IMMERSIVE TECHNOLOGIES

Most Civilian Agencies Are Using or Plan to Use Augmented Reality, Virtual Reality, and More

Report to Congressional Requesters

August 2024
GAO-24-106665
United States Government Accountability Office

Accessible Version

GAO Highlights

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Highlights of GAO-24-106665, a report to congressional requesters
August 2024

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Most Civilian Agencies Are Using or Plan to Use Augmented Reality, Virtual Reality, and More

Why GAO Did This Study

Immersive technologies integrate the physical environment with digital content to support user engagement. As the capabilities of these technologies expand, the need to understand in a comprehensive way how federal agencies are using them has become increasingly important.

GAO was asked to review how immersive technologies are used across federal civilian agencies. This report identifies and discusses (1) the federal civilian agencies that had programs or activities involving immersive technologies in 2022 and 2023, including the purposes and reported benefits of those technologies; (2) federal civilian agencies' plans for programs or activities involving immersive technologies for fiscal years 2024 through 2028; and (3) the challenges federal civilian agencies reported on the use and adoption of immersive technology.

GAO surveyed the 23 civilian agencies defined in the Chief Financial Officers Act of 1990, as amended. GAO received responses from all 23 agencies. Survey topics included the types and use of immersive technologies and the benefits and challenges associated with their use and adoption. GAO contacted agencies in writing or through interviews, as needed, to clarify responses to the survey.

What GAO Found

Federal civilian agencies use immersive technologies to train workers, improve agency processes, interact with the public, and execute their missions, among other reasons. In response to GAO's survey, 17 of the 23 civilian agencies reported activities involving immersive technologies in fiscal years 2022 and 2023, with 13 agencies reporting benefits from their use. Agencies used the technologies for workforce training and public outreach most often. For example, the Department of Homeland Security used simulators and other immersive technologies to train nearly 10,000 of its employees in fiscal year 2022 for law enforcement use-of-force training, transportation security training, and fire and emergency response training. The Department of Veterans Affairs used immersive technologies, such as virtual reality, as a tool for clinical staff to support mental health treatment, physical rehabilitation, and pain management. Agencies reported a better understanding of data, increased safety, and improved decision making as the most beneficial aspects of using immersive technologies.

Examples of How Federal Civilian Agencies Are Using Immersive Technologies

Source: GAO. | GAO-24-106665

Sixteen agencies reported plans to expand their activities involving immersive technologies during fiscal years 2024–2028. These agencies plan to use these technologies most frequently for data visualization and analysis, design and planning, public outreach, and remote collaboration. For example, the Department of Transportation's Federal Aviation Administration plans to use immersive technologies to demonstrate new architectural designs and concepts. Of the 16 agencies, 15 reported plans to adopt or expand their use of immersive technologies and 13 reported plans to conduct or fund research and development.

The most often cited challenges among agencies that have used or adopted the technologies were with meeting cybersecurity and privacy requirements and with high operation and maintenance costs. Agencies that do not plan to adopt or expand their use identified cybersecurity requirements as the most common barrier. In addition, immersive technologies may not be conducive to an agency's mission or the types of tasks its staff perform.

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Abbreviations

AR	augmented reality
CFO Act	Chief Financial Officers Act of 1990, as amended
DHS	Department of Homeland Security
DOE	Department of Energy
DOJ	Department of Justice
DOL	Department of Labor
DOT	Department of Transportation
EPA	Environmental Protection Agency
GSA	General Services Administration
HHS	Department of Health and Human Services
NASA	National Aeronautics and Space Administration
NRC	Nuclear Regulatory Commission
R&D	research and development
USAID	U.S. Agency for International Development
USDA	U.S. Department of Agriculture
VA	Department of Veterans Affairs
VR	virtual reality
XR	extended reality

U.S. GOVERNMENT ACCOUNTABILITY OFFICE
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August 8, 2024

The Honorable Ben Ray Luján
Chair
Subcommittee on Communications, Media, and Broadband
Committee on Commerce, Science, and Transportation
United States Senate

The Honorable Roger F. Wicker
United States Senate

The Honorable Todd Young
United States Senate

Immersive technologies integrate the physical environment with digital content to support user engagement. While some initial applications of immersive technologies have been for video games or entertainment, there are emerging commercial and governmental uses, including for education and training, health care, and design and construction. For example, federal agencies are using immersive technologies to train federal law enforcement and to support clinical staff in treating patients. In the commercial sector, there are web-based or smartphone applications that allow viewing different simulated furniture options in one's house or living space, or how eyeglasses might fit using a simulated image overlaid on a person's face.

As the use of immersive technologies continues to expand, the Congress and organizations have highlighted the importance of understanding in a comprehensive way how these technologies are used by federal agencies. For example, section 10381 of what is commonly referred to as the CHIPS and Science Act of 2022, established the Directorate for Technology, Innovation, and Partnerships. This directorate is intended to support use-inspired and translational research and accelerate the development and use of federally funded research; strengthen U.S. competitiveness by accelerating the development of key technologies; grow the domestic workforce in key technology focus areas, and expand the participation of U.S. students and researchers in areas of societal, national, and geostrategic importance at all levels of education.[1] The act specifically identified a list of key technology focus areas that includes advanced communications technology and immersive technology.[2] We have previously reported on extended reality technologies—which are a type of immersive technology—including opportunities, challenges, and policy questions.[3]

[1]Research and Development, Competition, and Innovation Act, Pub. L. No. 117-167, div. B, tit. III §§ 10381-10399A, 136 Stat 1366, 1576-98 (2022), to be codified at 42 U.S.C. §§ 19101-20. (Section 10381 of this act established the Directorate for Technology, Innovation, and Partnerships (TIP), a new directorate within the National Science Foundation (NSF)). Use-inspired research is scientific investigation that is driven by the research outcome's potential use. Translational research seeks to produce results that directly benefit the public more quickly. The TIP Directorate makes awards that would support accelerators and projects designed to achieve specific technology metrics or objectives and encourage the translation of research into innovations, processes, and products.

[2]Pub. L. No. 117-167, §10387(c)(6), 136 Stat. at 1579-80.

[3]GAO, *Science & Tech Spotlight: Extended Reality Technologies*, GAO-22-105541 (Washington, D.C.: Jan. 26, 2022).

You asked us to review the adoption of immersive technologies across federal civilian agencies. This report identifies and discusses (1) the federal civilian agencies that had programs or activities involving immersive technologies in fiscal years 2022 and 2023, including the purposes and reported benefits of those technologies; (2) federal civilian agencies' plans for programs or activities involving immersive technologies from fiscal years 2024 through 2028, including anticipated benefits; and (3) the challenges federal civilian agencies reported on the use and adoption of immersive technologies.

To address these objectives, we surveyed each of the 23 civilian Chief Financial Officers Act (CFO Act) agencies with questions about immersive technologies.[4] We received responses from all 23 civilian agencies.

Our survey questions related to: (1) current and planned use of immersive technologies, (2) current and planned research and development (R&D), (3) current and planned regulatory oversight of nonfederal entities, and (4) benefits and challenges of adoption and use.[5] The survey also asked more detailed questions about the individual immersive technology systems, programs, and activities conducted by agencies, which included the types of immersive technologies, the purpose(s), a brief description of their use, and obligations and sources of funding related to their use. For consistency of responses across all agencies, we provided a definition of immersive technologies.[6] We asked agencies to include the activities of all relevant components, bureaus, and offices in their responses.

To develop the survey questions, we used information from prior GAO reports; relevant literature; interviews with agency officials, industry, and other groups; and site visits. We conducted site visits to inform our understanding of the technologies, including visits to federal sites at the Department of Transportation (DOT), the National Aeronautics and Space Administration (NASA), and the Department of Energy (DOE), where we interviewed officials about their uses and experiences with immersive technologies and observed demonstrations of their systems. We pretested the survey with three agencies and performed an internal peer review of the survey.

We emailed our survey to the 23 civilian CFO Act agencies in September 2023. We closed the survey in November 2023 after receiving responses from all 23 agencies. We reviewed the responses and took quality control steps by performing checks for completeness, logical errors, and inconsistencies. We followed up with agencies in writing or through interviews, as appropriate, to clarify answers. Appendix I summarizes the responses from 15 agencies that reported current or planned activities involving immersive technologies. See

[4]The 23 agencies are those identified in the Chief Financial Officers Act of 1990 (CFO Act), Pub. L. No. 101-576, 104 Stat. 2838 (1990), as amended, codified at 31 U.S.C. § 901(b). They are the U.S. Departments of Agriculture, Commerce, Education, Energy, Health and Human Services, Homeland Security, Housing and Urban Development, the Interior, Justice, Labor, State, Transportation, the Treasury, Veterans Affairs, Environmental Protection Agency, National Aeronautics and Space Administration, U.S. Agency for International Development, General Services Administration, National Science Foundation, Nuclear Regulatory Commission, Office of Personnel Management, Small Business Administration, and Social Security Administration. Although the Department of Defense is a CFO Act agency under 31 U.S.C. § 901(b)(1)(C), it is not a civilian agency, and, therefore, outside the scope of this review.

[5]In our survey we asked agencies if they engaged in or planned to engage in any regulatory functions over nonfederal entities. As defined in our survey, "regulatory functions" includes, but is not limited to, investigatory and inspection activities, taking enforcement actions, prescribing requirements or guidance, conducting oversight, and maintaining performance standards. For the purposes of this report, nonfederal entities include state, local or tribal governments or agencies, or private companies—for example, technology companies, universities, police departments, banks, or airports.

[6]As defined in our survey, immersive technology is any technology that integrates the physical environment with digital content to support user engagement. It often includes hardware (such as a phone or head-mounted display), software (such as an app or software engine), and user interaction to and from the physical or virtual environment.

appendix II for additional information on our scope and methodology and appendix III for a copy of our survey instrument.

We conducted this performance audit from February 2023 to August 2024 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

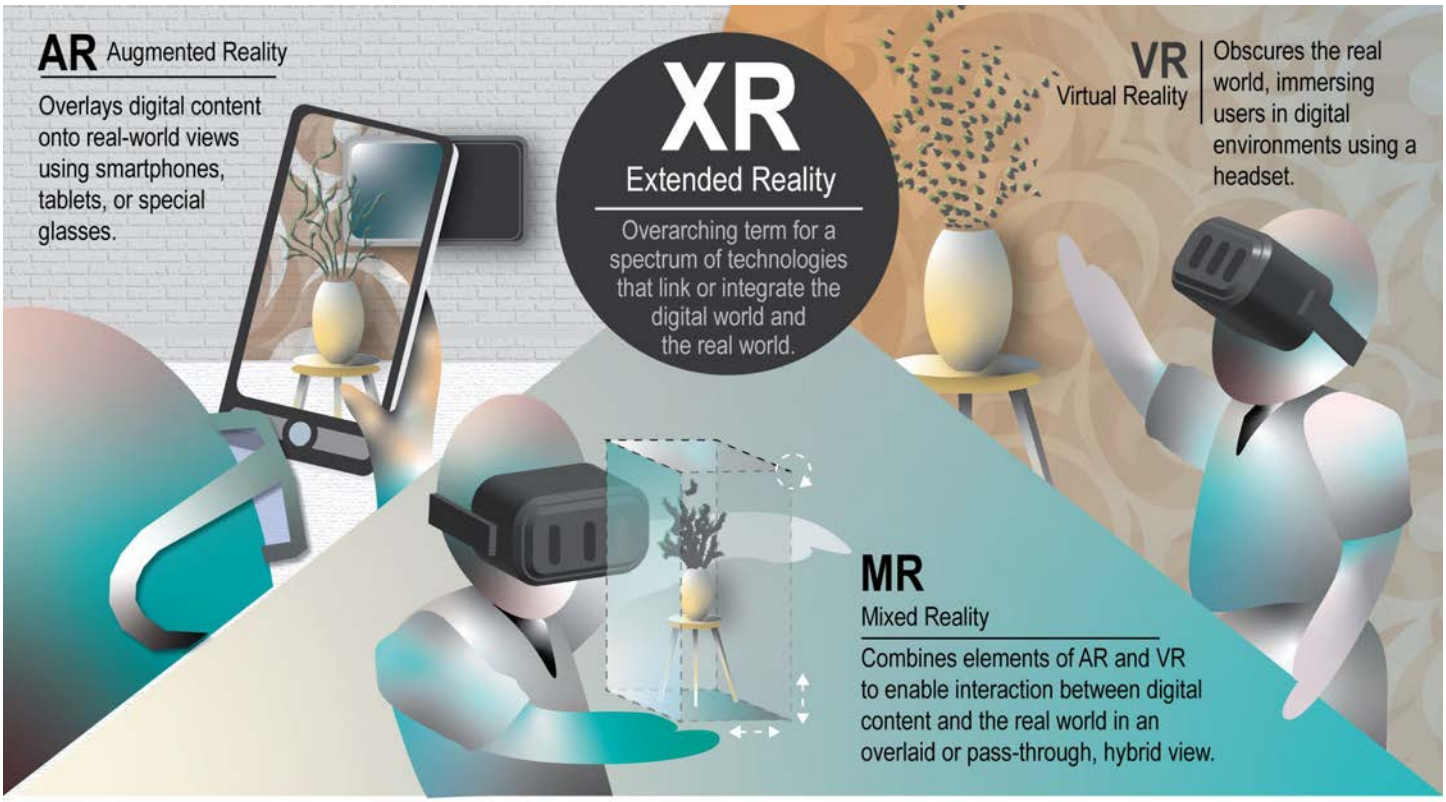
Background

Immersive Technologies

Immersive technologies are any technology that integrates the physical environment with digital content to support user engagement. Immersive technology often includes hardware (such as a phone or head-mounted display), software (such as an app or software engine), and user interaction to and from the physical or virtual environment. Immersive technologies include extended reality (XR). As we have previously reported and as seen in figure 1, XR is an overarching term for a spectrum of technologies that includes augmented reality (AR), mixed reality (MR), and virtual reality (VR).[7] MR is sometimes referred to as hybrid reality.

