



April 2017

# AVIATION RESEARCH AND DEVELOPMENT

## FAA Could Improve How It Develops Its Portfolio and Reports Its Activities

# GAO Highlights

Highlights of [GAO-17-372](#), a report to congressional requesters

## Why GAO Did This Study

The federal government conducts aviation R&D to advance U.S. technological leadership, foster a dynamic aerospace industry, and improve the safety of the civil aviation system. GAO was asked to review FAA's management of its R&D portfolio, including the extent to which FAA's R&D is structured and operated to achieve its mission. This report addresses (1) the extent to which FAA's management of its R&D portfolio follows requirements, guidance and leading practices, (2) the extent to which FAA and NASA coordinate on their R&D activities, and (3) how FAA cooperates with the private sector on R&D.

GAO compared FAA's R&D management activities from 2012 through 2016 against applicable statutory requirements, agency guidance and leading practices drawn from literature on R&D management and collaboration, including past GAO reports. GAO met with FAA and NASA and aviation stakeholders, including three private companies, to discuss R&D coordination. GAO selected stakeholders based partly on the size and extent of their R&D activities.

## What GAO Recommends

GAO recommends that the Secretary of the DOT require the FAA Administrator to: (1) identify long-term R&D research priorities, (2) disclose how projects are selected, and (3) ensure that the *NARP* and *R&D Annual Reviews* meet statutory requirements for content. DOT concurred with the recommendations.

View [GAO-17-372](#). For more information, contact Gerald Dillingham, Ph.D., (202) 512-2834 or [dillinghamg@gao.gov](mailto:dillinghamg@gao.gov).

April 2017

## AVIATION RESEARCH AND DEVELOPMENT

### FAA Could Improve How It Develops Its Portfolio and Reports Its Activities

## What GAO Found

The Federal Aviation Administration's (FAA) actions are not fully consistent with requirements, agency guidance, and leading practices related to the management of its research and development (R&D) portfolio. GAO assessed FAA's actions to manage its R&D portfolio in three key areas: (1) developing its portfolio of R&D projects, (2) tracking and evaluating these projects, and (3) reporting on the portfolio. We found that FAA could be more strategic in how it develops its R&D portfolio, chiefly in identifying long-term research needs and in improving disclosure of how projects are selected. As a result, FAA management cannot be assured that the highest priority R&D is conducted. GAO also found that while FAA tracks and evaluates its research projects consistent with leading practices, it does not fully address all statutory reporting requirements, such as identifying long-term research resources in the *National Aviation Research Plan (NARP)* or preparing the *R&D Annual Review* in accordance with government performance-reporting requirements. These reporting deficiencies can limit the usefulness of the reports to internal and outside stakeholders. FAA has begun to examine how it can improve the usefulness and timeliness of its R&D reports, but has not identified specific changes needed.

FAA's and the National Aeronautics and Space Administration's (NASA) aviation R&D coordination generally reflects selected leading practices for interagency collaboration that GAO has previously identified. GAO found that FAA and NASA have: (1) written agreements that define the scope and conditions for collaboration; (2) defined the roles and responsibilities of collaboration leaders and participants; (3) defined desired outcomes and accountability mechanisms; (4) bridged their two organizational cultures through coordinating bodies and joint activities; and (5) identified and leveraged resources through agreements. FAA and NASA officials that GAO interviewed reported that they coordinated on R&D. Such coordination is exemplified by the types of technology that have been transferred from NASA to FAA. For example, NASA developed software that improves air-traffic departure efficiency. NASA then tested the software alongside FAA's, before transferring it to FAA for use by air traffic controllers at airports.

FAA and the private sector cooperate on R&D activities through formal and informal mechanisms. Through funding agreements FAA uses private sector expertise and technology-transfer partnerships to share facilities, equipment, and staff. These agreements and partnerships are intended to extend FAA's capabilities and resources and expand the U.S. technology base. FAA also tracks private sector R&D activities through advisory committees and more informal relationships. In developing the R&D portfolio, FAA does not formally consider the impact of its R&D activities on the private sector because the FAA and the private sector have different research goals. According to three large private-sector firms GAO interviewed and to academic literature GAO reviewed, there is little evidence that FAA's activities have crowded out or precluded private firms from undertaking their own R&D.

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**Abbreviations**

CLEEN	Continuous Lower Energy, Emissions, and Noise Program
COE	center of excellence
CRDA	cooperative research and development agreement
DOT	Department of Transportation
FAA	Federal Aviation Administration
IG	Inspector General
IPO	Interagency Planning Office
JPDO	Joint Planning and Development Office
MOU	memorandum of understanding
NARP	National Aviation Research Plan
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NextGEN	Next Generation Air Transportation System
OMB	Office of Management and Budget
PPT	Program Planning Teams
R&D	research and development
REB	Research and development Executive Board
REDAC	Research, Engineering, & Development Advisory Committee
RTCA	Radio Technical Commission for Aeronautics
RTT	research transition teams
UAS	unmanned aerial system

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April 24, 2017

The Honorable Lamar Smith  
Chairman  
Committee on Science, Space, and Technology  
House of Representatives

The Honorable Brian Babin  
Chairman  
Subcommittee on Space  
House of Representatives

The commercial aviation industry is vital to the nation's economy. According to the Federal Aviation Administration (FAA), in 2012 this industry contributed roughly \$1.5 trillion in economic activity to the national economy and constituted about 5 percent of the U.S. gross domestic product. According to the *2006 National Aeronautics Research and Development Policy*, the federal government conducts research and development (R&D) on commercial aviation to advance U.S. technological leadership, foster a dynamic aerospace industry, and improve the safety of the civil aviation system.

FAA, along with the National Aeronautics and Space Administration (NASA), is responsible for the management of the federal government's commercial aviation R&D. FAA supports and coordinates a range of R&D activities on the safety, efficiency, and environmental impact of the civil aviation system and uses the results of this research in developing regulations, standards, and plans and policies for modernizing the system. In fiscal year 2015, FAA's budget included about \$415 million to support nearly 40 R&D programs and associated research activities performed by FAA as well as a range of partners, including other government agencies, universities, and private sector organizations.

Given the importance of commercial aviation R&D to the U.S. economy, you asked us to review FAA's management of its R&D portfolio, including the extent to which FAA's R&D is structured and operated to achieve its mission objectives. This report addresses: (1) the extent to which FAA's management of its R&D portfolio follows applicable requirements, guidance, and leading practices; (2) the extent to which FAA and NASA follow leading practices in coordinating their R&D activities; and (3) how FAA cooperates with the private sector on R&D and how, if at all, FAA considers the impact of its R&D on the private sector R&D investments.

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To address these objectives, we reviewed and analyzed documents related to FAA's R&D activities, including relevant statutes; FAA's plans, policy and guidance, and documents; and government reports and relevant literature on aviation R&D. To evaluate FAA's management of its R&D portfolio, reviewed FAA's budget data from fiscal years 2012 through 2016 to assess FAA's R&D portfolio and priorities, as well as reviewing other leading documents and interviewing key officials. Specifically, we reviewed documentation and interviewed officials from FAA's William J. Hughes Technical Center,<sup>1</sup> FAA's seven lines of business called Program Planning Teams (PPTs), and the chairman of FAA's Research, Engineering, and Development Advisory Committee (REDAC).<sup>2</sup> We also interviewed representatives from aviation stakeholders, including two of FAA's Centers of Excellence (COE),<sup>3</sup> MITRE Corporation, a federally funded research and development center,<sup>4</sup> as well as representatives from 8 aviation associations and 3 major private aviation manufacturers (i.e., private sector representatives). We selected the private sector companies based on FAA's fiscal year 2015 obligations for R&D funding, whether the company performs R&D with its own resources separate from its FAA-funded R&D efforts, and recommendations from industry representatives. While all of these organizations and companies provided a range of perspectives, they are not generalizable to all aviation stakeholders. We reviewed relevant statutory requirements, guidance from the Office of Management and

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<sup>1</sup>FAA's William J. Hughes Technical Center is FAA's facility for research and development, test and evaluation, and verification and validation in aviation research.

<sup>2</sup>REDAC is FAA's advisory body for R&D and reviews the needs, objectives, plans, approaches, contents, and accomplishments of FAA's research program. Specifically, REDAC considers aviation research needs in five areas: airport technology, aviation safety, environment and energy, National Airspace System operations, and human factors. REDAC also assists in ensuring FAA research activities are coordinated with other government agencies and industry. Committee members represent corporations, universities, associations, consumers, and government agencies, including NASA.

<sup>3</sup>Air Transportation Centers of Excellence (COE) are collaborative efforts between FAA, universities, and industry to advance aviation technologies and expand FAA research capabilities. Each COE is a cooperative research organization with researchers from many universities. Half of COEs' funding for FAA research projects comes from FAA and the other half comes through the COEs' cost sharing program. The two COEs we interviewed were selected based on the type and extent of research and that the research was at different phases in their respective life cycles.

<sup>4</sup>48 C.F.R. § 35.017. Federally funded research and development centers, such as MITRE, meet a long-term research need that cannot be met as effectively through in-house or contractor resources.

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Budget (OMB) and FAA's R&D Management Division, and leading practices for R&D portfolio management. We identified the requirements, guidance, and leading practices by reviewing GAO, FAA, and other government reports, and by conducting a literature search. We selected leading practices identified in literature that were specific to research and development and/or to DOT, FAA, or aviation research and development.<sup>5</sup> To evaluate R&D coordination between FAA and NASA, we identified how the agencies coordinate R&D by reviewing FAA and NASA documents, and interviewing officials from FAA, NASA, and related government offices as well as the same aviation stakeholders discussed above. We identified seven leading practices for interagency R&D collaboration from our previous work and compared these to FAA and NASA's collaboration activities.<sup>6</sup> To describe how FAA coordinates with the private sector and how FAA considers the impact of its R&D on private sector investments, we performed a search of research databases to identify literature on the impact of federal funding on private sector R&D efforts. We reviewed this literature to identify how, if at all, federal R&D funding affects private companies' R&D investment (see the bibliography at the end of this report for a list of the sources we reviewed). We also interviewed agency officials, aviation association representatives, and representatives from three selected private-sector companies, which were selected based on our review of FAA fiscal year 2015 obligations, whether the company performs R&D with its own resources, and recommendations from industry representatives. We selected the private-sector companies to speak about how FAA research affects their own research investments based on FAA's fiscal-year 2015 obligations for R&D funding, whether the company performs R&D with its own resources separate from its FAA-funded R&D efforts, and recommendations from industry representatives. For additional information on our methodology, please see appendix I.

