the safety of the national airspace and provide FAA and other decision-makers with confidence that FAA is focusing on the most critical safety risks posed by small UAS.

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### Abbreviations

AMA	Academy of Model Aeronautics
ARC	Micro Unmanned Aircraft Systems Aviation Rulemaking Committee
AUVSI	Association for Unmanned Vehicle Systems International
CAA	civil aviation authority
CNN	Cable News Network, Inc.
DHS	Department of Homeland Security
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of the Interior
DOJ	Department of Justice
DOTIG	Department of Transportation Office of Inspector General
EASA	European Aviation Safety Agency
FAA	Federal Aviation Administration
FBI	Federal Bureau of Investigation
ICAO	International Civil Aviation Organization
JARUS	Joint Authorities for Rulemaking on Unmanned Systems
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
UAS	unmanned aircraft systems
U.K.	United Kingdom
USDA	U.S. Department of Agriculture
UTM	Unmanned Aircraft System Traffic Management System

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May 24, 2018

Congressional Committees

The emergence of unmanned aircraft systems (UAS)<sup>1</sup>—commonly referred to as “drones”—has potential to provide significant social and economic benefits in the United States. Small UAS, those weighing less than 55 pounds, are used for a variety of purposes, including taking aerial photographs, monitoring crops, and inspecting infrastructure.<sup>2</sup> These aircraft are typically flown via remote control by a pilot who is located on the ground, and the aircraft are generally restricted from operating beyond the pilot’s line of sight or operating over people not involved with the operation of the aircraft. However, businesses and others are interested in expanding small UAS operations for uses such as delivering packages and gathering video for news reporting.

Small UAS are defined as “aircraft” in that they operate in the National Airspace System (NAS), and therefore the Federal Aviation Administration (FAA) has primary oversight responsibility for their safe operations. In addition to the restrictions mentioned above, FAA generally prohibits small UAS from flying above 400 feet, within certain distances of an airport without notifying the airport or obtaining prior authorization from its air traffic control, or at night—among other restrictions. However, beginning in early 2014, FAA began receiving reports from pilots of manned aircraft and others of sightings of UAS operating in a potentially unsafe manner, including around manned aircraft and airports, and the media have reported that UAS have struck and injured people on the ground. In September 2017, a small UAS collided with an Army helicopter near Staten Island, New York, and in October 2017, a small UAS collided

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<sup>1</sup>UAS operate by following commands from pilot-operated ground control stations or pre-programmed routes. UAS are also referred to as “unmanned aerial vehicles,” “unmanned aerial systems,” “remotely piloted aircraft systems,” “unmanned aircraft,” or “drones.” The term “unmanned aircraft systems” is used to recognize that UAS include not only the aircraft, but also associated elements such as a ground control station and communications links. For simplicity’s sake, throughout this report we use the term “UAS” to refer to both the entire unmanned aircraft system as well as just the aircraft portion.

<sup>2</sup>While this report focuses on small UAS, another category of UAS are those weighing greater than 55 pounds. Depending on their size and purpose, they generally fly at higher altitudes and are used for the purposes of surveillance, data gathering, and communications relay.

with a passenger aircraft in Canada, continuing to raise concerns about the harm that could be caused by such collisions.

FAA's data indicate that the number of small UAS users registered with the agency is almost three times the number of registered manned aircraft. Further, small UAS are capable of breaching traditional security perimeters at critical infrastructure and sensitive sites—such as nuclear power plants and at public venues such as sports stadiums—or interfering with the operation of other types of transportation, such as watercraft. Multiple federal agencies share responsibility for addressing security risks to the nation and addressing security issues involving small UAS, including the Department of Homeland Security (DHS). FAA coordinates with DHS and other federal agencies, as well as state and local law enforcement, state aviation agencies, and state and local legislative bodies regarding oversight of small UAS. Countries around the world face similar challenges in addressing the safety and security risks associated with small UAS.

As small UAS are being used more frequently and potentially for more purposes and as reports of potentially unsafe UAS encounters with people and manned aircraft continue, members of Congress have raised questions about the extent of unsafe use and FAA's efforts to address risks. You asked us to examine these issues and progress in integrating small UAS into the national airspace. This report examines: (1) what information is available to FAA about the extent of unsafe small UAS use in the NAS, (2) what steps FAA has taken to safely integrate small UAS into the NAS, (3) the extent to which FAA's management of safety risks posed by small UAS has followed key principles of risk management, (4) what steps selected federal agencies have taken to address security risks posed by small UAS operations in the NAS, and (5) what selected foreign countries have done to address safety risks associated with the operation of small UAS.<sup>3</sup>

We reviewed and synthesized available literature and documents related to the topic areas, including government and industry reports on efforts to address safety and security risks posed by UAS and related FAA policy, guidance, plans, and safety-risk management documents. We also reviewed relevant statutes and regulations. In addition, we interviewed

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<sup>3</sup>We also examined policy and technological tools that could mitigate the risks associated with unauthorized small UAS operations in the NAS and report on selected policies and technologies in appendix I.

FAA officials and conducted semi-structured interviews and obtained documentation from 46 aviation industry stakeholders, including a diverse variety of industry groups and associations, aviation companies, aviation experts, law firms, and academic institutions. We judgmentally selected these stakeholders based on our prior work, literature review, and interviews with FAA, other agencies, and aviation industry stakeholders, based on their knowledge and involvement with safety and security issues related to integration of small UAS in the national airspace. The information and viewpoints we obtained from our interviews cannot be generalized to all aviation industry stakeholders, but offer insight into understanding the issues examined in this report (see app. II for the complete list of stakeholders we interviewed).

To examine what information is available to FAA about the extent of unsafe small UAS use in the NAS, we obtained and analyzed recent FAA data. Specifically, we analyzed (1) reports by pilots of manned aircraft, air traffic controllers, and others of UAS sightings from February 2014 through April 2018; (2) reports by pilots of manned aircraft of near mid-air collisions between UAS and manned aircraft from January 2013 through April 2018;<sup>4</sup> (3) accidents, incidents, and malfunctions required to be reported by certain commercial small UAS operators to FAA from March 2015 through August 2017;<sup>5</sup> and (4) accidents required to be reported by commercial small UAS pilots operating under FAA's regulations from August 29, 2016, to May 1, 2018.<sup>6</sup> We also obtained data from a National Aeronautics and Space Administration's (NASA) database—maintained by NASA on FAA's behalf—on reports of potentially unsafe use of UAS from January 2005 through August 2016. We reviewed documentation about the FAA and NASA data and the systems that produced them and found the data to be sufficiently reliable for the purposes of our reporting objectives. We assessed the extent to which FAA's data meets federal

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<sup>4</sup>FAA defines "near mid-air collision" as an incident in which the possibility of a collision occurs as a result of an aircraft's proximity of less than 500 feet to another aircraft or if FAA receives a report from a pilot or flight crew member stating that a collision hazard existed between two or more aircraft.

<sup>5</sup>A commercial small UAS operator is a company responsible for the operation of a small UAS. In September 2014, FAA began reviewing and approving applications to allow certain UAS operations in the NAS prior to the agency's implementation of its regulations for allowing routine small UAS use in the NAS. FAA requires such operators to submit reports of accidents, incidents, and malfunctions to FAA.

<sup>6</sup>FAA's regulations, which took effect on August 29, 2016, require commercial small UAS pilots to report any operation of a small UAS involving serious injury to any person or loss of consciousness, or certain cases of damage to property. 14 C.F.R. § 107.9.

internal control standards related to using quality information to achieve objectives.<sup>7</sup>

We also obtained information on instances of UAS flying over selected agencies' property or facilities or interfering with their operations compiled by the Department of Defense (DOD), the Department of Energy (DOE), the U.S. Forest Service, the U.S. Park Police, and the Bureau of Prisons. We selected these agencies based on our discussions with DHS and on literature indicating that UAS incursions may have posed a safety or security risk to their facilities or operations. We determined the data to be sufficiently reliable for our reporting purposes. We also reviewed studies by two non-governmental entities—the Academy of Model Aeronautics (AMA)<sup>8</sup> and the Center for the Study of the Drone at Bard College—of FAA's reports on UAS sightings but did not verify these analyses. In addition, we interviewed our selected aviation industry stakeholders and FAA officials about their perspectives on safety risks posed by small UAS.

To examine the steps FAA has taken to safely integrate small UAS into the NAS, we reviewed FAA regulations, education outreach efforts, and planning and reporting documents related to UAS integration into the NAS. We also obtained FAA's data on (1) the locations of small UAS registrants as of October 31, 2017, and (2) all enforcement actions taken against small UAS pilots or operators related to unsafe and unauthorized use through May 2, 2018. We reviewed documentation about these data and the systems that produced them and interviewed knowledgeable FAA officials on how the data are collected, maintained, and verified, and we found the data to be sufficiently reliable for the purposes of our reporting objectives. We also interviewed officials from NASA and reviewed agency documents about the agency's development and testing of a traffic management system for small UAS.

To examine the extent to which FAA's management of safety risks posed by small UAS has followed key principles of risk management, we identified FAA's risk management practices related to small UAS and compared these practices to key risk-management principles in FAA's policy. We selected FAA efforts that involved development of regulations

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<sup>7</sup>GAO, *Standards for Internal Control in the Federal Government*, [GAO-14-704G](#) (Washington, D.C.: Sept. 10, 2014).

<sup>8</sup>AMA, founded in 1936, is the largest model aviation association and represents those who fly model aircraft for recreation and educational purposes.

for small UAS or issuing waivers or exemptions to those regulations or other aviation regulations. We identified the risk management principles based on our review of FAA's policy on safety risk management, from which we identified five key principles and 15 specific requirements that support those principles.<sup>9</sup> Federal internal control standards and the International Organization for Standardization's *Risk Management—Principles and Guidelines* include standards, principles, and guidelines that are similar to several of the principles and guidelines in these FAA policies.<sup>10</sup>

To examine steps that selected federal agencies have taken to address security risks posed by small UAS operations in the NAS, we obtained and reviewed documents related to security risks posed by small UAS from FAA and other selected federal agencies including DHS, DOD, DOE, Department of Justice (DOJ), Department of the Interior (DOI), and U.S. Department of Agriculture (USDA). We also obtained and reviewed documents from FAA and the other federal departments and agencies related to coordination on managing security risks from small UAS, as well as interviewed appropriate department and agency officials.

To describe actions that have been taken by selected foreign countries to address safety risks associated with the operation of small UAS, we reviewed publicly available information and interviewed FAA officials about countries that have developed a regulatory framework for ensuring safe operations of small UAS in their respective domestic airspace. We also interviewed aviation industry stakeholders about their perspectives on lessons that could be learned from other countries' experiences. We selected five countries—Australia, Canada, France, Japan, and the United Kingdom (U.K.)—that are leaders in the development of a framework for the safe and secure operation of small UAS in their respective domestic airspaces.<sup>11</sup> We reviewed each country's regulations and policies pertaining to small UAS operations. We interviewed officials for the civil aviation authorities (CAA)—foreign countries' counterpart to

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<sup>9</sup>The policy applies to all of FAA's operational and program functions when making planned changes to the NAS and when potential and previously unidentified hazards and ineffective safety risk controls are discovered. See FAA, Safety Risk Management Policy, Order No. 8040.4A (Washington, D.C.: April 30, 2012).

<sup>10</sup>See [GAO-14-704G](#) and International Organization for Standardization, *Risk Management—Principles and Guidelines*, ISO 31000:2009(E) (Geneva: Nov. 15, 2009).

<sup>11</sup>See GAO, *Unmanned Aerial Systems: FAA Continues Progress toward Integration into the National Airspace*, [GAO-15-610](#) (Washington, D.C.: July 2015).

FAA—of four of the selected countries and obtained written responses from the fifth and obtained and verified information regarding their statutes and regulations, as well as discussed the countries' approach to managing the safety risks associated with small UAS. To expand our coverage beyond the initial five countries, we selected an additional five countries—China, Germany, Israel, Poland, and South Africa—based on geographical location for diversity in our selections, membership standing with the Joint Authorities for Rulemaking on Unmanned Systems (JARUS),<sup>12</sup> and having UAS regulations in place. For these countries, we relied primarily on a study by the Law Library of Congress<sup>13</sup> and also reviewed documentation on their regulations and policies. The information on the foreign countries we reviewed cannot be generalized to other foreign countries, but offers insight into understanding the issues examined in this report. We did not independently verify this information with any CAA or government. See appendix II for further details on our scope and methodology.

We conducted this performance audit from October 2015 through May 2018 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

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## Background

The small UAS market in the United States has grown substantially in the last 10 years, in part, due to advancements in the technology for small UAS using multiple rotor blades (multi-rotor) to operate and control them. Today, small UAS are being manufactured in large quantities by various companies and small multi-rotor UAS are popular among commercial and recreational users. These aircraft are relatively easy to control, have the ability to hover, and are reasonably affordable. Their platforms commonly feature cameras, and they have given rise to companies using small UAS

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<sup>12</sup>Established in 2007, JARUS is a group of aviation experts from 50 countries, as well as the European Aviation Safety Agency (EASA), working to recommend a single set of technical, safety, and operational requirements for the safe operation of UAS.

<sup>13</sup>Law Library of Congress, *Regulation of Drones* (April 2016).

for providing videography services. The ability to hover makes this design highly flexible and adaptable, with commercial uses including aerial photography, infrastructure inspection, and agricultural crop surveys. In addition, insurance companies and government agencies are increasingly utilizing small UAS to survey property and infrastructure damage from floods and other catastrophic events. During such events, including in the recent hurricanes affecting parts of the southern United States, emergency responders have also used small UAS to assist with search and rescue missions. In addition, several media outlets operated small UAS over affected areas to provide news coverage to local residents and the nation about flooding and damage in the areas. There are also fixed-wing small UAS, which have greater range and endurance than small multi-rotor UAS, and are designed for being operated beyond the visual line of sight of the pilot, like inspecting pipeline and rails and monitoring crops.<sup>14</sup> Some companies are interested in using multi-rotor small UAS to do a variety of activities, such as to deliver packages to homes and businesses, to conduct roof inspections, or for surveying and mapping land. FAA estimated the small UAS fleet in the United States totaled around 1.2 million in 2017—used for recreational and commercial purposes—and projected the fleet will total around 2.9 million in 2022. Figure 1 shows examples of fixed-wing and multi-rotor small UAS aircraft.

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<sup>14</sup>Beyond the visual line of sight refers to operations that take the UAS farther than the pilot's or any other participating visual observer's direct vision of the UAS, with vision unaided by any device other than corrective lenses.

**Figure 1: Examples of Fixed-Wing and Multi-Rotor Small Unmanned Aircraft Systems Aircraft**

Sources: PrecisionHawk and DJI. | GAO-18-110

According to FAA, small UAS present some risks and hazards by operating in the NAS with manned aircraft. For instance, according to FAA, the unmanned nature of small UAS operations raises two unique safety concerns that are not present in manned-aircraft operations:

- the pilot of the small UAS, who is physically separated from it during flight, may not have the ability to see manned aircraft in the air in time to prevent a mid-air collision, and
- the pilot of the small UAS could lose control of it due to a failure of the communications link between the small UAS and the pilot's handset for controlling the UAS.

Small UAS are easy to purchase and fly in the NAS. This ease raises myriad safety and security concerns in the United States. FAA has a major role with regard to the operation of all aircraft, including UAS, in the NAS. Safety risks related to the use of small UAS include the potential for unintentional collisions between a small UAS and a manned aircraft or other objects, causing damage to property, or injury or death to persons. FAA's UAS Integration Office (located in the Office of Aviation Safety) seeks to integrate UAS operations into the NAS while ensuring the safety of the public and integrity of the airspace. Its efforts, in part, include promulgating regulations, researching and testing technology, and

ensuring compliance with guidelines and regulations.<sup>15</sup> In addition, the UAS Integration Office coordinates across various offices within the agency on UAS-related issues.

The FAA Modernization and Reform Act of 2012 (2012 act)<sup>16</sup> directed FAA to develop a comprehensive plan to safely accelerate the integration of UAS into the NAS and to issue a regulation that allows operations of small UAS in the NAS. However, the 2012 act prohibited FAA from promulgating any new regulations for recreational small UAS.<sup>17</sup> In response to a related requirement in the 2012 act, in November 2013, FAA issued a road map for integrating UAS into the NAS. This road map included a plan for developing a regulatory framework for small UAS operations inside the United States and for expanding UAS's uses. Since 2012, the technology for small UAS has been rapidly developing and, as we reported in July 2015, FAA had made progress in integrating UAS into the air system but had struggled to keep pace.<sup>18</sup>

Further, FAA and other federal agencies have faced significant challenges related to potential security risks. Since 2012, incidents have raised concerns over potential security threats posed by small UAS's being used to target critical infrastructure and sensitive areas such as commercial and government aircraft and watercraft, military bases, nuclear facilities and power plants, electricity facilities, government buildings and installations, prisons, and sports stadiums. For instance, in January 2015, a small UAS crashed on the White House grounds. Other

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<sup>15</sup>FAA is also responsible for providing safe and efficient air-traffic control services in the NAS.

<sup>16</sup>FAA Modernization and Reform Act of 2012, Pub. L. No. 112-95, 126 Stat. 11 (2012).

<sup>17</sup>The law defined model aircraft (which this report refers to as recreational small UAS) as unmanned aircraft that are (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. The operation of the aircraft must also meet the following conditions: (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 pilot of the aircraft provides the airport operator and the airport air traffic control tower with prior notice of the operation. FAA Modernization and Reform Act of 2012, § 336(c).

<sup>18</sup>See [GAO-15-610](#).

risk scenarios include the prospect of hackers “spoofing” a UAS communications signal and taking over the controls, potentially leading to a crash or using the aircraft to perform malicious acts. Multiple federal agencies—including DHS, DOD, and the Federal Bureau of Investigation (FBI)—share responsibility addressing security risks to the nation and for security issues related to small UAS.<sup>19</sup> The FAA Extension, Safety, and Security Act of 2016 (2016 act) also outlined several provisions for FAA and other federal agencies, with industry collaboration, for addressing safe integration and security threats of civil UAS’s operating into the NAS.<sup>20</sup> At the same time, an increasing number of states and local communities have passed laws banning or restricting the use of small UAS—in many cases related to privacy and criminal penalties for UAS misuse.

The issue of safe and secure small UAS operations is not limited to the United States. As discussed later in this report, the International Civil Aviation Organization (ICAO)<sup>21</sup> and JARUS are each taking steps to aid in the establishment of guidance and standards for UAS safety and integration. As a member of ICAO, the United States has agreed to conform to international standards and recommended practices, including for UAS. Many foreign countries are also experiencing an increase in small UAS use, and some countries’ CAAs have already established regulations and guidelines for operating commercial and recreational small UAS.

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<sup>19</sup>DHS has primary responsibility for protecting critical infrastructure. DOD, under the National Strategy for Aviation Security, has primary responsibility for defense of the national airspace system. DOJ, acting through FBI, is charged with preventing and protecting against federal crimes or threats to the national security that could be facilitated by UAS. FAA coordinates with DHS, DOD, DOJ, and other federal agencies.

<sup>20</sup>FAA Extension, Safety, and Security Act of 2016, Pub. L. No. 114-190, 130 Stat. 615 (2016).

<sup>21</sup>ICAO is the international body that, among other things, promulgates international standards and recommends practices in an effort to harmonize global aviation standards.