[7]GAO-22-105541.

Figure 1: Types of Immersive Technologies: Extended Reality



Source: GAO. | GAO-24-106665

Users interact with immersive technologies in different ways, depending on how the technology works. For example, a user may move or perceive moving through 3D space by manipulating hand controllers that provide input and feedback or wearing a headset. This is known as degrees of freedom. The headset tracks and updates the immersive view when the user turns their head left or right, tilts it forward or backward, or pivots side to side. A user's immersive experience may also be characterized by immersion, presence, and interaction (see text box).

Characteristics of an immersive experience: immersion, presence, and interaction

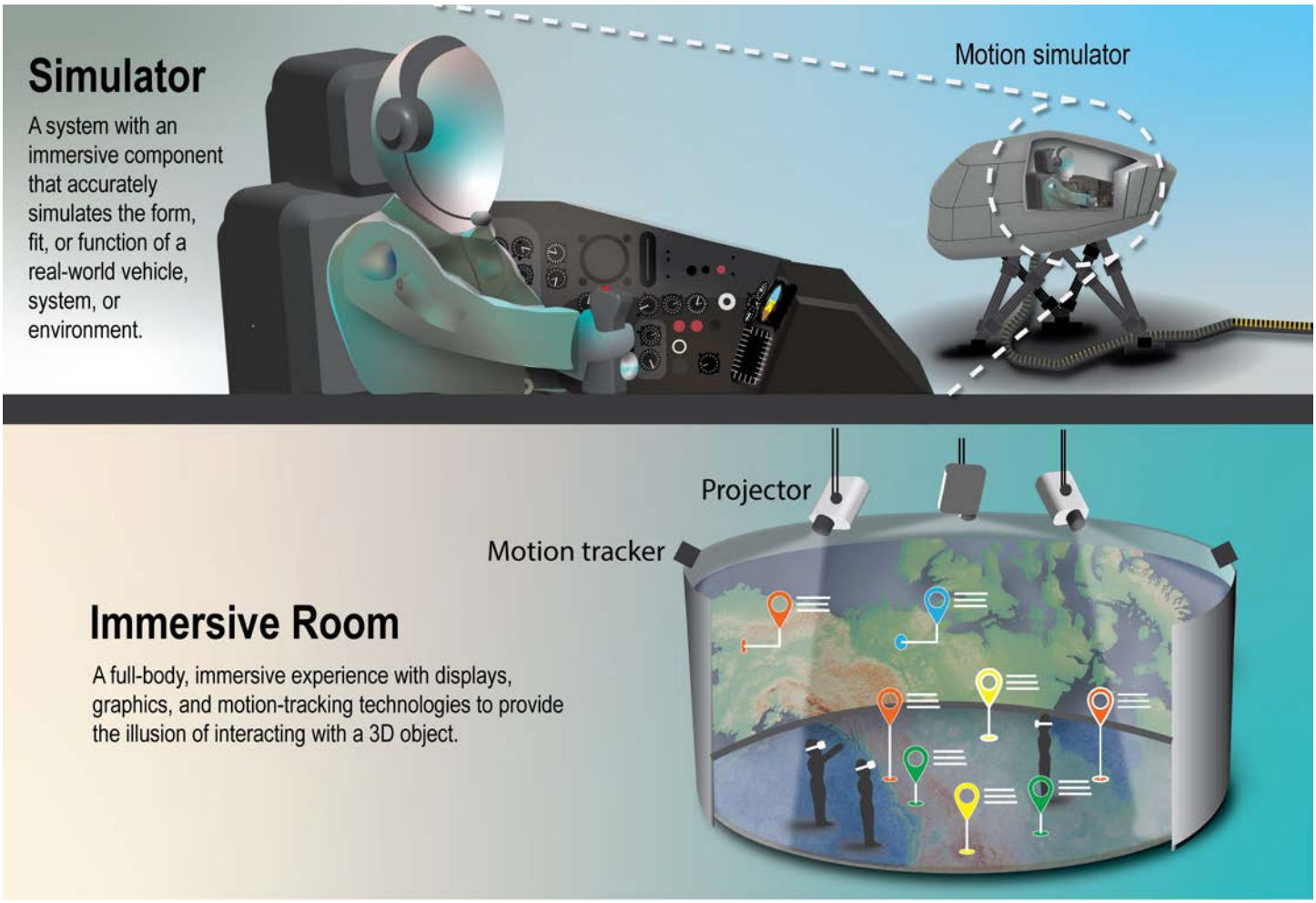
The level of an immersive experience is often characterized by three factors:

- **Immersion** refers to how the technology interacts with the body's senses within the immersive environment. For example, a system where a person uses their whole body—such as bending down to look underneath an object or looking around an object—would have a higher level of immersion than a system where the user can only turn their head. Immersion can be objectively assessed.
- **Presence** is the sense of "being there" in the virtual environment and is closely related to immersion. It is subjective and may vary from person to person.
- **Interaction** is the capacity to act and receive feedback between the real world and digital content.

Source: GAO analysis of Mel Slater and Sylvia Wilbur, "A Framework for Immersive Virtual Environments (FIVE): Speculations on the Role of Presence in Virtual Environments," *Presence: Teleoperators and Virtual Environments (1997)* (immersion and presence); Wilfredo Lopez-Ojeda and Robin A. Hurley, "Extended Reality Technologies: Expanding Therapeutic Approaches for PTSD," *Journal of Neuropsychiatry and Clinical Neurosciences*, vol. 34, no. 1 (2022) (immersion and interaction); and Department of Veterans Affairs, *Introductory Guide to Immersive Technology* (immersion and presence). | GAO-24-106665

Immersive technologies also include simulators and immersive rooms (see fig. 2). Immersive rooms are sometimes referred to as a "CAVE"—that is, Cave Automatic Virtual Environment. Another related term is spatial computing, which is an evolving form of computing that blends the physical world and virtual experiences using a wide range of technologies.

Figure 2: Types of Immersive Technologies: Simulator and Immersive Room



Source: GAO. | GAO-24-106665

Federal Use of Immersive Technologies

Federal civilian agencies use immersive technologies to train workers, improve agency processes, interact with the public, and execute their mission, among other uses. We grouped these uses into nine different categories:

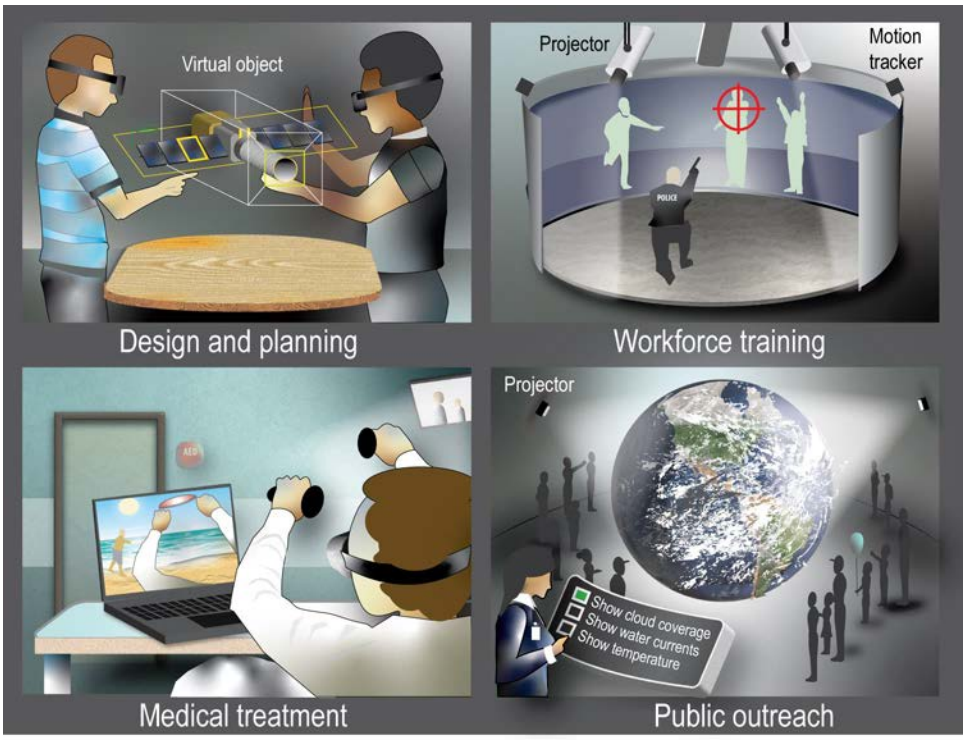
- **Workforce training.** Using hands-on, interactive, and immersive tools to help employees develop, improve, and maintain the knowledge and skills to perform their jobs, such as training pilots on aircraft flight controls or law enforcement officers on firearms use.
- **Data visualization and analysis.** Analyzing and presenting complex information in an immersive environment to help employees grasp difficult concepts and identify patterns in data.[8]

[8]An immersive environment is an environment created with a combination of hardware and software that provides the user with a psychological and physical experience of being immersed in a computer-generated scene.

- **Human factors research.** Creating immersive experiences to observe how users interact with technologies or the environment—such as a new control panel or new roadway design—to determine whether equipment is suitable for the users and their environment with each design iteration.
- **Public outreach.** Creating more interactive and engaging experiences to inform the public about a given subject or highlight the agency's work and activities.
- **Remote collaboration.** Allowing employees and other users in multiple locations to work together in an immersive 3D environment.
- **Design and planning.** Creating designs of objects, processes, and systems that can then be tested iteratively using immersive technologies to evaluate design trade-offs.
- **Medical assessment or treatment.** Assessing, treating, managing, or supporting medical and mental health conditions using immersive tools for patients in a medical or clinical setting. For example, for patients who may have not responded well to conventional treatment or who could find it difficult to attend appointments in person.
- **Real-time assistance, guidance, and inspection.** Making more information available instantly to employees, allowing them to work more efficiently. For example, AR glasses could project additional information onto a user's view when performing an inspection.
- **Other purposes.** Additional purposes that do not fit into the categories above—for example, remote operation of robots, rovers, and other computer-enabled devices, as well as showcasing immersive technologies' capabilities to stakeholders.

Examples of some of these purposes are shown in figure 3.

Figure 3: Examples of Federal Civilian Agencies' Use of Immersive Technologies



Source: GAO. | GAO-24-106665

Most Federal Civilian Agencies Reported Activities Involving Immersive Technology

Of the 23 federal civilian agencies we surveyed, 17 reported engaging in one or more activities involving immersive technology in fiscal year (FY) 2022 (FY 2022) or FY 2023. Specifically, 14 agencies reported using immersive technologies; 15 agencies reported conducting or funding R&D related to immersive technologies. In addition, 11 agencies reported other immersive technology-related activities—all with nonfederal entities (see table 1).