We conducted this performance audit from January 2016 to April 2017 in accordance with generally accepted government auditing standards.

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<sup>5</sup>See the bibliography for a list of the sources we used to identify leading practices for managing R&D.

<sup>6</sup>GAO, *Results Oriented Government: Practices That Can Help Enhance and Sustain Collaboration among Federal Agencies*, [GAO-06-15](#) (Washington, D.C.: Oct. 21, 2006); GAO, *Managing For Results: Key Considerations for Implementing Interagency Collaborative Mechanisms*, [GAO-12-1022](#), (Washington, D.C.: Sept. 27, 2012); and GAO, *Managing For Results: Implementation Approaches Used to Enhance Collaboration in Interagency Groups*, [GAO-14-220](#), (Washington, D.C.: Feb. 14, 2014).

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

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## Background

FAA's process for developing its commercial aviation research portfolio spans the agency. The guiding principles and inventory of FAA's R&D activities are expressed in the *National Aviation Research Plan (NARP)* and in *FAA's Fiscal Year R&D Annual Review*, which provides summaries of R&D accomplishments, both of which FAA is required to annually submit to Congress.<sup>7</sup> To develop the *NARP* and its R&D portfolio, FAA's PPTs, which focus on specific research program areas, identify R&D projects to meet one of three guiding R&D principles according to any of 25 goals within 41 program areas and present budget requirement for the R&D programs.<sup>8</sup> The three guiding principles are to improve aviation safety, improve operational efficiency, and reduce environmental impact. FAA's PPTs are composed of staff members who possess scientific, engineering, and technical expertise, and each PPT oversees one major R&D area: airports, aviation safety, commercial space transportation, environment & energy, national airspace system operations, weather, and mission support. All but one of these—mission support—sponsor R&D activities.

FAA's portfolio development process is presented in figure 1. FAA's R&D Executive Board (REB) provides guidance and oversight over the agency's portfolio development process.<sup>9</sup> In this role, the REB coordinates the development of the agency's R&D portfolio investment across three appropriations accounts and 41 budget line items, and approves the *NARP*. In addition, REDAC, a statutorily created advisory committee, conducts external reviews of FAA's R&D programs for relevance, quality, and performance and makes recommendations to FAA on the proposed R&D portfolios and budgets for PPTs. The REB also presents the *NARP* to FAA's Joint Resources Council which reviews investment decisions. Once DOT and OMB approve FAA's R&D budget,

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<sup>7</sup>49 U.S.C. § 44501(c).

<sup>8</sup>There were 41 program areas in 2016 based on the appropriations budget's line items described in FAA's R&D budget.

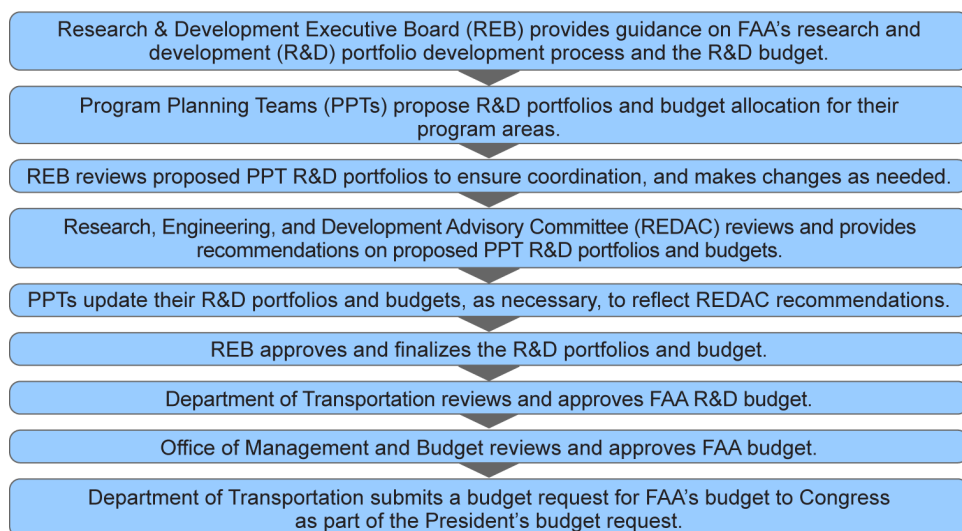
<sup>9</sup>The REB includes senior executives representing each of the seven PPTs.



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the budget is submitted to Congress as part of the President's budget along with the *NARP*.

**Figure 1: The Process for Developing FAA's Research and Development Portfolios**



Source: GAO analysis of Federal Aviation Administration (FAA) information. | GAO-17-372

In fiscal year 2015, FAA's total R&D-related budget was \$415 million. Once the programs receive funding, the PPTs carry out the R&D projects within FAA—for example, at FAA's William J. Hughes Technical Center in Atlantic City, New Jersey—or by coordinating with various government agencies, such as NASA, one of FAA's 11 COEs, MITRE Corporation, or by contracting private companies.

NASA manages and performs aviation research under its Aeronautics Research Mission Directorate. NASA devoted roughly \$460 million to commercial aerospace research during fiscal year 2016. In general, FAA and NASA have different time horizons for aeronautics research. NASA often focuses on fundamental, or early stage, research, with the goal of transferring research to FAA or the private sector for further development. In contrast, FAA focuses on conducting applied R&D that ensures the safe operation of the aviation system, among others goals. For example, NASA developed Precision Departure Release Capability software, which it tested alongside FAA, then transitioned to FAA for use in air traffic management activities. In addition, while NASA performs some near-term research, NASA's strategic plan identifies the focus on long-term research (with possible implementation into the National Airspace System

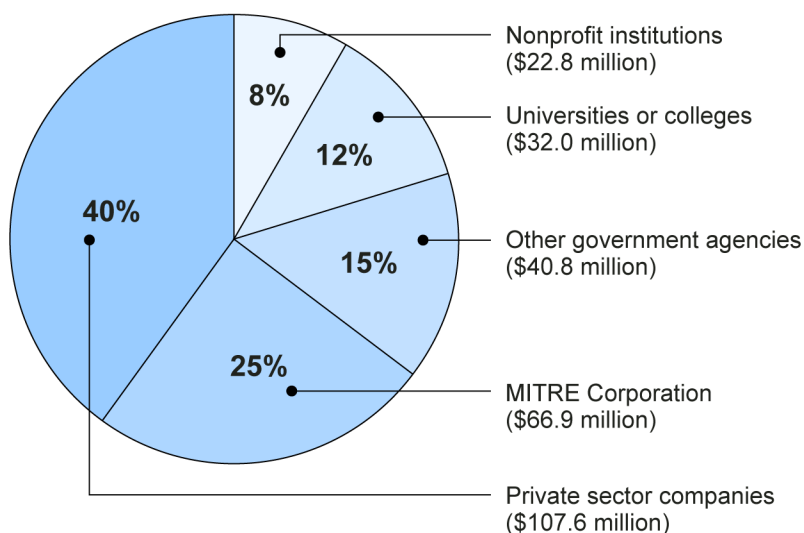
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in 10 or more years), whereas FAA’s strategic plan tends to concentrate its efforts on the near-term (with implementation into the National Airspace in the next 5 years).

The private sector spends the majority of commercial aerospace research funding in the United States, mostly focusing on developing new technologies and innovative products to introduce into the market. According to industry estimates, U.S. aerospace companies, many of which support the commercial aviation industry, spent more than \$14 billion on aerospace R&D in 2015. In addition, the federal government and some states offer tax credits to aerospace companies, along with other companies, for their R&D activities.<sup>10</sup> Many of these companies also enter into contracts with FAA to conduct FAA R&D or, in some cases, jointly fund research efforts that are mutually beneficial. In fiscal year 2015, roughly two-thirds, or \$270 million, of FAA’s \$415 million R&D budget was obligated to organizations outside FAA (see figure 2 below).

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**Figure 2: FAA’s Obligations for R&D to External Organizations by Sector, in Fiscal Year 2015**



Source: GAO analysis of Federal Aviation Administration (FAA) information. | GAO-17-372

Note: The figure above does not include funding for FAA management and oversight of the R&D portfolio.

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<sup>10</sup>26 U.S.C. § 41.

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## FAA Does Not Fully Adhere to Requirements, Guidance, and Leading Practices Related to the Development, Tracking, and Reporting of Its R&D Portfolio

We found that FAA's actions are not fully consistent with requirements, agency guidance, and leading practices related to the management of its R&D portfolio. We assessed FAA's actions to manage its R&D portfolio in three key areas: developing its portfolio of R&D projects, tracking and evaluating these projects, and reporting on the portfolio. In particular, we found that FAA could be more strategic in how it develops its R&D portfolio and more transparent in prioritizing projects to fund. We also found that while FAA tracks and evaluates its research projects consistent with leading practices, it does not fully address all statutory reporting requirements, such as requirements for the timely submission of the *NARP* to Congress, identifying long-term research resources in the *NARP*, and preparing the R&D Annual Review in accordance with government performance reporting requirements. FAA's actions in these three areas are critical to ensuring the relevance, quality, and performance of its R&D program.

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## FAA Does Not Fully Adhere to Requirements, Guidance, and Leading Practices Related to Portfolio Development

FAA statutory requirements, guidance, and leading practices for R&D portfolio development fall under one of three categories:

- taking a strategic approach to portfolio development;
- providing transparency in project prioritization and selection; and
- coordinating with internal stakeholders during the portfolio's development.

According to leading practices identified in past GAO reports and literature, taking a strategic approach to R&D portfolio development, in turn, involves: (1) developing R&D goals and priorities that align with organizational needs, (2) a forward-looking R&D portfolio, and (3) a portfolio that can adapt to changes in environment.<sup>11</sup> As shown in table 1 and discussed in more detail below, we found that in developing the R&D portfolio, FAA is meeting some, but not all, applicable legal requirements, internal guidance, and leading R&D management practices.

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<sup>11</sup>See, for example, GAO, *Managing For Results: Implementation Approaches Used to Enhance Collaboration in Interagency Groups*, [GAO-14-220](#), (Washington, D.C.: Feb. 14, 2014); GAO, *Department of Homeland Security: Oversight and Coordination of Research and Development Should Be Strengthened*, [GAO-12-837](#) (Washington, D.C.: Sept. 12, 2012), and National Academies of the Sciences "Transformation in the Air: A Review of the FAA's Certification Research Plan" (Washington, D.C.: National Academies Press, 2015).