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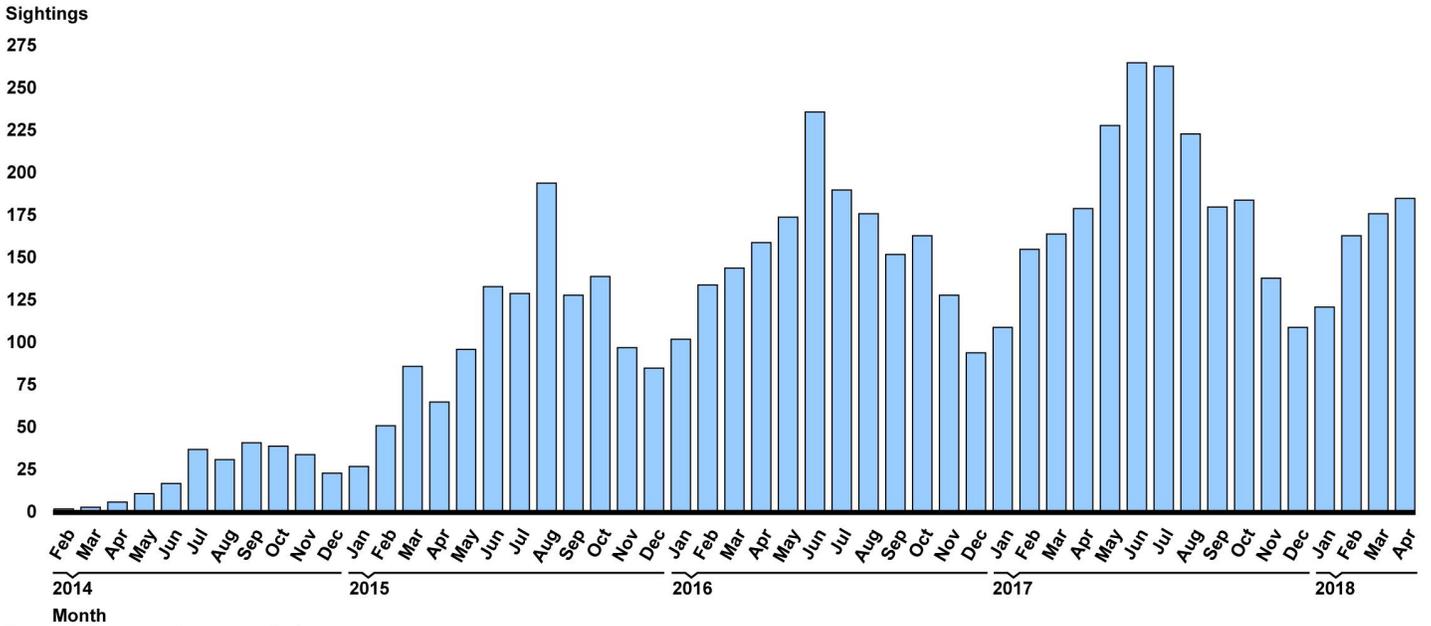
## FAA Lacks Reliable Information about the Extent of Unsafe Use of Small UAS in the NAS

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### FAA Has Collected Thousands of Reports of Potentially Unsafe Use of UAS, but Most of These Reports Offer Limited Information

From February 2014 through April 2018, FAA collected 6,117 reports of sightings of potentially unsafe use of UAS. According to FAA officials, the large majority of reports are from pilots who generally submit statements of possible UAS sightings or encounters to FAA's air traffic control facilities, while some reports are submitted by the general public, law enforcement, air traffic controllers, and others. The reports typically involve sightings of UAS operating around airports or airborne manned aircraft, and not collisions. Even so, such UAS could be at heightened risk of colliding with manned aircraft, and some pilots reported maneuvering their aircraft to avoid the UAS. Such maneuvers can increase the risk of the pilot losing control of their aircraft or cause injury to crew members or passengers. The number of reported sightings increased about five-fold from 233 in 2014 to 1,218 in 2015, and increased by another 51 percent in 2016 to 1,840 (see fig. 2). The 2,185 reported sightings in 2017 represented a 19 percent increase over the number reported in 2016. According to FAA, the risk of potentially unsafe operations would be expected to increase as more UAS enter the NAS.

**Figure 2: The Federal Aviation Administration’s (FAA) Monthly Reports of Unmanned Aircraft Systems Sightings, February 2014 through April 2018**



Source: GAO analysis of FAA data. | GAO-18-110

However, the extent that these reports represent actual incidents of unsafe use is unclear, for the following reasons:

FAA told us that most of the reports cannot be verified because a small UAS typically is not detected by radar, the small UAS pilot is usually not identified, or the small UAS or other physical evidence is not recovered. FAA and some aviation industry stakeholders also told us that the reliability of many of the reports is questionable; FAA explained that this is because pilots can have difficulty positively identifying objects as small UAS, given their small size, their distance from the observed position, the speeds at which a manned aircraft and a UAS are operating, or the various factors competing for the pilot’s attention.

FAA officials told us the agency generally does not attempt to make a determination on the validity of the UAS reports that are received, or to otherwise investigate, and stores all of the information provided in a tracking database. One agency official noted that the reports often do not contain sufficient information to enable FAA to follow up and conduct investigations.

FAA also told us that some of the reports, despite the reporting pilots’ concerns, may have involved UAS operating in a safe and authorized manner.

FAA has also stated that although its sightings data includes several reports of pilots claiming UAS strikes on their manned aircraft, investigations have found that instead of UAS, the reported collisions involved either birds, impacts with other items, or structural failure not related to colliding with a UAS.

Although FAA has not categorized or made distinctions about which of the reports may have potentially led to an unsafe or hazardous situation, such as a near mid-air collision, two nongovernmental entities reviewed some of FAA's reports of sightings and came to differing conclusions regarding the potential extent of unsafe use:

AMA analyzed FAA's reports of sightings for the period November 13, 2014, to August 20, 2015, and concluded that about 4 percent of the reports involved near misses.<sup>22</sup> AMA classified a report as a near-miss if the report narrative contained one of the terms "near miss," "near collision," or "NMAC" (near mid-air collision), or some other term that indicated a potential near miss.

In contrast, two researchers at the Center for the Study of the Drone at Bard College analyzed largely the same reports and concluded that about 36 percent of the reports involved close encounters between UAS and manned aircraft.<sup>23</sup> The higher rate reflects the Center's use of broader criteria for classifying an incident as a close encounter, namely, the incident report indicated that a UAS came within 500 feet of a manned aircraft, that the pilot of the manned aircraft used descriptive language indicating that the UAS came dangerously close to the manned aircraft, or that the pilot of the manned aircraft took evasive action.

On FAA's behalf, NASA also collects reports of potentially unsafe use of UAS, but many of the reports cannot be verified.<sup>24</sup> From January 2005

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<sup>22</sup>Academy of Model Aeronautics, *A Closer Look at the FAA's Drone Data* (Muncie, Ind.: Sept. 14, 2015).

<sup>23</sup>The researchers analyzed reports that dated from December 17, 2013, through September 12, 2015, in which the majority were the same FAA reports that AMA analyzed. The remaining reports that were analyzed were DOI reports. See Arthur Holland Michel and Dan Gettinger, *Drone Sightings and Close Encounters: An Analysis*, Center for the Study of the Drone at Bard College (Annandale-on-Hudson, New York: Dec. 11, 2015).

<sup>24</sup>In support of an FAA aviation safety reporting program, NASA collects and analyzes reports of aviation safety incidents so that FAA, NASA, and aviation industry stakeholders can take actions to lessen the likelihood of aviation accidents. The reports are submitted voluntarily and confidentially by pilots, air traffic controllers, and others, who receive immunity from FAA enforcement actions under certain conditions. NASA, rather than FAA, administers the system so that the identity of the reporting party remains unknown to FAA.

through August 2016, NASA received 246 reports of safety incidents involving UAS; 202 of these incidents occurred since 2014. Of the 246 incidents, 172 were reported by the pilot of a manned aircraft, 38 were reported by the pilot of a UAS, 32 were reported by an air traffic controller, and 4 were reported by an observer.

FAA also reviews reports of accidents, incidents, and malfunctions submitted to the agency by commercial small UAS operators. Only commercial entities whose use of small UAS was authorized by FAA under a transitional process prior to the implementation of the agency's small UAS regulations were required to report each of those types of events.<sup>25</sup> The reports covering the period from March 2015 through August 2017 included 98 events where damage resulted to the UAS and one accident that resulted in an injury.<sup>26</sup> FAA officials told us it would be impossible to know if operators have reported all of their accidents and incidents; therefore, the data may not be complete. Since August 29, 2016, when FAA's small UAS regulations took effect, FAA has required commercial pilots of small UAS to report any operation involving serious injury to any person or loss of consciousness, or certain cases of damage to property.<sup>27</sup> Through May 1, 2018, FAA had confirmed two reports of accidents, one of which resulted in minor property damage and the other resulted in a person losing consciousness. In addition, in December 2017, the National Transportation Safety Board completed an investigation of a collision between a small UAS and a U.S. Army helicopter near Staten Island, New York, in which the helicopter sustained minor damage and the UAS was destroyed.

FAA officials told us that they are aware that the agency's data on potential unsafe use of small UAS have limitations. Nevertheless, FAA

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<sup>25</sup>As required under section 333 of the 2012 act, in September 2014, FAA began approving applications to allow certain UAS operations in the NAS under a transitional process prior to the implementation of its regulations for allowing routine small UAS use in the NAS. Under this transitional process, which is described in more detail later, approved operators were required to report their accidents, incidents, and malfunctions to FAA for the duration of their approved operations—typically 2 years.

<sup>26</sup>According to an FAA official, there is a lag time for small UAS operators to report information to FAA. The data that FAA provided to us was the most recent reporting information that was available as of October 2017.

<sup>27</sup>As discussed later in more detail, FAA's regulations on small UAS operations—codified at 14 C.F.R. §§ 107.1-107.205—took effect on August 29, 2016, and replaced FAA's transitional process for authorizing commercial use.

uses these data in monitoring the safety of small UAS operating in the NAS and in managing risks they pose. FAA policy requires the agency to collect and analyze operational data to assess the safety of the NAS and manage safety risks.<sup>28</sup> Further, federal internal control standards state that an agency's management should identify the information requirements needed to achieve its objectives and address risks. They further state that management should obtain data from reliable sources based on the identified information requirements and that such data should be reasonably free from error and bias and faithfully represent what they purport to represent.

FAA is making some efforts to improve its data on small UAS operations and safety events. As described in more detail later in this report, FAA is in the middle stages of implementing its plan for integrating UAS into the NAS. FAA's fiscal year 2018 UAS implementation plan includes efforts to improve FAA's data on the safety of small UAS operations. More specifically, the plan calls for FAA to:

- identify safety data to be collected on UAS accidents and incidents;

- develop a web-based system for the public to report any sightings of UAS that are a safety or privacy concern;

- survey UAS users to determine the number of UAS operations in the NAS and obtain other information on UAS activity to enable FAA to anticipate and meet demand for NAS facilities and services, assess the impact of regulatory changes on the UAS fleet, and implement measures to assure safe integration of UAS in the NAS.

While FAA's plan did not include specific time frames for completing these efforts, according to FAA, each of the efforts is under way and at varying stages of development and implementation.

In August 2016, FAA announced the creation of a team of industry and government stakeholders, which is charged with analyzing safety data and developing recommendations to FAA on non-regulatory approaches for enhancing safety. The team's initial efforts include:

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<sup>28</sup>FAA, Safety Management System, Order No. 8000.369A (Washington, D.C.: May 8, 2013).

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- helping FAA develop the survey of UAS users described above,
  - developing a system to enable UAS operators to self-report hazardous situations anonymously, and
  - having a small group of aviation industry members volunteer flight data from UAS operations to examine the benefits of analyzing different datasets.

In addition, although the primary purpose is not to improve FAA's data on UAS safety, FAA is undertaking two efforts to evaluate technologies that FAA officials told us could improve the data. First, as discussed in more detail later, FAA is evaluating technologies for detecting unauthorized UAS operating at or near airports. FAA plans to use the results of its evaluation to develop recommendations for standards that will guide the selection of UAS detection systems for airports nationwide. Second, as discussed in more detail later and in appendix III, FAA is evaluating technologies for UAS to broadcast identification information that would allow FAA, law enforcement, homeland defense, and national security agencies to track UAS. FAA is in the early stages of developing a rule on such identification technology.

While FAA's current data provide some limited insight into the safety of small UAS operations in the NAS, improving the accuracy and completeness of information on small UAS operations and safety events could improve the agency's ability to understand the extent of unsafe uses of small UAS in the NAS. Without this information, FAA is limited in its ability to oversee how safely small UAS are being integrated into the NAS, including taking corrective actions to reduce the level of unsafe use and identifying new safety hazards posed by small UAS operations.

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### Some Federal Agencies Other Than FAA Have Compiled Reports That Indicate UAS Might Have Posed Risks to Their Facilities or Operations

Several federal agencies have recorded multiple instances of UAS flying over their property or facilities or interfering with their operations (see table 1). Officials from several of the agencies told us that they are confident that the reports are valid because, for example, the reporting personnel on the ground were able to distinguish the UAS from manned aircraft or flying animals or the agency was able to contact the pilot of the UAS. In contrast, as discussed above, FAA officials told us the agency is

generally not able to make a determination on the validity of its sightings reports.

**Table 1: Selected Federal Departments' and Agencies' Recorded Incidents of Unmanned Aircraft Systems (UAS) Sightings, Various Time Frames in 2013–2017**

U.S. department or agency	Time frame of recorded incidents	Number of recorded incidents	Information related to recorded incidents
Department of Defense	January 2015 through December 2016	128	At a March 2017 Congressional hearing, a Department official testified that unauthorized UAS flights over Navy and Air Force installations represent a growing threat to the safety and security of nuclear weapons and personnel. Department officials told us that the Department's work on technology improvements to enable pilots to detect and track small UAS when they are in close proximity to manned aircraft could lead to enhancements in the reliability and detail of sightings reports.
Department of Energy	August 1, 2013, through October 27, 2016	25	Department officials told us that these incidents were not considered to pose an immediate threat to any of the involved facilities or employees and that the reasons for these incidents are unknown.
U.S. Forest Service	June 22, 2015, through September 7, 2016	59	Service officials told us the recorded incidents involved a UAS interfering with wildfire fighting operations. <sup>a</sup> Firefighting operations were adversely affected in 32 of the 59 incidents, e.g., an aircraft was shut down or sent away from the affected area.
U.S. Park Police	January 2013 through mid-January 2016	47	The agency made contact with the UAS pilot in 37 of the 47 incidents and issued citations in 19 of those incidents. <sup>b</sup> The Service is concerned that UAS operating in National Parks could endanger park visitors, facilities, or wildlife and has largely banned launching, landing, or operating a UAS from or in the National Park system, with certain exemptions.
Bureau of Prisons	November 2015 through December 2017	7	Agency officials told us in each instance, individuals attempted to introduce contraband inside a federal prison.

Source: GAO summary of departments' and agencies' information. | GAO-18-110

<sup>a</sup>In more than half of the recorded incidents, the wildfire fighting operations were either managed by the Forest Service or co-managed by it and one or more other state or federal agencies. A service official told us that in the other incidents, the Forest Service may have provided resources in support of the operations.

<sup>b</sup>The incidents included only sightings of UAS in areas of primary jurisdiction of the Park Police located within the National Capital Region, the Park Police New York Field Office, and the Park Police San Francisco Field Office.

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## FAA Is Taking Steps Aimed at Safely Expanding Access of Small Recreational and Commercial UAS to the NAS

FAA has taken steps aimed at safely expanding both 1) recreational UAS use, by developing guidelines and educating and registering users and 2) commercial UAS use, initially by authorizing commercial small UAS operators on a case-by-case basis, and subsequently by allowing UAS to operate routinely in the NAS under various limitations. FAA has plans to further expand commercial use of UAS by allowing operations over people and out of users' line of sight, among other expanded activities, until UAS are fully integrated into the NAS. To supplement this regulatory effort, FAA is collaborating with NASA on determining the feasibility of developing a system to manage UAS traffic. Additionally, FAA may have opportunities to explore other new technologies to support full integration of small UAS into the NAS.

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### FAA Has Taken Steps to Promote Safe Recreational and Commercial Use of Small UAS in the NAS

#### Guidelines

FAA is legally prohibited from promulgating any new regulations for recreational small UAS users.<sup>29</sup> In its Interpretation of the Special Rule for Model Aircraft (i.e., recreational small UAS), FAA clarified its position that recreational small UAS users must satisfy criteria established in the law in order to be exempt from future rulemaking.<sup>30</sup> In September 2015, FAA also issued additional guidelines that reflect current law governing recreational use of unmanned aircraft.<sup>31</sup> These guidelines encouraged pilots to, among other things, operate recreational small UAS at or below 400 feet above ground level, not interfere with and give way to manned aircraft, and give the airport operator or control tower advanced notice when flying within 5 miles of an airport. Although FAA cannot require

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<sup>29</sup>FAA Modernization and Reform Act of 2012, § 336.

<sup>30</sup>Interpretation of the Special Rule for Model Aircraft, 79 Fed. Reg. 36,172 (June 25, 2014).

<sup>31</sup>FAA, Model Aircraft Operating Standards, AC No. 91-57A, September 2, 2015.

recreational users to comply with certain aspects of these guidelines, such users must meet statutory requirements of a recreational small UAS, follow the guidelines of a community-based organization, and refrain from endangering the safety of the NAS.

In December 2015, FAA also issued guidelines to local, state, and federal law enforcement agencies on how to respond to unsafe use, including when and how to notify FAA. FAA also encourages members of the public to notify local law enforcement when they observe unsafe UAS use. For instance, on FAA's website, the public is advised to call local law enforcement if a UAS crashes in their yard, hurts someone, or damages property. The website also advises the public to call local law enforcement if they see someone operating a UAS in a reckless or irresponsible manner.

### Education Efforts

FAA also educates recreational and commercial small UAS pilots—both unilaterally and through coordination with other federal departments and agencies as well as industry—regarding current guidelines and registration requirements. FAA partnered with three industry groups—the Association for Unmanned Vehicle Systems International (AUVSI),<sup>32</sup> AMA, and the Small UAV Coalition<sup>33</sup>—to develop and implement the Know Before You Fly Program,<sup>34</sup> a campaign to educate prospective users about the safe and responsible operation of UAS. In addition, in January 2016, FAA released its B4UFLY<sup>35</sup> smartphone application that helps UAS pilots determine whether any restrictions or requirements are in effect at the location where they intend to fly. FAA's educational efforts have also included attending industry conferences and holding its own

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<sup>32</sup>AUVSI represents the views of the unmanned systems and robotics community to government officials, regulators, media, and the public.

<sup>33</sup>The Small UAV Coalition is a partnership of consumer and technology companies to support and advocate for a law and policy changes that will embrace and encourage the growth of the UAV industry.

<sup>34</sup>For more information, see <http://knowbeforeyoufly.org/>.

<sup>35</sup>For more information, see [http://www.faa.gov/uas/where\\_to\\_fly/b4ufly/](http://www.faa.gov/uas/where_to_fly/b4ufly/).

annual UAS symposium, where stakeholders can speak directly to regulators and industry representatives.<sup>36</sup>

FAA has taken further action in response to a 2016 act requiring manufacturers of small UAS to make a safety statement available to the owner that satisfies certain requirements, including recommendations for using small UAS in a safe manner.<sup>37</sup> This requirement is to take effect one year after FAA develops relevant guidance. In the interim, FAA has developed a sample safety statement intended to serve as an example that small UAS manufacturers may use. The sample statement describes some of the regulations, and safety tips consumers need to know when operating UAS.<sup>38</sup>

FAA has also partnered with the Forest Service and federal, state, and local wildland fire agencies to educate recreational small UAS pilots about not flying near forest-firefighting operations. In 2015, the Department of the Interior, the Forest Service, and FAA implemented If You Fly, We Can't, a UAS awareness campaign, as a communication tool to keep UAS pilots away from airspace used by aerial-firefighting operations. FAA has expressed concern about the effect of the range of state and local laws on UAS operations, and how these varying laws might adversely affect safety in the NAS. Therefore, in December 2015, FAA published a fact sheet intended to help states and localities ensure that any legislation or regulation they are considering that affects UAS is consistent with the federal statutory and regulatory framework for aviation.

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<sup>36</sup>The first symposium was held on April 19-20, 2016 in Daytona Beach, Florida. The second forum was held March 2017 in Reston, Virginia. The 2018 symposium was held March 6-8 in Baltimore, Maryland.

<sup>37</sup>FAA Extension, Safety, and Security Act of 2016, § 2203.

<sup>38</sup>The act required that this guidance be published one year after its enactment, which occurred in July 2016.

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## Registration Requirements

In addition to educating users, in December 2015, FAA began requiring recreational small UAS users to register their UAS with FAA.<sup>39</sup> (Commercial users were already required to register their UAS.) Historically, according to agency officials, FAA did not enforce aircraft registration requirements for traditional model aircraft<sup>40</sup> but did have a registration system in place.<sup>41</sup> In 2015, in the interests of public safety and the safety of the NAS and in light of the rapid proliferation of UAS in the NAS, FAA reevaluated its registration process for small UAS and determined that its paper-based registration system was overly burdensome. Therefore, in December 2015, the agency published a rule that provides recreational and commercial small UAS pilots and operators a web-based UAS registration process for the registration of recreational and commercial small UAS as an alternative to the existing paper-based registration system.<sup>42</sup> As of October 31, 2017, FAA's data indicated over 919,700 registrations had been received—about 820,200 recreational users and about 99,500 commercial users—which in total represent almost three times the approximately 316,000 manned aircraft registered with the agency.<sup>43</sup> Figure 3 indicates the locations of small UAS registrants across the 50 states and District of Columbia.

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<sup>39</sup>This requirement was not in effect from May 19, 2017 (when it was invalidated by a United States Court of Appeals based on the prohibition in § 336 of the 2012 act against FAA promulgating regulations regarding recreational small UAS) until December 12, 2017 (when it was restored by a newly enacted law). *Taylor v. Huerta*, 856 F.3d 10889 (D.C. Cir. Mar. 14, 2017); National Defense Authorization Act for Fiscal Year 2018, Pub. L. No. 115-91 § 1092(d), 131 Stat. 1283 (2017).