Table 1: Immersive Technology Activities Reported by Federal Civilian Agencies, Fiscal Years 2022–2023

Immersive technology activity				
Agency	**Use**	**Conduct or fund research and development**	**Other—nonfederal entity activities: Entered into transactions[a]**	**Other—nonfederal entity activities: Regulated nonfederal entities[b]**
Department of Agriculture	yes	yes	yes	no
Department of Commerce	yes	yes	yes	no
Department of Education	no	yes	yes	no
Department of Energy	yes	yes	yes	no
Department of Health and Human Services	yes	yes	yes	yes
Department of Homeland Security	yes	yes	no	yes
Department of Housing and Urban Development	no	no	no	no
Department of the Interior	yes	yes	no	no
Department of Justice	yes	yes	yes	not sure
Department of Labor	yes	no	no	no
Department of State	no	no	no	no
Department of Transportation	yes	yes	yes	yes
Department of the Treasury	no	no	not sure	not sure
Department of Veterans Affairs	yes	yes	no	no
Environmental Protection Agency	yes	yes	no	no
National Aeronautics and Space Administration	yes	yes	yes	no
Agency for International Development	no	not sure	yes	no
General Services Administration	yes	yes	no	no
National Science Foundation	no	yes	no	no
Nuclear Regulatory Commission	yes	yes	yes	no
Office of Personnel Management	no	no	no	no
Small Business Administration	no	no	not sure	no

Agency	Use	Conduct or fund research and development	Other—nonfederal entity activities: Entered into transactions[a]	Other—nonfederal entity activities: Regulated nonfederal entities[b]
Social Security Administration	no	no	no	no
Total	14	15	10	3

● = Yes; ○ = No; ? = Not sure[c]

Source: GAO analysis of federal civilian agency survey data. | GAO-24-106665

Note: The data in this table come from survey questions 2, 11, 15 and 17.

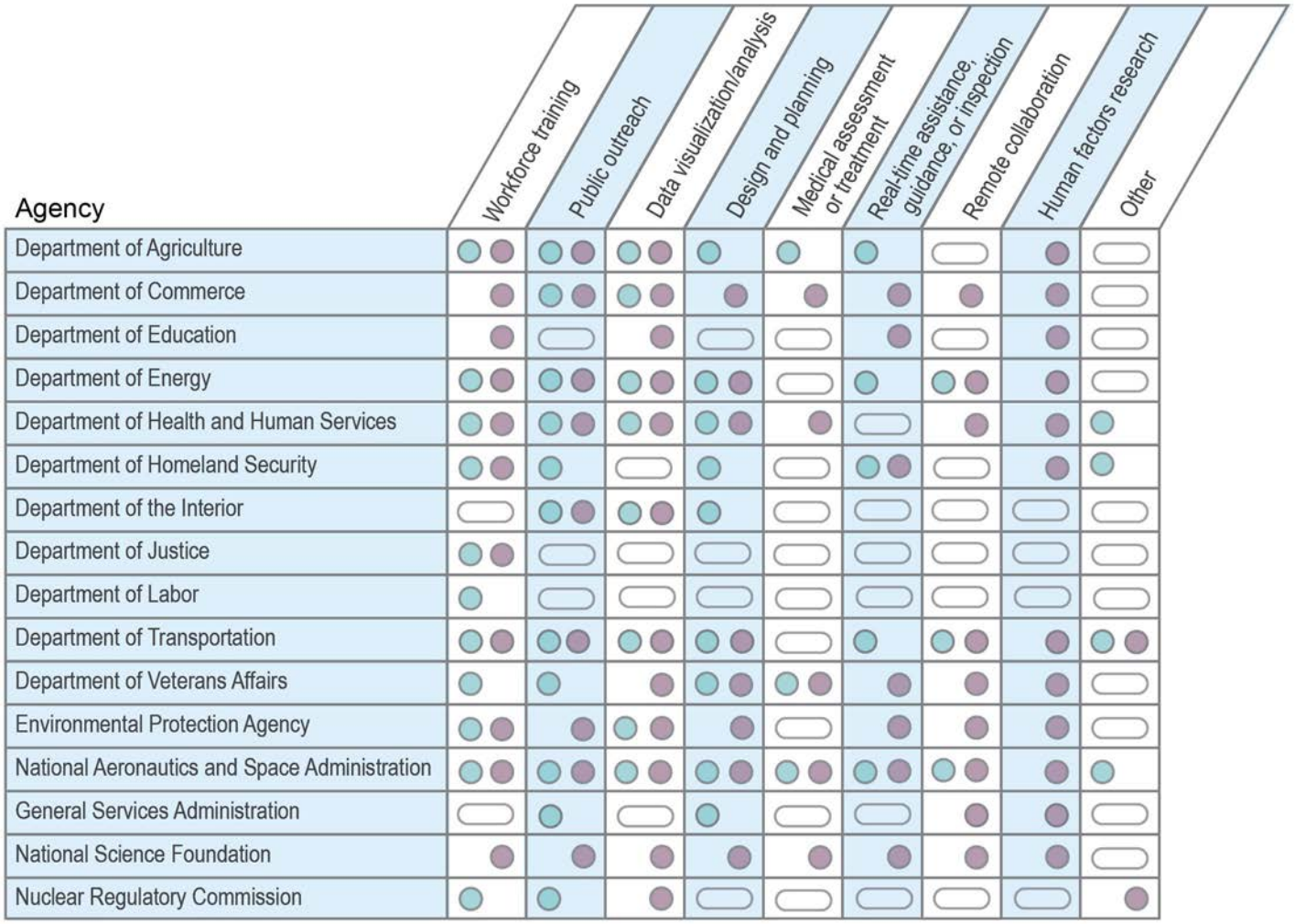
[a]By "entered into transactions with nonfederal entities" we mean that the agency awarded grants, entered into contracts, leases, or cooperative agreements, provided direct loans or loan guarantees, or entered into any other transactions using any other transactional authority that would enable nonfederal entities to develop, purchase, or use immersive technologies for their own uses. We only asked agencies about this type of activity for current (FY 2022–2023) use.

[b]In our survey we asked agencies if they engaged in or planned to engage in any regulatory functions over nonfederal entities that use immersive technologies. For the purposes of this survey, we explained that "regulatory functions" includes, but is not limited to, conducting investigatory and inspection activities, taking enforcement actions, prescribing requirements or guidance, conducting oversight, and maintaining performance standards. We also explained that for the purposes of this survey, nonfederal entities include state, local or tribal governments or agencies, or private companies—for example, technology companies, universities, police departments, banks, or airports.

[c]"Not sure" means that the agency selected this as a response to the survey question.

Agencies reported using or conducting R&D involving immersive technologies for a variety of purposes. They most often reported training workers, performing public outreach, and visualizing and analyzing data (see fig. 4).

Figure 4: Immersive Technology Use and Research and Development by Purpose as Reported by Federal Civilian Agencies, Fiscal Years 2022–2023



Source: GAO analysis of federal civilian agency survey results. | GAO-24-106665

Note: The data in this figure come from survey questions 4 and 14a.

[a]"Not sure" means that the agency selected this as a response to the survey question.

Fourteen Agencies Used Immersive Technologies and Reported Benefits

Fourteen federal civilian agencies reported using immersive technologies in FY 2022 and FY 2023, most frequently for workforce training, public outreach, data visualization and analysis, and design and planning (see fig. 4). The three types of technology with the highest reported use among these agencies were simulators, VR, and AR. Nine of these agencies reported using at least one type of immersive technology on a weekly basis. The most frequently used immersive technologies were simulators and mixed reality, each of which was used at least once a week by six and five agencies, respectively.

Further, 13 of 14 agencies reported benefits to using immersive technology. Agencies reported a better understanding of data, increased safety, and improved decision-making as the most beneficial aspects of using immersive technologies. Four of the top five reported benefits relate to a user's understanding of the information or situation. Conversely, agencies did not find the versatility of immersive technologies—meaning the ability to be used on a wider range of platforms or scale up for different purposes—to be as beneficial as other aspects.

The following sections provide overall summaries of how federal civilian agencies reported using immersive technologies for different purposes, as well as specific agency examples for each.

Workforce Training

Eleven agencies reported using immersive technologies for workforce training. Agencies used immersive technologies to train employees on managing and responding to specific scenarios in real-time. Ten of the 11 agencies using immersive technologies for workforce training reported that the technologies were beneficial and five reported that they were extremely beneficial for increased user engagement and learning retention. A study by the Institute for Defense Analyses found the effectiveness of immersive technology on training depends on factors such as the type of AR or VR technology used, the virtual content provided, the user, and the types of tasks to be done.[9]

- The Department of Homeland Security (DHS) reported using immersive technologies to train nearly 10,000 of its employees in fiscal year 2022 for law enforcement use of force training, transportation security training, and fire and emergency response training across five components. This included U.S. Customs and Border Protection, which uses simulators for use-of-force proficiency training (see fig. 5).

[9]Institute for Defense Analyses, *Training Effectiveness Framework for Augmented and Virtual Reality: Developing a Knowledge Base* (2022).

Figure 5: U.S. Customs and Border Protection Use of a Simulator for Federal Law Enforcement Training

Source: U.S. Department of Homeland Security, U.S. Customs and Border Protection. | GAO-24-106665

- The Department of Labor's (DOL) Occupational Safety and Health Administration reported using AR to train employees to identify safety hazards associated with excavations and to show and discuss different methods of cave-in protection.

Public Outreach

Eleven agencies reported using immersive technologies for public outreach by engaging with the public at in-person events and through content available online. Agencies also used immersive technologies to facilitate outreach with industry representatives.

- The Department of Energy (DOE) reported using VR headsets to allow multiple users to interact with a virtual manufacturing floor at an open house event.
- The National Aeronautics and Space Administration (NASA) reported developing VR demonstrations of emerging technologies for use at public outreach events. It also reported developing an AR phone application to educate the public about its aircraft and aviation research programs.
- The Department of Health and Human Services' (HHS) Centers for Disease Control and Prevention created the Pittsburgh Mining Virtual Reality System to provide worker safety simulation and research to industry partners and mining operators.

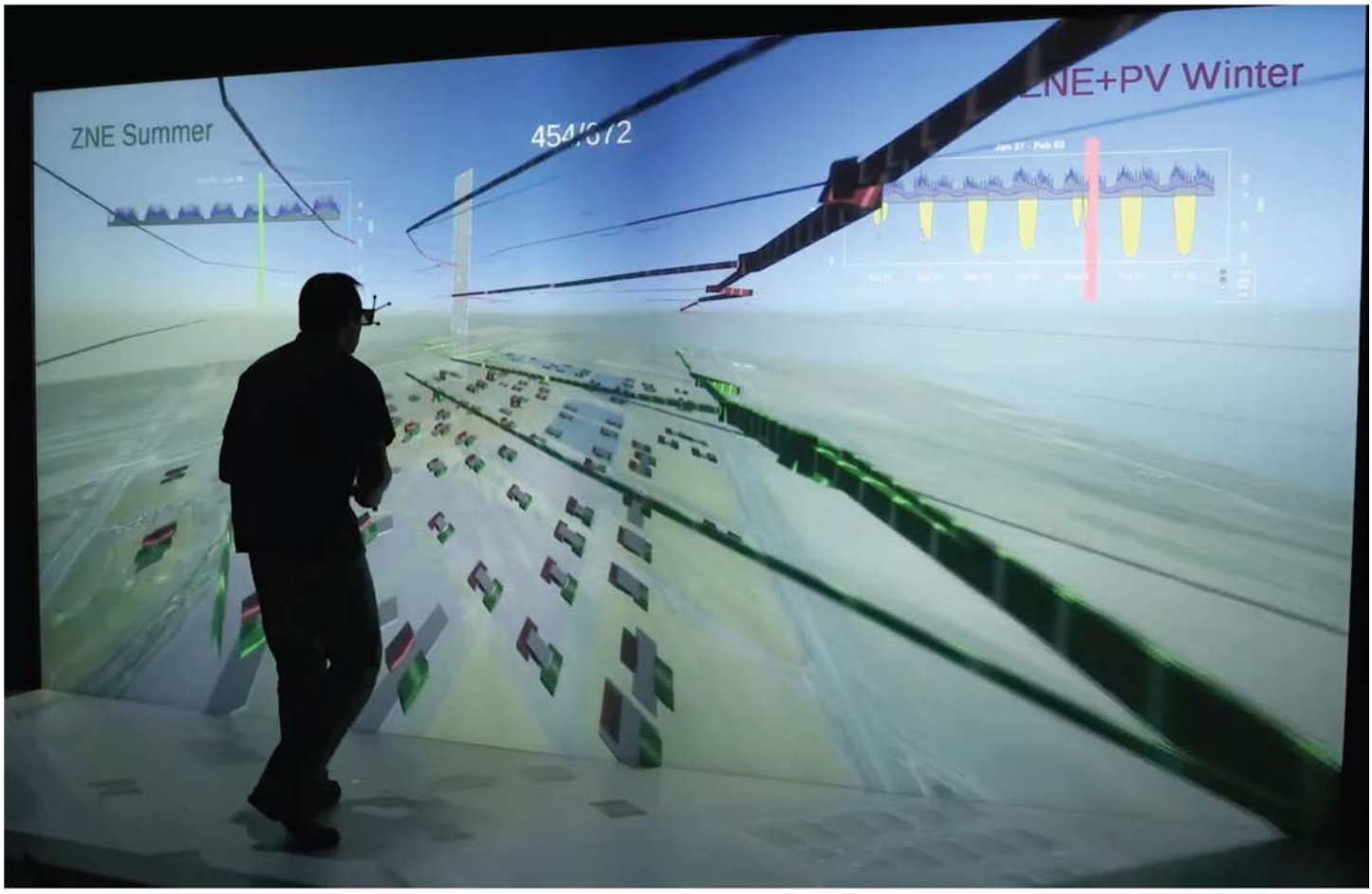
Data Visualization and Analysis

Gaining a better understanding of data was reported as a top benefit to using immersive technologies. By providing a more intuitive way to interact with data, immersive technologies can help federal agencies make more informed decisions and improve their overall effectiveness. Eight agencies reported using immersive

technologies to display and analyze data, which may help users better understand complex concepts and identify patterns that may not be immediately apparent in traditional two-dimensional visualizations. Agencies also reported using immersive technologies to visualize data being generated in real-time.