**Table 1: Consistency of the Federal Aviation Administration’s (FAA) Portfolio Development Activities, with Statutory Requirements, Guidance, and Leading Practices**

Statutory requirements, guidance, and leading practices by category	Are FAA’s actions consistent?	GAO analysis
<b>1. Take a strategic approach to portfolio development</b>		
<b>Develop R&amp;D goals and priorities that align with organizational needs</b>		
Publish annually a national aviation research plan with goals and priorities for major categories of R&D. (requirement and guidance)	Yes	FAA annually publishes a <i>National Aviation Research Plan (NARP)</i> that is organized according to major categories of research
Align R&D goals to organization missions, needs, priorities, or strategies. (leading practice)	Yes	The <i>NARP</i> is organized according to FAA mission goals and priorities.
<b>Develop a forward-looking R&amp;D portfolio</b>		
Describe the R&D that the agency considers necessary for a 5-year period. (requirement and guidance)	Yes	Portfolio development as reflected in the <i>NARP</i> is based on a 5-year planning horizon.
Allocate at least 15 percent of R&D appropriations to long-term research projects. (requirement)	No	Portfolio development does not identify long-term research, only that which is initiated within a 5-year horizon.
Develop a research portfolio that addresses the needs of the future (leading practice)	No	Portfolio development does not identify long-term needs.
<b>Develop an R&amp;D portfolio that can adapt to changes in environment</b>		
Develop a research portfolio that can adapt to changing needs (leading practice)	Partially	FAA’s R&D portfolio has not always been able to readily adapt to emerging needs.
<b>2. Make project prioritization and selection transparent</b>		
Project prioritization and selection should be transparent to users of the R&D portfolio (leading practice)	Partially	Two of the six Program Planning Teams (PPTs) that undertake research use a transparent approach to project prioritization and selection.
<b>3. Coordinate R&amp;D portfolio within FAA</b>		
Coordinate with all internal stakeholders to ensure that duplication or gaps in research do not occur (requirement and leading practice)	Yes	The R&D management team coordinates portfolios across PPTs.

Source: 49 U.S.C. § 44501(c), § 48102(b), § 44507, § 44506 and GAO analysis of literature and FAA information. GAO-17-372

### Strategic Approach to Portfolio Development

With respect to taking a strategic approach to portfolio development, we found that FAA develops R&D goals and priorities that align with organizational needs, but the agency’s steps to develop a portfolio that is forward-looking and can adapt to changes fall short of some statutory requirements and key practices. Taking a strategic approach to portfolio development is important to FAA and its stakeholders because it can help ensure that the agency is both performing research that addresses

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current, future, and emerging research needs and spending its limited resources on its highest priorities.

### **Developing Goals and Priorities That Align with Organizational Needs**

We found that FAA follows a statutory requirement and a leading practice to develop R&D goals and priorities that align with organizational needs. As required by statute, FAA annually develops the *NARP*, which identifies the agency's R&D principles and goals and research programs that PPTs have prioritized for their respective areas.<sup>12</sup> FAA also follows a leading practice that calls for developing research portfolios that align R&D goals to an organization's overall mission, needs, priorities, or strategies.<sup>13</sup> Specifically, based on our detailed review of the 2016 *NARP*, we found the *NARP* principles, goals, and research programs align with each other. For instance, the 2016 *NARP* identifies three agency-wide R&D principles, 25 underlying goals that support FAA's accomplishment of the three principles, and nearly 40 PPT-prioritized research programs that sponsor research activities to help achieve those goals. In addition, the 2016 *NARP* states, and our analysis confirms, that FAA's R&D goals, principles, and programs align with agency and department priorities and goals identified in FAA's *Strategic Initiatives 2014-2018* and DOT's strategic plan.<sup>14</sup>

### **Developing a Forward-looking R&D Portfolio**

FAA has not taken sufficient actions to fulfill statutory requirements and a leading practice for being forward-looking in its research portfolio development. Specifically, the FAA Administrator is required to describe the long-term R&D that the agency will undertake and allocate at least 15 percent of its annual R&D appropriations to long-term research projects, which FAA and REDAC officials consider to be projects that will not

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<sup>12</sup>49 U.S.C. § 44501(c).

<sup>13</sup>Project Management Institute, Inc. *The Standard for Portfolio Management*—third edition (Newtown Square, PA: 2013).

<sup>14</sup>In addition, FAA's R&D goals, principles, and programs align with the 2006 White House Office of Science and Technology's *2006 National Aeronautics Research and Development Policy*, which established principles to guide the nation's aeronautics R&D activities.

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conclude within the current 5-year *NARP* timeframe.<sup>15</sup> We found that the *NARP* does not describe long-term R&D and that FAA is not tracking the percentage of funds devoted to long-term research or explicitly considering it as part of its portfolio development. FAA officials acknowledge that they do not track long term research, stating that it is hard to segregate funding based on time estimates for the completion of research. In addition, FAA officials told us that it is inherently difficult to identify or assess how much of its research budget is allocated to long term research projects because the length of an R&D project is dependent on many factors outside FAA's control, including the availability of funding, budget delays, and timing of R&D. While identifying the long-term research that is being funded may be difficult, without identifying or assessing long-term research efforts, FAA will not be as well positioned to communicate how it is prioritizing the long-term R&D that will allow the agency to plan for future research needs.

Echoing the leading practice that calls for research portfolios to address the needs of the future, both REDAC and the DOT Inspector General (IG) have recommended that FAA identify research needs beyond a 5-year period. For example, in November 2014, REDAC members provided their perspectives to FAA on emerging, future, and high-priority research areas that they believe will become relevant for FAA's research portfolio in a 5- to 15-year time frame.<sup>16</sup> REDAC stated that efforts to identify emerging, future, and high-priority research areas can help FAA anticipate future research needs and develop future research plans. Similarly, in August 2016, the DOT IG reported that while a near-term vision of research is important to meeting current needs, a clear, long-term vision for research can help FAA plan for the future. For NextGen in particular, the IG found that developing a long-term vision or plan for NextGen research beyond a 10-year time frame (i.e., beyond 2025) could help FAA better anticipate

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<sup>15</sup>49 U.S.C. § 44501(c), 49 U.S.C. § 48102(b). While long-term is not defined in the statute, FAA and other stakeholders generally consider it to be research that will culminate beyond the next 5 years.

<sup>16</sup>As part of this work, REDAC identified several thematic areas, such as the integration of unmanned aerial systems (UAS) in the national airspace and cybersecurity that would be useful for FAA to consider during the stated timeframe. The Chair of REDAC told us that FAA has made some progress in addressing the thematic areas REDAC identified.

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future NextGen needs.<sup>17</sup> While FAA is taking actions to address these recommendations, it is still in the process of determining the specific steps the agency will take, and it remains to be seen how completely they will be addressed.

### **Developing an R&D Portfolio That Can Adapt to Changing Needs**

Both we and others have found certain instances where FAA's research portfolio has not readily adapted to change—a leading practice in portfolio development. Ensuring that a research portfolio can adapt to a change in environment, including addressing emerging issue areas, is important because this approach can help an organization better position itself to fulfill its mission in the future. In 2014, REDAC found that FAA did not initially adapt its research portfolio to address the increased demand for unmanned aerial systems (UAS) in the National Airspace. Furthermore, in 2014, REDAC reported that FAA needed to “get ahead” of research on cyber-security so that the agency can develop policies to secure the growth in the volume of data associated with aviation operations. We found in 2015 that while FAA has undertaken research in both UAS and cybersecurity, it took several years for that research to occur, a situation that has limited FAA's ability to respond to its oversight of these two issues.<sup>18</sup>

Two factors make it difficult for FAA's research portfolio to readily adapt to changes in needs such as emerging issue areas:<sup>19</sup> (1) the timing of the agency's R&D planning and budget cycle and (2) limitations on shifting funds across research areas. First, FAA's 3-year budget cycle means that FAA began developing its fiscal-year 2018 R&D portfolio and budget in 2015. The REDAC chair explained that because of the R&D planning and budget process, FAA tends to keep working in existing research areas

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<sup>17</sup> The DOT IG recommended that FAA establish and document a process for identifying and prioritizing long-term NextGen R&D. FAA agreed with the recommendation and officials told us that they will take action to address the recommendation by September 2017. Department of Transportation, Office of the Inspector General, *FAA Lacks a Clear Process for Identifying and Coordinating NextGen Long-term Research and Development*, AV-2016-094, (Washington, D.C: August 2016).

<sup>18</sup> See GAO, *Unmanned Aerial Systems: FAA Continues Progress toward Integration into the National Airspace*,

<sup>19</sup> [GAO-15-610](#) (Washington, D.C.: July 16, 2015) and GAO, *Air Traffic Control: FAA Needs a More Comprehensive Approach to Address Cybersecurity As Agency Transitions to NextGen*, [GAO-15-370](#) (Washington, D.C: Apr. 14, 2015)

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and has been slow to place priority on research in emerging areas, including those previously mentioned, as well as new manufacturing techniques and or software integrity. Second, it is challenging for FAA to reprogram funds within appropriation budget accounts and to transfer funds among accounts because R&D program areas are funded by individual budget line items within appropriation accounts as prescribed by appropriators. FAA must get agreement from congressional appropriations committees to transfer funds between programs. FAA can reprogram up to \$5 million or 10 percent, whichever is less, within appropriations accounts or programs without congressional consultation.<sup>20</sup> While FAA has done this in the past to meet emerging needs, FAA officials told us that it is challenging to decide from which research areas within an appropriations account to transfer funding, given planned priorities. This budgetary challenge highlights why it is important for FAA to undertake a strategic and forward-looking approach to identifying emerging needs.

## Transparency in Project Prioritization and Selection

Another leading practice for R&D development is to use a transparent process for identifying and selecting projects for funding because it allows management to understand the project decisions and priorities. While FAA does provide some guidance to PPTs on R&D portfolio development, the guidance only suggests that PPTs consider describing how they identify and prioritize their R&D requirements. As a result, we found that most PPTs do not have a transparent selection process in order to ensure that the selected projects clearly meet the agency's top priorities. Specifically, we found that of the six PPTs that prioritize research, two use a structured and transparent approach based on pre-established criteria.<sup>21</sup> Both PPTs document the results of their ranking and selection. By contrast, four use an informal approach that is not documented or transparent to those outside the PPT. Officials from these PPTs told us that they identify and prioritize projects based on conversations with staff to identify research needed to meet safety, regulatory, industry, or other needs. FAA officials told us that varying approaches reflect differences across the PPTs. For example, the

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<sup>20</sup>Pub. L. No. 113-235, Div. K, Title IV, §§ 405 (5) and (6), 128 Stat. 2130, 2763. Program funds are identified by budget line items, which are separate appropriations within the relevant appropriations accounts. Any reprogramming of funding above this threshold requires consultation with Congress

<sup>21</sup>The remaining PPT, Mission Support, supports administrative functions and maintains the William J. Hughes Technical Center. The PPT does not identify, prioritize, or fund research.