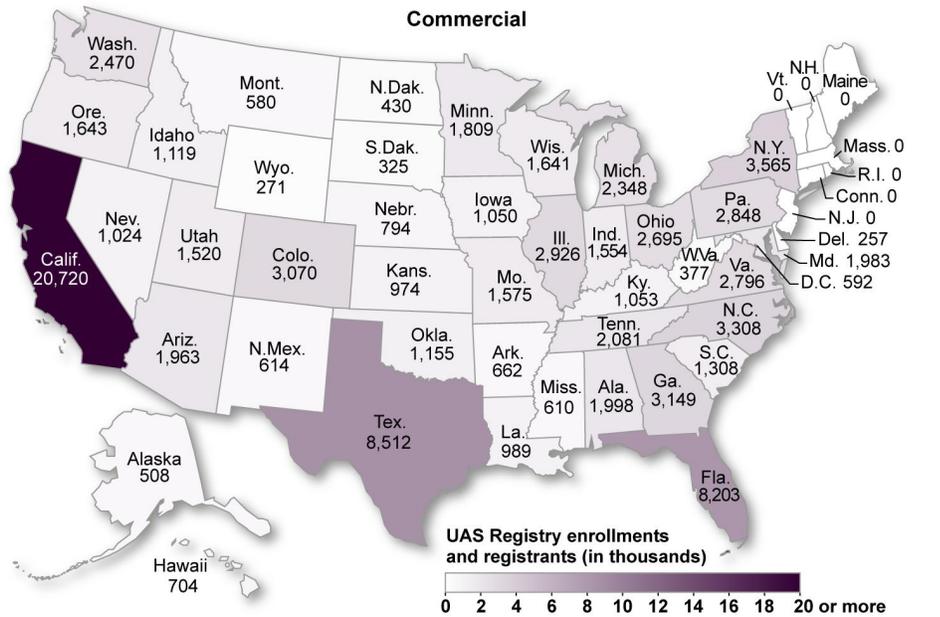
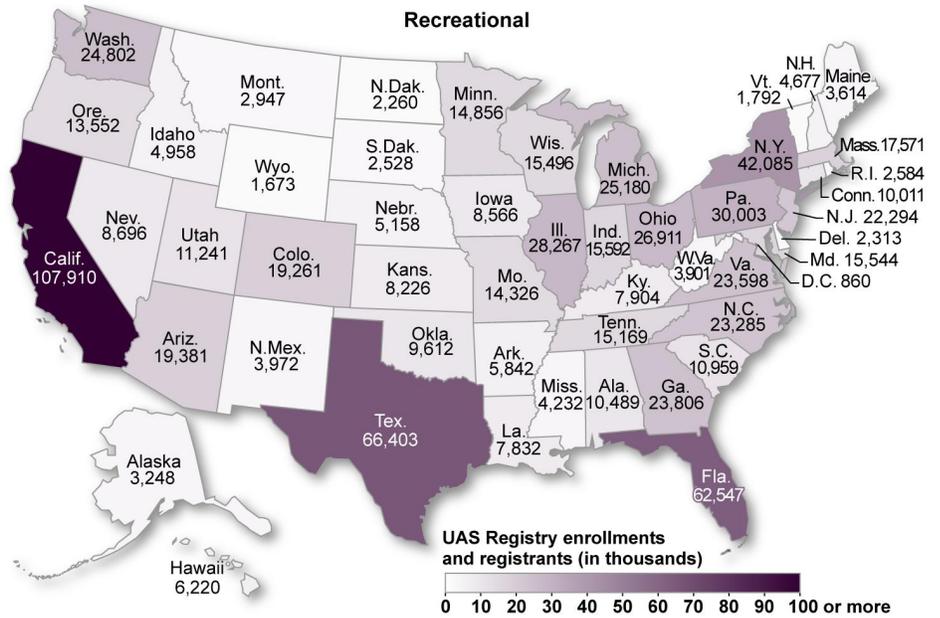
<sup>40</sup>While some types of small UAS are relatively new, traditional fixed-wing unmanned aircraft have been in development since World War I, and since World War II, the UAS market has been a hobbyist market.

<sup>41</sup>Under 14 C.F.R. pt. 47, all aircraft are required to be registered under a paper-based registration system with FAA.

<sup>42</sup>Prior to issuance of the final rule, FAA required all commercial, public, and non-recreational UAS operators and pilots to register each small UAS aircraft being used for business purposes—which will be discussed later. The new rule allowed commercial users to register their small UAS using the alternative, web-based aircraft registration process as of March 31, 2016. *Registration and Marking Requirements for Small Unmanned Aircraft*, 80 Fed. Reg. 78,594 (Dec. 16, 2015).

<sup>43</sup>Under the Registration and Marking Requirements Rule, recreational users can include one or more UAS in the same registration, while commercial users must register each UAS separately. The counts do not include the more than 3,300 registrations of users based in U.S. territories.

**Figure 3: The Federal Aviation Administration’s Registrations of Recreational and Commercial Small Unmanned Aircraft Systems (UAS) Users, as of October 31, 2017**



Sources: GAO analysis of Federal Aviation Administration registration data and Map Resources. | GAO-18-110

According to FAA, registration will help make sure that operators know the rules and remain accountable to the public for flying their unmanned aircraft responsibly. Failure by recreational users to register can result in

civil penalties up to \$27,500 or criminal penalties or fines of up to \$250,000 and/or imprisonment up to 3 years. FAA noted that registration has another benefit in that several times it allowed FAA to send out important safety messages to registrants. In our discussions with a variety of UAS stakeholders about FAA's efforts regarding registration, many (15) indicated that the new requirement could achieve a positive impact. Some agreed with FAA that registration would encourage safe use (11) and allow FAA to better reach out to operators and pilots (10). However, some (5) believed registration would do little to encourage safe use because, for example, the vast majority of events involving unsafe operation of small UAS, the UAS is not recovered or the operator or pilot is not located. In part to help address these concerns and in response to a legal mandate, FAA convened industry stakeholders to provide recommendations on the technologies available for remote identification and tracking of UAS.<sup>44</sup> The stakeholders provided their recommendations to FAA in October 2017. FAA is in the preliminary stages of a rulemaking on identification and tracking, and expects to solicit public comments for 3 months beginning in August 2018 to help shape a proposed rule.

### FAA Has Taken Some Incremental Steps toward Allowing Limited Commercial Small UAS Use in the NAS

In response to the 2012 act, FAA began working on a plan for integrating commercial small UAS operations into the NAS safely and efficiently.<sup>45</sup> In November 2013, FAA issued a road map for integrating UAS into the NAS that outlined a path forward for developing a regulatory framework for small UAS operations inside the United States, and for expanding UAS uses.<sup>46</sup> As shown in table 2, FAA began taking incremental steps in 2014 toward this goal and has completed phases 1 and 2.

**Table 2: The Federal Aviation Administration's (FAA) Incremental Approach for Developing a Regulatory Framework for Small Unmanned Aircraft Systems' (UAS) Operations**

Phase	UAS operations covered	Time frame
1	Allow operations on a case-by-case basis	September 2014 (actual)

<sup>44</sup>FAA Extension, Safety, and Security Act of 2016, § 2202.

<sup>45</sup>FAA Modernization and Reform Act of 2012, § 332.

<sup>46</sup>FAA, *Integration of Civil Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS) Roadmap* (November 2013).

2	Finalize regulations allowing routine commercial small UAS use	August 2016 (actual)
3	Allow routine operations over people	Late 2019 (planned)
4	Allow routine beyond line-of-sight operations	Late 2020 (planned)
5	Allow operations in areas where manned aircraft regularly fly	March 2020 (planned)
6	Allow unmanned cargo and UAS passenger operations	Beyond 2020 (planned)

Source: GAO summary of FAA information. | GAO-18-110

FAA has approached developing a regulatory framework for small UAS, much in the same incremental way the agency has approached new developments with manned aircraft. Fully integrating UAS into the NAS would entail FAA’s establishing all necessary rules, policies, and procedures to allow UAS and manned aircraft to operate in the same airspace. Each incremental step towards full integration involves UAS operations of increasing risk and complexity for operating in the NAS, and FAA’s fiscal year 2018 UAS implementation plan for integrating UAS into the NAS notes that the agency will determine that an acceptable level of safety can be maintained before taking each step.

Approval of Operations on a Case-by-Case Basis

As required by law, in September 2014, FAA began reviewing and approving applications for exemption<sup>47</sup> of certain commercial UAS operations in the NAS on a case-by-case basis.<sup>48</sup> This transitional process—used prior to the agency’s implementation of its regulations for allowing routine commercial small UAS use in the NAS—provided commercial small UAS operators a legal entry into the NAS, while maintaining the safety of the NAS. Applicants were required to describe their proposed use and any mitigation that would minimize risk to other aircraft and to persons and property on the ground, and UAS pilots were required to hold a traditional FAA pilot’s certificate. As of August 29,

<sup>47</sup>The authorizations involved FAA exempting UAS from the agency’s aircraft airworthiness certification requirements. In broad terms, FAA’s aircraft airworthiness certification requirements are that aircraft (1) conform to the FAA-approved design for the aircraft’s type and (2) are in condition for safe flight.

<sup>48</sup>FAA Modernization and Reform Act of 2012, § 333. The case-by-case authorizations typically involved an operator’s being authorized to conduct a particular type of operation during a certain time period, typically lasting 2 years.

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2016—when FAA’s small UAS regulations took effect—FAA had granted exemptions to over 5,000 commercial small UAS operators.<sup>49</sup>

### Regulations Allowing Routine Small UAS Use

In June 2016, FAA issued the first regulations allowing routine commercial small UAS operations in the NAS.<sup>50</sup> The regulations took effect in August 2016, replacing FAA’s transitional process for authorizing commercial use. Among other things, the regulations require commercial users to fly their UAS at or below 400 feet and within their visual line of sight. Instead of the traditional pilot certificate that FAA had required under the transitional process, the regulations require commercial small UAS pilots to obtain a new type of pilot certificate. While these regulations do not apply to recreational operations, FAA concurrently codified a prohibition on recreational users from endangering the NAS. Some selected requirements of the regulations include:

UAS must weigh less than 55 pounds, including equipment and cargo.

A person operating a small UAS must be at least 16 years old, either hold a remote pilot certificate with a small UAS rating and pass a security background check by the Transportation Security Administration, or be under the direct supervision of a person who holds a certificate.

Visual line-of-sight and daylight operations only.

No operations in certain classes of airspace without air traffic control permission.

Small UAS pilots must yield right of way to other aircraft.

Maximum altitude of 400 feet above ground level and maximum groundspeed of 100 miles per hour.

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<sup>49</sup>FAA was required to certify by October 13, 2016, that the agency’s waiver process include small UAS operations associated with critical infrastructure and that involve beyond visual line-of-sight and daytime or nighttime operations. FAA Extension, Safety, and Security Act of 2016, § 2210. In January 2017, FAA provided the required certification to Congress.

<sup>50</sup>These regulations are referred to as Part 107, and are codified at 14 C.F.R. §§ 107.1-107.205. The regulations apply to all civil small UAS operations other than operations included under the special rule for model aircraft and public aircraft —e.g., aerial photography; educational and academic purposes; inspections of antennas, bridges, pipelines, and powerlines; and research and development.

FAA allows users to request a waiver for most of the operational restrictions in its small UAS regulations. To obtain a waiver, users must demonstrate to FAA that they can safely conduct the proposed operation. For instance, if a commercial operator wants to conduct small UAS operations at night, the operator would have to apply to FAA and demonstrate the ability to safely do so. As of May 10, 2018, FAA had issued 1,784 waivers, most of which waived the requirement for daylight operations (1,598).

Going forward, FAA plans to continue to follow this incremental approach of adding to and amending its small UAS regulations to eventually allow both small and large UAS full access to the NAS. Thus far, FAA has made progress in planning for the phases that allow operations over people and expanded operations beyond line of sight, as described below.

### Operations over People

FAA is developing standards designed to routinely and safely allow small UAS operations over people who are not directly involved in the operation of the aircraft (the public) in urban areas. In February 2016, FAA chartered the Micro Unmanned Aircraft Systems Aviation Rulemaking Committee (ARC) to develop recommendations for developing a performance-based standard that would allow certain UAS to be operated over non-participating people. In recommendations issued in an April 2016 report, the ARC identified four small UAS categories defined primarily by level of risk of injury posed by operations over people. For each category, the ARC recommended performance standards and operational restrictions to minimize risks. FAA had planned to issue a proposed rule on operations over people by the end of 2016 and a final rule by the end of 2017. FAA tentatively plans to issue a regulation allowing routine operations over people in late 2019. FAA also expects the proposed rule to be informed by FAA's Pathfinder 1 project being conducted in partnership with Cable News Network (CNN) to explore safe

methods of small UAS operations in populated areas.<sup>51</sup> See figure 4 for more information about the Pathfinder 1 project.

**Figure 4: Description of the Federal Aviation Administration’s (FAA) Pathfinder 1 Project for Small Unmanned Aircraft Systems (UAS) for Operations over People**



**Pathfinder 1** – FAA has partnered with Cable News Network (CNN) to explore how small UAS might be safely used over people, within a pilot's direct vision. As part of this effort, in October 2017, FAA granted CNN a waiver to operate a specific make and model of small UAS at up to 150 feet above ground level for newsgathering over crowds of people. The approved small UAS weighs 1.37 pounds and is designed to break apart on impact so as to reduce the potential for injury or property damage.

Sources: FAA and Vantage Robotics. | GAO-18-110

<sup>51</sup>FAA signed a cooperative research and development agreement with Cable News Network for conducting the Pathfinder project. A cooperative research and development agreement is entered into between one or more federal agencies or laboratories and one or more non-federal parties under which the government, through its laboratories, provides personnel, services, facilities, equipment, intellectual property, or other resources with or without reimbursement (but not funds to non-federal parties), and the non-federal parties provide funds, personnel, services, facilities, equipment, intellectual property, or other resources toward the conduct of specified research or development efforts that are consistent with the mission of the agencies or laboratories; except that such term does not include a procurement contract or cooperative agreement as those terms are used in 31 U.S.C. §§ 6303, 6304, and 6305 nor does such term include other transactions, as that term is used in 49 U.S.C. § 106(l)(6). See 15 U.S.C. § 3710a(d)(1).

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### Beyond Line-of-Sight Operations

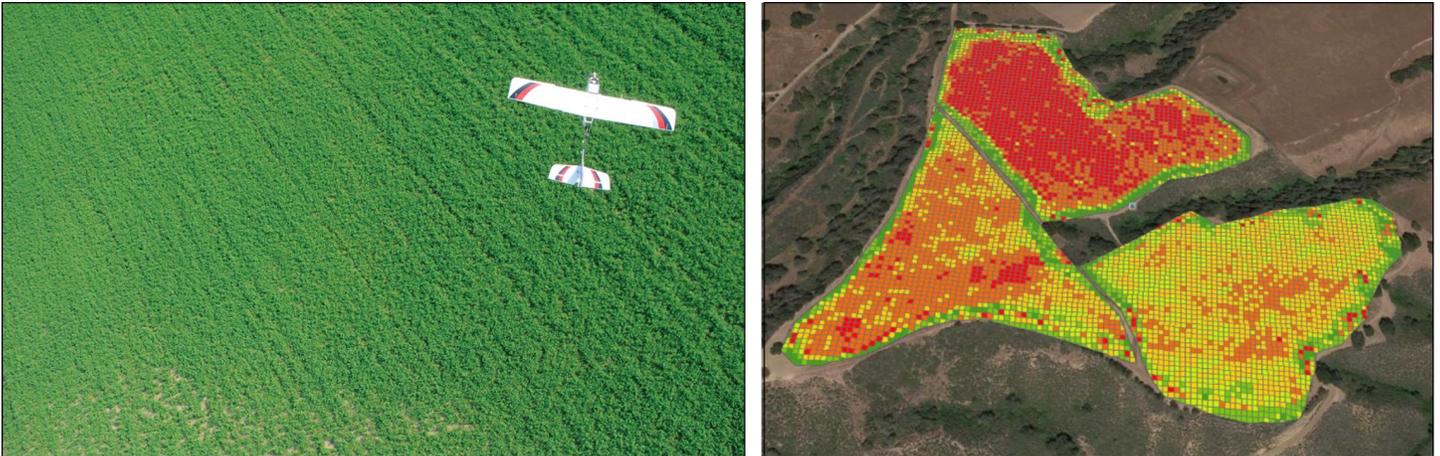
FAA also plans to develop standards designed to routinely and safely allow small UAS operations beyond the visual line of sight of the pilot, for those operations that are not currently allowed without a waiver.<sup>52</sup>

According to FAA and some aviation industry stakeholders we interviewed, beyond visual line-of-sight operations are critical to enabling the commercial potential of small UAS. For instance, many of the proposed commercial uses, such as package delivery and infrastructure inspection, will require the aircraft to be able to fly safely well beyond the visual range of the pilot. Through cooperative research and development agreements, FAA is engaged in two additional Pathfinder projects intended to inform the agency's development of standards for expanded operations: Pathfinder 2 with PrecisionHawk to test and evaluate extended visual line-of-sight operations in rural areas and Pathfinder 3 with BNSF Railway to test and evaluate beyond visual line-of-sight operations in rural or isolated areas. See figure 5 for additional information on these projects.

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<sup>52</sup>As mentioned above, *beyond visual line of sight* refers to operations that take the UAS farther than the pilot's or any other participating visual observer's direct vision of the UAS, with vision unaided by any device other than corrective lenses. *Extended visual line of sight* refers to operations outside the UAS pilot's direct vision but within an area in which the UAS pilot or one or more remote visual observers are able to spot manned aircraft that happen to fly into the area. This definition of extended visual line-of-sight is not statutory, but instead based on PrecisionHawk's definition.

**Figure 5: Descriptions of the Federal Aviation Administration’s (FAA) Pathfinder Projects 2 and 3 for Small Unmanned Aircraft Systems (UAS) for Beyond Line-of-Sight Operations**



**Pathfinder 2** – FAA has partnered with PrecisionHawk, a UAS manufacturer, to explore using UAS for operations outside the UAS pilot’s direct vision but within an area in which the UAS pilot or one or more remote visual observers are able to spot manned aircraft that may happen to fly into the area (i.e., extended visual line-of-sight), e.g., surveying and monitoring agricultural crops. PrecisionHawk completed the test flight operations in September 2016, and has identified the operational risk associated with visual detection of an incoming aircraft and the ability to make a safety decision while operating a UAS under extended visual line-of-sight conditions.



**Pathfinder 3** – FAA has partnered with BNSF Railway, a rail freight company, to explore challenges with using small UAS beyond a pilot’s direct vision (i.e., beyond visual-line-of-sight) to inspect rail system infrastructure in rural/isolated areas. FAA is testing beyond-line-of-sight operations in which the small UAS are being used to inspect rail lines in a sparsely populated area. BNSF has conducted a series of test flights using a Boeing ScanEagle small UAS without using visual observers, and controlled the small UAS utilizing a control radio data-link network.

Source: FAA, PrecisionHawk, Inc., and BNSF Railway. | GAO-18-110

Half of the industry stakeholders who discussed the Pathfinder projects with us expressed positive views about them. However, some noted that although these projects are a good starting point, changes are needed. For example, three stakeholders said the projects need to be expanded to include other companies, while two others were not clear on what is to be

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done with the resulting data. FAA tentatively plans to issue a regulation allowing routine beyond visual line-of-sight operations in late 2020.

### Final Actions to Full Integration

FAA has taken some steps toward fully integrating UAS into the NAS. For example, the agency has developed a plan and taken preliminary steps for the next-to-final phase of integrating UAS into the NAS—non-segregated operations that would enable both larger UAS and small UAS to operate in the same airspace as manned aircraft. According to FAA, such operations might involve interaction between UAS pilots and air traffic controllers in a manner similar to how a manned aircraft conducting flight under instrument flight rules does today. Also, the UAS operating in this environment might be required to meet FAA’s performance and equipage standards for the airspace class or route used.<sup>53</sup> FAA’s plan calls for the agency to issue a final rule to allow non-segregated operations in the second quarter of fiscal year 2020. FAA is also developing a detailed implementation plan to reach the final phase of integrating UAS into the NAS—the use of UAS for delivering small cargo within state boundaries and the use of larger UAS for transporting passengers.

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<sup>53</sup>14 C.F.R. pt. 91 codifies federal aviation regulations for governing the operation of an aircraft within the United States including, among other things, equipage requirements and performance standards. To operate an aircraft in the different classes of airspace and at various altitudes in the NAS, specific equipage and performance standards must be met for the aircraft being operated. An example for an equipage requirement for operating an aircraft in an airspace class could be the requirement for having a transponder, i.e., equipment that would help identify the precise location of the aircraft or to electronically transmit identification information. Further, each aircraft is designed to meet certain operational and performance standards—e.g., pertaining to takeoff, rate of climb, range of flight, rate of descent, and landing—that determine the practical use of the aircraft’s capabilities and limitations.