- The Department of the Interior reported using an immersive room system to convey complex geological data, such as 3D seismic data, to multidisciplinary audiences. Displaying this information in 3D makes it easier for other audiences to recognize features in the data, which in turn facilitates communication and helps build common ground.
- DOE reported that its National Renewable Energy Laboratory has used VR to visualize energy data in a 3D environment, allowing researchers to better understand the relationships between different variables (see fig. 6).

Figure 6: Department of Energy National Renewable Energy Laboratory Using an Immersive Room to Visualize Energy Data



Source: U.S. Department of Energy National Renewable Energy Laboratory. | GAO-24-106665

- The Department of Transportation (DOT) reported using immersive technologies to support data visualizations for simulations in which key aircraft data are super-imposed on the pilot's out-the-window view.

Design and Planning

Nine agencies reported using immersive technologies to help design and plan projects and processes.

- The U.S. Department of Agriculture (USDA) reported that the U.S. Forest Service uses immersive technologies to aid in wildfire preparation and response efforts, including prescribed burn planning and post-fire restoration operations.
- The Department of the Interior reported using immersive technologies to show planners and operators how complex engineering projects, such as construction of an offshore wind farm, will appear in the existing environment. This visualization allows stakeholders to see the cumulative effects of multiple projects in an area and better understand the impact of projects on existing land uses, such as recreation and tourism.

Real-Time Assistance, Guidance, or Inspection

Five agencies reported using immersive technologies for real-time assistance, guidance, or inspection.

- USDA reported that the U.S. Forest Service has used immersive technologies to inspect and help service aircraft and equipment.
- DHS reported using immersive technologies to provide assistance and feedback on decisions made by emergency responders in training environments. This feedback strengthens decision-making and provides insight into the cause-and-effect relationship of actions taken during an emergency.

Medical Assessment or Treatment

Three agencies reported using immersive technologies as a tool for medical assessment or treatment.

- The Department of Veterans Affairs (VA) reported using immersive technologies as a tool for clinical staff to support medical treatment, including mental health care, physical rehabilitation, and pain management (see fig. 7).

Figure 7: Department of Veterans Affairs Uses Immersive Technologies to Support the Delivery of Medical Treatment

Source: U.S. Department of Veterans Affairs. | GAO-24-106665

- NASA reported using immersive technologies such as XR to carry out physiological and cognitive studies on human subjects performing in simulated off-Earth environments. For instance, NASA used immersive technology to study how changes in gravity affect human balance and coordination. It also tested human performance during simulated off-Earth tasks such as working outside of vehicles on the surface of Mars.

Remote Collaboration

Three agencies reported using immersive technology to facilitate remote collaboration. A NASA official told us that immersive technologies are particularly beneficial for remote collaboration with partners in industry and academia. The official said that a shared physical-digital space for collaboration makes communication easier, especially when working with partners in different time zones.

- NASA and DOT both reported using immersive technology to integrate with other entities' simulation platforms, including each other's. The agencies use this capability to leverage the assets and tools at other facilities and collaborate on large-scale, multi-vehicle simulations.
- DOE reported that it used immersive technologies to support multiple simultaneous and immersive views of datasets for remote analysis.

Fifteen Agencies Conducted or Funded R&D

Most of the 15 agencies that conducted or funded R&D involving immersive technology in FY 2022 and FY 2023 reported conducting R&D for applications related to workforce training (11), data visualization and analysis (12), and human factors research (12) (see fig. 4). Of the 15 agencies,13 reported conducting internal R&D, and 12 reported funding R&D through grants or contracts with external entities. Among agencies that funded R&D through external entities, the most common recipients of funding were universities, followed by private research institutions (such as federally funded R&D centers), private companies, and other government entities, including state and local entities.

Agencies reported conducting R&D using immersive technology in different ways. In some cases, agencies used immersive technology as a tool to facilitate research on another topic. For example, USDA reported that researchers and farmers working at its AI Institute for Resilient Agriculture use VR headsets and controllers to view and interact with 3D models of plants from the field (see fig. 8). This allows researchers to remotely examine and assess plants' response to drought, heat, and flooding. In other cases, agencies reported conducting R&D to assess how the agency might use immersive technology to accomplish its mission. The Department of Education awarded multiple grants for research to evaluate the use of immersive technologies to improve learning outcomes. Agencies also reported conducting R&D on immersive technology itself to advance or mature the technology. NASA reported developing or improving several XR systems that can be used for a variety of research and training applications, such as those related to the Artemis lunar missions.

Figure 8: U.S. Department of Agriculture National Institute of Food and Agriculture grantee, Artificial Intelligence Institute for Resilient Agriculture (Iowa State University), Use of Immersive Technologies to Conduct Research and Development

Source: Artificial Intelligence Institute for Resilient Agriculture, Iowa State University. | GAO-24-106665

The following sections provide overall summaries of how federal civilian agencies reported conducting R&D involving immersive technology for different purposes, as well as specific agency examples for each.

Workforce Training

Eleven agencies reported conducting R&D related to workforce training. When asked to rate how beneficial certain aspects of immersive technology are to them, every agency that provided ratings reported that

immersive technology provided an increase in user engagement and learning retention, with nine of the agencies reporting immersive technology as very or extremely beneficial in this regard.

- The Environmental Protection Agency (EPA) reported developing a VR system to train responders on the collection of environmental samples for chemical, biological, and radiological contaminants. The system tracks user performance and offers metrics and feedback on their sampling activities. Similarly, the agency is developing a VR-based system to train responders on identifying oil spills and other contaminants from the air without requiring real-world overflights.
- DHS reported that its Transportation Security Administration is developing a "classroom-in-a-box," which allows students to observe simulated airport checkpoints through VR headsets and receive virtual instruction. DHS also reported that the Federal Protective Service constructed and finished a new VR center for law enforcement in January 2024. Since then, the Federal Protective Service has used it to train approximately 300 law enforcement officers.

Data Visualization and Analysis

Twelve agencies reported conducting R&D related to data visualization and analysis. When asked to rate how beneficial certain aspects of immersive technology are to them, every agency that provided ratings reported that immersive technology provided a better understanding of data and easier access to information. Notably, 12 agencies rated immersive technology as very or extremely beneficial for an improved understanding of data.

- The Department of Commerce reported that its National Institute of Standards and Technology uses an immersive cave to conduct R&D by visualizing computer simulations of complex materials, such as high-performance concrete, and studying signals from wearable medical devices, such as a device to detect fluid build-up in the wearer's lungs (see fig. 9).

Figure 9: National Institute of Standards and Technology Research and Development Involving Immersive Technologies to Visualize Data

Source: U.S. Department of Commerce National Institute of Standards and Technology. | GAO-24-106665

Human Factors Research

Twelve agencies reported conducting R&D related to human factors research. Agencies reported increased safety as one of the top benefits of immersive technology, with eight agencies rating it as extremely beneficial.

- DOT reported that its Federal Highway Administration conducted a study to investigate the behavior of passenger vehicle drivers in the presence of groups of trucks, and another study to identify safety challenges associated with autonomous vehicles and their interaction with other users of roadways.
- GAO visited the Federal Highway Administration Turner-Fairbank Research Center to better understand DOT's use of immersive technologies, including human factors research. Here, DOT demonstrated a VR-enabled pedestrian simulator used to test interactions between pedestrians and other road users at a virtual intersection (see fig. 10).

Figure 10: Using Immersive Technologies for Human Factors Research at the Department of Transportation

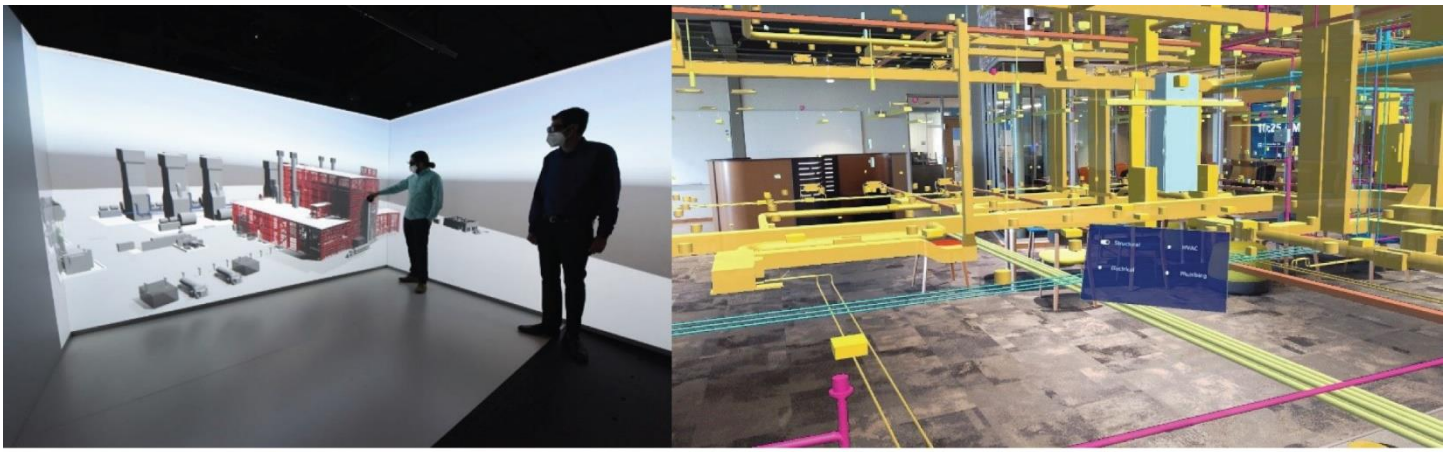
Source: GAO. | GAO-24-106665

Design and Planning

Eight agencies reported conducting R&D related to design and planning.

- DOE reported that its Idaho National Laboratory is using AR to enable real-time viewing of planned facility design and infrastructure placement (see fig. 11).

Figure 11: Department of Energy Employees Using an Immersive Room (left) and Augmented Reality (right) for Design and Planning



Source: U.S. Department of Energy Idaho National Laboratory. | GAO-24-106665

- DOT reported that its Federal Aviation Administration is using VR to research optimal configurations and assess new locations for facility environments, such as air traffic control towers.

Public Outreach

Nine agencies reported conducting R&D related to public outreach.

- DOT reported developing virtual interactive tours of a laboratory to provide external outreach on its laboratory capabilities.
- USDA reported that its Forest Service hosted a booth at the Department of Labor Federal Tech Day 2023 that allowed attendees to use the same VR system that interagency wildland firefighters use for immersive training (see fig. 12).

Figure 12: USDA Used Immersive Technologies for Public Outreach at the Department of Labor Federal Tech Day 2023

Source: U.S. Department of Agriculture (USDA), Forest Service. | GAO-24-106665

Remote Collaboration

Nine agencies reported conducting R&D related to remote collaboration.