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Coordinating R&D Portfolio  
Development across the  
Agency

Aviation Safety PPT has a structured approach because it has wide-ranging research areas and multiple offices within FAA with which it needs to coordinate to develop its portfolio. In contrast, the Environment and Energy PPT uses a simpler approach because all the staff work in one office under one Director but still coordinates with other PPTs as necessary. However, while the processes may vary among PPTs, clarifying the guidance to make the project prioritization and selection more transparent could enable stakeholders, such as other PPTs and REDAC, as well as the REB, to better understand how decisions are made.

We found that FAA coordinates with various internal and external stakeholders when developing its portfolio, consistent with statutory requirements for FAA, FAA guidance, and leading R&D management practices. Specifically, FAA is required by law to obtain the advice and recommendations of REDAC in establishing research and development priorities. FAA guidance to PPTs on portfolio development also advises them to coordinate with REDAC as well as with internal stakeholders such as individuals responsible for sponsoring or performing research and the REB. Finally, a leading practice for R&D portfolio-development calls for obtaining input from internal and external stakeholders when planning research portfolios.<sup>22</sup>

- REDAC: FAA obtains advice and recommendations from REDAC on a semiannual basis. During these meetings, REDAC provides guidance on how FAA should develop and invest funding in its R&D portfolios for the upcoming portfolio development cycle. REDAC also reviews and provides recommendations on proposed R&D portfolios.
- Internal FAA stakeholders: The REB is responsible for coordinating the development of the agency's R&D portfolio. In this role, the REB meets with each PPT multiple times during the portfolio development process to discuss and provide feedback on the PPTs' respective portfolios. In our review of minutes from these meetings, we found that the REB identified an opportunity where PPTs could better exchange information with each other to support their respective portfolio development efforts. The REB also communicates with and obtains input and approval from FAA senior management on *NARP*.
- Industry and other stakeholders: PPT officials told us that they obtain input from NASA and relevant industry partners, some of which may

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<sup>22</sup>Project Management Institute, Inc., *The Standard for Portfolio Management*.

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be users of the research, when developing their research portfolios. FAA coordination with NASA and the private sector is discussed in greater detail later in this report.

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### FAA's Tracking and Evaluation of Its R&D Portfolio Is Consistent with Leading Practices

FAA's management of its R&D portfolio is consistent with leading practices that call for organizations to use a centralized system to support the agency's portfolio development process and to track the progress of research projects.<sup>23</sup> According to these leading practices, organizations can benefit from evaluating the performance of R&D projects to ensure that the research provides value. This evaluation should consider the performance of the R&D portfolio as a whole against the organization's broader strategy and goals, a process that in turn, can identify whether changes in strategy are needed.

FAA uses a centralized, automated tracking system to support the agency's portfolio development process, as well as track PPTs' research portfolios and budgets. The system maintains documentation on R&D programs and projects as well as tracks R&D accomplishments for *FAA's R&D Annual Review* of accomplishments. FAA officials also use this system to track the status of research activities throughout the year, and to develop reports to management on milestones and funding levels of research within research programs. The six PPTs with R&D portfolios also track progress of individual research projects and perform project reviews. According to officials, the type of project review may vary and may include a cost-benefit analysis or an assessment of whether the research was implemented into airspace operations or resulted in a regulatory change. For example, the Weather PPT uses operational metrics, such as whether a new technology helped pilots navigate through certain types of weather. The Environment and Energy PPT tracks publications to identify how its research is being used, including in new technologies. However, an FAA official cautioned that not all research results in a tangible technology and that some projects help develop fundamental knowledge on a particular topic.

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<sup>23</sup>Project Management Institute, Inc. *The Standard for Portfolio Management*.

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**FAA's National Aviation  
Research Plan and Fiscal  
Year R&D Annual Review  
Do Not Fully Address  
Statutory Reporting  
Requirements**

Based on our review of the most recent *NARP* (2016) and the most recent *Fiscal Year R&D Annual Review* (2015), we found that FAA does not fully meet its reporting requirements established by Congress.<sup>24</sup> Most reporting requirements were fully or partially met, while two requirements were not met. As shown in table 2, the 2016 *NARP* fully addressed 2 of 8 statutory reporting requirements. The *NARP* fully complied with the requirements to describe FAA's planned research, engineering, and development for a 5-year period and to identify some individual R&D projects for each funding category in the annual budget request. However, FAA's *NARP* partially addressed or did not address the remaining six reporting requirements.

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<sup>24</sup>49 U.S.C. § 44501(c).

**Table 2: Extent to which the Federal Aviation Administration’s (FAA) National Aviation Research Plan (NARP) Addressed Statutory Reporting Requirements**

Statutory reporting requirement	Are FAA’s actions consistent?	GAO Analysis
<b>National Aviation Research Plan (NARP)</b>		
The Administrator of the FAA shall prepare and publish annually a national aviation research plan (Plan) and submit the Plan to Congress no later than the submission of the President’s budget to Congress.	Partially	FAA submitted the fiscal year 2016 <i>NARP</i> to Congress 2 months late. However, FAA officials stated that delayed submissions have been the result of delayed budget instructions to FAA.
The Plan shall describe the research, engineering, and development that the agency considers necessary for a 5-year period.	Yes	The <i>NARP</i> describes research and development the agency plans to perform during the next 5 years.
The Plan shall provide estimates by year on the schedule, cost, and workforce levels for R&D, including research activities carried out under cooperative agreements with other federal departments and agencies.	Partially	The <i>NARP</i> provides estimates, by year, on the schedule and cost, including workforce levels, for R&D activities. However, the 2016 <i>NARP</i> does not provide information on specific R&D carried out under cooperative agreements.
The Plan shall specify the goals and priorities for allocation of resources for major categories of R&D, including the rationale for the priorities identified as necessary for FAA to perform.	Partially	The <i>NARP</i> identifies 25 goals and describes research programs that align with those goals. The research programs are those that Program Planning Teams (PPT) have prioritized for their respective program areas. However, the <i>NARP</i> does not describe the rationale for how selected programs were deemed necessary for FAA to perform.
The Plan shall identify allocation of resources for long-term research, near-term research, and development activities	No	The <i>NARP</i> categorizes its R&D budget by applied and developmental research in the near-term, but does not distinguish what is long-term research (outcomes beyond 5 years).
The Plan shall identify individual R&D projects in each funding category described in the annual budget request.	Yes	The <i>NARP</i> describes some individual R&D projects for each funding category.
The Plan shall highlight R&D activities that address the recommendations of the research advisory committee (REDAC), and document the recommendations not accepted, specifying the reasons for non-acceptance	No	While REDAC recommendations are identified on FAA’s public website, neither the public website nor the 2016 <i>NARP</i> clearly highlight R&D activities that address REDAC recommendations or identify the recommendations that FAA did not accept and the reasons for non-acceptance.
The Plan shall highlight R&D technology transfer among government, industry, and academia. These are pursuant to the Stevenson-Wydler Technology Improvement Act, which includes provisions to encourage the government to participate in technology transfer.	Partially	The <i>NARP</i> identifies very generally the mechanisms used to transfer technology across the government, industry, and academia but does not provide a detailed discussion on the topic, such as, the types of technology transferred.

Source: 49 U.S.C. § 44501(c) and GAO analysis. | GAO-17-372

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FAA officials provided several reasons why the *NARP* partially addressed or did not address the reporting requirements. FAA officials told us that the delayed *NARP* submissions resulted from challenges with coordinating the R&D portfolio and budget within the agency and with OMB, as well as delayed budget cycles. FAA officials said that they are working to improve the timeliness of the *NARP* by coordinating within DOT and with OMB earlier in the portfolio development process. These efforts have already yielded results, helping FAA reduce the delay over previously submitted *NARPs*. However, FAA officials emphasized that much of the budget process remains outside of their control. FAA officials suggested that submitting the *NARP* 60 to 90 days after the budget submission would allow for a more orderly integration and alignment with final OMB budgetary guidance. In regard to not reporting on long-term research activities and project prioritization rationale, FAA officials stated that these long-term activities are not currently part of FAA's portfolio development process that information on long-term R&D is not currently available to report on. While FAA tracks information on cooperative agreements and technology transfer, it is not fully reported in the *NARP* because of FAA concerns about the usefulness of that information.<sup>25</sup> Similarly, FAA also tracks REDAC recommendations, and at one time had reported them in the *NARP*, but FAA officials were unable to recall why they no longer do.

In addition, as shown in table 3, the *Fiscal Year 2015 R&D Annual Review*, the most recent report on R&D accomplishments, partially addressed or did not address three applicable reporting requirements.<sup>26</sup> For example, the *2015 R&D Annual Review* does not clearly describe new technologies developed or the dissemination of research results to the private sector and is not organized in a way to allow comparison with the *NARP* (see table 3). Such a comparison would enable stakeholders to evaluate the performance achieved against previously identified performance goals and may help FAA identify areas of improvement. In addition, the *2015 Annual Review* was generally not prepared in accordance with federal performance reporting requirements, such as including a comparison of performance achieved against performance

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<sup>25</sup>The Technology Transfer Commercialization Act of 2000 (Pub.L.No. 106-404, §10, 114 Stat. 1742, 1747) contains technology transfer reporting requirements for certain federal agencies and the Department of Commerce. In support of these requirements, DOT, as well as other department and agencies prepares an annual report on tech transfer activities.

<sup>26</sup>Federal Aviation Administration, *Fiscal Year 2015 R&D Annual Review* (April 2016).

goals, actions the agency plans to take to address unmet goals, and a summary of program evaluation findings.<sup>27</sup> FAA officials told us that they designed the Annual Review to identify the accomplishments of selected research projects, not to provide a comparison to the NARP or meet federal performance reporting requirements.