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## FAA Has Used a Variety of Actions to Address Noncompliance and Unsafe Use of Recreational and Commercial Small UAS

FAA has sought to ensure compliance with safety standards related to recreational and commercial small UAS operations by taking a variety of actions. While FAA is legally prohibited from promulgating regulations for recreational small UAS, FAA has the authority to take enforcement action against the operator or pilot of any small UAS that endangers the safety of the national airspace system or persons and property on the ground. FAA officials told us that the agency is following its “compliance philosophy” to help ensure users abide by the small UAS regulations.<sup>54</sup> Under this philosophy, FAA’s approach involves three types of possible actions: (1) compliance actions,<sup>55</sup> (2) administrative actions, and (3) legal enforcement actions (see table 3). The compliance philosophy also calls for FAA to emphasize the use of compliance actions over enforcement actions whenever appropriate. According to FAA’s data, from June 7, 2007 through May 2, 2018 the agency took 420 compliance actions, 49 administrative actions, and 49 enforcement actions against small UAS users; the data do not distinguish between recreational and commercial users.

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<sup>54</sup>Before June 2015, FAA’s regulatory policy focused on legal enforcement action as a first step to address regulatory noncompliance. FAA now allows individuals and organizations the agency oversees to take steps to address a noncompliance finding and demonstrate compliance before initiating an enforcement action, except in certain cases such as an unwillingness or inability to comply.

<sup>55</sup>The term “compliance action” is new for FAA and refers to non-enforcement methods—such as counseling, on-the-spot corrections, and additional training—for correcting unintentional deviations or noncompliance that arise. A compliance action is not adjudication, nor does it constitute a finding of violation.

**Table 3: Numbers of Actions Taken by the Federal Aviation Administration (FAA) to Address Noncompliant or Unsafe Use of Small Unmanned Aircraft Systems, from June 7, 2007 through May 2, 2018**

Type of action	Description	Number of actions taken
<b>Compliance</b>	FAA uses on-the-spot correction, counseling, additional training, or other cooperative means for correcting unintentional deviations or noncompliance that arise from factors such as flawed systems and procedures, simple mistakes, lack of understanding, or diminished pilot skills	<b>420</b>
	• Counseling or other informal action	368
	• On-the-spot correction	21
	• Additional training	6
	• Other	25
<b>Administrative</b>	FAA issues warning notices or letters of correction when the agency determines that a compliance action would be ineffective and when enforcement action is not required or warranted. <sup>a</sup>	<b>49</b>
	• Warning notice	40
	• Letter of correction	9
<b>Legal enforcement</b>	FAA assesses civil penalties or suspension or revocation of pilots' or operators' certificates in cases of intentional or reckless deviations from FAA's standards or in cases that are otherwise unacceptably unsafe, and also in some cases of repeated noncompliance or where pilots or operators fail to correct noncompliance following an FAA compliance or administrative action.	<b>49</b>
	• Civil penalty	46
	• Suspension of certificate	1
	• Revocation of certificate	2

Source: FAA. | GAO-18-110

<sup>a</sup>A warning notice advises the noncompliant entity of the facts and circumstances constituting noncompliance and requests future compliance. A letter of correction serves the same purposes as a warning notice and also memorializes the specific agreement between FAA personnel and the regulated entity as to the particular corrective action taken.

FAA officials told us that given its overall responsibilities for aviation safety and the lower risk posed by small UAS compared to manned aircraft, its resources for actively pursuing unsafe small UAS users are limited, and identifying such users is challenging. The 2016 act authorized FAA to begin immediately assessing civil penalties of up to \$20,000 for UAS pilots or operators who knowingly or recklessly interfere with wildfire suppression, law enforcement, or other emergency response activities.<sup>56</sup> FAA told us that as of May 2018, FAA had used this authority to assess

<sup>56</sup>FAA Extension, Safety, and Security Act of 2016, § 2205.

one civil penalty in the amount of \$9,700 and to initiate another enforcement case that was still open. Additionally, since 2016, the Department of Transportation Inspector General (DOTIG) has been conducting investigations of serious violations of UAS related regulations—e.g., involving injury to persons, property damage, or operating near an airport. As of May 2018, the DOTIG had initiated 25 cases nationwide, with five investigations ongoing; however, no indictments or convictions had resulted. According to DOTIG, these investigations have largely been initiated as a result of police reports to FAA that FAA referred to DOTIG, which has criminal investigative authority whereas FAA does not.<sup>57</sup>

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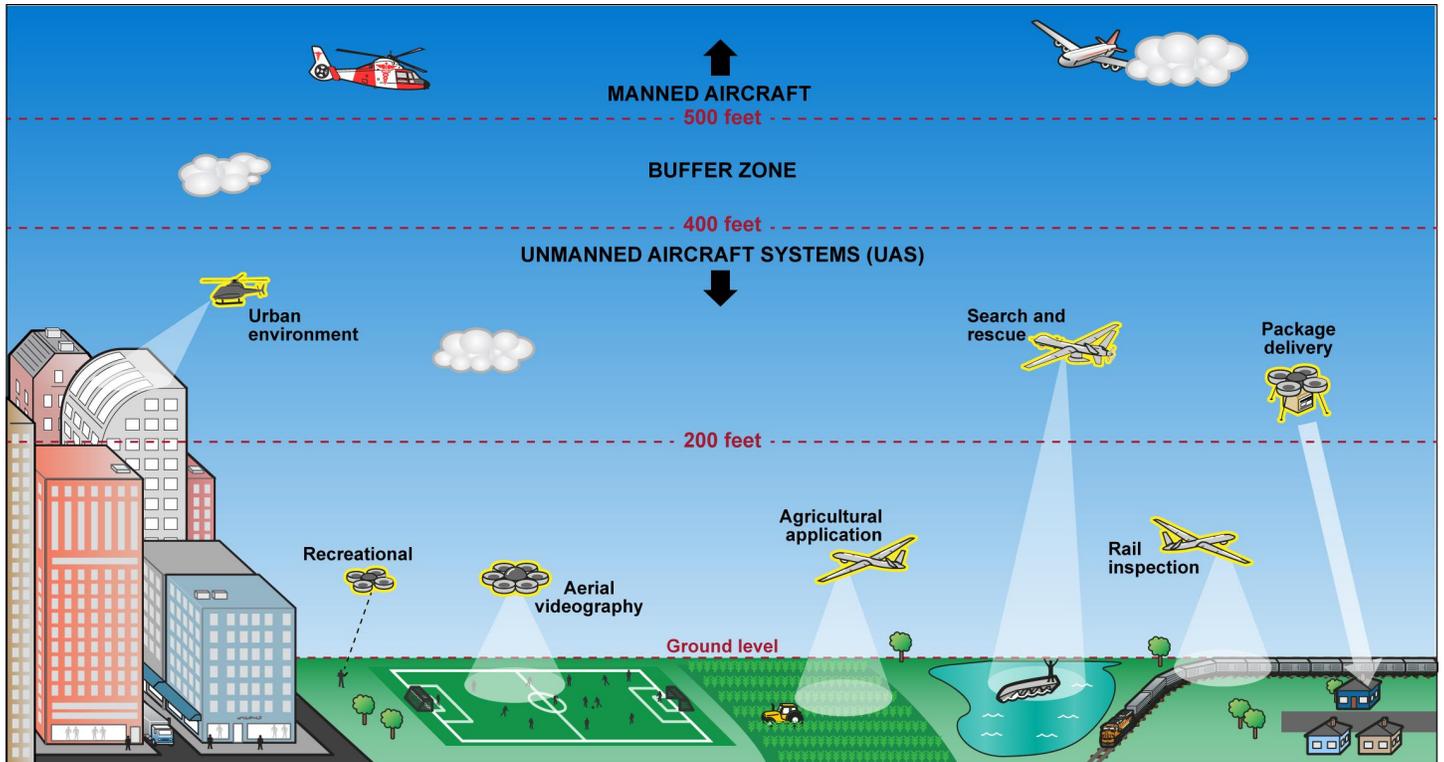
### FAA Is Collaborating with NASA to Determine Feasibility of a System for Managing UAS Traffic

According to FAA and NASA, in order to fully integrate commercial small UAS in the NAS, a traffic management system that is similar to FAA's air-traffic-control system for manned aviation may be needed to control access and flight operations. In 2013, NASA began developing a concept of operations for a UAS Traffic Management System (UTM) that would enable routine, diverse small commercial UAS operations that are below 400 feet and beyond the line of sight, and operated in a manner that allows for multiple user interactions. Such operations could include delivery of small packages, as proposed by Amazon and Google. UTM is not considered to be a single full system for the continental United States but, according to NASA officials, will likely be composed of small local and regional systems (see fig. 6). According to a 2017 NASA Office of Inspector General report, the project received a total of \$47.6 million in funding in fiscal years 2015 through 2017. NASA officials noted that UTM is a step beyond the Pathfinder Program because it allows for multiple or diverse user interactions.

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<sup>57</sup>DOTIG coordinates its investigations with FAA, DOJ, local police, airports, and state and local governments.

**Figure 6: Illustration of a Potential Model for the National Aeronautics and Space Administration’s (NASA) Concept of Operations for the Unmanned Aircraft System Traffic Management System**



Source: GAO illustration of National Aeronautics and Space Administration (NASA) information. | GAO-18-110

NASA is leading the research, development, and testing of the various technologies that would comprise the system, and is coordinating with FAA and other government agencies as well as over 200 industry and academic partners. The work is taking place in four phases, each increasing in complexity. See table 4 for the project’s schedule. Finally, FAA’s long-term vision includes fully integrated commercially operated small UAS operating in the same airspace as manned aircraft and using many of the same air-traffic-management systems and procedures. This will represent a substantial shift from the approach of requiring UAS to operate separately in the NAS. According to NASA officials, the agency has held three large events on its progress on UTM and participated in many of the national and international conferences with presentation panels on UTM.

**Table 4: The National Aeronautics and Space Administration’s (NASA) Project Schedule for a Traffic Management System for Unmanned Aircraft Systems (UAS)**

Phase	Completion date	Focus area	Application
1	August 2015	Field testing and additional testing at an FAA site. Technologies in this activity included “geofencing”—which establishes virtual fences around areas or points of interest to keep UAS away—altitude “rules of the road,” and scheduling of UAS flight trajectories.	Agriculture, firefighting, and infrastructure monitoring
2	February 2017	Beyond visual line-of sight operations in sparsely populated areas. Researchers tested technologies that allow dynamic adjustments to availability of airspace and management of contingencies, such as the loss of the communications link between the small UAS and the pilot’s handset for controlling the UAS.	Longer range applications
3	February 2018	Testing technologies that maintain safe spacing between cooperative (responsive) and non-cooperative (non-responsive) UAS over moderately populated areas.	Public safety, limited package delivery
4	October 2019	UAS operations in higher-density urban areas for tasks such as news gathering and package delivery and testing technologies that could be used to manage large-scale contingencies, such as unanticipated severe weather and outages of cell phone and global positioning system services that could support the UAS traffic management system.	News gathering, package delivery, and personal use

Source: NASA and the Federal Aviation Administration (FAA). | GAO-18-110

In 2015, FAA and NASA established a research transition team to coordinate the UTM initiative. NASA expects to transfer the results of its research in the form of airspace integration requirements to FAA, and FAA will determine next steps with UTM research. FAA officials told us that the agency does not expect to operate such a system but according to NASA officials, if FAA chooses not to implement and operate UTM, other organizations could do so with commercially developed traffic management systems. Furthermore, FAA officials have stated that there are policy, regulatory, and infrastructure implications that must be fully understood and addressed before a UTM could be implemented, and that it is possible that alternatives to, or portions of, the concept could be implemented rather than the entire concept. Most of the industry stakeholders with whom we discussed UTM spoke positively about it. In September 2017, NASA’s Inspector General reported that NASA’s UTM project was progressing as planned within allocated cost and schedule resources, and that as a result of UAS flight tests in realistic operating environments, NASA researchers have made progress in addressing

specific technology challenges related to UTM.<sup>58</sup> The Inspector General for NASA also reported that NASA had collaborated effectively with FAA to establish a process for transferring UTM research results from NASA to FAA.

Pursuant to law, FAA, in coordination with NASA, is required to develop a research plan for UTM by January 11, 2017.<sup>59</sup> The agency and NASA collaborated to develop such a plan, and FAA officials told us that the agency submitted it to Congress in April 2017. FAA, in coordination with NASA and the Drone Advisory Committee, is also required to establish a 2-year pilot program for UTM within 90 days of completing the research plan. FAA officials told us the agency is working with NASA and the Drone Advisory Committee to prepare for the pilot program, which FAA plans to begin in 2018.

In addition to a UTM, some policy and technological tools have been identified by federal agencies, aviation industry stakeholders, and others as having the potential to mitigate risks associated with unauthorized small UAS operations and aid in achieving FAA's goal of full integration of small UAS in the NAS. See appendix I for a listing and descriptions of selected technologies that are at various stages of research and development. FAA has also coordinated with industry and academic stakeholders on efforts intended to inform its decisions for how to manage the safety risks associated with small UAS and to support and facilitate integrating small UAS into the NAS. See appendix III for descriptions of several of these efforts.

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<sup>58</sup>NASA, Office of Inspector General, *NASA's Research Efforts and Management of Unmanned Aircraft Systems*, Report No. IG-17-025 (Washington, D.C.: Sept. 18, 2017).

<sup>59</sup>FAA Extension, Safety, and Security Act of 2016, § 2208.

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## In Selected Efforts Related to Small UAS, FAA Followed Risk Management Principles to Varying Extents

To support FAA's mission to provide a safe and efficient National Airspace System, FAA's policy on safety risk management<sup>60</sup> requires FAA to follow a process for managing risk that includes identifying hazards;<sup>61</sup> analyzing and assessing associated safety risks;<sup>62</sup> and developing and monitoring safety risk controls to reduce the risks to an acceptable level. From this policy, we identified five key FAA principles for safety risk management and 15 specific requirements that support those principles (see table 5). We assessed FAA's risk management practices for selected agency efforts related to small UAS against these principles and requirements. We selected FAA efforts that involved development of regulations for small UAS or issuing waivers or exemptions to those regulations or other aviation regulations. The efforts were:

- development of the rule on registration of small UAS;
- the transitional process for authorizing commercial small UAS use;
- development of the small UAS regulations;
- the process for waiving certain requirements in the small UAS regulations;
- the process for approving requests from small UAS pilots for authorization to operate in airspace served by air traffic control; and

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<sup>60</sup>The policy applies to all of FAA's functions when making planned changes to the NAS and when potential and previously unidentified hazards and ineffective safety risk controls are discovered.

<sup>61</sup>FAA defines *hazard* as a condition that could foreseeably cause or contribute to an accident.

<sup>62</sup>FAA defines *safety risk* as the composite of predicted severity and likelihood of the potential effect of a hazard. FAA defines *severity* as the consequence or impact of a hazard's effect or outcome in terms of degree of loss or harm. FAA defines *likelihood* as the estimated probability or frequency, in quantitative or qualitative terms, of a hazard's effect or outcome.

- the two Pathfinder projects.<sup>63</sup>

We identified FAA's risk management practices for these efforts by reviewing FAA documents that describe the agency's processes and decisions for each effort.<sup>64</sup> We then determined whether each principle was followed—meaning all three requirements under the principle were followed; not followed—meaning all three requirements under the principle were not followed; or partially followed—meaning that the principle was neither followed nor not followed. Our assessments of the extent to which FAA followed the requirements under each principle served as the basis of our overall assessments of the extent to which FAA followed each principle. Appendix II provides further detail on our methodology.

As shown in table 5, of the five key principles of safety risk management, we determined that FAA followed two and partially followed three in managing risks for the selected agency efforts related to small UAS. More specifically, we found that of the 15 requirements under those key principles, FAA followed 9 and partially followed 6. The discussion that follows provides more detail on our results.

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<sup>63</sup>We assessed FAA's risk management practices for the Pathfinders with BNSF Railway and PrecisionHawk. However, we did not assess FAA's risk management process for the Pathfinder with CNN because that process mainly involved FAA approving CNN's operations under the agency's transitional process for authorizing commercial small UAS use, and we assessed that process separately.

<sup>64</sup>These documents included documents that FAA refers to as "Safety Risk Management Documents" (standardized documentation on the agency's risk management steps taken for the effort, such as risk assessments and selections of safety risk controls); two rules; and authorizations issued under its transitional process and that FAA used as a basis for expediting its reviews of subsequent requests for authorization of similar operations.

**Table 5: GAO’s Assessment of the Extent to Which the Federal Aviation Administration’s (FAA) Management of Safety Risks Posed by Small Unmanned Aircraft Systems Followed Key Risk Management Principles**

<b>Principles and supporting requirements</b>	<b>Extent Followed</b>
Define appropriate roles and responsibilities for safety risk management	Followed
Identify teams or individuals responsible for conducting the safety-risk management process	Followed
Team must include representatives from the various FAA organizations that could be affected by safety risk management decisions	Followed
Identify managers accepting safety risks	Followed
Describe the aviation system under consideration and identify its hazards	Followed
Describe the aviation system and issue under consideration	Followed
Identify hazards	Followed
Identify existing safety risk controls	Followed
Analyze and assess safety risks	Partially Followed
Identify potential causes and effects associated with each hazard	Followed
Analyze safety risks in terms of severity and likelihood	Partially Followed
Assess the acceptability of safety risks based on their severity and likelihood compared to risk acceptance criteria	Partially Followed
Control safety risks	Partially Followed
Identify safety risk controls considered	Followed
Select controls and provide rationale	Followed
Determine that any remaining safety risks are acceptable based on their severity and likelihood compared to risk acceptance criteria	Partially Followed
Monitor hazards and related controls and adjust controls as needed	Partially Followed
Describe how hazards and related controls will be monitored against safety-risk acceptance criteria	Partially Followed
Monitor the effectiveness of safety risk controls	Partially Followed
Modify or add controls as needed	Partially Followed

Source: FAA's policy on safety risk management and GAO assessment. | GAO-18-110

***Define appropriate roles and responsibilities for safety risk***

***management:*** We found that FAA, in the selected efforts related to small UAS, followed this principle. In particular, for each effort, the agency:

identified teams or individuals responsible for conducting the safety- risk management process,

indicated that the agency included on the teams representatives from the various FAA organizations that could be affected by decisions based on the analyses, typically FAA's air traffic organization and FAA's safety office, and identified managers accepting safety risks, with name, title, and signatures in the primary safety-risk management document.

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**Describe the aviation system under consideration and identify its hazards:** We found that FAA followed this principle, as the agency, for each selected effort:

Described the aviation system under consideration. For example, in the safety-risk management document for the PrecisionHawk Pathfinder project, FAA explained that the aviation system included, among other things, the agency's transitional process for authorizing commercial small UAS use.

Described the issue under consideration. For example, in the safety risk management document for the BNSF Railway Pathfinder project, FAA explained that the issue under consideration was that FAA was seeking to identify areas and conditions where UAS inspections of rail lines could occur safely beyond the visual line of sight of the UAS pilot.

Identified hazards. For example, in a safety-risk management document related to the transitional authorization process, FAA identified the following four hazards: the pilot of a manned aircraft has difficulty seeing a small UAS; failure of the communications link between a small UAS and its control station; a small UAS flies away from its pilot in an uncontrolled manner; and the pilot loses visual contact with the small UAS.

Identified existing safety risk controls. For example, in a safety-risk management document related to the transitional authorization process, FAA identified several existing controls, including that small UAS pilots were required to hold a private pilot certificate and that pilots were required to operate their small UAS during the daytime and within their visual range.

**Analyze and assess safety risks:** We found that FAA, in the selected efforts related to small UAS, partially followed this principle. While FAA followed the requirement of describing potential causes and effects for each hazard, it did not consistently analyze safety risks in terms of severity and likelihood or consistently assess their acceptability by comparing them to the agency's risk acceptance criteria:

FAA generally described potential causes and effects for each hazard identified in documents related to safety risk management on these efforts. For example, in several documents, FAA identified the hazard that the pilot of a manned aircraft has difficulty seeing a small UAS. The potential causes FAA described for this hazard included the small UAS's size, color, lack of lighting, performance characteristics, lack of motion

relative to the manned aircraft, and airspeed; the potential effects FAA described included a collision and a near midair collision between the manned aircraft and the small UAS.

FAA did not consistently analyze safety risks in terms of severity and likelihood, and did not consistently assess risks by comparing them to the agency's risk acceptance criteria, as required by FAA's policies. FAA did these for two of the selected efforts related to small UAS, however, the agency did not for four others.