- The General Services Administration (GSA) reported completing a pilot study to determine if work productivity could be enhanced via an immersive VR workspace, allowing GSA organizations to better interact and collaborate with one another.
- DOE reported developing a multi-user virtual environment to facilitate cross-site collaboration through VR.

Real-time Assistance, Guidance, or Inspection

Seven agencies reported conducting R&D related to real-time assistance, guidance, or inspection.

- DOE reported developing immersive systems that use digital twins to visualize infrastructure placement and additive manufacturing processes to aid inspections and provide analysis.[10]
- The Department of Education reported awarding multiple grants for research on using immersive technologies to actively assist students while learning.

Medical Assessment and Treatment

Five agencies reported conducting R&D related to medical assessment and treatment.

- HHS reported that its Food and Drug Administration engages in regulatory science on the evaluation of medical use of XR in the Office of Science and Engineering Laboratories (OSEL) Medical Extended Reality Program and supports collaborative research through the Centers of Excellence in Regulatory Science and Innovation (CERSI) program with University of Maryland.
- VA reported conducting multiple research projects that used VR to treat a range of issues. For example, VA reported using VR to allow stroke patients to practice movements in a safe and motivating environment and reported developing a VR game to study physical and mental rehabilitation for stroke survivors.

Eleven Agencies Reported Activities with Nonfederal Entities

Of the 11 agencies that reported activities with nonfederal entities, 10 reported funding nonfederal entities for the entities' own use of immersive technologies. In addition, three agencies reported regulating nonfederal entities that use immersive technologies.

Specifically, USDA, the Department of Commerce, the Department of Education, DOE, HHS, The Department of Justice (DOJ), DOT, NASA, the U.S. Agency for International Development (USAID), and the Nuclear Regulatory Commission (NRC) reported providing resources to nonfederal entities that would enable their own use or acquisition of immersive technology. For example, DOE reported providing selected public schools with virtual reality headsets through its K-12 science outreach programs. Other agencies reported providing resources that could be used for immersive technologies. For example, DOJ's Office of Community Oriented Policing Services made grant funding available for law enforcement agencies to develop or enhance their de-escalation training efforts, which can include the acquisition of AR or VR technology packages.[11] Some agencies also reported entering into cooperative agreements with nonfederal entities. For example, USAID has a cooperative agreement with the government of Morocco to establish an Interactive Digital Center to improve knowledge transfer using VR and AR. DOT's National Highway Traffic Safety Administration (NHTSA) has a

[10]Digital twins are virtual representations of people or physical objects, processes, or systems, ranging from vehicles to industrial plants to clinical trial patients. The digital twin integrates with data from a physical twin, such that any changes made to the physical twin can automatically lead to changes in the digital twin. Digital twins can be used to remotely maintain or monitor the physical twin or predict how it will perform. See *Science & Tech Spotlight: Digital Twins—Virtual Models of People and Objects*, GAO-23-106453 (Washington, D.C.: Feb. 14, 2023)

[11]De-escalation refers to the range of verbal and nonverbal skills used by law enforcement officers to slow down the sequence of events, enhance situational awareness, conduct proper threat assessments, and allow for better decision-making to reduce the likelihood that a situation will escalate into a physical confrontation or injury and to ensure the safest possible outcomes.

cooperative agreement that allows the University of Iowa to use its advanced driving simulator for non-NHTSA purposes.

DHS, DOT, and HHS reported engaging in regulatory functions over nonfederal entities that use immersive technologies. For example, within HHS, the Food and Drug Administration is responsible for evaluating whether medical products that use immersive technologies are safe and effective for use. HHS reported reviewing and authorizing devices involving immersive technologies across several treatment domains, including pediatrics, pain management, and mental health. Within DOT, the Federal Aviation Administration is responsible for the approval of simulators used for flight crew training and qualification. However, DOT reported that federal standards do not currently address the use of other immersive technology in flight simulation training devices. DOT reported working with several applicants to enable the use of immersive technologies in their devices and is planning to publish guidance material to address this issue.

Sixteen Agencies Will Likely Adopt or Expand Activities Involving Immersive Technologies in the Next 5 Years

Of the 23 federal civilian agencies surveyed, 15 reported they will likely adopt or expand activities using immersive technology, and 13 reported plans to conduct or fund R&D involving immersive technology in the next 5 fiscal years (see table 2). Two agencies—DOL and NRC—plan to continue using immersive technologies at current levels. In addition, three agencies—DHS, DOT, and HHS—reported plans to continue engaging in regulatory functions over nonfederal entities that use immersive technologies.

Table 2: Planned Immersive Technology Activities Reported by Federal Civilian Agencies, Fiscal Years 2024–2028

Agency	Immersive technology activity: Adopt or expand use[a]	Immersive technology activity: Conduct or fund research and development	Immersive technology activity: Regulate nonfederal entities[b]
Department of Agriculture	yes	yes	not sure
Department of Commerce	yes	yes	no
Department of Education	yes	yes	not sure
Department of Energy	yes	yes	no
Department of Health and Human Services	yes	yes	yes
Department of Homeland Security	yes	yes	yes
Department of Housing and Urban Development	yes	not sure	no
Department of the Interior	yes	yes	no
Department of Justice	yes	not sure	not sure
Department of Labor	not sure	not sure	not sure
Department of State	no	no	no
Department of Transportation	yes	yes	yes
Department of the Treasury	not sure	not sure	no
Department of Veterans Affairs	yes	yes	no
Environmental Protection Agency	yes	yes	no
National Aeronautics and Space Administration	yes	yes	no
Agency for International Development	not sure	not sure	no
General Services Administration	yes	yes	no
National Science Foundation	not sure	yes	no
Nuclear Regulatory Commission	not sure	not sure	not sure
Office of Personnel Management	yes	no	no
Small Business Administration	no	no	no
Social Security Administration	not sure	not sure	no
Total	15	13	3

● = Yes; ○ = No; ? = Not sure[c]

Source: GAO analysis of federal civilian agency survey data. | GAO-24-106665

Note: The data in this table come from survey questions 20, 26, and 30.

[a]Agencies reported that they were somewhat, moderately, very, or extremely likely to adopt or expand use.

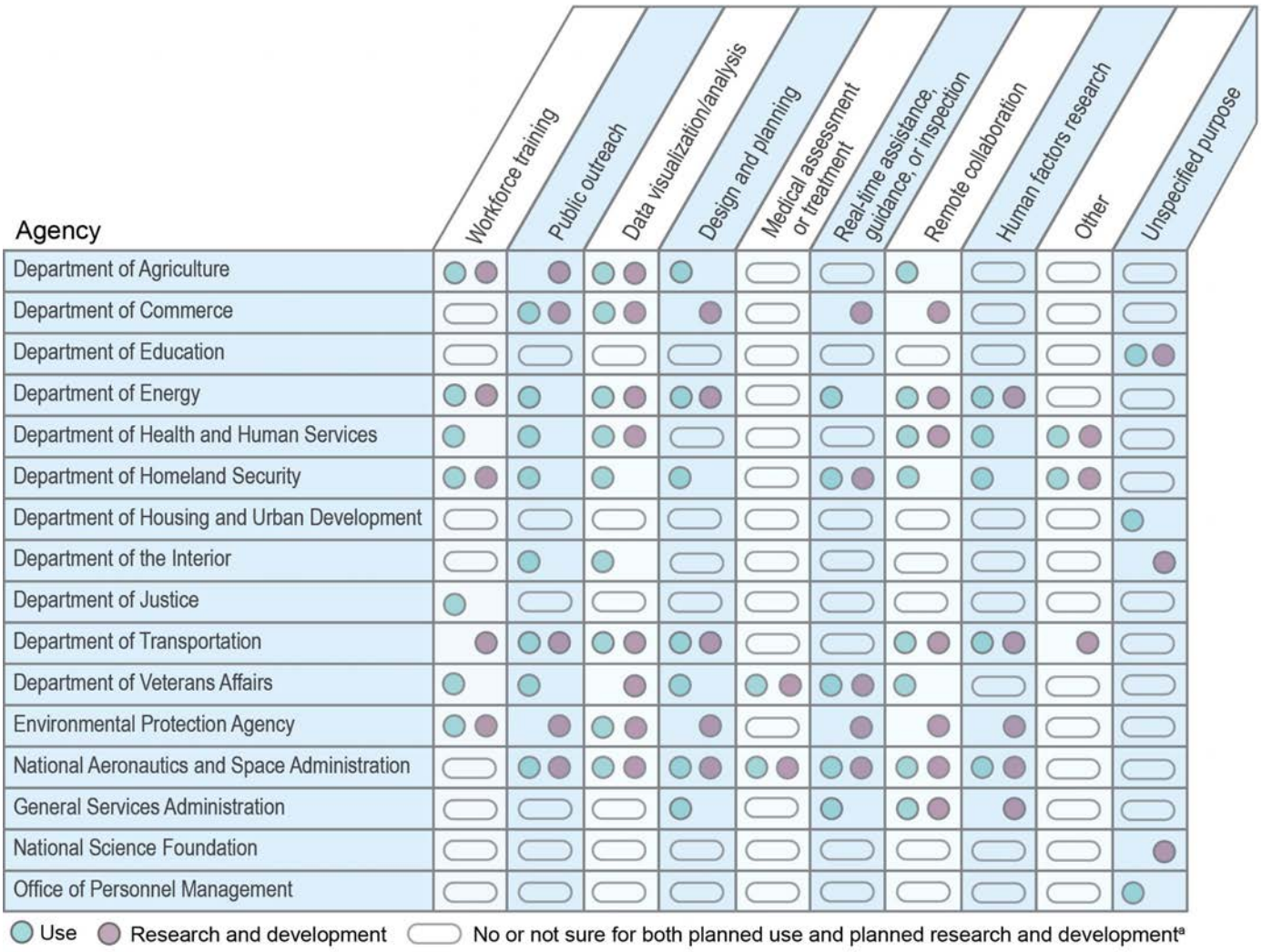
[b]In our survey we asked agencies if they engaged in or planned to engage in any regulatory functions over nonfederal entities that use immersive technologies. For the purposes of this survey, we explained that "regulatory functions" includes, but is not limited to, conducting investigatory and inspection activities, taking enforcement actions, prescribing requirements or guidance, conducting oversight, and maintaining performance standards. We also explained that for the purposes of this survey, nonfederal entities include state, local or tribal governments or agencies, or private companies—for example, technology companies, universities, police departments, banks, or airports.

[c]"Not sure" means that the agency selected this as a response to the survey question.

Fifteen Agencies Will Likely Adopt or Expand Their Use of Immersive Technologies and Reported Benefits

Of the 15 agencies that reported they will likely adopt or expand use, 10 reported they were “very” or “extremely likely” to adopt or expand use—USDA, Commerce, DOE, DHS, Interior, DOT, VA, EPA, NASA, and GSA—and five reported they were “somewhat likely” or “moderately likely” to adopt or expand use—Education, HHS, the Department of Housing and Urban Development, DOJ, and the Office of Personnel Management. Agencies most frequently reported data visualization and analysis, design and planning, public outreach, and remote collaboration as the purposes for adopting or expanding their use of immersive technologies (see fig. 13). Further, agencies most frequently reported using XR technologies in their plans to expand or adopt the use of immersive technologies. For example, the U.S. Geological Survey plans to use AR on a mobile device platform to aid in field operations.

Figure 13: Immersive Technology Planned Use and Research and Development by Purpose as Reported by Federal Civilian Agencies, Fiscal Years 2024–2028



Source: GAO analysis of federal civilian agency survey results. | GAO-24-106665

Notes: The data in this figure come from survey questions 20, 21, 26, and 28a.
Unspecified purpose means that an agency reported plans to use or conduct or fund research and development with immersive technologies, but did not specify any purpose(s).

[a]"Not sure" means that the agency selected this as a response to the survey question.

Like the benefits that agencies reported from using immersive technologies, adopting or expanding the use of immersive technology may provide an increase in user engagement and improved learning retention, as well as better decision-making and improved efficiency. While many benefits are possible with immersive technology, the extent of these benefits are dependent on multiple variables.

The following sections provide summaries and examples of agencies' reported plans to adopt or expand their use of immersive technologies for different purposes:

Data Visualization and Analysis

Nine agencies reported plans to use immersive technologies for data visualization and analysis. Agencies reported plans to use immersive technologies to visualize different kinds of data and for digital twins.