**Table 3: GAO’s Assessment of the Extent to which the Federal Aviation Administration’s (FAA) 2015 R&D Annual Review Addressed Statutory Reporting Requirements**

Statutory reporting requirement	Are FAA’s actions consistent?	GAO analysis
<b><i>Fiscal Year 2015 R&amp;D Annual Review</i></b>		
The Administrator of the FAA should submit an annual report on the accomplishments of research completed during the prior fiscal year to Congress, including a description of new technologies developed and the dissemination to the private sector of research results.	Partially	In each of the past 5 fiscal years, FAA submitted an annual review on accomplishments to Congress. The <i>Fiscal Year 2015 R&amp;D Annual Review</i> —FAA’s most recent report—describes accomplishments of numerous research projects. The <i>2015 Annual Review</i> provides technical details on the activities and results of selected projects but does not clearly describe new technologies developed or the dissemination of research results to the private sector.
The annual report should be submitted with <i>NARP</i> and be organized to allow comparison with the plan in effect for the prior fiscal year	Partially	While the FAA submitted the <i>Fiscal Year 2015 R&amp;D Annual Review</i> with the <i>NARP</i> , the Review is not organized in a way to allow comparison with the <i>NARP</i> in effect for the prior fiscal year.
The annual report should be prepared in accordance with performance reporting requirements described in 31 U.S.C. § 1116, which states that agency performance reports should include, among other things, a comparison of actual performance achieved against performance goals, actions the agency plans to take to address unmet goals, and a summary of program evaluation findings.	No	The <i>2015 Annual Review</i> is not prepared in accordance with agency performance reporting requirements.

Source: 49 U.S.C. § 44501(c), Pub.L.No. 111-352, 124 Stat. 3866, and GAO analysis of FAA information. | GAO-17-372.

FAA officials told us that they are currently working on a re-design of the *NARP* and the *Annual Review*, which they expect to deliver an initial version in fiscal-year 2018 for the 2019 budget submission and complete the final version in fiscal-year 2019 after incorporating feedback from REDAC, OMB and OST. However, as FAA is in the early stages of this review, they could not say what new information will be included in either

<sup>27</sup>31 U.S.C. § 1116.

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report or how the reports will otherwise change. According to FAA officials, the re-design of the *Annual Review* intends to, among other things, make it easier for the public to understand R&D accomplishments and allow a better comparison to the *NARP*. The officials did not, however, identify specific steps they intend to take to achieve those two goals but

FAA officials did state the redesigned *NARP* and *Annual Review* will comply with statutory reporting and federal performance requirements. If FAA does not include required information in the current or re-designed *NARP* and *Annual Review*, Congress and other external stakeholders such as REDAC will not have the information they need to make informed decisions or recommendations about FAA's R&D budget or portfolio.

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## FAA's and NASA's R&D Coordination Is Generally Consistent with Leading Practices

We found that FAA's and NASA's aerospace R&D coordination generally reflects selected leading practices for interagency collaboration we identified in a prior report.<sup>28</sup>

- Having written guidance and agreements: This leading practice calls for agencies to document, in writing, their agreement to collaborate. Written documents can include information on the roles and responsibilities identified in the next bullet.
- Defining clear roles and responsibilities: This leading practice calls for agencies to define the roles and responsibilities of each agency, its participants, and its leaders.
- Defining outcomes and achieving accountability: This leading practice calls for the collaborating agencies to clearly define the outcomes of the projects on which they collaborate as well as on their collaborative endeavors overall. The leading practice advises the agencies to have a way of tracking and monitoring progress towards these outcomes in order to achieve accountability.
- Bridging organizational cultures: This leading practice calls for the collaborating agencies to have ways for operating across agency boundaries as well as compatible organizational cultures.

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<sup>28</sup>We have previously identified seven leading practices for implementing interagency collaborative mechanisms. In this report we do not discuss two of the seven leading practices, 1) leadership and 2) participants, because those practices are evidenced in our review of the five leading practices identified above. See [GAO-12-1022](#) for the list of seven leading practices for implementing interagency collaboration.

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- Identifying and leveraging resources: This leading practice calls for the collaborating agencies to ensure that they identify and leverage the financial resources they need in order to conduct their collaborative activities and achieve their collaborative goals.

By engaging in these leading practices, we have found that agencies can enhance and sustain their collaborative efforts.<sup>29</sup>

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## FAA and NASA Collaboration Relies on Written Guidance and Agreements

Consistent with the leading practice for interagency collaboration on having written guidance and agreements, FAA and NASA have two overarching documents and other program- and project-specific documents that describe their agreement to collaborate. The two overarching documents—FAA’s and NASA’s 2006 memorandum of understanding (MOU) and their 2009 *Charter and Guidance for Research Transition Teams (RTT Charter)*—state that the two agencies agree to collaborate on R&D and describe agency-level roles and responsibilities.<sup>30</sup> Having these agreements is important because we have found that agencies that document their agreement to collaborate can strengthen their commitment to working collaboratively.<sup>31</sup> Each agency also has plans, such as DOT’s *Research, Development, and Technology Strategic Plan* and NASA’s *Aeronautics Strategic Implementation Plan*, that describe the respective agency roles similarly to the MOU. NASA officials we interviewed said that their distinct missions and roles help them avoid unnecessary duplication and overlap of their R&D efforts. Similarly, the *RTT Charter* specifies how specific technologies will be transitioned from NASA to FAA. Additionally, FAA and NASA have documents such as RTT plans and interagency agreements that describe roles and responsibilities of leaders and participants for specific programs and projects.<sup>32</sup>

While the *RTT Charter* and the 2006 MOU describe an agreement to cooperate on R&D, these two documents include some outdated information, such as coordinating bodies that no longer exist. For

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<sup>29</sup>[GAO-12-1022](#).

<sup>30</sup>RTTs are joint FAA-NASA teams that provide a structured forum for officials at FAA and NASA to work together on R&D on a continuing basis with the goal of transitioning research from NASA to FAA.

<sup>31</sup>[GAO-12-1022](#).

<sup>32</sup>We discuss the contents of these plans in more depth in the next sub-section.



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example, the *RTT Charter* assigns responsibilities to the Joint Planning and Development Office (JPDO), an interagency office established by Congress in 2003 to assist with coordination and planning related to the R&D-supported NextGen. This office, however, was not issued a funding line by Congress in 2014 and some of its duties moved to the FAA Interagency Planning Office (IPO). A recent DOT IG report examined how FAA will continue to conduct NextGen long-term planning in light of the shift from JPDO to IPO, and recommended that FAA update the *RTT Charter*, updating that FAA agreed to do.<sup>33</sup> Similarly, the 2006 MOU assigns R&D oversight responsibility to the FAA/NASA Executive Research Steering Committee (Steering Committee), composed of representatives from the two agencies.<sup>34</sup> However, FAA officials explained that there is no record of Steering Committee meetings after the 2006 MOU was signed because it no longer fit NASA's new organizational structure and because of new program-specific coordination mechanisms, such as JPDO, that included FAA and NASA officials from many of the same offices as the Steering Committee. Also, FAA officials stated that other senior-level groups currently carry out the Steering Committee's coordination and oversight duties. Today, FAA and NASA use over a dozen groups for coordination and oversight of their collaborative activities; some of the groups are described in written documents and agreements; see Table 4 for examples of FAA-NASA coordinating bodies and activities.

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<sup>33</sup>The Department of Transportation Office of the Inspector General reported that the 2009 Charter and Guidance for RTTs contained some outdated information, and recommended that FAA update the document to include: (a) assignments by position instead of by name; (b) updated organization names and roles; and (c) current projects in an annex rather than in the main document to allow for easier updates. Department of Transportation, Office of the Inspector General, *FAA Lacks a Clear Process for Identifying and Coordinating NextGen Long-term Research and Development*, AV-2016-094, (Washington, D.C: August 2016).

<sup>34</sup>Specifically, the Steering Committee was tasked with providing executive direction and oversight of the agencies' joint R&D efforts, monitoring progress toward the agencies' complementary goals, and proposing adjustments to agency road maps, plans, and resources as necessary.

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**Table 4: Selected Mechanisms Used by the Federal Aviation Administration (FAA) and the National Aeronautics and Space Administration (NASA) to Coordinate on Aeronautics Research and Development**

- Advisory groups: Research, Engineering, and Development Advisory Committee, Next Generation Air Transportation System Advisory Committee
- Offices: White House’s Office of Science and Technology Policy, FAA’s Interagency Planning Office
- Interagency working groups: Research Transition Teams, Commercial Aviation Safety Team (CAST), Continuous Lower Energy, Emissions, and Noise Program Consortium, Unmanned Aircraft Systems Executive Committee
- Regularly scheduled meetings: Quarterly meetings between FAA & NASA Associate Administrators
- Ongoing communications, as needed: among senior-level officials, program- and project-level officials, and researchers
- Detailees: Each agency provides a staff member to work at the other agency.
- Other: NASA project reviews

Source: GAO analysis of FAA, NASA, and White House information. | GAO-17-372

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## FAA and NASA Collaboration Is Based on Defined Roles and Responsibilities

FAA and NASA clearly define each agency’s respective R&D roles and responsibilities at the agency level and at the program and project-level. The two documents described in the prior section—the 2006 MOU and 2009 *RTT Charter*—broadly describe the agencies’ respective R&D roles and responsibilities. For example, at the agency level, the 2006 MOU defines the R&D missions, or roles, of each agency. It states that NASA will focus on foundational or early stage, research, whereas FAA will primarily conduct applied research. The MOU also requires senior management, including coordinating bodies composed of senior management at FAA and NASA to provide accountability by monitoring the collaborative activities necessary to accomplish FAA’s and NASA’s complementary goals in aviation and space transportation.<sup>35</sup> At the program and project level, FAA’s and NASA’s RTT plans and interagency agreements (introduced above) provide details on the roles and responsibilities of each agency. Specifically, based on our review of select RTT plans and agreements, these documents clarified the relevant participants each agency should include in their R&D work and designated FAA and NASA staff members as leads and participants. In addition, the RTT plans we reviewed stated the “technology readiness level,” or maturity level, of the research product being transitioned from NASA to FAA. NASA officials told us that documents such as RTT plans

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<sup>35</sup>We discuss monitoring in depth later in this section when we talk about defining outcomes and achieving accountability.

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are important because they help ensure that the research transitioned from NASA to FAA is useful to FAA.