For example, in a document related to the transitional authorization process, FAA analyzed the risk, in terms of severity and likelihood, associated with the hazard of a pilot of a manned aircraft having difficulty seeing a small UAS. FAA then determined the acceptability of the risk by plotting the risk on FAA's risk matrix based on the risk's severity and likelihood (see fig. 7).<sup>65</sup> FAA's analysis concluded that the hazard could result in a near midair collision between the manned aircraft and the small UAS, which is the second-highest level on FAA's five-level severity scale. FAA also estimated the likelihood of such a collision as being extremely remote, which is the second-lowest level of FAA's scale. Based on the combined severity and likelihood of this risk and FAA's criteria for risk acceptance, FAA determined that the risk is medium-level, meaning the risk is acceptable, although mitigation is recommended.

Conversely, for four other efforts related to small UAS, FAA did not analyze risks in terms of their severity and likelihood or assess their acceptability by comparing them to the agency's risk acceptance criteria.<sup>66</sup> While FAA's documents related to those efforts generally describe the potential causes and effects associated with hazards—such as the hazard of the pilot of a manned aircraft failing to see a small UAS due to the difficulty of seeing it, and resulting in a collision between the manned aircraft and the small UAS—they did not assign severity levels, nor did they include estimates of their likelihoods. Therefore, while FAA

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<sup>65</sup>FAA's risk levels are low, medium, and high. FAA's criteria for acceptability of risks are that low-level risks are acceptable without any mitigation; medium-level risks are acceptable, although mitigation is recommended; and high-level risks are unacceptable, and the proposed change to the NAS cannot be implemented unless the risk is mitigated to medium or low.

<sup>66</sup>The four efforts were the transitional authorization process, development of the small UAS regulations, the process for waiving certain requirements in the small UAS regulations, and the rule on registration requirements for small UAS.

made determinations of whether risks were acceptable, its determinations were not based on assessments of severity and likelihood levels. FAA officials told us that the agency does not always have sufficient data to assess the likelihood of risks. However, for some of its other key efforts for which it lacked sufficient data on which to base estimates of severity and likelihood, FAA relied on expert judgment to make estimates, as allowed under the agency’s safety risk management policy. As discussed earlier, FAA’s lack of reliable data about the extent of unsafe use of small UAS limits its ability to oversee the safe integration of these aircraft into the NAS. Absent an assessment of severity and likelihood, FAA could not demonstrate that the risks it identified as needing mitigation exceeded the agency’s risk acceptance criteria or that the risks it identified as acceptable fell below the criteria.

**Figure 7: The Federal Aviation Administration’s (FAA) Air Traffic Organization’s Criteria for Acceptability of Safety Risks Posed by Unmanned Aircraft Systems (UAS)**

Likelihood of risk	Severity of risk				
	Minimal <sup>a</sup>	Minor <sup>b</sup>	Major <sup>c</sup>	Hazardous <sup>d</sup>	Catastrophic <sup>e</sup>
<b>Frequent</b> At least once per week	Low	Medium	High	High	High
<b>Probable</b> Less than once per week and at least once per 3 months	Low	Medium	High	High	High
<b>Remote</b> Less than once per 3 months and at least once per 3 years	Low	Medium	Medium	High	High
<b>Extremely remote</b> Less than once per 3 years and at least once per 30 years	Low	Low	Medium	Medium	High
<b>Extremely improbable</b> Less than once per 30 years	Low	Low	Low	Medium	High

- The risk level is “low,” meaning the risk is acceptable without any mitigation
- The risk level is “medium,” meaning the risk is acceptable, although mitigation is recommended
- The risk level is “high,” meaning the risk is unacceptable unless it is mitigated to a level of “low” or “medium”

Source: GAO presentation of Federal Aviation Administration information. | GAO-18-110

Notes: FAA defines safety risk as the composite of predicted severity and likelihood of the potential effect of a hazard. FAA defines likelihood as the estimated probability or frequency, in quantitative or qualitative terms, of a hazard’s effect or outcome. FAA defines severity as the consequence or impact of a hazard’s effect or outcome in terms of degree of loss or harm.

<sup>a</sup>Minimal severity refers to outcomes in which a UAS causes discomfort to those on the ground.

<sup>b</sup>Minor severity refers to outcomes in which a UAS causes non-serious injury to three or fewer people on the ground

<sup>c</sup>Major severity refers to outcomes in which (1) a UAS causes non-serious injury to more than three people on the ground; (2) a UAS crew experiences a reduced ability to cope with adverse operating conditions to the extent that there would be a significant reduction in safety margins; or (3) a UAS

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causes a manned aircraft to make an evasive maneuver, but the UAS and the manned aircraft remain greater than 500 feet apart.

<sup>d</sup>Hazardous severity refers to outcomes in which (1) the UAS crew is incapacitated; (2) a UAS flies within 500 feet of a manned aircraft; or (3) a UAS causes injury to persons other than the UAS crew.

<sup>e</sup>Catastrophic severity refers to outcomes in which a UAS collides with a manned aircraft or (2) a UAS causes a fatality or fatal injury to one or more persons other than the UAS crew.

<sup>f</sup>For risks with likelihood of extremely improbable and a severity of catastrophic, the risk level is high when the undesirable effect could result from certain types of system failures.

**Control safety risks:** We found that FAA, in selected efforts related to small UAS, partially followed this principle:

FAA's documents related to its safety risk management for the selected efforts generally (1) describe the safety risk controls the agency considered, (2) identify the controls it selected, and (3) describe the agency's rationale for its selections. For example, FAA's final rule for small UAS operations described several different types of certificates that FAA considered requiring for pilots of commercial small UAS, including those for airline transport pilots and commercial pilots of manned aircraft, as well as a new type of certificate designed for pilots of commercial small UAS. The final rule also stated that FAA decided to require the new type of certificate because the other types would not ensure that commercial small UAS pilots would have all the skills necessary to safely operate a small UAS—such as how to maintain visual line of sight—and would also impose the burden of training in areas of knowledge inapplicable to small UAS operations, such as how to conduct maneuvers of a manned aircraft, including takeoff and landing. According to FAA, the new category of remote pilot certification from Part 107 has many controls built within the operational rule to ensure that a new operator is safer than a non-certificated operator.

FAA's documents related to its safety risk management for these efforts did not consistently identify any safety risks that could remain after implementation of controls in terms of severity and likelihood, as required by FAA's policies. For example, to mitigate the risk associated with the pilot of a manned aircraft having difficulty seeing a small UAS, one safety-risk management document called for implementing the following two risk controls, beyond those already in place: (1) requiring commercial small UAS pilots to file, 24 hours in advance of their operation, a notice with FAA that describes their operation so that FAA can disseminate the information to pilots of manned aircraft, and (2) requiring commercial small UAS pilots to operate their UAS at least 2 nautical miles from heliports, seaports, "gliderports," and certain airports not served by an air traffic control tower. The safety-risk management document includes FAA's assessments that after those controls are implemented, the

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remaining risk associated with the pilot of a manned aircraft having difficulty seeing a UAS will be related to the potential for a near mid-air collision between a small UAS and a manned aircraft, with a severity of level of catastrophic (the highest severity level on FAA's five-level scale) and a likelihood level of extremely improbable (the lowest likelihood on FAA's five-level scale).

In contrast, FAA's safety-risk management documents for its process for waiving certain requirements in the small UAS regulations did not discuss remaining risks at all. In other selected efforts, FAA's documents identified remaining risks but did not provide estimates of their severity and likelihood. For example, for an authorization that FAA granted under its transitional process, allowing small UAS to operate on closed film sets, FAA identified a remaining risk of injury to persons in close proximity to the UAS. FAA determined that the risk was acceptable due in part to the limited size, weight, and safety features of the UAS, but did not provide estimates of its severity and likelihood. Furthermore, FAA's safety-risk management documents for its process for waiving certain requirements in the small UAS regulations did not discuss remaining risks at all. Without descriptions of any remaining, unmitigated safety risks in terms of their severity and likelihood, FAA lacked a sound basis for deciding which safety controls to implement.

**Monitor hazards and related controls and adjust controls as needed:**

We found that FAA, in the selected efforts related to small UAS, partially followed this principle. Specifically, FAA did not consistently describe how it would monitor hazards and related controls against the agency's risk acceptance criteria.

In documents related to several of these efforts, FAA did describe how it would perform such monitoring. For example, in a safety-risk management document related to the agency's transitional authorization process, FAA said it would annually review data on near midair collisions between manned aircraft and commercial small UAS, and established an acceptability criterion of no more than three such collisions in one year involving a commercial small UAS operating under a certain authorization. In contrast, in documents related to several of its other risk management efforts, FAA described the data it would monitor but did not establish any acceptability criteria. For example, FAA requires commercial small UAS pilots to report to FAA accidents that meet certain thresholds for injuries or property damage, but did not establish any acceptability criteria, such as a maximum acceptable accident rate. Because these risk management efforts lack monitoring plans tied to FAA's risk acceptance criteria, FAA does not have the basis required by the agency's policies for making decisions about whether to adjust the controls. As a result, these decisions are more susceptible to error.

To monitor the effectiveness of risk controls and determine whether to modify or add controls, FAA reviewed data on accidents, incidents, and malfunctions; near mid-air collisions; and sightings of small UAS, but

these data have limitations. Specifically, FAA generally used self-reported data from commercial small UAS operators as well as reports initiated by pilots regarding near mid-air collisions. For example, after streamlining the process in March 2015 for approving small UAS operations at or below 200 feet, FAA monitored data on near midair collisions between manned aircraft and small UAS. Almost a year later, FAA decided to double the maximum altitude of allowable operations from 200 feet to 400 feet. FAA based its decision in part on its monitoring of near mid-air collisions—which indicated that there had not been any such reports involving authorized commercial small UAS. According to FAA, it made the change in order to more expeditiously meet the needs of many commercial operators, following an increase in the number of such operators who were requesting waivers from the 200 foot maximum. FAA told us that it also monitors data on sightings of small UAS to assess the effectiveness of its risk controls in the small UAS regulations. FAA also cited the sightings data in its assessment of safety risks from small UAS operations in the rule requiring small UAS registration. However, these sources of FAA data on potential unsafe uses of small UAS have limitations that affect reliability.

Furthermore, FAA's data on near mid-air collisions does not include reliable information on whether the involved UAS was an authorized commercial small UAS, because FAA currently lacks the means to identify the operator or pilot in most such events. Therefore, while FAA's data includes 504 reports of near mid-air collisions between a UAS and a manned aircraft from January 2013 through April 2018, the data do not indicate how many of these events involved authorized commercial small UAS. As such, the data are missing key information that FAA needs to monitor the effectiveness of the risk controls in place under the 200 foot maximum. As discussed earlier, FAA is taking steps to improve its data on the safety of UAS operations.

FAA officials told us that, for the selected efforts, the agency did not consistently analyze and assess risks or describe remaining risks in terms of severity and likelihood or describe how it would monitor hazards and related controls against the agency's risk acceptance criteria because at the time, the agency did not believe that its safety-risk management policy applied to all of these efforts. However, in our discussions with these officials, they acknowledged that the policy does in fact apply. However, FAA has not documented this new position or developed a method to ensure proper risk analyses are conducted. Federal internal control standards state that an agency's management should design

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control activities, such as policies and procedures, to achieve objectives and respond to risks.

Collectively, FAA's partial use of key risk-management principles in its efforts related to small UAS limits its ability to perform effective safety oversight in this area. In particular, its inconsistent analyses of safety risks posed by these systems and methods for determining which safety control to implement limits its ability to determine and implement a level of controls and oversight appropriate to the risks these systems pose.

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## FAA and DHS Have Taken Some Actions and Coordinated with Other Agencies to Address Security Risks Posed by Small UAS

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### FAA Is Coordinating with DHS and Other Agencies on Assessing Small UAS Security Risks

According to DHS, it is responsible for responding to airborne threats, in concert with other agencies, and for coordinating efforts for protecting the nation's critical infrastructure. FAA has been coordinating with DHS and participating in interagency work groups to assess, detect, and mitigate security risks posed by small UAS to the NAS and critical infrastructure. In December 2015, FAA and DHS began cooperating on broad research activities that support the integration of UAS into the NAS with an emphasis on enhancing both aviation safety and security. This research has focused specifically on UAS detection and identification technologies. The detection of potential threats posed by small UAS operations has become increasingly important, as there are more reported sightings of UAS flying close to aircraft at some of the country's busiest airports and other sensitive areas. FAA has also been coordinating with DHS and others on detection technologies to address safety and security risks associated with small UAS operations in the proximity of airports. Table 6 below describes each of these efforts.

**Table 6: Federal Efforts to Research Technologies for Detecting Unmanned Aircraft Systems' (UAS) Operations near U.S. Airports**

Name of effort	Description
UAS Detection Initiative	In October 2015, the Federal Aviation Administration (FAA) initiated a cooperative research and development agreement with CACI International Inc. to evaluate how the company's technology can help detect UAS in the vicinity of airports. Starting in January 2016, FAA and Department of Homeland Security (DHS) evaluated the company's UAS detection system. In May 2016, FAA expanded this effort, called the UAS Detection Initiative, by signing cooperative research and development agreements with three additional UAS detection system manufacturers—Gryphon Sensors, Liteye Systems Inc., and Sensofusion. In November 2016 FAA evaluated systems from Liteye Systems, Sensofusion, and CACI at Denver International Airport and in April 2017 FAA evaluated Gryphon Sensors' technology at Dallas-Ft. Worth Airport. FAA plans to use the data and findings to develop recommendations for standards that will guide the selection of UAS detection systems for airports nationwide.
Interagency UAS Detection at Airports Strategy Working Group	In support of FAA's UAS Detection Initiative (described above) related to the safety and security needs of airports threatened by errant or hostile UAS, FAA and DHS are co-leading an Interagency UAS Detection at Airports Strategy Working Group that includes several federal departments and agencies, such as the Department of Defense (DOD), Federal Bureau of Investigation (FBI), Department of Energy, and Department of the Interior.
The Federal Bureau of Investigation's (FBI) detection system	FAA has partnered with FBI to evaluate a different UAS detection technology. Specifically, in May 2016, FAA and FBI evaluated an existing FBI-developed UAS detection system at John F. Kennedy International Airport.
Department of Defense (DOD) test	In September 2016, as part of its annual joint-U.S. military services exercise to demonstrate and test the latest countermeasure technologies for defense against UAS—DOD tested an airport detection scenario at a DOD facility in support of FAA's detection research. Small UAS mitigation technologies were evaluated, technologies that would be legally prohibited at a civilian airport. FAA provided flight scenarios, air traffic controllers, and a mobile control tower for the test.
MITRE Challenge	To assist in the federal government's counter-UAS technology research, MITRE—a research and development center funded by federal agencies including FAA, DHS, and DOD—sponsored an award competition (for a total of \$100,000) to identify technology solutions that are best able to detect and defeat UAS under 5 pounds that could pose a threat to manned aircraft, critical infrastructure, and urban areas. MITRE held a demonstration event in August 2016 for field evaluations of the eight finalists' counter-UAS technology at the U.S. Marine Corps Base in Quantico, Virginia.

Source: GAO summary of FAA, DHS, and MITRE information. | GAO-18-110

Pursuant to law, FAA—in conjunction with DHS and other relevant federal departments and agencies—is required to establish a pilot program for mitigating airspace hazards posed by UAS at airports and other critical infrastructure.<sup>67</sup> The purpose of the pilot is to ensure that technologies that are developed, tested, or deployed to mitigate threats posed by errant or hostile UAS operations do not adversely affect or interfere with safe airport operations, navigation, air traffic services, or the safe and efficient operation of the NAS. FAA officials told us that while detecting UAS intrusions at airports falls within FAA's mission and authority, the agency's mission does not include countering or disabling small UAS that

<sup>67</sup> FAA Extension, Safety, and Security Act of 2016, § 2206.

may pose a safety or security risk at airports, action that FAA believes is a law enforcement function and responsibility. Congress authorized \$6 million to be appropriated from the Airport and Airway Trust Fund for the pilot and required that FAA report the results by January 15, 2018.<sup>68</sup>

According to FAA, the agency's work through the Interagency UAS Detection at Airports Strategy Working Group, described in table 6 above, will meet this requirement. In May 2018, FAA told us that a draft of the report was being reviewed internally within FAA and the agency could not project a date for the final report to Congress.

FAA is also required, by January 11, 2017, to develop a process for entities to request that FAA prohibit or restrict the operation of UAS in close proximity to critical infrastructure (such as energy production, transmission, and distribution facilities and equipment); oil refineries; chemical facilities; amusement parks; and other locations that warrant such restrictions.<sup>69</sup> FAA officials told us that rulemaking is needed to fully address this requirement, which FAA does not expect to complete until at least 2 years after the deadline in the 2016 act. The officials said FAA will continue to consider requests for temporary flight restrictions—which include restrictions against operations of small UAS—from DOD and other federal security or intelligence agencies to address situations determined to be detrimental to the interests of national security.

According to DHS, the National Security Council is also leading an interagency effort, which includes FAA and other agencies, to assess security risks posed by small UAS and other non-traditional aircraft in the National Capital Region.<sup>70</sup> In a May 2016 risk assessment under that effort, DHS identified 1,560 incidents and encounters of small UAS nationwide. DHS conducted the assessment in collaboration with DOD, U.S. Park Police, DOJ, FAA, and the Washington, D.C., Metropolitan Police Department. DHS assessed the risks related to various scenarios

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<sup>68</sup>The Airport and Airway Trust Fund finances nearly all of FAA's capital investments in the airport and airway system, such as construction and safety improvements at airports and technological upgrades to the air traffic control system. The trust fund is principally funded by a variety of excise taxes paid by users of the NAS.

<sup>69</sup>FAA Extension, Safety, and Security Act of 2016, § 2209.

<sup>70</sup>The National Capital Region is a collection of sovereign jurisdictions whose communicators and public information officers collaborate to achieve the safety and security of the region. Jurisdictions that comprise the region include the District of Columbia; Rockville and Montgomery and Prince George's County, Maryland; and Alexandria and Arlington and Fairfax County, Virginia.

involving either a small UAS or a manned ultralight aircraft. DHS is also co-leading another interagency effort with White House Office of Science and Technology Policy to identify technologies capable of mitigating security risks from UAS.

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### Federal Agencies May Face Legal Restrictions against Countering Potential UAS Security Threats

Agencies may face legal restrictions to detect or mitigate UAS threats. DOJ officials told us that while some use of certain detection technologies for UAS may generally be permissible under current law (e.g., systems that use radar, electro-optical, acoustic, or radio frequency sensors that are configured to passively scan a geographic area for the presence of UAS), other activities—such as jamming or hijacking the radio signals that control a UAS or taking down a UAS by hitting it with a projectile—may be restricted under current statutes. Furthermore, according to DOD, some of the most promising technologies for detecting and mitigating UAS may be construed to be illegal. For example, several provisions in Title 18 designed to protect the privacy of electronic communications are especially problematic and could inhibit the use of detection systems that would record, decode, or capture radio frequency signals transmitted by UAS.<sup>71</sup> Also according to DOD, mitigation systems that would disable, damage, or destroy UAS may conflict with a statute criminalizing destructive actions with respect to aircraft<sup>72</sup> and potential liability under current law restricts innovation, evaluation, and operational use of counter-UAS technologies. In response to several agencies' concern about such restrictions, in May 2017, DOD proposed to Congress to grant federal agencies legal authority to detect UAS to determine whether they pose a threat to the agencies' facilities or operations and to redirect or disable those UAS determined to pose such a threat. DOD included the proposed authority in one of its legislative proposals for the National

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<sup>71</sup>Such statutes include the Pen Register Statute and the Trap and Trace Statute, the Wiretap Act, or the Computer Fraud and Abuse Act 18 U.S.C. §§ 3121–3127; Title III of the Omnibus Crime Control and Safe Streets Act of 1968, 18 U.S.C. §§ 2510–2522; 18 U.S.C. § 1030.

<sup>72</sup>Aircraft Sabotage Act of 1984, Pub. L. No. 98-473, 98 Stat. 1837 (codified at 18 U.S.C. § 32).

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Defense Authorization Act for Fiscal Year 2018. The enacted version of the act did not include the proposed authority.<sup>73</sup>

As part of the National Defense Authorization Act for Fiscal Year 2017, DOD and DOE were granted authority to take actions—including detecting, tracking, and using reasonable force—that are necessary to mitigate the threat that a UAS poses to the safety or security of a covered facility or asset.<sup>74</sup> Both agencies are taking initial steps to utilize this authority. For instance, according to a DOD official’s written testimony at a congressional hearing in March 2017, the Navy and Air Force are working to field counter-UAS capabilities that can effectively detect, track, and, if necessary, engage small UAS vehicles. The official also stated at a congressional hearing in April 2017 that DOD must update its legal guidance, policies, and rules of engagement for its services on how to respond to a UAS posing a threat. In an interview with DOE officials, they emphasized that the mitigation authority is new and the department is developing and implementing the policies necessary to carry out this authority, in consultation with the Secretary of Transportation. In addition, according to DOE officials, there are other laws that must still be considered, such as those related to radio frequency signals.