- DOT reported that its Federal Aviation Administration plans to use immersive technologies for data visualization of aircraft trajectories and flight information.
- GSA reported that it plans to adopt enhanced visualization technologies to enable faster and more efficient design, construction, maintenance, and space management of its built inventory.
- Commerce reported plans to use immersive technologies to expand its use of digital twins for visualization.

Public Outreach

Eight agencies reported plans to use immersive technologies for public outreach. For example, DOT reported that its Federal Aviation Administration plans to use VR headsets to provide virtual tours at trade shows and conferences.

Remote Collaboration and Workforce Training

Eight agencies reported plans to use immersive technologies for remote collaboration, and seven agencies reported plans to use immersive technologies for workforce training. Agencies reported plans to use or explore the use of immersive technologies for remote collaboration—that is, coordination and execution of activities at multiple locations or with multiple users—and to train their workers.

- DOT reported that its Federal Aviation Administration's William J. Hughes Technical Center plans to use immersive technologies to support remote collaboration, which allows the Federal Aviation Administration to integrate simulation platforms and leverage the assets, tools, and capabilities of its partners.
- DOE reported that its Office of Cybersecurity, Energy Security, and Emergency Response[12] anticipates that entities funded by its Rural and Municipal Utility Cybersecurity Program will use remote collaboration technologies to conduct simulated cybersecurity training exercises.
- DHS reported that its Transportation Security Administration plans to continue to explore the use of immersive technologies such as AR and VR for workforce training. It is considering a wide range of training activities but will focus primarily on security-related skills—for example, searching persons or property and self-defense, among others. Additionally, it will continue to use simulators to train Transportation Security Officers on threat detection in X-ray images during instructor-led training, individual practice sessions, and certification or qualification testing.

[12]DOE's Office of Cybersecurity, Energy Security, and Emergency Response addresses emerging threats, including cyber threats, by improving energy infrastructure security and supporting the DOE's national security mission.

Design and Planning

Seven agencies reported plans to use immersive technologies for design and planning. For example, DOT reported that its Federal Aviation Administration's William J. Hughes Technical Center plans to use immersive technologies to demonstrate new architectural designs and concepts.

Thirteen Agencies Plan to Conduct or Fund R&D for Immersive Technology

The 13 agencies reporting plans to conduct or fund R&D most frequently reported doing so for data visualization and analysis and remote collaboration efforts. As explained previously, agencies can conduct or fund R&D that uses immersive technology as a tool for several reasons, including to accomplish their missions. For example, the EPA plans to develop an AR platform for navigating indoor environments and locating environmental samples, which could help it accomplish its mission to protect human health and the environment. Agencies can also conduct or fund R&D to facilitate research on topics relevant to the agency, such as the USDA using immersive technology to study plants (see p. 20), or to research immersive technology to advance or mature the technology.

The following sections provide summaries and examples of agencies' reported plans to conduct or fund R&D involving immersive technologies for different purposes:

Data Visualization and Analysis

Eight agencies reported that they plan to conduct or fund R&D related to data visualization and analysis.

- DOE reported that its National Energy Technology Laboratory plans to visualize and analyze data in its Center for Artificial Intelligence and Machine Learning, which is under construction as of March 2024.

Human Factors Research

Five agencies reported that they plan to conduct or fund R&D related to human factors research.

- Commerce reported that its National Institute of Standards and Technology Communications Technology Laboratory has two planned R&D projects. The Augmented Reality Tracking Visualization project examines how the use of AR can affect the decision-making of users when interacting with 3D building models and locations of first responders or other objectives inside a building. The Extended Reality Onboarding project will evaluate the effects that different onboarding styles have on user interactions in XR.
- DOT reported that its Federal Aviation Administration's Technical Center plans to use 3D human models to support facility redesigns.

Remote Collaboration and Public Outreach

Seven agencies reported that they plan to conduct or fund R&D related to remote collaboration, and five agencies reported that they plan to conduct or fund R&D related to public outreach.

- DOE reported that its National Energy Technology Laboratory has deployed select capabilities for its immersive room. If successful, the National Energy Technology Laboratory hopes the facility will encourage R&D collaboration among internal teams across different sites, generate excitement with key stakeholders in the field of geology, and generate excitement with the general public as an educational tool for public-facing site tours.

  EPA reported that its Office of Research and Development plans to develop an AR platform for remote collaboration and design and planning. Specifically, the AR platform will be used for navigating indoor environments and locating environmental samples.

Workforce Training

Five agencies reported that they plan to conduct or fund R&D related to workforce training.

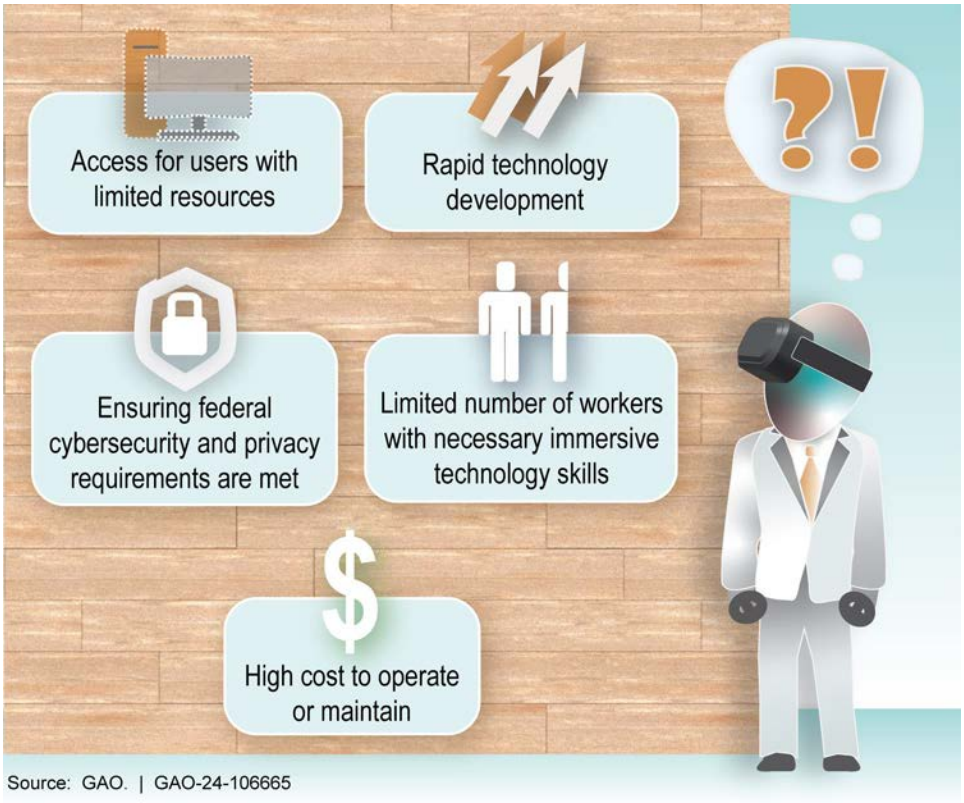
- DOT reported that its Federal Aviation Administration's William J. Hughes Technical Center plans to study immersive flight simulation technologies to develop standards for qualifying their use as part of pilot training, including such technologies as XR and simulated air traffic control environments.
- DHS reported that its U.S. Coast Guard has an ongoing mission support project aiming to improve the efficiency and effectiveness of maintenance and training across the agency.

Agencies Reported Challenges and Barriers with the Use of Immersive Technologies

Challenges of Immersive Technologies Include Cybersecurity, Privacy, and High Costs

While agencies reported benefits of using immersive technologies, they also identified several challenges. As seen in figure 14, agencies currently using or in the process of adopting the technology reported five challenges most frequently.

Figure 14: Top Challenges in Current Use and Adoption of Immersive Technologies Reported by Federal Agencies



Agencies identified meeting federal cybersecurity and privacy requirements as the top challenge.[13] Immersive technologies may require a large amount of data processing and storage, potentially adding security concerns and risks to data privacy. We have previously reported on cybersecurity challenges across the federal government. GAO has identified cybersecurity as a high-risk area since 1997, and in 2015 we expanded this high-risk area to include protecting the privacy of personally identifiable information.[14] The security and privacy concerns may be particularly relevant with newer technologies that track the user's eye and hand movement and features that identify and track the user's physical surroundings, which may include personally identifiable information. Agency officials noted that some of their immersive technologies operate as stand-alone systems and are not connected to the agency network.

Immersive technologies are evolving and maturing frequently, with improved devices and new features added with each version. This pace of technology development may be difficult for federal agencies to keep pace with due to agencies' acquisition processes and annual federal budgeting cycles. Additionally, some purposes may require highly specialized immersive technologies that are not currently available or may not be able to justify

[13]The individual requirements may vary depending on the specific use and application of the immersive technology in question but may include complying with requirements of the Privacy Act of 1974, 5 U.S.C. § 552a, The e-Government Act of 2002, Pub. L. No. 107–347, 116 Stat. 2899, 44 U.S.C. § 101 note, H.R. 2458/ S. 803, and Cybersecurity and Infrastructure Security Agency cybersecurity best practices.

[14]GAO, Cybersecurity High-Risk Series: Challenges in Protecting Privacy and Sensitive Data, GAO-23-106443 (Washington, D.C.: Feb. 14, 2023).

the cost of implementing immersive technologies. Implementing immersive technologies can be costly due to the need for specialized hardware and software, and the cost of maintaining these technologies. Additional costs can be involved with training personnel to use the technologies. Further, as a developing technology, there may be a limited number of workers who are familiar with and who accept the technology as a valuable tool.

Federal civilian agencies reported that the challenges to adopting immersive technologies are similar to their current challenges. Federal civilian agencies identified cybersecurity and privacy requirements and the high cost to operate or maintain as the top challenges for future adoption of immersive technologies. Additional challenges anticipated by agencies are related to maturing technologies, such as the rapid pace of technology evolution, limited number of workers with the necessary immersive technology skills, and an unclear application of the technologies to meet the agencies' needs. These challenges can make it difficult for federal agencies to justify the adoption of immersive technologies, especially when there are other agency priorities competing for limited resources.

Future Adoption of Immersive Technologies Is Uncertain for Some Agencies

When asked how likely it is that they will adopt or expand the use of immersive technologies in the next 5 fiscal years, roughly one third of agencies (eight of 23) reported that they were "Not at all likely" or "Not sure." Agencies identified the following barriers as the most challenging to adopting or expanding their use of immersive technologies in the next 5 years:

- Ensuring federal cybersecurity and privacy requirements are met[15]
- Technology may not meet the agency's needs
- Limited number of workers with necessary immersive technology skills
- Limited standards or lack of common definition across industry or federal government
- Dependency on enabling technologies

Several agencies stated that limited standards or a lack of common definitions across industry and government was a barrier for future adoption. For example, officials at the Departments of Agriculture, the Interior, Labor, and Transportation told us that they do not have a formal or agreed upon definition of the term immersive technology. Without common terminology for collaboration, discussion, and advancement, the development and subsequent use of any technology, such as immersive technology, could be hindered. Further, the Institute of Electrical and Electronics Engineers found that a lack of policy on ethics for immersive technology could be a barrier to adoption.[16] To achieve their full potential, immersive technologies may require other technologies—such as artificial intelligence and high-speed networks—that are not yet mature.

[15]The individual requirements may vary depending on the specific use and application of the immersive technology in question but may include complying with requirements of the Privacy Act of 1974, 5 U.S.C. § 552a, The e-Government Act of 2002, Pub. L. No. 107–347, 116 Stat. 2899, 44 U.S.C. § 101 note, H.R. 2458/ S. 803, and Cybersecurity and Infrastructure Security Agency cybersecurity best practices.

[16]Mangina, Eleni, The IEEE Global Initiative on Ethics of Extended Reality (XR) Report: Extended Reality (XR) in Ethics in Education (New York, NY: IEEE, 2021)

While also being a challenge to current and future use, cybersecurity requirements and the possibility that immersive technology may not meet the agency's needs were also reported as top barriers for adopting immersive technology. In some cases, immersive technologies may not be conducive to an agency's mission or the types of tasks its staff perform. For example, an Office of Personnel Management official stated that one of its roles is as an annuitant organization that largely deals with retirees, which does not appear to be a natural fit with the adoption of immersive technology.

Similar to challenges with using and adopting immersive technologies, agencies also reported that a limited number of skilled technology workers would be a barrier, or a limiting factor, to adopting immersive technology in the future.