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### FAA's and NASA's Collaboration Is Based on Defined Outcomes and Accountability

FAA and NASA generally follow the leading practice for defining outcomes and requiring accountability at the program- and project-level and at the senior and strategic level. FAA and NASA have both inter- and intra-agency mechanisms that define, track, and monitor program and project outcomes. For the programs and projects on which they collaborate, FAA and NASA generally define the desired outcomes in the interagency documents discussed above. These agreements generally culminate with NASA delivering specific technology to FAA, with the RTT plans including an agreed upon technology readiness level for the technology. Specifically, FAA officials told us that each RTT plan has documents that are to be delivered incrementally or at the RTT's closeout. For example, under an RTT, NASA developed Precision Departure Release Capability software, which it tested alongside FAA, then transferred to FAA for use in air traffic management activities.<sup>36</sup> Also, we found that FAA and NASA individually review the outcomes of their own agencies' projects through their respective intra-agency processes. We describe how FAA tracks and monitors its projects in a previous section of this report. NASA officials also told us that they track and monitor the outcomes of the agency's projects through regular project reviews; according to both agencies, FAA participates in some of these reviews where the two agencies' R&D interests overlap.

At the strategic level, FAA and NASA also conduct activities to define, track, and monitor progress towards broader goals for their collaborative relationship. The two agencies broadly define the desired outcomes, or goals, of their collaborative relationship in their 2006 MOU.<sup>37</sup> As we have previously reported, establishing broad outcomes is important because it

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<sup>36</sup>The Precision Departure Release Capability software will enable FAA air traffic controllers to improve the overall efficiency of air traffic management by reducing missed or delayed departures and allowing more aircraft to depart within a given time frame. It will also help controllers react more quickly when conditions change because of weather or other problems.

<sup>37</sup>The 2006 MOU states that the agencies "are committed to a close partnership in the pursuit of complementary goals in aviation and space transportation. These goals include aviation and space transportation safety, airspace system efficiency, environmental compatibility, international leadership, and others." and that "FAA and NASA agree to cooperate and collaborate, in the best interest of the public, in all relevant areas of aeronautics and space transportation research."

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allows a collaborative group to shape its own vision and define its own purpose, and provides agency officials with a reason to participate in the collaborative endeavors.<sup>38</sup> One way in which FAA and NASA track and monitor their progress toward achieving these broader inter-agency goals is through feedback on their collaborative relationship from other federal government officials as well as from outside parties via FAA's advisory committees. For example, REDAC has recently addressed the effectiveness of FAA's and NASA's collaborative relationship. In fall of 2015, REDAC recommended that FAA involve NASA on a specific R&D endeavor that REDAC highlighted, and in spring of 2016, it recommended that FAA develop a joint work plan to achieve even greater benefits from its collaboration with NASA. However, in fall of 2015 and spring of 2016, REDAC reported that FAA has worked well with other entities, including NASA, on R&D. Though REDAC has not yet closed its FAA-NASA collaboration recommendations, FAA concurred with the one to which it has responded. In addition, agency officials told us that FAA and NASA associate administrators discuss their collaborative relationship during their quarterly meetings, providing another forum for monitoring FAA's and NASA's collaborative relationship.

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## FAA and NASA Collaboration Bridges Their Organizational Cultures

Consistent with the leading practice for interagency collaboration in bridging organizational cultures, FAA and NASA officials have multiple ways of operating across agency boundaries and maintaining positive working relationships among agency officials in order to create compatible organizational cultures. FAA and NASA have a variety of different ways of communicating with one another to plan, execute, and oversee their R&D programs and projects. For example, to coordinate their strategic planning efforts, FAA provides input into the NASA's *Aeronautics Strategic Implementation Plan* and into NASA's roadmaps for carrying out that strategic plan. NASA officials, as members of FAA's REDAC, also learn about and comment on FAA's R&D plans for the future. Also, as mentioned earlier in this section and as outlined in table 4, the two agencies have established numerous coordinating bodies and activities to operate across agency boundaries throughout the R&D process. We have previously reported that frequent communication

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<sup>38</sup>[GAO-12-1022](#).

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between agencies is important because it helps prevent misunderstandings.<sup>39</sup>

Also consistent with this leading practice, we found that FAA and NASA officials generally have positive working relationships that help the agencies have compatible organizational cultures and a more effective collaborative relationship. FAA officials and NASA officials with whom we spoke separately said that the two agencies have strong working relationships on R&D. Some provided explanations and historical context for these relationships, citing: the use of RTTs (which began in 2008), a culture of collaboration on R&D, improved relationships among staff members at all levels of the organizational system (researchers, mid-level managers, senior level managers), and a better understanding of and respect for each other's work. As we have previously reported, a shared interest or background in an area and the ability to understand others' viewpoints help build trust.<sup>40</sup>

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## FAA and NASA Collaboration Depends on Identifying and Leveraging Resources

Consistent with the leading practice of identifying and leveraging resources, FAA and NASA reported that they generally have the financial resources they need to sustain R&D collaboration. As we have previously reported, ensuring adequate resources is important because it helps agencies accomplish their collaborative goals and complete the activities associated with the other leading collaboration practices.<sup>41</sup> One way in which FAA leverages NASA's resources is by using NASA's research results as the basis for further research or for implementation into the National Airspace System (NAS), rather than having to fund that early-stage research itself. For example, under an RTT plan, FAA and NASA have agreed that NASA will transfer a variety of R&D results related to the Integrated Arrival/Departure/Surface Airspace Technology Demonstration 2 to FAA so that FAA can use them to inform its future work.<sup>42</sup> Also, FAA and NASA leverage each other's resources by using each other's facilities. For example, for research related to air traffic

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<sup>39</sup>[GAO-06-15](#).

<sup>40</sup>[GAO-14-220](#) and [GAO-06-15](#).

<sup>41</sup>[GAO-12-1022](#).

<sup>42</sup>The Airspace Technology Demonstration 2 is one of several R&D projects on Integrated Arrival/Departure/Surface that FAA and NASA have conducted as part of their NextGen-related R&D. The primary goal of this demonstration is to improve the predictability and the operational efficiency of the air traffic system in very large metropolitan areas.

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management for unmanned aerial systems (drones), FAA and NASA collaborated such that NASA conducted some research in NASA facilities and flight tests at FAA's facilities. However, officials in FAA's Interagency Planning Office (IPO) said that they do not have sufficient funding to carry out some of their duties, including developing a comprehensive NextGen budget and ensuring that there is a common up-to-date multi-agency plan for NextGen implementation. Nonetheless, IPO officials said that these duties are being carried out by other offices within FAA, and FAA and NASA officials in offices other than IPO generally reported that any resource constraints that they had encountered did not negatively affect their collaboration.

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## FAA and Private Sector Organizations Cooperate on FAA R&D

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### FAA Uses Numerous Mechanisms to Cooperate with the Private Sector on R&D Activities

The U.S. National Aeronautics R&D policy was established to advance U.S. technological leadership in aerospace by fostering a vibrant and dynamic R&D community that includes government, industry, and academia.<sup>43</sup> The policy also states the need for cooperation with private sector companies and to ensure that R&D activities do not preclude, deter, or compete with U.S. commercial aerospace activities. In addition, FAA's NARP and other R&D planning documents identify FAA's efforts to partner with private sector and other organizations to leverage resources and capabilities to ensure that the agency can achieve its goals and objectives.

FAA cooperates directly with private sector companies through a variety of mechanisms to achieve its R&D goals, including entering into agreements with private sector companies to conduct research and transfers of technology to the private sector, as well as receiving advice and assistance from industry and working groups.

- *R&D funding agreements:* FAA obligates funds to private sector companies, as well as other federal agencies, universities, and non-profit organizations, to conduct R&D in support of FAA's R&D principles. FAA awards contracts, grants, and cooperative agreements with organizations to perform R&D activities. FAA PPTs use project level agreements and project plans that outline the milestones, deliverables, and obligations for the R&D projects identified by FAA. For example, in fiscal year 2015, FAA obligated approximately \$108 million to private sector companies for various R&D activities, including projects that helped develop and mature NextGen aircraft technologies through the Continuous Lower Energy, Emissions and Noise (CLEEN) II Program. These CLEEN II activities are focused on developing engine and aircraft technologies and advancing sustainable alternative fuels as part of FAA's

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<sup>43</sup>National Science and Technology Council, Executive Office of the President, *National Aeronautics Research and Development Policy*, (Washington D.C.: December 20, 2006).

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environmental goals. According to the FAA, by collaborating in a cost share partnership with industry, the program will accelerate the maturation of engine and aircraft technologies to reduce aviation noise, fuel use, and emissions. CLEEN II and other parts of the R&D research such as the COE Program are performed under cost-sharing agreements, which require the private sector and other non-federal government partners to, at a minimum, match the R&D funding provided by FAA.

*Technology transfer:* FAA shares the scientific and technical knowledge and the technology developed from its R&D activities with the private sector and other organizations by promoting the transfer of FAA technologies to private sector commercial applications. FAA enters into cooperative research and development agreements (CRDA)—collaborative working agreements that allow FAA to share facilities, equipment, services, intellectual property, personnel, and other resources—with non-federal entities, including private sector organizations. FAA identified 50 active CRDAs, including the integration of UAS into the National Airspace System, technical evaluation of NextGen concepts and research, and advancement of the technology in aircraft rescue and firefighting in fiscal year 2015.

Technology transfer is managed by FAA's Technology Transfer Office and is intended to expand the U.S. technology base and extend the value of federal R&D investments. For example, FAA established cooperative cost-sharing ventures and coalitions with private sector companies and universities, such as the Commercial Aviation Alternative Fuels Initiative, to transfer knowledge, equipment, or capabilities developed by FAA's R&D programs to the private sector and to expand aviation technology. According to the FAA, as of 2016, the work of the initiative members has resulted in approving the use of five new alternative aviation fuels and enabled the commercial use of alternative aviation fuels by United Airlines at Los Angeles International Airport.<sup>44</sup> FAA also authorizes the licensing of patented technology from FAA R&D for commercialization. FAA has two active commercialization licenses on a patented technology for fire safety technology. According to an FAA official, the limited number of

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<sup>44</sup>We have previously reported on alternative fuels in the aviation industry. See GAO, *Alternative Jet Fuels: Federal Activities Support Development and Usage, but Long-term Commercial Viability Hinges on Market Factors*, [GAO-14-407](#) (Washington, D.C.: May 7, 2014).



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licenses is due to the fact that FAA-licensed technology is not easily commercialized.

- *Private Sector Company R&D Input:* FAA also coordinates with private sector companies through advisory groups such as REDAC, the RTCA, and the NextGen Advisory Committee.