In our discussions with DHS, officials highlighted the lack of any specific authority to counter the threat of nefarious use of UAS, but discussed broad authorities that could potentially be utilized. However, as stated earlier, Title 18 of the U.S. code may potentially limit the exercise of those broad authorities. DHS officials indicated that several of its agencies have broad authority that could potentially apply to UAS threat mitigation. For example, they told us the Transportation Security Administration has broad statutory authority to respond to threats to all modes of

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<sup>73</sup>See National Defense Authorization Act for Fiscal Year 2018, Pub. L. No. 115-91.

<sup>74</sup>National Defense Authorization Act for Fiscal Year 2017, Pub. L. No. 114-328, §§ 1697, 3112, 130 Stat. 2000. For DOD, a covered facility or asset means any facility or asset that is (a) identified by the Secretary of Defense; (b) located in the United States, including territories and possessions; and (c) relates to DOD’s nuclear deterrence, missile defense, or national security space missions. For DOE, a covered facility or asset means any facility or asset that is (a) identified by the Secretary of Energy; (b) located in the United States, including territories and possessions; and (c) owned by the United States or contracted to the United States to store or use special nuclear material. The National Defense Authorization Act for Fiscal Year 2018 expanded the definition of a covered asset or facility to include those that relate to several other DOD’s missions including protecting the President or the Vice President and special operations activities. National Defense Authorization Act for Fiscal Year 2018, Pub. L. No. 115-91 § 1692, 131 Stat. 1283 (2017).

transportation and to ensure the adequacy of security measures at airports and other transportation facilities. The United States Coast Guard is authorized to protect ports and waterways from terrorism pursuant to the Ports and Waterways Safety Act. Finally, the Federal Protective Service could use its law enforcement authorities to protect federal facilities from any threats, including those posed by UAS. DHS noted, however, that laws related to radio frequency signals may place limitations on DHS's ability to test and operate some of the most promising counter-UAS technologies.

Other agencies highlighted their lack of authority to counter UAS threats. For example, a DOI official told us that DOI has no authority to mitigate threats from small UAS. However, he noted that the agency has some authority to act when its regulations are violated, but this varies widely from agency to agency. For example, all National Park Service locations are closed to the operations of both commercial and recreational UAS; the Park Service typically fines violators, although violators are also subject to up to a 6-month jail sentence. USDA's Office of General Counsel indicated that USDA has no agency-specific authority to mitigate threats from UAS. However, while not specific to USDA enforcement, a recent law established that civil penalties can be assessed up to \$20,000 for UAS pilots who interfere with wildfire suppression, law enforcement, or other emergency response activities—and according to FAA, it will impose these civil penalties.<sup>75</sup> According to U.S. Forest Service officials, the agency is considering proposing additional prohibitions related to UAS use.

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<sup>75</sup>FAA Extension, Safety, and Security Act of 2016, Pub. L. No. 114-190, §2205, 130 Stat. 615 (2016).

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## Selected Foreign Countries Are Addressing Safety Risks from Small UAS Operations

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### The Selected Countries All Had Regulations in Place for Commercial Operations to Address Safety Issues

Table 7 summarizes and compares the regulatory frameworks for small UAS operations in the United States and our five selected countries (Australia, Canada, France, Japan, and the United Kingdom).<sup>76</sup>

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<sup>76</sup>As noted in appendix II, our selection was based on the countries that were suggested by a leading UAS industry trade group; that were most often mentioned in our stakeholder interviews; that were among the leading countries in the development of a framework to ensure the safe and secure operation of small UAS in their respective domestic airspace; that have established classes or definitions of UAS; and are members of JARUS. We reviewed the regulations and policies of each country.

**Table 7: Comparison of Regulatory Frameworks for Small Unmanned Aircraft Systems’ (UAS) Operations in the United States and Five Selected Countries**

Element	United States	Australia	Canada	France	Japan	United Kingdom
Distinguishes between commercial and recreational use	√	√	√	√		√
Regulates recreational small UAS <sup>a</sup>			√		√	√
Regulates commercial small UAS	√	√	√	√	√	√
Enforces compliance with laws and regulations	√	√	√	√	√	√
Requires authorization to use particular airspace	√	√	√	√	√	√
Divides small UAS into weight classifications		√	√	√	√	√
Requires pilot training or certification	√	√	√	√		√
Allows beyond visual line-of-sight operations <sup>b</sup>	√	√	√	√	√	√
Restricts altitude	√	√	√	√	√	√
Restricts airport proximity	√	√	√	√	√	√
Requires small UAS registration	√		√	√		

Source: GAO analysis of UAS regulations in foreign countries. | GAO-18-110

Note: These are very general comparisons based on each country’s regulations for both small commercial and recreational UAS operations. Therefore, a country may be checked as having a regulatory requirement even though a specific regulatory requirement does not apply to both commercial and recreational operations.

<sup>a</sup>In the United States, FAA regulates recreational small UAS by prohibiting recreational small UAS from endangering the NAS. However, the FAA Modernization and Reform Act of 2012 prohibits FAA from promulgating any regulation regarding a recreational small UAS.

<sup>b</sup>All allow beyond line-of-sight operations with conditions, such as in a very limited capacity on a case-by-case basis in segregated airspace.

In addition to the regulations of the five selected countries for integrating UAS into their respective airspace, officials from these countries reported to us the following actions:

Two of our five selected countries, like the United States, have chosen to rely on community-based organizations—many of whom represented the early UAS pilots before the rapid growth of small UAS manufacturing and sales—for assistance in providing guidelines and education for recreational small UAS pilots.

All five noted that they coordinate and collaborate with other government agencies, and four indicated that they do so with industry.

All five reported collecting data on either encounters with UAS or on accidents and incidents involving UAS.<sup>77</sup>

Officials from three of our selected countries told us that they were using new and reallocated internal resources to meet the new challenge of overseeing the emerging small UAS industry.

Table 8 summarizes and compares the regulatory frameworks for small UAS operations in the United States and our five additional selected countries (China, Germany, Israel, Poland, and South Africa).<sup>78</sup>

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<sup>77</sup>For example, the U.K.'s CAA, which also collects UAS sightings reports, uses a board of aviation experts to review and vet the reports. The vetting process includes an assessment panel of 14 experienced current or former pilots and air traffic controllers who, on a monthly basis, review reports of near-misses between aircraft, including reports involving small UAS. The panel assesses the information to determine what factors caused the incident and the risk of collision on a five-level scale: (1) serious; (2) safety compromised; (3) no risk; (4) insufficient information; or (5) normal safety standards pertained.

<sup>78</sup>See Law Library of Congress, *Regulation of Drones*, April 2016. We reviewed the study to summarize these countries' statutes, regulations, policies, and other efforts regarding small UAS safety. We did not independently verify this information with any of the CAAs or governments.

**Table 8: Comparison of Regulatory Frameworks for Small Unmanned Aircraft Systems' (UAS) Operations in China, Germany, Israel, Poland, and South Africa**

Element	United States	China	Germany	Israel	Poland	South Africa
Distinguishes between commercial and recreational use	√		√		√	√
Regulates recreational small UAS		√	√	√		√
Regulates commercial small UAS	√	√	√	√	√	√
Enforces compliance with laws and regulations	√	√	√	√	√	√
Requires authorization to use particular airspace	√	√	√	√	√	√
Divides small UAS into weight classifications		√	√			√
Requires pilot training or certification	√			√	√	√
Allows beyond visual line-of-sight operations <sup>a</sup>	√	√	√		√	√
Restricts altitude	√		√	√		√
Restricts airport proximity	√	√	√	√	√	√
Requires small UAS registration	√	√				√

Source: GAO presentation of Law Library of Congress analysis. | GAO-18-110

Note: These are very general comparisons based on each country's regulations for both small commercial and recreational UAS operations. Therefore, a country may be checked as having a regulatory requirement even though a specific regulatory requirement does not apply to both commercial and recreational operations.

<sup>a</sup>All allow beyond line-of-sight operations with conditions, such as in a very limited capacity on a case-by-case basis in segregated airspace.

See appendix IV for additional information on the selected countries' actions to address the safety risks from small UAS operations.

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## International Organizations and the European Union Are Also Addressing Small UAS Safety

Beginning in 2007, through the ICAO's UAS Study Group and with FAA's participation, ICAO has been involved with establishing guidance on the fundamental international regulatory framework needed to support routine operation of UAS throughout the world. In 2011, ICAO issued a publication aimed at providing a first step in developing such a framework for UAS through standards, recommended practices, and guidance material.<sup>79</sup> In January 2015, ICAO published its *Manual on Remotely Piloted Aircraft Systems* to provide guidance to the entire UAS community—including regulators, manufacturers, operators, pilots, and air-navigation service providers—on technical and operational issues related to the integration of UAS in airspace used by manned aircraft and at airports. In December 2016, ICAO added to its website a UAS toolkit designed to assist states with development of UAS operational guidance, regulations, and enabling operations in a safe manner; and to help UAS operators and pilots operate their UAS safely and responsibly. ICAO has also hosted social media events to encourage the use of the toolkit as well as UAS-related symposiums and workshops.

Another global effort aimed at international harmonization of UAS standards is led by JARUS. JARUS's key aim is to recommend a single set of technical, safety and operational requirements for the certification and safe integration of UAS.<sup>80</sup> To date, JARUS has published nine documents related to a range of UAS topics that provide recommendations and guidance materials that countries' aviation authorities can use in developing their own rules and regulations—e.g., on specifications for unmanned rotorcraft and aircraft and uniform

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<sup>79</sup>ICAO, *Unmanned Aircraft Systems*, Circular 328 (Montreal, Quebec, Canada: 2011). It is in this publication that ICAO shifted from use of the term "UAS" to "remotely piloted aircraft system." The shift was made to better reflect that UAS are piloted.

<sup>80</sup>JARUS has implemented seven working groups that focus on (1) a concept of operations for an appropriate UAS regulatory framework; (2) operations requirements, including requirements for access to airspace; (3) requirements for the oversight of organizations in such activities as operations and UAS pilot training; (4) establishing UAS airworthiness and certification provisions or specifications; (5) designing appropriate performance provisions and functions for UAS detect and avoid systems; (6) establishing performance provisions for communications systems; and (7) designing UAS airworthiness, system safety objectives, and guidance material.

personnel licensing and competencies in UAS operation—and has five more documents in development.

Currently, the European Aviation Safety Agency (EASA) has no power to regulate the use of civilian UAS that weigh 330 pounds or less. This is left to the member states, and, according to an EASA official, each of the 28 members has its own national system for regulating UAS. However, the European aviation community agreed on principles for UAS use in a March 2015 declaration.<sup>81</sup> The declaration included the following key guiding principles to be taken under consideration in the future regulation of UAS:

The European Union must deal with UAS as a new type of aircraft and any safety rules imposed must be proportional to the risk of each operation.

The European Union must establish safety rules, technology requirements, and standards for the integration of UAS into civil aviation.

A legislative process is underway aimed at shifting responsibility for developing a regulatory framework for operations of UAS weighing 330 pounds or less from the European Union's member states to EASA. Under this framework, EASA would develop the rules and regulations for UAS that would be applied by member states, but the oversight of UAS operations would be conducted by each member state's CAA. In August 2016, EASA published proposed regulations to give member states an idea of what to expect should EASA receive this expanded UAS authority.<sup>82</sup> In December 2017, the member states endorsed an agreement to the framework and, according to the European Council, the framework is expected to be formally approved in spring 2018.

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## Conclusions

FAA's actions to expand the safe use of small UAS in the national airspace system have helped enable an increase in the number of

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<sup>81</sup>Riga Declaration on Remotely Piloted Aircraft (Drones), *Framing the Future of Aviation*, (Mar. 6, 2015).

<sup>82</sup>European Aviation Safety Agency, "'Prototype' Commission Regulation on Unmanned Aircraft Operations," August 22, 2016. The EASA official also noted that should EASA not receive authority to regulate UAS less than 330 pounds, the proposed regulations would serve as a guide for member states developing their own regulations.

commercial and recreational uses. As FAA proceeds with its plans to achieve full integration of small UAS into the NAS, it will be important for FAA to ensure that the safety risks from increased and expanded uses are addressed, while enabling development of this technology's commercial potential. However, FAA's ability to perform effective safety oversight is limited by FAA's lack of reliable data on unsafe use of small UAS and deficiencies in FAA's risk management approach. Specifically, FAA's ability to determine and implement a level of controls and oversight appropriate to the risks these systems pose is hindered by FAA's lack of reliable data on the safety of these systems in operation and by FAA's inconsistent application of safety risk management principles and requirements in the agency's policies related to analyzing, addressing, and monitoring safety risks. FAA is taking steps to improve its data on unsafe use of UAS, including evaluating technologies for detecting UAS. Improved risk-management practices would help FAA determine whether additional actions are needed to ensure the safety of the NAS and would provide FAA and other decision makers with confidence that FAA was focusing on the most critical safety risks posed by small UAS.

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## Recommendation for Executive Action

We are making the following recommendation to FAA:

The Administrator of FAA should establish a mechanism, such as an internal review procedure, to ensure that FAA's management of safety risks posed by small UAS operations in the NAS follows all applicable principles and requirements in FAA's policies.

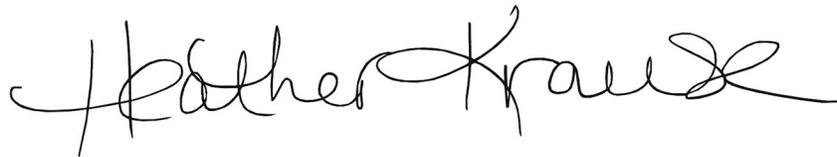
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## Agency Comments

We provided a draft of this report to the departments of Agriculture, Defense, Energy, Homeland Security, the Interior, Justice, and Transportation (FAA), and the National Aeronautics and Space Administration for review and comment. In its official comments, reproduced in appendix V, FAA agreed with our recommendation and provided technical comments, which we incorporated as appropriate. The departments of Defense, Homeland Security, and Justice also provided technical comments, which we incorporated as appropriate. The departments of Agriculture, Energy, and the Interior, and the National Aeronautics and Space Administration had no comments.

We are sending copies of this report to the appropriate congressional committees, the Secretary of Transportation, the FAA Administrator, and other interested parties. In addition, the report is available at no charge on the GAO website at <http://www.gao.gov>.

If you or your staff have any questions about this report, please contact me at (202) 512-2834 or by e-mail at [KrauseH@gao.gov](mailto:KrauseH@gao.gov). Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made major contributions to this report are listed in appendix VI.



Heather Krause  
Director, Physical Infrastructure Issues

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*List of Requesters*

The Honorable John Thune  
Chairman  
The Honorable Bill Nelson  
Ranking Member  
Committee on Commerce, Science, and Transportation  
United States Senate

The Honorable Bill Shuster  
Chairman  
The Honorable Peter DeFazio  
Ranking Member  
Committee on Transportation and Infrastructure  
House of Representatives

The Honorable Frank A. LoBiondo  
Chairman  
The Honorable Rick Larsen  
Ranking Member  
Subcommittee on Aviation  
Committee on Transportation and Infrastructure  
House of Representatives

## Appendix I: Policy and Technology Tools Identified as Helpful for Addressing Risks Posed by Small Unmanned Aircraft Systems

Based on literature we reviewed and interviews we conducted with selected federal agencies, aviation industry stakeholders, and others, some policies and technologies have been identified as having the potential for addressing safety and security risks associated with the use of small unmanned aircraft systems (UAS). Table 9 below describes these policies and technologies as well as the Federal Aviation Administration's (FAA) status in implementing selected policies and technologies. The literature we reviewed included publicly available information and documentation from federal agencies—Bureau of Reclamation within Department of the Interior, Department of Defense, Department of Energy, Department of Homeland Security, FAA, and the National Aeronautics and Space Administration—selected aviation industry stakeholders and others with expertise on this topic. We also conducted interviews with aviation industry stakeholders and officials from FAA and the other federal agencies from the obtained documentation. We selected these federal and industry stakeholders based on our prior work, literature review, and interviews. In consultation with one of our technology experts, we reviewed the information we obtained from the listed sources that identified policy and technology tools that could mitigate the risks associated with unauthorized small UAS operations. We did not independently review or assess the information we obtained related to these policies and technologies. We also did not attempt to determine the appropriateness or potential impact. For further details on our methodology, see appendix II.

**Appendix I: Policy and Technology Tools  
Identified as Helpful for Addressing Risks  
Posed by Small Unmanned Aircraft Systems**

**Table 9: Selected Policy and Technology Tools That Have Been Identified as Potentially Helping to Address Risks Posed by Small Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS)**

Tool	Description
<b>Airspace designation</b>	<p>Would limit small UAS flights to designated airspace, thereby separating UAS flights from most manned aircraft flights.</p> <p>FAA currently requires those operating small UAS under the agency’s small UAS regulations to fly below 400 feet and remain clear of airspace in which FAA provides air-traffic control service unless a waiver or special authorization is obtained.</p>
<b>Flight preparation</b>	<p>Would require the pilot of the small UAS to take steps prior to flight such as inspecting the UAS to ensure it is in condition for safe flight; becoming familiar with the area of operation including local weather conditions, local airspace and any flight restrictions, the location of persons and property on the ground, and any other ground hazards; or the filing of a flight plan.</p> <p>FAA currently requires those operating small UAS under the agency’s small UAS regulations to conduct a pre-flight check to ensure the UAS is in condition for safe operation.</p>
<b>Pilot certification</b>	<p>Would require the pilot of the small UAS to take a knowledge-based or skills-based test prior to being allowed to operate the aircraft.</p> <p>FAA currently requires only pilots of commercial small UAS to pass a knowledge-based test. Individuals who wish to be certified to pilot small UAS and who have a traditional pilot’s certificate may take FAA’s online training course and apply for a small UAS rating.</p>
<b>Operator certification</b>	<p>Would require prospective commercial operators—i.e., the companies responsible for the operation of the small UAS—to apply for permission or certification to operate. Applicants could be required to describe how their proposed use would minimize risk to other aircraft and to persons and property on the ground.</p> <p>FAA does not require commercial operators to apply for permission or certification to operate.</p>
<b>User education or training</b>	<p>Would require recreational small UAS operators (individuals) to be provided with information in some form—for example, online, in UAS packages at purchase, or in web applications. FAA could also provide or require training on knowledge and skills required to operate small UAS, such as small UAS operating principles and rules and airspace rules and procedures.</p> <p>Although FAA cannot require such training to educate recreational small UAS operators,<sup>a</sup> FAA has implemented, in collaboration with the industry, the Know Before You Fly Program and created the Before You Fly mobile application. FAA staff also attends industry meetings and FAA holds its own forums to educate and train the industry regarding UAS operations.</p>
<b>Permanent and temporary flight restriction areas</b>	<p>Would require certain areas or sites to be designated as “No Drone Zones” either temporarily (e.g., for a major sporting event) or permanently to protect national historic and other sites and the people who use them from danger that could be caused by UAS.</p> <p>FAA has designated “No Drone Zones” in the United States. For example, the nation’s capital is governed by a Special Flight Rules Area within a 30-mile radius of Ronald Reagan Washington National Airport, which restricts all flights in the greater Washington, D.C., area. The Special Flight Rules Area is divided into a 15-mile radius inner ring and a 30-mile radius outer ring. Flying a UAS within the 15-mile radius inner ring is prohibited without specific FAA authorization. Flying a UAS between 15 and 30 miles from Washington, D.C., is allowed under certain operating conditions.</p>
<b>UAS certification</b>	<p>Would require small UAS, prior to their use, to be certified by FAA to operate within the NAS. Certification involves FAA approval of the design, manufacturing, and operations of the aircraft. UAS certification could be accomplished via a certificate of conformity. This document would certify that the vendor’s product met all certification requirements designed to assure operational safety. Currently, all manned aircraft must be certified by FAA to operate within the NAS.</p> <p>FAA currently does not require certification of UAS but says that it may require such certification in the future depending on the type of UAS and the type of operation.</p>

**Appendix I: Policy and Technology Tools  
Identified as Helpful for Addressing Risks  
Posed by Small Unmanned Aircraft Systems**