Agency Comments

We provided a draft of this report to each of the 23 civilian CFO Act agencies for review and comment. We received written comments from USAID, NRC, and the Social Security Administration that are reprinted in appendices IV, V, and VI, respectively. USAID in its written comments noted that the report was comprehensive and reflective of the current landscape of immersive technology use among federal civilian agencies. NRC in its written comments agreed, in general, with our findings. NRC also provided technical comments that we incorporated as appropriate. The Social Security Administration in its written comments reaffirmed that it is not using immersive technologies. We received technical comments from nine agencies—Commerce, DOE, HHS, DHS, DOT, NASA, GSA, NSF, and the Office of Personnel Management—which we incorporated as appropriate. Eleven agencies—USDA, Education, Housing and Urban Development, Interior, DOJ, DOL, State, Treasury, VA, EPA, and the Small Business Administration—informed us that they had no comments.

As agreed with your offices, we plan no further distribution until 14 days from the product issuance date. At that time, we will send copies of this report to the appropriate congressional committees, the heads of the 23 civilian CFO Act agencies, and other interested parties. In addition, the report will be available at no charge on the GAO website at https://www.gao.gov.

If you or your staff have any questions about this report, please contact Brian Bothwell at (202) 512-6888 or bothwellb@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 key contributions to this report are listed in appendix VII.

Brian Bothwell
Director
Science, Technology Assessment, and Analytics

Appendix I: Summaries of Immersive Technology Activities Reported by Selected Federal Civilian Agencies

This appendix provides summaries of 15 civilian Chief Financial Officers Act agencies that, in response to our survey, reported activities related to immersive technologies in fiscal years (FY) 2022 or 2023, planned activities related to immersive technologies from FY 2024 through FY 2028, or both.[1] Specifically, we provide summaries for the following agencies:

- Department of Agriculture
- Department of Commerce
- Department of Education
- Department of Energy
- Department of Health and Human Services
- Department of Homeland Security
- Department of the Interior
- Department of Justice
- Department of Transportation
- Department of Veterans Affairs
- Environmental Protection Agency
- National Aeronautics and Space Administration
- General Services Administration
- National Science Foundation
- Nuclear Regulatory Commission

We asked each agency the following questions, among others, which correspond to the information provided in each agency's summary:

[1]We surveyed each of the 23 civilian Chief Financial Officers Act (CFO Act) agencies with questions about immersive technologies. This appendix summarizes the responses from 15 agencies that reported current or planned activities involving immersive technologies. The 23 agencies are those identified in the Chief Financial Officers Act of 1990, Pub. L. No. 101-576, 104 Stat. 2838 (1990), as amended, codified at 31 U.S.C. § 901(b). They are the U.S. Departments of Agriculture, Commerce, Education, Energy, Health and Human Services, Homeland Security, Housing and Urban Development, the Interior, Justice, Labor, State, Transportation, the Treasury, Veterans Affairs, Environmental Protection Agency, National Aeronautics and Space Administration, U.S. Agency for International Development, General Services Administration, National Science Foundation, Nuclear Regulatory Commission, Office of Personnel Management, Small Business Administration, and Social Security Administration. Although the Department of Defense is a CFO Act agency under 31 U.S.C. § 901(b)(1)(C), it is not a civilian agency, and, therefore, outside the scope of this review.

1. Does your agency currently (FY 2022 or FY 2023) use immersive technologies?
2. Does your agency currently (during FY 2022 or FY 2023) conduct or fund research and development (R&D) involving immersive technologies?
3. At any time during FY 2022 or FY 2023, did your agency engage in any regulatory functions over nonfederal entities that use immersive technologies?
4. Did your agency award grants; enter into contracts, leases, or cooperative agreements; provide direct loans or loan guarantees; or enter into any other transactions using any other transactional authority that would enable nonfederal entities to develop, purchase, or use immersive technologies for their own uses?
5. How likely is it that your agency will adopt or expand the use (excluding R&D) of immersive technologies in the next 5 fiscal years (FY 2024–2028)?
6. Does your agency plan to conduct or fund R&D involving immersive technologies in the next 5 fiscal years (FY 2024–2028)?
7. Can your agency provide funding information for immersive technologies?
8. Does your agency plan to engage in any regulatory functions over nonfederal entities that use immersive technologies in the next 5 fiscal years (FY 2024–2028)?

In the survey, we used the Office of Management and Budget definitions of basic research, applied research, and experimental development.[2] Basic research means experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts. Applied research is defined as original investigation undertaken to acquire new knowledge. It is directed primarily toward a specific practical aim or objective. Experimental development involves creative and systematic work, drawing on knowledge gained from research and practical experience, which is directed at producing new products or processes or improving existing products or processes.

We explained that “regulatory functions” include, but are not limited to, conducting investigatory and inspections activities, taking enforcement actions, prescribing requirements or guidance, conducting oversight, and maintaining performance standards (see question 3 above).

We also explained that, for the purposes of the survey, nonfederal entities include state, local or tribal governments or agencies, or private companies—for example, technology companies, universities, police departments, banks, or airports.

By “entered into transactions with nonfederal entities” we meant that the agency awarded grants; entered into contracts, leases, or cooperative agreements; provided direct loans or loan guarantees; or entered into any other transactions using any other transactional authority that would enable nonfederal entities to develop, purchase, or use immersive technologies for their own uses (see question 4 above). We only asked agencies about this type of activity for current (FY 2022–2023) use.

The information in these summaries is from survey responses or requests for information provided by the agencies. We present details on the types of immersive technologies the agency uses, including augmented

[2]Office of Management and Budget, *Preparation, Submission, and Execution of the Budget,* OMB Circular No. A-11 (Washington, D.C.: August 15, 2022).

reality, mixed reality, virtual reality, simulators, and immersive rooms. We also report how often the agency uses a given immersive technology.

We present current activities related to immersive technologies, including current uses, current R&D, current transactions with nonfederal entities and regulatory activities with nonfederal entities. Further, we present planned activities related to immersive technologies, including planned uses, planned R&D, and planned regulatory functions over nonfederal entities that use immersive technologies.

We also present agencies' current and planned obligations for immersive technologies, as applicable. Each agency provided information about its obligations in its survey response; as necessary, some provided additional information in a follow-up interview. We are presenting obligations data for informational purposes only because we did not corroborate it through other means, such as document requests, and some agencies reported immersive technologies obligations as part of categories within their budgets.

Our survey included a list of 13 benefits and 16 challenges that agencies selected from. We present the benefits and challenges that agencies reported related to current use and adoption, as well as the top reported benefits and challenges for future use and adoption. The current benefits listed represent those reported by each agency as "extremely beneficial" or "very beneficial," and the challenges listed represent those reported by each agency as "extremely challenging" or "very challenging." We also asked agencies to identify the top benefits and challenges to adopting or expanding the use of immersive technologies in the next 5 fiscal years.

This appendix does not include summaries for six agencies—the Departments of Housing and Urban Development, State, and the Treasury; the Office of Personnel Management; the Small Business Administration; and the Social Security Administration—because they reported they had no activities related to immersive technologies in FY 2022–2023 or planned activities related to immersive technologies from FY 2024–2028.

Further, this appendix does not include summaries for two agencies—the U.S. Agency for International Development and the Department of Labor—because they each reported only one activity related to immersive technologies in FY 2022 and FY 2023 and no planned activities for FY 2024–2028. Specifically, the U.S. Agency for International Development reported modifying a cooperative agreement in 2023 to deploy immersive technologies to improve knowledge transfer in Morocco and other areas of Africa. The Department of Labor reported using immersive technologies for one training program for trenching and excavation so workers can identify hazards and protect themselves from cave-ins in mining operations.

Department of Agriculture

The U.S. Department of Agriculture (USDA) reported using immersive technologies and conducting and funding immersive technologies research and development (R&D) in FY 2022 and FY 2023. USDA also reported that it plans to use immersive technologies and plans to conduct or fund R&D involving immersive technologies for FY 2024–2028.

Source: U.S. Department of Agriculture. | GAO-24-106665

Types of Immersive Technologies Used

USDA reported that it currently uses simulators, immersive rooms, virtual reality (VR), augmented reality (AR), and mixed reality (MR), specifying that it uses simulators at least once a week and VR, AR, and MR at least once per month. Further, it reported that it currently uses different types of simulators—flat screen, one or more screens, immersive environment with multiple input devices, and VR or AR headsets. USDA also reported that it plans to expand the use of VR, AR, and MR in the next 5 fiscal years.

Current Uses (FY 2022–2023)

USDA reported using at least eight different systems, programs, or activities for six different purposes in FY 2022 and FY 2023 (see table 3). USDA reported that approximately 736 employees had been trained using immersive technologies in FY 2022 or FY 2023.

Table 3: U.S. Department of Agriculture Use of Immersive Technologies, Fiscal Years 2022–2023

USDA Office	Description	Purpose
Office of the Chief Information Officer (OCIO)	OCIO used interactive training to augment in-classroom training and certification for the USDA workforce that required hands-on or inspection-type use cases.	Workforce training
U.S. Forest Service (FS)	FS used immersive technologies to train aviation staff, wildland firefighters, and incident management teams as well as to support EMT training. FS used virtual reality (VR) to train employees on equipment operation, repair, and maintenance activities, such as generators and fire water pump capabilities	Workforce training
FS	FS used VR and artificial intelligence solutions to model what an area of burned forest looked like before a fire. The model allows a user to understand the watershed, plant life, and wildlife to inform decisions about restoring the ecosystem. Teams also use immersive technologies to model the effects of weather on fire operations and response as part of their planning and remediation efforts.	Data visualization and analysis

USDA Office	Description	Purpose
FS	FS educated the public on the impacts of wildland fire to ecosystems, on using immersive technologies to plan for and respond to wildland fire incidents or to execute restoration efforts, and on understanding the impacts of climate change on the environment and ecosystems.	Public outreach
FS	FS used immersive technologies to aid wildfire planning and response efforts, including operations and activities before and after a fire.	Design and planning
FS	FS used VR for medical support personnel on the front lines of fire operations. It began exploring immersive technologies for assessment and treatment of fire-related injuries.	Medical assessment or treatment
FS	FS used immersive technologies to inspect and service aircraft or equipment.	Real-time assistance, guidance, or inspection

Source: GAO analysis of United States Department of Agriculture (USDA) survey results. | GAO-24-106665

Current R&D Activities (FY 2022–2023)

USDA reported that it conducted or funded R&D involving immersive technologies for four purposes and provided examples from one office for FY 2022 and FY 2023 (see table 4). In addition to the purposes listed in table 4, USDA reported that it conducted or funded R&D involving immersive technologies for public outreach and human factors research. USDA reported that it conducted or funded basic research, applied research, and experimental development involving immersive technologies. It also reported that it funds R&D with outside entities through grants and conducts R&D itself.

Table 4: U.S. Department of Agriculture Examples of Research and Development (R&D) Involving Immersive Technologies, Fiscal Years 2022–2023

USDA Office	Description	Purpose
National Institute of Food and Agriculture (NIFA)	1) Northern Marianas College is using virtual reality (VR) to allow faculty and students to participate in interactive VR labs and create VR video content that highlights agricultural experiences in the Commonwealth of the Northern Mariana Islands to provide a gateway for students to pursue a career in food and agricultural science. 2) Iowa State University founded the Artificial Intelligence Institute for Resilient Agriculture (AIIRA), a collaborative project involving eight universities and organizations in the United States. One of its projects uses VR to rate plants for climate resiliency. It has also built an immersive environment in which it can view and interact with 3D models of soybeans to examine the plant's features and responses to stress, such as drought, heat, and flooding.	1) Workforce training 2) Data visualization and analysis

Source: GAO analysis of United States Department of Agriculture (USDA) survey results. | GAO-24-106665

Current Transactions with Nonfederal Entities for Entity's Own Use (FY 2022–2023)

USDA reported that it provided funding to universities and nonprofit entities in FY 2022–2023 to conduct R&D involving immersive technologies. USDA reported that the National Institute of Food and Agriculture awarded grants that enabled nonfederal entities to develop, purchase, or use immersive technologies. Additionally, USDA reported that it funded colleges and universities as well as private and nonprofit entities to enable the entities' use of immersive technologies for workforce training, data visualization and analysis, and public

outreach. USDA reported that it awarded funding to projects with nonfederal entities but did not specify what portion of the awards funded projects related to immersive technologies.

Current Regulatory Functions Over Nonfederal Entities That Use Immersive Technologies (FY 2022–2023)

None reported.