REDAC: This statutorily created advisory group includes representatives from private sector organizations on its full committee and subcommittees. As discussed above, REDAC provides advice and recommendations to the FAA Administrator on the needs, objectives, plans, approaches, content, and accomplishments of the aviation research portfolio.

RTCA:<sup>45</sup> The commission is a non-profit organization that includes representatives from academia, airlines, airports, aviation service providers, government agencies, general aviation, labor unions, and manufacturers. The commission works in response to requests from FAA to develop recommendations on technical performance standards for key components for air transportation and to facilitate implementation of air traffic management system improvements.

NextGen Advisory Committee: The NextGen Advisory Committee was created to provide advice on policy issues facing the aviation community in implementing NextGen and to foster industry collaboration among NextGen stakeholders. The committee includes representatives from airlines, airports, air traffic controllers, pilots, and air traffic controllers, the Department of Defense, environmental groups, and technology manufacturers.

FAA officials and representatives from select private sector companies also stated that they utilize informal mechanisms to cooperate and communicate on R&D. FAA officials, for example, reported discussing the agency's R&D efforts at conferences and aerospace forums. Private sector representatives we interviewed also reported using conferences, REDAC committee meetings, and regular communication by phone or email to cooperate with FAA. These representatives stated that FAA's R&D priorities were clear and consistent. Furthermore representatives from one private sector company stated that, during the execution of

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<sup>45</sup>RTCA was founded in 1935 as the Radio Technical Commission for Aeronautics.

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R&D, company representatives and FAA held bi-weekly progress meetings, as well as semi-annual conference meetings with NASA officials and other R&D companies and stakeholders.

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**FAA Does Not Formally Consider the Impact of Its R&D Activities on the Private Sector Because It and the FAA Have Different Research Goals**

The government's role in aerospace R&D is, in part, to undertake research that directly benefits the public by improving public safety and security, by promoting energy efficiency, or by protecting the environment and not to undertake research that is more appropriately performed by the private sector, according to the *National Aeronautics Research and Development Policy*. For example, commercial applications of certain aerospace technologies like new airframe materials are undertaken by the private sector as part of the companies' product development, while FAA may fund research to ensure that materials are safe to introduce into the National Airspace System.<sup>46</sup> According to FAA officials, the agency does not formally consider the impact of its R&D investments on private sector organizations when setting its R&D priorities because its R&D goals differ from those in the private sector. FAA's R&D is focused on three goals: improving efficiency of the aviation system, improving the safety of the aviation system, and reducing the environmental impacts of the aviation industry, according to FAA. In contrast, private sector R&D companies are focused on different goals, generally, the application of R&D to its commercial products. For example, representatives from one private-sector company that engages in aerospace R&D stated that the company goals and responsibilities start with ensuring its customers receive products that allow them to be competitive in the aerospace industry and operate efficiently within commercial airspace. Furthermore, according to representatives from three companies that conduct independent R&D, as well as R&D funded by FAA, because FAA R&D priorities differ from their companies' respective priorities, the companies may not have pursued the same R&D projects without the government funding. While FAA does not formally consider the impact federal R&D may have on private sector companies, both FAA officials and private sector company representatives told us that, through the cooperative mechanisms discussed above, FAA is aware of private sector R&D.

According to representatives from the three selected private-sector companies we interviewed, FAA's R&D has not precluded or deterred

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<sup>46</sup>GAO, *Aviation Safety: Status of FAA's Actions to Oversee the Safety of Composite Airplane*, [GAO-11-849](#) (Washington, D.C.: Sept. 21, 2011).

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their companies' R&D investments or activities. The representatives were unaware of any examples of when their company did not undertake new research or scaled back ongoing research because of a similar R&D activity funded by FAA. Rather, the company representatives, as well as representatives from two aerospace industry groups, highlighted the benefits of FAA funding on private sector R&D investment. For example, one company representative stated that FAA R&D funding has helped his company to quickly get technologies to the marketplace and to maintain a competitive advantage in the global marketplace. Representatives from another company stated that FAA R&D funding has enabled the company to invest in longer-term research that may have otherwise been difficult to pursue.

A comparison of R&D investments made by private sector companies with FAA's R&D budget illustrates that the latter is considerably smaller and thus may have only a limited impact on the R&D investments of private sector companies. In fiscal year 2015, FAA's R&D budget totaled \$415 million, while industry estimates totaled more than \$14 billion for all aerospace R&D in 2016. In addition, according to company annual reports, the aerospace R&D budgets of our three selected private companies totaled more than \$7 billion in 2016.<sup>47</sup> However, smaller aerospace companies may have smaller R&D budgets and may have a greater reliance on FAA-funding R&D activities than the major aerospace companies we interviewed.

Evaluating the effect of federal R&D on the private sector is outside the scope of our review, but considerable research and literature exists on the relationship between federal R&D spending and its effect on private sector investment. The literature we reviewed, some of which was specific to aviation R&D investment, provided differing views on that effect (see the bibliography at the end of this report for a list of research articles we reviewed for this report). Some research identified the potential for federal R&D to crowd out, or reduce, private sector R&D. For example, a National Bureau of Economic Research study of energy sector R&D reported some evidence of crowding out within sectors that perform significant energy R&D.<sup>48</sup> A study of the effect of publicly

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<sup>47</sup>Industry estimates include all aerospace R&D, which includes both commercial aviation and defense-related aviation R&D.

<sup>48</sup>David Popp and Richard G. Newell, *Where Does Energy R&D Come From? Examining Crowding Out From Environmentally-Friendly R&D*, National Bureau of Economic Research, NBER Working Paper No. 15423 (October 2009).

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financed R&D noted that while publicly financed R&D reduces costs to industry and enhances national productivity, the overall effect of publicly funded R&D is to reduce company financed R&D across a variety of manufacturing industries.<sup>49</sup> In a study that examined the effects of federal support for R&D, the Congressional Budget Office noted that statistical data suggests that overall, firms' spending for private R&D increases in response to federal R&D spending. According to the report, in specific instances the federal government may have funded some R&D activities that the private sector would otherwise have financed, but identifying the instances in which such crowding out has occurred is difficult.<sup>50</sup> Another study of public R&D spending reported that in some instances, public R&D failed to provide significant spillovers (the impact of R&D technologies on the productivity of other companies) on private sector commercial applications.<sup>51</sup> However, that same study, which reviewed 35 years of published research on public and private R&D, concluded that the impact of public R&D funding on the private sector was inconclusive.

Conversely, some of the literature we reviewed reported that government-funded R&D complements private sector R&D and identified potential beneficial impacts of government R&D. According to the same Congressional Budget Office study noted above, federal spending in support of basic research over the year has, on average, had a significantly positive return, according to the best available research.<sup>52</sup> Another paper that surveyed studies of publicly funded R&D similarly reported that publicly funded R&D can complement and stimulate private sector R&D.<sup>53</sup> Another research paper reported that there are large

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<sup>49</sup>Theofanis P. Mamuneas and M. Ishaq Nadiri, *Public R&D policies and cost behavior of the US manufacturing industries*, Journal of Public Economics, vol. 63 (1996).

<sup>50</sup>Congressional Budget Office, *Federal Support for Research and Development* (Washington, D.C.: June 2007).

<sup>51</sup>Paul A. David, Bronwyn Hall, and Andrew Toole, *Is public R&D a complement or substitute for private R&D? A review of the econometric evidence*, Research Policy, vol. 29 (2000).

<sup>52</sup>Congressional Budget Office, *Federal Support for Research and Development*. (Washington, D.C.: June 2007).

<sup>53</sup>David, Hall, and Toole, *Is public R&D a complement or substitute for private R&D?*, 499.

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private benefits to the firms carrying out these government-funded R&D projects.<sup>54</sup>

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## Conclusions

The development of FAA's aerospace R&D portfolio is critically important to the national economy, the United States' continued leadership in the aerospace industry, and the continued safety of the U.S. commercial aviation industry. To achieve this mission, FAA must carefully manage and oversee its \$415 million R&D budget and maximize its results by collaborating with NASA and the private sector. Our review found that FAA does many things well in managing and overseeing its R&D portfolio and in coordinating with NASA and being familiar with private industry's R&D efforts. However, there are also areas in which FAA could improve its management of R&D in order to improve how the R&D portfolio is developed and to communicate its plans and results outside the FAA. FAA recognizes both the need to take a more strategic approach to R&D portfolio development and to develop guidance for prioritizing and selecting R&D activities, but these efforts are in the early stages of development and are not yet completed. While taking a long term strategic approach is difficult for FAA because of how its R&D budget is formulated, identifying and prioritizing its strategic vision across its entire R&D portfolio would help FAA focus and communicate its priorities internally as well as to Congress and outside stakeholders. Further, providing PPTs with additional guidance that calls for greater transparency over how projects are prioritized would help ensure the REB that FAA is directing its limited R&D budget toward its greatest priorities. Finally, fully meeting statutory requirements for the NARP and the *R&D Annual Review* would allow Congress to identify how R&D moneys are spent and how the public has benefited.

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## Recommendations for Executive Action

To help FAA better manage and oversee its portfolio of R&D activities, we recommend that the Secretary of Transportation direct the FAA to take the following actions:

1. FAA should take a more strategic approach to identifying research priorities across the agency, including developing guidance to identify

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<sup>54</sup>Tor Jakob Klette, Jarle Møen, and Zvi Griliches, *Do subsidies to commercial R&D reduce market failures? Microeconomic evaluation studies*, Research Policy, vol. 29 (2000).

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long-term priorities and emerging issue areas, as part of FAA's portfolio development process.

2. FAA should clarify its portfolio development guidance to call for each PPT to disclose the process it used for prioritizing and selecting research projects so that decision-making is more transparent for FAA management.
3. FAA should develop guidance to ensure that future *National Aviation Research Plans (NARP)* and *R&D Annual Reviews* meet statutory requirements to the extent practicable, including
  - a. The *NARP* lists activities that are carried under cooperative agreements.
  - b. The *NARP* describes the rationale for the prioritized research programs.
  - c. The *NARP* identifies how resources were allocated for long-term and near-term research.
  - d. The *NARP* identifies REDAC recommendations that are accepted, not accepted, and the reasons for non-acceptance.
  - e. The *NARP* provides a detailed description of technology transfer to government, industry, and academia.
  - f. The Annual Review describes new technologies developed and the dissemination of research results to the private sector.
  - g. The Annual Review allows a comparison to the *NARP*.
  - h. The Annual Review is prepared and presented in accordance with agency performance reporting requirements.