<b>Tool</b>	<b>Description</b>
<b>UAS registration and markings</b>	<p>Would require that pilots who are operating small UAS or the UAS itself, or both, be registered with FAA as a means to interact directly with them on rules for operating UAS and to provide some operator accountability should an accident or violation of regulations occur.</p> <p>FAA currently requires commercial and recreational small UAS operators to register their UAS with FAA. In December 2015, FAA required all small UAS users to register with FAA through a new online registration system or through the traditional paper-based system. As part of the registration process, users are required to mark their UAS with their registration number.</p>
<b>Sense and avoid system</b>	<p>Would provide small UAS with the capability to avoid collisions with other manned and unmanned aircraft operating in the NAS. These technologies use instruments on the small UAS that sense other aircraft and avoid coming within an unsafe distance of those aircraft. Sensing of other aircraft is typically accomplished by receiving a signal from those aircraft. Some technologies sense and avoid other obstacles, such as buildings and infrastructure.</p> <p>FAA does not require this technology for small UAS. However, FAA is working with industry partners to develop standards for sense-and-avoid systems to meet FAA's requirements for being used in the NAS.</p>
<b>Command and control link</b>	<p>Would provide small UAS with the capability to be operated beyond the visual line of sight of a pilot. These technologies use radio spectrum for communications links between the small UAS and its control station. These links can be broken by interference from other signals or hacking, causing potentially dangerous situations. According to FAA, the reliability of command and control links needs to improve before the agency will allow more routine operations of small UAS beyond the visual line of sight of the pilot.</p> <p>FAA requires this technology for small UAS. Command and control link technologies are being researched and developed in several countries, including the United States.</p>
<b>Geofencing</b>	<p>Would provide the capability to establish or define geographic perimeters separating areas where small UAS operations are permissible and those where they are not. These technologies use software that is installed on the UAS to compare the UAS's position with the location of the geographic perimeter and determine whether it is in a location where flight operations are permitted.</p> <p>FAA does not require this technology for small UAS. However, research and development efforts are under way for this technology, and at least three major small UAS manufacturers are providing geofencing functionality with their products.</p>
<b>Radio frequency detection</b>	<p>Would provide a method to detect small UAS by the radio signals emitted by most commercially available UAS.</p> <p>Several commercial off-the-shelf products exist for this technology, and research and development efforts are under way for this technology. However, these technologies have not yet been deployed by FAA or other federal agencies in part because of technical, legal, or operational issues related to their use.</p>
<b>Electro-optical detection</b>	<p>Would provide a method to detect small UAS by the visible light emitted or reflected by an object.</p> <p>Several commercial off-the-shelf products exist for this technology, and research and development efforts are under way for this technology. However, these technologies have not yet been deployed by FAA or other federal agencies in part because of technical, legal, or operational issues related to their use.</p>
<b>Infrared detection</b>	<p>Would provide a method to detect small UAS by the heat that is emitted by UAS.</p> <p>Several commercial off-the-shelf products exist for this technology. Research and development efforts are under way for this technology. However, these technologies have not yet been deployed by FAA or other federal agencies in part because of technical, legal, or operational issues related to their use.</p>

**Appendix I: Policy and Technology Tools  
Identified as Helpful for Addressing Risks  
Posed by Small Unmanned Aircraft Systems**

<b>Tool</b>	<b>Description</b>
<b>Acoustic detection</b>	<p>Would provide a method to detect small UAS by the sounds that are generated by a UAS.</p> <p>Several commercial off-the-shelf products exist for this technology. Research and development efforts are under way for this technology. However, these technologies have not yet been deployed by FAA or other federal agencies in part because of technical, legal, or operational issues related to their use.</p>
<b>Radar detection</b>	<p>Would provide a method to detect small UAS in which radio waves from a transmitter reflect off the object and return to a receiver, giving information about the object's location and speed, and would be similar to radars used to detect aircraft in the NAS.</p> <p>Several commercial off-the-shelf products exist for this technology. Research and development efforts are underway for this technology. However, these technologies have not yet been deployed by FAA or other federal agencies in part because of technical, legal, or operational issues related to their use.</p>
<b>Disabling technologies</b>	<p>Would provide the capability to disable small UAS. Once a small UAS is detected, disabling technologies could use either physical or electronic communications means to either trap it, destroy it, or to force the small UAS to land.</p> <p>There are several technologies with disabling capability available and in development. However, these technologies have not yet been deployed by FAA or other federal agencies in part because of technical, legal, or operational issues related to their use.</p>

Source: GAO review of literature and interviews with selected stakeholders. | GAO-18-110

<sup>a</sup>The FAA Modernization and Reform Act of 2012 prohibited FAA from promulgating any new regulations for small UAS being operated exclusively as model aircraft (which this report refers to as "recreational small UAS"), as defined by the law. The law defined model aircraft as unmanned aircraft that are (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. The operation of the aircraft must also meet the following conditions: (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 with prior notice of the operation. FAA Modernization and Reform Act of 2012, §§ 336(c), 336(a)(1)-(5).

## Appendix II: Objectives, Scope, and Methodology

This report focuses on the potential safety and security risks posed by small unmanned aircraft systems (UAS) operating in the national airspace system (NAS) and potential mitigations for those risks. Specifically, this report examines: (1) what information is available to the Federal Aviation Administration (FAA) about the extent of unsafe small UAS use in the NAS, (2) what steps FAA has taken to safely integrate small UAS into the NAS, (3) the extent to which FAA's management of safety risks posed by small UAS has followed key principles of risk management; (4) what steps selected federal agencies have taken to address security risks posed by small UAS operations in the NAS, and (5) what selected foreign countries have done to address safety risks associated with the operation of small UAS. In addition, this report includes descriptions of selected policies and technologies that have been identified as potentially helping to address the risks posed by small UAS in the NAS in appendix I.

We reviewed and synthesized available literature and documents related to the topic areas, including relevant laws, FAA regulations, government and industry reports on efforts to address safety and security risks, and related FAA policy, guidance, plans, and safety-risk management documents. We also reviewed relevant statutes and regulations. In addition, we interviewed FAA officials and conducted semi-structured interviews with a broad variety of aviation industry stakeholders, including aviation industry groups, aviation companies, aviation experts, law firms, and academic institutions. See table 10 for a list of the aviation industry stakeholders we interviewed. We judgmentally selected these 46 stakeholders based on our prior work, literature review, and interviews with FAA, other agencies, and aviation industry stakeholders, to include those with expertise or experience related to small UAS safety or security issues related to integration of small UAS in the national airspace. We primarily used a semi-structured interview format with open-ended questions to obtain aviation stakeholder perspectives on safety issues posed by small UAS operations. The information we obtained from our interviews cannot be generalized for aviation industry stakeholders, but offers insight into understanding the issues examined in this report.

**Table 10: List of Aviation Industry Stakeholders That GAO Interviewed**

<b>Category</b>	<b>Interviewee</b>
Aviation and other industry groups	Airlines for America (A4A)
	American Association of Airport Executives (AAAE)
	Associated Aerial Firefighters (AAF)
	Airports Council International-North America (ACI-NA)
	Aerospace Industries Association (AIA)
	Association of Air Medical Services (AAMS)
	American Helicopter Services & Aerial Firefighting Association (AHSFA)
	Airborne Law Enforcement Association (ALEA)
	Academy of Model Aeronautics (AMA)
	Aircraft Owners and Pilots Association (AOPA)
	Association for Unmanned Vehicles Systems International (AUVSI)
	General Aviation Manufacturers Association (GAMA)
	Helicopter Association International (HAI)
	International Association of Chiefs of Police (IACP)
	National Agricultural Aviation Association (NAAA)
	National Association of Mutual Insurance Companies (NAMIC)
	National Association of State Aviation Officials (NASAO)
Remote Control Aerial Platform Association (RCAPA)	
Small UAV Coalition	
Companies	Amazon Prime Air
	The Boeing Company
	CACI International
	DJI
	DroneShield
	GE Aviation
	Google X
	Gryphon Sensors
	Honeywell
	Liteye
Lockheed Martin Corporation	
Robinson Helicopter	
Transport Risk Management	
Employee organizations	Air Line Pilots Association (ALPA)
	National Air Traffic Controllers Association (NATCA)
Experts	Loretta Alkalay, Vaughn College of Aeronautics

**Appendix II: Objectives, Scope, and Methodology**

<b>Category</b>	<b>Interviewee</b>
	John Goglia, independent consultant; formerly Board Member of the National Transportation Safety Board
	John Hansman, Massachusetts Institute of Technology
	Nathan Schuett, PreNav
	Jim Williams, Dentons; formerly head of FAA's UAS Integration Office
Law Firms	Hogan Lovells
	Riley Wein
Universities	Embry Riddle Aeronautical University (ERAU)
	University of North Dakota (UND)
	Virginia Tech
Others	MITRE
	Radio Technical Commission for Aeronautics (RTCA)

Source: GAO. | GAO-18-110

To examine what information is available to FAA about the extent of unsafe small UAS use in the NAS, we obtained and analyzed recent FAA data on (1) reports by pilots of manned aircraft, air traffic controllers, and others of UAS sightings from February 2014 through April 2018; (2) reports by pilots of manned aircraft of near mid-air collisions between UAS and manned aircraft from January 2013 through April 2018; (3) accidents, incidents, and malfunctions required to be reported by certain commercial small UAS operators to FAA from March 2015 through August 2017;<sup>1</sup> and (4) accidents required to be reported by commercial small UAS pilots operating under FAA's regulations from August 29, 2016, to May 1, 2018.<sup>2</sup> We reviewed documentation about these data and the systems that produced them and interviewed knowledgeable FAA officials on how the data are collected, maintained, and verified, as well as on limitations related to the reliability of the data, and we found the data to be sufficiently reliable for our reporting purposes.

<sup>1</sup>A commercial small UAS operator is a company responsible for the operation of a small UAS. In September 2014, FAA began reviewing and approving applications to allow certain UAS operations in the NAS prior to the agency's implementation of its regulations for allowing routine small UAS use in the NAS—as required under section 333 of the FAA Modernization and Reform Act of 2012 (2012 act). FAA requires such operators to submit reports of accidents, incidents, and malfunctions to FAA. FAA was able to provide us data covering reporting for March 2015 through August 2017.

<sup>2</sup>FAA's regulations, which took effect on August 29, 2016, require commercial small UAS pilots to report any operation of a small UAS involving serious injury to any person or loss of consciousness, or certain cases of damage to property.

In addition, we used information obtained during our interviews with knowledgeable FAA officials and relevant studies of FAA's data from the Academy of Model Aeronautics (AMA)<sup>3</sup> and the Center for the Study of the Drone at Bard College to determine the extent to which FAA's data may inform the extent of potentially unsafe use in the NAS. We assessed the extent to which FAA's data meet federal internal control standards related to using quality information to achieve objectives.<sup>4</sup> Some of our selected aviation industry stakeholders we interviewed shared their perspectives on the reliability of FAA's data on UAS sightings. We obtained data from the National Aeronautics and Space Administration's (NASA) Aviation Safety Reporting System—which NASA maintains on behalf of FAA—on reports of potentially unsafe use of UAS from January 2005 through August 2016. We reviewed documentation about these data and the system that produced them, including how the data are collected, maintained, and verified, and we found the data to be sufficiently reliable for our reporting purposes. We also obtained information other selected federal agencies collected on UAS sightings related to their missions and assets, specifically from the Department of Homeland Security (DHS), the Department of Defense (DOD), Department of Energy (DOE), the Bureau of Prisons within the Department of Justice (DOJ), the U.S. Park Police within the Department of the Interior (DOI), and the U.S. Forest Service within the U.S. Department of Agriculture (USDA). We selected these agencies based on our discussions with DHS and on literature indicating that UAS incursions may have posed a safety or security risk to their facilities or operations. We determined the data to be sufficiently reliable for our reporting purposes. In addition, we interviewed our selected aviation industry stakeholders and FAA officials to obtain their views on the safety risks posed by small UAS.

To examine the steps FAA has taken to safely integrate small UAS into the NAS, we reviewed FAA regulations, education outreach efforts, and planning and reporting documents related to UAS integration into the NAS. For example, we obtained and reviewed the agency's 2013 Roadmap for the Integration of UAS into the NAS, its fiscal years 2017 and 2018 implementation plans for UAS integration into the NAS, its 2016 Report to Congress on its UAS Detection Initiative, as well as rulemaking

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<sup>3</sup>AMA, founded in 1936, is the largest model aviation association and represents those who fly model aircraft for recreation and educational purposes.

<sup>4</sup>GAO, *Standards for Internal Control in the Federal Government*, [GAO-14-704G](#) (Washington, D.C.: Sept. 10, 2014).

documents and aviation advisory and rulemaking committees' reports. We also obtained FAA's data on (1) the locations of small UAS registrants as of October 31, 2017, and (2) all enforcement actions taken against small UAS operators related to unsafe and unauthorized use through May 2, 2018. We reviewed documentation about these data and the systems that produced them and interviewed knowledgeable FAA officials on how the data are collected, maintained, and verified, and we found the data to be sufficiently reliable for our reporting purposes. We also reviewed documentation from FAA's Research and Development Advisory Committee and FAA's Micro UAS Aviation Rulemaking Committee. In addition, we interviewed our selected aviation industry stakeholders about their perspectives on FAA's actions. We also interviewed officials from NASA and reviewed agency documents about the agency's development and testing of a traffic management system for small UAS.

To examine the extent to which FAA's management of safety risks posed by small UAS has followed key principles of risk management, we identified five key principles and 15 supporting requirements from FAA's policy on safety risk management and compared FAA's risk management actions to the principles and requirements.<sup>5</sup> We selected the requirements based on our judgement that following the requirements collectively should ensure that FAA's policy objective for safety risk management "to provide supporting information for decision-makers by identifying hazards, analyzing safety risk, assessing safety risk, and developing controls to reduce risk to an acceptable level" would be met. Several of the principles and requirements in FAA's policies are similar to standards, principles, and guidelines in the federal internal control standards and the *International Organization for Standardization's Risk Management—Principles and Guidelines*.<sup>6</sup>

We evaluated FAA's risk management practices involved in carrying out selected agency efforts related to small UAS. We selected FAA efforts that involved development of regulations for small UAS or issuing exemptions or waivers to those regulations or other aviation regulations. The selected efforts were (1) development of the rule on registration of

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<sup>5</sup>The policy applies to all aspects of FAA's oversight functions for making planned changes to the NAS and when potential and previously unidentified hazards and ineffective safety-risk controls are discovered. FAA, Safety Risk Management Policy, Order No. 8040.4A (Washington, D.C.: April 30, 2012).

<sup>6</sup>[GAO-14-704G](#) and International Organization for Standardization, *Risk Management - Principles and Guidelines*, ISO 31000:2009(E) (Geneva: Nov. 15, 2009).

small UAS; (2) the transitional process for authorizing commercial small UAS operations;<sup>7</sup> (3) development of the small UAS regulations; (4) the process for waiving certain requirements in the small UAS regulations; (5) the process for approving requests from small UAS pilots for authorization to operate in airspace served by air traffic control; and (6) two Pathfinder projects.<sup>8</sup> For each of these efforts, we assessed FAA's practices against the five key principles and related supporting requirements by examining, as relevant, FAA's safety-risk management documents, final rules, monitoring data, and other related documents, and by interviewing FAA officials. We then determined whether each requirement was followed—meaning all or nearly all of FAA's practices followed the requirement; partially followed—meaning some of FAA's practices followed the requirement; or not followed—meaning all or nearly all of FAA's practices did not follow the requirement. We then determined whether each principle was followed—meaning all three requirements under the principle were followed; not followed—meaning all three requirements under the principle were not followed; or partially followed—meaning that the principle was neither followed nor not followed. For example, if we found supporting evidence that FAA followed two of the three requirements under a principle but only partially followed the other requirement, we would determine that FAA partially followed the principle. One analyst performed the assessment, and a second analyst reviewed the assessment and resolved any disagreements with the first analyst.

To examine steps that selected federal agencies have taken to address security risks posed by small UAS operations in the NAS, we obtained and reviewed documents related to security risks posed by small UAS from FAA and other selected federal agencies including DHS, DOD, DOE, DOJ, DOI, and USDA. We also obtained and reviewed documents from FAA and the other federal departments and agencies related to

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<sup>7</sup>In September 2014, FAA began reviewing and approving applications for exemption of UAS from the agency's aircraft airworthiness certification requirements—as required under section 333 of the 2012 act—to allow certain commercial UAS operations in the NAS prior to the agency's implementation of its regulations for allowing routine small UAS use in the NAS. In broad terms, FAA's aircraft airworthiness certification requirements are that aircraft (1) conform to the FAA-approved design for the aircraft's type and (2) are in condition for safe flight.

<sup>8</sup>We assessed FAA's risk management practices for the Pathfinders with BNSF Railway and PrecisionHawk. However, we did not assess FAA's risk management process for the Pathfinder with Cable News Network (CNN) because that process mainly involved FAA approving CNN's operations under the agency's transitional process for authorizing commercial small UAS use, and we assessed that process separately.

inter-agency coordination on managing security risks from small UAS and interviewed appropriate department and agency officials. In addition, we interviewed our selected aviation industry stakeholders about their perspectives on FAA's and other federal agencies' actions.

To describe actions that have been taken by selected foreign countries to address safety risks associated with the operation of small UAS, we reviewed publicly available information and interviewed FAA officials about leading countries in development of a regulatory framework for ensuring safe operations of small UAS in their respective domestic airspace. We also interviewed our selected aviation industry stakeholders about their perspectives on lessons that could be learned from other countries' experiences. We selected five countries—Australia, Canada, France, Japan, and the United Kingdom (U.K.)—that are leaders in the development of a framework for the safe and secure operation of small UAS in their respective domestic airspaces. Our selection was based on the countries that were suggested by a leading UAS industry trade group; were most often mentioned in our stakeholder interviews; were among the leading countries in the development of a framework to ensure the safe and secure operation of small UAS in their respective domestic airspace—according to MITRE;<sup>9</sup> have established classes or definitions of UAS; and are members of Joint Authorities for Rulemaking on Unmanned Systems (JARUS).<sup>10</sup> We reviewed the regulations and policies of each country. We conducted semi-structured interviews with officials from the civil aviation authorities (CAA)—foreign countries' counterparts to FAA—of Australia, Canada, France, and the United Kingdom and obtained written responses from the CAA of Japan. We obtained information and verified the information for their regulations, as well as discussed perspectives, experiences, challenges, and lessons learned about the countries' approach to managing the safety risks associated with small UAS.

To expand our coverage beyond the initial five countries to achieve geographic diversity in our selections, we conducted a literature review and selected an additional five countries—China, Germany, Israel, Poland, and South Africa—based on publicly available information and

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<sup>9</sup>MITRE Corporation, *UAS International Harmonization: A Comparative Policy Assessment of Selected Countries*, Outcome 6, Output 4 (fiscal year 2014).

<sup>10</sup>Established in 2007, JARUS is a group of aviation experts from 50 countries, as well as the European Aviation Safety Agency (EASA), working to recommend a single set of technical, safety, and operational requirements for the safe operation of UAS.

reviewed documentation to summarize their regulations and policies, and other efforts regarding small UAS safety. These countries were also members of JARUS and had UAS regulations in place. We relied primarily on a study by the Law Library of Congress for this information.<sup>11</sup> We did not contact these countries directly and did not independently verify this information with any of these countries' CAAs or governments. The information on the foreign countries we reviewed cannot be generalized to other foreign countries, but offers insight into understanding the issues examined in this report. We also interviewed officials from the International Civil Aviation Organization, the European Aviation Safety Agency (EASA), and JARUS because these organizations play important roles in recommending or establishing UAS regulations in Europe or around the world.<sup>12</sup>

To identify policies and technologies that have been identified as potentially helping to address risks posed by small UAS in the NAS, we reviewed publicly available literature and obtained documents or interviewed officials from the following federal agencies: DOD, DHS, the Park Police and the Bureau of Reclamation within DOI, FAA, the Federal Bureau of Investigation, and NASA. We reviewed the information we obtained—the results of our semi-structured interviews and the documents obtained from aviation industry stakeholders and foreign CAAs—to identify available policy and technological tools that could mitigate the risks associated with unauthorized small UAS operations. For example, we reviewed FAA's final rule on small UAS operations and NASA's concept of operations for an unmanned traffic management (UTM) system. We also reviewed MITRE presentations on counter UAS technologies and Sandia National Laboratories' report, *UAS Detection, Classification, and Neutralization: Market Survey 2015*. We did not attempt to assert the appropriateness or the potential effect for implementation of such policies and technologies by FAA.

We conducted this performance audit from October 2015 through May 2018 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe

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<sup>11</sup>Law Library of Congress, *Regulation of Drones* (April 2016).

<sup>12</sup>ICAO is the international body that, among other things, promulgates international standards and recommends practices in an effort to harmonize global aviation standards.

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that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

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## Appendix III: Federal Aviation Administration's Coordination Efforts with Industry and Academic Stakeholders

The Federal Aviation Administration (FAA) is coordinating with industry and academic stakeholders on efforts intended to inform its decisions for how to manage the safety risks associated with small unmanned aircraft systems (UAS) and to support and facilitate integrating small UAS into the national airspace system (NAS). Table 11 below describes examples of these efforts.