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## Agency Comments

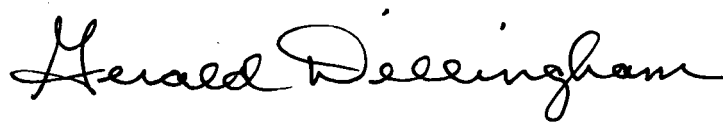
We provided a draft of this report to DOT and NASA for review and comment. In written comments, reproduced in appendix II, DOT concurred with our recommendations and highlighted steps FAA was taking to redesign the *NARP* and research development activities. DOT also provided technical comments that were incorporated, as appropriate. We requested comments from NASA, but none were provided.

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We are sending copies of this report to the appropriate congressional committees, the Secretary of Transportation, the FAA Administrator, the NASA 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 [dillinghamg@gao.gov](mailto:dillinghamg@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 III.

A handwritten signature in black ink that reads "Gerald Dillingham". The signature is written in a cursive style with a large initial "G".

Gerald L. Dillingham, Ph.D.  
Director, Physical Infrastructure Issues

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# Appendix I: Scope and Methodology

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To assess the Federal Aviation Administration’s (FAA) management of its research and development (R&D) activities, we identified applicable requirements, guidance, and leading practices, reviewed past GAO, FAA, and other government reports, and interviewed FAA officials and other aviation stakeholders. We identified applicable requirements from the U.S. Code (Title 49),<sup>1</sup> applicable guidance from the Office of Management and Budget (OMB),<sup>2</sup> and FAA’s Research and Development Management Division,<sup>3</sup> and leading practices from literature on managing R&D,<sup>4</sup> including GAO. To identify leading practices for managing R&D, we performed a search of research databases to review literature relevant to managing research and development. We selected leading practices identified in literature that were relevant and specific to research and development and/or specific to DOT, FAA, or aviation research and development. We reviewed FAA’s *National Aviation Research Plan (NARP)* and budget data from fiscal years 2012 through 2016 to assess FAA’s R&D portfolio and priorities. To assess FAA’s management of R&D, we reviewed documentation and interviewed officials from FAA Headquarters, FAA’s William J. Hughes Technical Center, and 6 of FAA’s 7 Program Planning Teams (PPT).<sup>5</sup> To obtain the perspectives of aviation stakeholders on FAA’s R&D priorities and decisions and their views on FAA’s portfolio development process, we interviewed officials from two of FAA’s centers of excellence (COEs)—the Partnership to Enhance General Aviation Safety, Accessibility and Sustainability and the Partnership for AiR Transportation Noise and Emissions Reduction—eight aviation associations, one federally funded research and

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<sup>1</sup>49 U.S.C. § 44501(c)(1)(2) - *National Aviation Research Plan (NARP)*, 49 U.S.C. § 44501(c)(3) - *National Aviation Research Plan (NARP)* Annual Report, 49 U.S.C. § 44509 – Demonstration projects, 49 U.S.C. § 44511 – Aviation Research Grants, 49 U.S.C. § 44512 – Catastrophic failure prevention research grants, 49 U.S.C. § 44513 – Regional Centers of Air Transportation Excellence, 49 U.S.C. § 48102(b) – Research and Development Financing

<sup>2</sup>OMB, *Multiagency Science and Technology Priorities for the FY17 Budget*, (July 2015).

<sup>3</sup>Each year, FAA’s Research and Development Management Division publishes guidance on the process FAA will use to develop its annual R&D portfolio and related budget.

<sup>4</sup>See the bibliography at the end of this report for a list of sources we used to identify leading practices for portfolio development and management.

<sup>5</sup>The remaining PPT, mission support, supports administrative functions and maintains the William J. Hughes Technical Center. The PPT does not identify, prioritize, or fund research. As a result, we did not meet with the mission support PPT.



development center, and three major private aviation manufacturers.<sup>6</sup> We selected COEs that perform research on a wide range of topics and are at different phases in their life cycles. We also interviewed representatives from MITRE, a federally-funded research and development center that carries out R&D for FAA and the private sector, to obtain their perspective on FAA's R&D management and prioritization. The private companies were selected based on our review of FAA's fiscal-year-2015 obligations data for R&D funding, whether the company performs R&D with its own resources separate from its FAA-funded R&D efforts, and recommendations from industry representatives. To assess how FAA manages its R&D programs, we analyzed management systems and processes that FAA's Technical Center and PPTs use to inventory and track progress of R&D programs. To understand whether agency R&D priorities and recommendations from the Research, Engineering, and Development Advisory Committee (REDAC) influence FAA's R&D portfolio, we interviewed the REDAC chair, reviewed REDAC documentation (e.g., meeting minutes), and analyzed REDAC recommendations.

To assess the R&D coordination between FAA and the National Aeronautics and Space Administration (NASA), we identified leading practices for interagency R&D collaboration, reviewed FAA and NASA documents, and interviewed officials from FAA, NASA, and related government offices as well as aviation stakeholders. We identified seven leading practices that are described in our previous work that can help enhance and sustain interagency collaboration: (1) by defining outcomes and achieving accountability; (2) by bridging organizational cultures; (3) by defining clear roles and responsibilities of each agency; (4) by establishing clear leadership; (5) by including appropriate participants; (6) by identifying and leveraging resources; and (7) by having written guidance and agreements.<sup>7</sup> In this report we do not discuss two of the seven leading practices, establishing clear leadership (number 4 in the list above) and including appropriate participants (number 5 in the list above), because those practices are evidenced in our review of the five other leading practices. To identify areas of potential collaboration, we

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<sup>6</sup>The eight aviation associations are: Aerospace Industries Association (AIA), Flight Safety Foundation (FSF), National Business Aviation Association (NBAA), General Aviation Manufacturers Association (GAMA), Airlines for America (A4A), Airports Council International-North America (ACI-NA), Air Line Pilots Association (ALPA), Airline Owners and Pilots Association (AOPA).

<sup>7</sup>[GAO-12-1022](#).

compared FAA's and NASA's R&D portfolios and reviewed agency budgets to identify areas of similar research. To assess how FAA and NASA coordinate, we interviewed FAA and NASA officials who oversee and conduct research in similar areas, and reviewed documentation and interviewed officials from entities that help FAA and NASA collaborate, such as FAA-NASA Research Transition Teams, the White House Office of Science and Technology Policy, and FAA's Interagency Planning Office. To obtain private sector perspectives on FAA and NASA coordination, we interviewed the eight aviation associations and three major private aviation manufacturers identified above. Finally, we compared leading practices to FAA and NASA's collaborative activities to assess the extent to which FAA follows leading practices.

To describe how FAA coordinates with the private sector and considers the impact of its R&D on private sector investments, we interviewed agency officials and private sector representatives and reviewed relevant literature. We reviewed documentation and interviewed FAA officials from its Technology Transfer Program, Technical Center, 7 PPTs, and 2 COEs. We also interviewed government-wide stakeholders, such as the White House Office of Science and Technology Policy to obtain the perspectives on the impact of FAA's R&D funding on private-sector organizations' investments, we interviewed representatives from the previously identified aviation associations and private sector companies.

To obtain a broader perspective on the role of federal investment in R&D and how federal R&D affects private sector investment in research, we performed a search of research databases to review relevant literature on the impact of federal funding on private sector R&D efforts. We reviewed 21 articles that examined federal R&D funding and the impact on private sector's R&D investment.<sup>8</sup> We analyzed the literature to identify the perspectives and assessments of the role of federal investment in R&D and how, if at all, federal R&D affects private sector investment in R&D. The literature review is not a comprehensive or exhaustive list of relevant research, and is not generalizable, but is intended to review a broad range of research to describe the impact of federal R&D on the private sector R&D investments.

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<sup>8</sup>See the bibliography at the end of this report for a list of sources we used to describe the impact of federal funding for research and development on private sector research and development funding.

# Appendix II: 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 29 2017

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

Mr. Dillingham:

In 2016, the Federal Aviation Administration (FAA) recognized the need for the National Aviation Research Plan (NARP) to be a more strategic document. This led us to initiate a cross-agency effort to redesign the NARP and its companion document, the Research & Development (R&D) Annual Review.

Currently, the NARP's emphasis is on FAA's five-year planned research activities considered necessary to ensure the continued safety and efficiency of aviation in the United States. The NARP redesign effort will go beyond these planned research activities and include, at a minimum, emerging technologies and forecasted needs of civil aeronautics, FAA's long-term research priorities, and integrated research goals, priorities, and activities. The redesign effort will also ensure both NARP and R&D Annual Review documents comply with statutory reporting requirements.

The FAA also plans to deliver the initial redesigned NARP and R&D Annual Review in fiscal year (FY) 2018, at the time of the President's 2019 budget submission, solicit design feedback from the Research Engineering & Development Advisory Committee, the Office of Management and Budget, and the Office of the Secretary of Transportation, and finalize design changes in FAA's FY 2019 NARP and R&D Annual Review publications.

Upon preliminary review of the draft report, we concur with the three recommendations and will provide a detailed response to each recommendation within 60 days of final report's issuance.

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 or if you would like to obtain additional details.

Sincerely,

A handwritten signature in blue ink, appearing to read "Keith Washington".

Keith Washington  
Deputy Assistant Secretary for Administration

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# Appendix III: GAO Contact and Staff Acknowledgments

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## GAO Contact

Gerald L. Dillingham, Ph.D., (202) 512-2834 or [dillinghamg@gao.gov](mailto:dillinghamg@gao.gov)

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## Acknowledgments

In addition to the contact named above, the following individuals made important contributions to this report: Paul Aussendorf, Assistant Director, Colenn Berracasa, Maya Bhalodia, Roshni Davé, Molly Laster, John F. Miller, Katherine Morris, Richard Hung, Charles Bausell, Delwen Jones, and Elizabeth Spurgeon.

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Automated answering system: (800) 424-5454 or (202) 512-7470

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## Congressional Relations

Katherine Siggerud, Managing Director, [siggerudk@gao.gov](mailto:siggerudk@gao.gov), (202) 512-4400, U.S. Government Accountability Office, 441 G Street NW, Room 7125, Washington, DC 20548

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## Public Affairs

Chuck Young, Managing Director, [youngc1@gao.gov](mailto:youngc1@gao.gov), (202) 512-4800, U.S. Government Accountability Office, 441 G Street NW, Room 7149, Washington, DC 20548

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