**Appendix III: Federal Aviation Administration's  
Coordination Efforts with Industry and  
Academic Stakeholders**

**Table 11: Examples of the Federal Aviation Administration's (FAA) Efforts to Coordinate with Industry and Academic Stakeholders to Inform the Agency's Management of Safety Risks Posed by Small Unmanned Aircraft Systems' (UAS) Operations**

Name of effort	Description
UAS Test Sites	In December 2013, FAA chose six UAS test sites across the country to provide research findings and data from operations by UAS companies and industry groups to help the agency develop regulations and operational procedures for the safe integration of UAS into the NAS. Several of the test sites are supporting FAA and the National Aeronautics and Space Administration's (NASA) joint effort to determine the feasibility of a system for managing UAS traffic.
Center of Excellence for UAS	In May 2015, FAA selected this research team led by Mississippi State University. In April 2017, the center completed a study that used computer simulations to estimate the effects of collisions between a small UAS and people and property on the ground. In November 2017, the center completed another study that used computer simulations supported by physical tests to estimate the effects of collisions between small UAS and manned aircraft.
Drone Advisory Committee	In May 2016, FAA announced the formation of this committee of government and industry stakeholders; the committee is charged with advising FAA on the needs of UAS users and proposing ways for FAA to address issues affecting the efficiency and safety of integrating UAS into the NAS. In September 2016, the committee identified three initial high-priority issue areas: (1) the relative roles of the federal, state, and local governments in regulating the use of UAS; (2) a process for how FAA is approving new types of UAS operations; and (3) how FAA and other government activities related to integration of UAS in the NAS should be funded, and which of those activities should be privatized, if any.
Unmanned Aircraft Safety Team	In August 2016, FAA announced the creation of this team of government and industry stakeholders; the team is charged with analyzing safety data and developing recommendations to FAA on non-regulatory approaches for enhancing UAS safety. The team's initial efforts include helping FAA develop an annual survey aimed at understanding the population of UAS registered and flown in the United States, developing a system to enable UAS operators to self-report hazardous situations anonymously, and having a small group of industry members volunteer flight data to examine the benefits of analyzing different datasets. <sup>a</sup>
UAS Identification and Tracking Aviation Rulemaking Committee	In June 2017, FAA announced the formation of the committee to advise FAA on issues such as UAS identification and tracking, air traffic management for UAS, concerns and authorities of local law enforcement, and potential legal considerations. The committee includes representatives from the UAS and manned aviation industries, researchers, standards groups, and local law enforcement.
Probabilistic Risk Assessment for UAS Integration	In April 2017, FAA contracted with the National Academy of Sciences to complete a study by July 2018 on the potential use of probabilistic risk assessments <sup>b</sup> by FAA to streamline the integration of UAS into the NAS. <sup>c</sup>

Source: GAO summary of FAA information. | GAO-18-110

<sup>a</sup>The team is modeled on the Commercial Aviation Safety Team, whose work, according to the team, helped reduce the fatality rate of commercial air travel in the United States by 83 percent from 1998 to 2008.

<sup>b</sup>FAA entered into this contract in response to Section 2213 of the FAA Extension, Safety, and Security Act of 2016, which required that, by August 14, 2016, FAA arrange for the National Academies of Sciences, Engineering, and Medicine to conduct such a study, with the results to be provided to Congress by July 15, 2017.

<sup>c</sup>According to NASA and the Department of the Interior's Bureau of Safety and Environmental Enforcement, probabilistic risk assessment is a systematic and comprehensive methodology to evaluate risks associated with complexly engineered technological entities. This assessment involves the assignment of numeric values in the assessment of probability and consequence and attempts to consider all events and consequences in one assessment, allowing for a more robust estimation of risk.

## Appendix IV: Statutory and Regulatory Requirements for Small Unmanned Aircraft Systems' Operations in Select Countries

We selected five countries—Australia, Canada, France, Japan, and the United Kingdom (U.K.)—for review. The information below on these countries is based on our review of each country's regulations and policies pertaining to small unmanned aircraft system (UAS) operations and interviews of officials representing the civil aviation authorities (CAA) of four of the selected countries and written responses from the fifth. In addition, we reviewed the regulations and actions associated with UAS operations of China, Germany, Israel, Poland, and South Africa.<sup>1</sup> The information below on these countries is based primarily on a study by the Library of Congress that summarized these countries' efforts regarding small UAS safety.<sup>2</sup> We did not interview CAA or other officials from these additional countries and we did not independently verify this information with any of the CAAs or governments. See appendix II for further details on our scope and methodology.

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### Australia

Australia does not regulate small UAS used for recreational purposes. Recreational small UAS in Australia are defined as weighing 4.4 to 55 pounds and very small UAS as weighing less than 4.4 pounds. According to officials from Australia's CAA, the agency generally leaves oversight of recreational operations to associations and clubs and prefers to emphasize education and conduct safety promotions. The Australian CAA's general operating guidelines are that recreational small UAS be operated in the visual line of sight of the operator, in unpopulated areas to avoid flying over people or near large groups of people, at or below 400 feet, and not within 3 miles of the movement area of a controlled airfield.

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<sup>1</sup>These countries were selected to provide additional geographic dispersion to the initial group of selected countries.

<sup>2</sup>Law Library of Congress, *Regulation of Drones* (April 2016).

Australia has regulated commercial UAS since 2002, and Australia's CAA is responsible for enforcing the provisions of Australian law relevant to the operations of commercial small UAS. Commercial operators must acknowledge they are aware of and will follow the CAA's regulations. For example, operating a UAS in a way that is hazardous to another aircraft, another person, or property could subject the operator to a penalty. The operating conditions for commercial UAS weighing less than 4.4 pounds include flying only during the day and in the visual line-of-sight of the operator and below 393 feet. Flying is not permitted within 3.4 miles of an air-traffic-controlled airport; over populous areas such as beaches, parks, and sports fields; or near emergency operations, such as firefighting, accidents, or search and rescue. Also, operators must notify the CAA of their intention to conduct operations and the location where the operations will take place. According to CAA officials, the CAA has been attempting to coordinate with state police in the hope that the police can provide them with evidence of such violations.

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## Canada

In March 2017, Transport Canada, Canada's CAA, announced interim measures governing the use of recreational aircraft heavier than 0.55 pounds and up to 77 pounds. According to these interim measures, recreational aircraft must be operated within visual line of sight and no higher than 300 feet above ground level. They also must not operate less than 250 feet from structures and unassociated people and within 5.6 miles from the center of an airport. Contravention of these measures could result in fines for operators, whether individuals or corporations.

According to officials from the CAA, the agency has also generally emphasized education and enforcement for recreational operators. The CAA officials also launched a national safety awareness campaign for UAS to help Canadians better understand areas where it may be illegal or unsafe to fly a UAS and set up a web page that provides guidelines and other information for UAS operators. In December 2016, the CAA launched an online incident-reporting tool, and also collaborates with the aviation and real estate industries and is trying to engage a broad spectrum of users by hosting public UAS events, known as drone fairs. The CAA has also partnered with retailers to provide safety information at the point of sale.

Under the current Canadian commercial regulations, the CAA issues special flight-operating certificates to commercial UAS operators on a

case-by-case basis. Since November 2014, UAS that weigh up to 25 kilograms can be commercially operated with an exemption to the requirement for a special flight-operating certificate while subject to specific operating conditions. In May 2015, the CAA published a notice of proposed amendment for small UAS of 57 pounds or less operated under visual line of sight. Under the proposed new framework, there would no longer be a distinction between commercial and recreational operations. Other proposed changes included exclusion for modeling associations with robust safety guidelines, marking and registration for small complex UAS, and requiring liability insurance for all categories of UAS.

According to officials from the CAA, the agency enforces UAS laws and its regulations through collaboration with law enforcement and works primarily with the Royal Canadian Mounted Police (which is similar to the U.S. Federal Bureau of Investigation). CAA is considering encouraging local law enforcement to detect, track, and identify UAS operators who are in violation of laws or regulations. The operation of a UAS in Canada without a special flight-operating certificate may result in fines for individual and corporate operators.

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## France

France has issued guidelines to its recreational operators in the form of a 10-point letter. The guidelines included such requirements as not flying close to airports or over people and not flying below 492 feet. The guidelines were issued through France's largest UAS manufacturer, Parrot, and an association of operators.

France published its first commercial UAS regulations in 2012, and new regulations became effective in January 2016. According to officials from the France's CAA, in France, UAS are primarily used for commercial operations, such as photography, infrastructure inspections, and surveying. Commercial small UAS operators must request operating approvals from the French CAA; requests are evaluated on a case-by-case basis. France also requires a design certification and safety requirements for some types of UAS, depending on weight and use scenarios.

All civilian UAS operations are subject to geographic restrictions, primarily to protect people, property, and other aircraft. For instance, UAS may not be flown over public areas of urban zones without governmental approval and are required to fly under certain altitudes. Failure to comply with

design and safety requirements is punishable by up to 1 year in jail and a fine.

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## Japan

In 2015 and 2016, Japan promulgated UAS regulations to protect the safety of flying aircraft and people and properties on the ground. Under the 2015 regulations, Japan does not distinguish between recreational and commercial UAS operations. The scope and requirements of the regulation depend on the risk level of the UAS operation, regardless of the purpose of the operation. These UAS are allowed to operate in daytime only, within visual line of sight of the operator, at a distance of 98 feet from persons or properties, and never over event sites where many people gather. If the rules are violated, the UAS operator could be liable for a fine. To fly a UAS over areas where air traffic is expected, such as airports, above 492 feet, and over densely populated areas, UASs' operators are required to apply for permission from the country's civil aviation authority. The 2016 regulation prohibits flying UAS within a 328-yard radius of designated facilities, including the Prime Minister's office building, the Supreme Court building, the Imperial Palace, embassies, and nuclear facilities. Flying a UAS over a designated facility can result in the destruction of the UAS and is punishable by a prison term or a fine.

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## United Kingdom

The U.K. distinguishes between recreational and commercial (known as "aerial work") small UAS operations and regulates both types of operations. The regulations provide basic safety measures. For example, UAS are to be flown below 400 feet, 150 feet from people and property, not near airports, and not near other aircraft. To ensure that the public is aware of the regulations, the U.K. CAA's website includes its "drone code". In addition, the U.K.'s main air-traffic provider, NATS, has developed a web site, <http://dronesafe.uk/>, and Drone Assist, a new drone-safety application. An individual who operates a drone for commercial purposes must obtain a license from the CAA.

The U.K. CAA is responsible for ensuring compliance with the Air Navigation Order and works with the police and other agencies in doing so. Most enforcement actions by the CAA are aimed at operators who use UAS for commercial purposes without a license. In December 2015, the CAA announced that it would begin taking enforcement actions

against recreational operators who do not follow the regulations. Failing to observe the regulations can result in a criminal prosecution and a fine.

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## China

China issued UAS provisions in December 2015. The provisions divided UAS into seven categories based primarily on weight. The categories do not distinguish between recreational and commercial operations. The smallest category of UAS—those that weigh less than 3.3 pounds—are required to be operated safely and to avoid causing injury to others, but are not otherwise subject to the UAS Operation Provisions. For the remaining categories of UAS, the Provisions include the requirements that UAS be operated in the daytime, within visual line of sight, and with insurance for covering liability for third parties on the ground. The Provisions require a pilot-in-command who is directly in charge of the operation and has the right to make final decisions

The Provisions also set up an online, real time supervision that has two components: the electric fence and the UAS cloud. The electric fence is a hardware and software system that stops aircraft from entering certain areas. The UAS cloud is a dynamic database management system that monitors flight data in real time. It has an alarm function that is activated when UAS connected to it fly into the electronic fence.

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## Germany

German law addressed UAS in 2007. Germany defines UAS as unmanned aircraft that are not used for hobby or recreational purposes. UAS used for hobby or recreational purposes are defined as model aircraft. Authorization from the German state in question is required to operate a UAS that weighs more than 11 pounds. There are two types of these authorizations. A general authorization is granted for UAS that do not weigh more than 11 pounds and do not have a combustion engine. A specific authorization may be obtained for UAS that weigh between 11 and 55 pounds, but only for the limited time and place specified in the authorization. There are also general restrictions to be observed when operating a UAS in Germany. The UAS cannot weigh more than 55 pounds, must be kept within visual line of sight, must be flown below 328 feet above ground, cannot be flown within about 1 mile of an airport, unless a special permit is granted, and may not fly over people or public gatherings.

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## Israel

In Israel, the CAA licenses and supervises civilian UAS flight operations, and CAA directives regulate UAS activities. For example, UAS flights over populated areas must be conducted at 5,000 feet or higher, unless there is special prior approval, and they generally must not be operated in the same airspace as manned aircraft. UAS are also generally required to have specific equipment, including a properly operating transponder. According to the Aviation Law, an individual working in the aviation profession (including flying, inspecting, and instructing) is required to be licensed, including UAS operators. Violation of licensing requirements results in the same penalties that apply to manned aviation, in which the penalties range from administrative fines to imprisonment.

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## Poland

Poland has regulated the operation of UAS in Polish airspace since 2013. Further, commercial UAS pilots must have a certificate of competency from the CAA; this certificate is issued to those who have passed a medical check-up, taken theoretical and practical tests, and have insurance. To operate in visual line of sight, the applicant must obtain a certificate of competency for which he or she signs a declaration of knowledge of relevant regulations and basic theory and passes theoretical and practical tests. To operate beyond visual line of sight, the applicant must successfully pass training courses in addition to passing the theoretical and practical tests to obtain the certificate of competency. Currently, beyond visual line-of-sight flights are limited to dedicated and segregated airspace. The certificate of competency can also be limited to certain UAS weight ranges (e.g., less than 4.4 pounds to less than 330 pounds) and classes of UAS (e.g., airplane, helicopter, or multirotor).

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## South Africa

Since 2015, South Africa has regulated UAS. South Africa permits different types of UAS operations: private, commercial, corporate, and non-profit. South Africa, defines a UAS as an unmanned aircraft piloted from an pilot's station, excluding model aircraft (an unmanned vehicle used for competition, sport, or recreational purposes) and toy aircraft (intended for use in play by children). A private operation is the use of a UAS for an individual's personal and private purpose where there is no

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commercial outcome, interest, or gain. Private operations must be conducted with UAS weighing less than 15.4 pounds, cannot be flown more than 400 feet above the ground, and only in restricted visual line of sight. Non-private operations are allowed with the issuance of a remotely piloted aircraft letter of approval, a certificate of registration, a remote pilot license, and a UAS operator certificate. Only operator certificate holders are permitted to operate beyond visual line of sight and directly over people).

## Appendix V: Comments from the Department of Transportation



U.S. Department of  
Transportation

Office of the Secretary  
of Transportation

Assistant Secretary for Administration

1200 New Jersey Avenue SE  
Washington, DC 20590

MAR 09 2018

Gerald L. Dillingham  
Director, Physical Infrastructure Issues  
U.S. Government Accountability Office (GAO)  
441 G Street NW  
Washington, DC 20548

The Federal Aviation Administration's (FAA) goal is integrating Unmanned Aircraft System (UAS) technology while maintaining the highest levels of safety of manned aircraft, people, and property by ensuring compliance with regulations and guidelines, by publishing regulations, and researching and testing technology. The Small UAS (sUAS) Rule was one of the most significant accomplishments to enable nationwide sUAS routine operations while maintaining the highest levels of safety. The FAA Safety Risk Management (SRM) process has evolved over time and requires FAA to conduct SRM through the sUAS rulemaking and policy development processes. Risks identified are mitigated through the current structure with layers of protection built into the existing processes. The FAA is working in partnership with industry to develop a framework for gathering and analyzing safety data, which can be used to develop safety enhancements to mitigate identified UAS risks.

FAA offers the following comments in response to issues raised in GAO's draft report:

- FAA followed the SRM process that existed when policies/rules related to small UAS operations were developed and will continue to do so for future development efforts. However, the FAA agrees it could improve the documentation of its SRM activities related to small UAS operations, including the safety risk assessments and decisions made based on the results.
- FAA investigates any report of any two aircraft, including UAS, coming too close together based on the information available. Because reports involving UAS often do not contain sufficient information to enable the FAA to follow up and conduct investigations, the FAA is generally not able to make a determination on the validity of the UAS reports that are received. The agency stores all the information in a tracking database
- The Agency also would like to clarify that the reassessment of the proposed 2018 beyond-visual line of-sight operations regulation date is in response to security concerns.

Upon review of the draft report, we concur with the recommendation to establish a mechanism to ensure that FAA's management of safety risks posed by small UAS operations in the National Airspace System follows all applicable principles and requirements in FAA's policies. We will provide a detailed response to the recommendation within 60 days of final report issuance.

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**Appendix V: Comments from the Department  
of Transportation**

We appreciate the opportunity to respond to the GAO draft report. Please contact Madeline Chulumovich, Audit Relations and Program Improvement, at (202) 366-6512 with any questions.

Sincerely,



Keith Nelson  
Assistant Secretary for Administration

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## Appendix VI: GAO Contact and Staff Acknowledgments

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### GAO Contact

Heather Krause at (202) 512-2834 or [KrauseH@gao.gov](mailto:KrauseH@gao.gov)

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### Acknowledgements

In addition to the contact named above, the following individuals made important contributions to this report: Gerald L. Dillingham, Ph.D. (Director); Vashun Cole, Assistant Director; David Goldstein, Analyst-in-Charge; Melissa Bodeau; Russell Burnett; Carole Cimitile; Camilo Flores; James Geibel; Richard Hung; Joshua Ormond; William Reinsberg; Amy Rosewarne; and Pamela Vines.

## Appendix VII: Accessible Data

### Data Tables

**Data Table for Figure 2: The Federal Aviation Administration's (FAA) Monthly Reports of Unmanned Aircraft Systems Sightings, February 2014 through April 2018**

Month	Sightings
Feb 2014	1
Mar	2
Apr	5
May	10
Jun	16
Jul	36
Aug	30
Sep	40
Oct	38
Nov	33
Dec	22
Jan 2015	26
Feb	50
Mar	85
Apr	64
May	95
Jun	132
Jul	128
Aug	193
Sep	127
Oct	138
Nov	96
Dec	84
Jan 2016	101
Feb	133
Mar	143
Apr	158
May	173
Jun	235

Month	Sightings
Jul	189
Aug	175
Sep	151
Oct	162
Nov	127
Dec	93
Jan 2017	108
Feb	154
Mar	163
Apr	178
May	227
Jun	264
Jul	262
Aug	222
Sep	179
Oct	183
Nov	137
Dec	108
Jan 2018	120
Feb	162
Mar	175
Apr	184

**Figure 3: The Federal Aviation Administration’s Registrations of Recreational and Commercial Small Unmanned Aircraft Systems (UAS) Users, as of October 31, 2017**

State	Recreational	Commercial
All	827,492	99,809
AK	3,248	508
AL	10,489	1,998
AR	5,842	662
AZ	19,381	1,963
CA	107,910	20,720
CO	19,261	3,070
CT	10,011	.
DC	860	592
DE	2,313	257
FL	62,547	8,203

Appendix VII: Accessible Data

State	Recreational	Commercial
HI	6,220	704
IA	8,566	1,050
ID	4,958	1,119
IL	28,267	2,926
IN	15,592	1,554
KS	8,226	974
KY	7,904	1,053
LA	7,832	989
MA	17,571	.
MD	15,544	1,983
ME	3,614	.
MI	25,180	2,348
MN	14,856	1,809
MO	14,326	1,575
MS	4,232	610
MT	2,947	580
NC	23,285	3,308
ND	2,260	430
NE	5,158	794
NH	4,677	.
NJ	22,294	.
NM	3,972	614
NV	8,696	1,024
NY	42,085	3,565
OH	26,911	2,695
OK	9,612	1,155
OR	13,552	1,643
PA	30,003	2,848
RI	2,584	.
SC	10,959	1,308
SD	2,528	325
TN	15,169	2,081
TX	66,403	8,512
UT	11,241	1,520
VA	23,598	2,796
VI	149	.
VT	1,792	.

State	Recreational	Commercial
WA	24,802	2,470
WI	15,496	1,641
WV	3,901	377
WY	1,673	271

**Data Table for Figure 7: The Federal Aviation Administration’s (FAA) Air Traffic Organization’s Criteria for Acceptability of Safety Risks Posed by Unmanned Aircraft Systems (UAS)**

Likelihood of Risk	Minimal	Minor	Major	Hazardous	Catastrophic
Frequent	Low	Medium	High	High	High
Probable	Low	Medium	High	High	High
Remote	Low	Medium	Medium	High	High
Extremely Remote	Low	Low	Medium	Medium	High
Extremely Improbable	Low	Low	Low	Medium	Medium / High

The risk level is “low,” meaning the risk is acceptable without any mitigation.  
 The risk level is “medium,” meaning the risk is acceptable, although mitigation is recommended.  
 The risk level is “high,” meaning the risk is unacceptable unless it is mitigated to a level of “low” or “medium”.

## Agency Comment Letter

### Text of Appendix V: Comments from the Department of Transportation

Page 1

Gerald L. Dillingham

Director, Physical Infrastructure Issues

Government Accountability Office (GAO) 441 G Street NW

Washington, DC 20548

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Page 2

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Sincerely

Keith Nelson  
Assistant Secretary for Administration

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