Planned Use of Immersive Technologies (FY 2024–2028)

USDA plans to adopt or expand the use of immersive technology for the following purposes:

- Workforce training
- Data visualization and analysis
- Remote collaboration
- Design and planning

Planned R&D Involving Immersive Technologies (FY 2024–2028)

USDA reported plans to conduct or fund R&D involving immersive technologies for workforce training, data visualization and analysis, and public outreach in the next 5 fiscal years.

Planned Regulatory Functions Over Nonfederal Entities That Use Immersive Technologies (FY 2024–2028)

USDA reported that it was not sure about its plans to engage in regulatory functions over nonfederal entities that use immersive technologies for the next 5 years.

Current and Planned Obligations

USDA reported that NIFA funded approximately $34.5 million for R&D and use of immersive technologies through its grant programs.

Benefits and Challenges of Immersive Technologies

USDA reported various benefits and challenges to current use and adoption, and future use of immersive technologies.

USDA identified the following as the top benefits of adopting the use of immersive technologies from FY 2022–2023:

- Better understanding of data

- Decision-making error reduction and efficiency improvement
- Increased user engagement and learning retention
- Modularity
- Reconfigurability
- Cost savings
- Increased safety
- Portability
- Scalability
- Time savings

USDA identified the following as the top challenges of adopting the use of immersive technologies from FY 2022–2023:

- Dependency on enabling technologies
- Ensuring federal cybersecurity and privacy requirements are met[3]
- Limited standards or lack of common definition across industry or federal government
- Technology may not meet the agency's needs
- Acquisition costs
- Limited acquisition options
- Limited number of workers with necessary immersive technology skills
- Rapid technology development
- User acceptance of immersive technology

USDA identified the following as the top benefits of adopting or expanding the use of immersive technologies from FY 2024–2028:

- Better understanding of data
- Cost savings
- Decision-making error reduction and efficiency improvement
- Easier access to information
- Increased user engagement and learning retention
- Time savings

[3]The individual requirements may vary depending on the specific use and application of the immersive technology in question, but may include complying with requirements of the Privacy Act of 1974, 5 U.S.C. § 552a, The e-Government Act of 2002, Pub. L. No. 107–347, 116 Stat. 2899, 44 U.S.C. § 101 note, H.R. 2458/ S. 803, and Cybersecurity and Infrastructure Security Agency cybersecurity best practices.

USDA identified the following as the top challenges of adopting or expanding the use of immersive technologies from FY 2024–2028:

- Access for users with limited resources
- High cost to operate or maintain
- How data are collected, stored, and/or transmitted
- Limited understanding of how to use immersive technologies
- Rapid technology development
- Technology may not meet the agency's needs

Which USDA Components Contributed to the Survey

The following USDA components and offices contributed to the agency's survey response:

- Agricultural Research Service
- Economic Research Service
- Forest Service
- National Institute of Food and Agriculture
- Office of the Chief Financial Officer
- Office of the Chief Information Officer

Department of Commerce

Source: U.S. Department of Commerce. | GAO-24-106665

The U.S. Department of Commerce (Commerce) reported using immersive technology and funding immersive technology R&D in FY 2022 and FY 2023. Commerce also reported that it plans to use immersive technologies and plans to conduct or fund R&D involving immersive technology for FY 2024–2028.

Types of Immersive Technologies Used

Commerce reported that it uses AR, MR, VR, immersive rooms, simulators, and another custom-made immersive technology—Science on a Sphere.[4] Further, it reported that it currently uses different types of simulators—flat screen, one or more screens, and AR or VR-enabled simulators. Commerce uses all these immersive technologies—AR, MR, VR, immersive rooms, and simulators—at least once per week.

Current Uses (FY 2022–2023)

Commerce reported using at least five different systems, programs, or activities for two different purposes in FY 2022 and FY 2023 (see table 5).

Table 5: Department of Commerce Use of Immersive Technology, Fiscal Years 2022–2023

Commerce Office	Description	Purpose
National Oceanic and Atmospheric Administration (NOAA)	Forecast visualizations: NOAA is experimenting with volumetric visualizations of forecast models, such as visualizing atmospheric pressure levels over a city as clouds, via virtual reality headsets.	Data visualization and analysis
NOAA	Virtual visits: NOAA is using virtual reality to highlight the temperature variations within cities, such as Washington D.C., showing areas that retain more heat due to factors like large asphalt spaces or lower canopy coverage. Science on a Sphere: NOAA's Science on a Sphere system projects animated planetary data onto a 6-foot diameter sphere, analogous to a giant animated globe. Science on a Sphere systems are installed in 195 locations around the world, including several locations operated by NOAA.	Public outreach

[4] Researchers at NOAA developed Science On a Sphere as an educational tool to help illustrate Earth System science to people of all ages.

Commerce Office	Description	Purpose
NOAA	Virtual ocean exploration: NOAA created virtual reality experiences that allow users to experience National Marine Sanctuaries. It leverages immersive 360 video and photo experiences for enhanced engagement, experiential learning, and increased accessibility. The videos are viewed using virtual reality headsets at outreach events and through formal education programming and are also available to the public online.	Public outreach
NOAA	Navigating Tornado Safety: This VR experience instructs users on tornado safety and simulates a scenario where users must seek shelter from a nearby tornado.	Public outreach

Source: GAO analysis of Department of Commerce (Commerce) survey results. | GAO-24-106665

Current R&D Activities (FY 2022–2023)

Commerce reported conducting or funding R&D for at least eight different systems, programs, or activities for various purposes in FY 2022 and FY 2023 (see table 6). In addition to the four purposes listed in table 6, Commerce reported that it conducted or funded R&D involving immersive technologies for workforce training, remote collaboration, medical assessment and/or treatment, and real-time assistance or guidance. Commerce reported that it conducted or funded basic research, applied research, and experimental development involving immersive technologies. It also reported that it funds R&D with outside entities through grants or contracts and conducts R&D itself.

Table 6: Department of Commerce Examples of Research and Development (R&D) Involving Immersive Technology, Fiscal Years 2022–2023

Commerce Office	System Name and Description, or Explanation of R&D	Purpose
National Institute of Standards and Technology (NIST) – Information Technology Laboratory (ITL)	Project name: Visualization of the Flow of Dense Suspensions: Commerce's research description: Uses an immersive room to gain insight into the results of high-performance computer simulations of the flow of complex materials, such as additive manufacturing and the development of high-performance concrete.	Data visualization and analysis
NIST ITL	Project name: Modifications and Enhancements to Software for Immersive Scientific Visualization Commerce's research description: Develop and implement enhancements to an open-source scientific visualization software system to enable it to be used for immersive visualizations, as well as to embrace emerging standards in the immersive visualization space.	Data visualization and analysis
NIST ITL	Project name: Internet of Things for Healthcare Applications Commerce's research description: Uses immersive room visualizations to gain insight into the results of computer simulations of the propagation of signals from medical monitoring devices in or around the human body. A recent example is the design of a system to detect buildup of fluid in the lungs.	Design and planning

Commerce Office	System Name and Description, or Explanation of R&D	Purpose
NIST – Communications Technology Laboratory (CTL)	Project name: Command Dashboard Integrating Next-Gen Technology Challenge Commerce's research description: NIST organized a prize challenge in 2022 that sought the development of interfaces that incident commanders could leverage with location, mapping, sensors, video streams, and analytic information. Interfaces were open to all platform types if they were mobile in nature. Several teams were awarded prizes for the Augmented Reality (AR) and Virtual Reality (VR) solutions they developed. Funds obligated: Commerce reported the prize purse for the competition was $1,000,000.	Multiple (see below)
NIST – Engineering Laboratory (EL)	Project name: Performance of Human-Robot Interaction Develop robot interfaces that monitor and report operator usage statistics as part of a human subject study on the impacts of interfaces on human-robot teaming performance, and evaluation of human factors such as operator preferences, effort, and trust. Funds obligated: Commerce reported providing approximately $90,000 to Michigan Technological University through this grant.	Human factors research
National Oceanic and Atmospheric Administration (NOAA)	Project name: Spheres Beyond Reality: Expanding NOAA's Science On a Sphere with XR Technologies Commerce's research description: Expansion of Science on a Sphere program into Extended Reality (XR).	Public outreach
NOAA	Project name: VR visualizations of Urban Heat Islands Commerce's research description: NOAA reported that its VR visualizations of urban heat islands provide a vehicle for further research and development into using immersive technology.	Other
NOAA	Project name: Echoes of Siaolin: XR Visualization of Typhoon Impact and Landscape Transformation Commerce's research description: Incorporates XR to recreate a typhoon that hit Taiwan in 2009 and allow users to move backwards and forwards in time to gain a better understanding of the event and to eventually develop AI weather models using digital twins.	Data visualization and analysis

Source: GAO analysis of Department of Commerce (Commerce) survey results. | GAO-24-106665

Current Transactions with Nonfederal Entities for Entity's Own Use (FY 2022–2023)

Commerce reported providing funding to colleges and universities, private entities,[5] and other government entities[6] for their own use of immersive technologies (see table 7). For example:

[5]In our survey we asked agencies if they provided funding to private entities including, but not limited to federally funded research and development centers.

[6]In our survey we asked agencies if they provided funding to government entities, including other federal entities, state, or local entities.

Table 7: Transactions with Nonfederal Entities for Entity's Own Use, Fiscal Years 2022–2023

Commerce Component or Office	Description
National Institute of Standards and Technology (NIST) – Communications Technology Laboratory (CTL)	The Public Safety Innovation Accelerator Program 2022 (PSIAP-2022) funding opportunity supports the emerging Nationwide Public Safety Broadband Network[a] and recognizes the urgent need for first responders to have access to the same broadband communications and innovative technologies that consumers on commercial networks now expect. Out of a total award package of $10 million, $5.4 million was awarded to four entities proposing Virtual Reality (VR) and Augmented Reality (AR) solutions for supporting the program's User Interface (UI) and User Experience (UX) objectives.
NIST CTL	A project with a robotics and automation company is developing a First Responder Intelligent Assistant (FRIA) to synthesize, structure, and route actionable insights from small unmanned aerial vehicle data and present it in context to first responders and machine systems.
NIST CTL	Texas A&M University's project is developing a testbed and models to provide a VR environment for first responders and emergency managers to engage, experience, and explore the latest sensing and communication technologies.
NIST CTL	A project with an engineering and technical services company to develop head-mounted AR technology for use by first responders working in the field that convey information to users and provide a tailored solution guided directly by public safety for public safety.
NIST CTL	The University of North Carolina – Greensboro's project is working to accelerate the adoption of AR UI by first responders by using existing data in addition to systematic collaboration with first responders to identify areas where AR can most benefit public safety and investigate how to solve for challenges through a modular design approach.
NIST CTL	The 2022 Command Dashboard Integrating Next-Gen Technology Challenge, a competition focused on advancing technology available to first responders, included a $1 million prize purse for competition finalists, including several teams focused on immersive technology.
NIST – Engineering Laboratory	A grant was provided to Michigan Technological University to research human-robot interfaces

Source: GAO analysis of Department of Commerce (Commerce) survey data. | GAO-24-106665

[a]The Nationwide Public Safety Broadband Network is a national public safety communications network established in 2012 to create a single, nationwide broadband network specifically for first responders. It is overseen by the U.S. Department of Commerce's National Telecommunications and Information Administration.

Current Regulatory Functions Over Nonfederal Entities That Use Immersive Technologies (FY 2022–2023)

None reported.

Planned Use of Immersive Technologies (FY 2024–2028)

Commerce plans to adopt or expand the use of immersive technology for the following purposes and provided one example:

- Data visualization and analysis
- Future expansion of digital twin visualizations.
- Public Outreach

Planned R&D Involving Immersive Technologies (FY 2024–2028)

Commerce plans to conduct or fund R&D involving immersive technology for the following purposes, and it provided two examples:

- Data Visualization/Analysis
- Human Factors Research
    - The Augmented Reality Tracking Visualization project seeks to understand how the use of AR can affect the decision-making of users when interacting with 3D building models and indoor location of first responders or objectives. The project will look at ways of presenting this information, including iconography and 2D/3D representations.
    - The Extended Reality Onboarding project will evaluate what effects onboarding styles have for user interactions in XR. The project will conduct a study using text, animations, and audio instructions to assess their impacts on different interaction modalities.
- Public Outreach
- Remote Collaboration
- Design and Planning
- Real-time assistance, guidance, and/or inspection

Planned Regulatory Functions Over Nonfederal Entities That Use Immersive Technology (FY 2024–2028)

None reported.

Current and Planned Obligations

Commerce reported it was not sure it could provide its current (FY 2022–2023) obligations for the use of immersive technology or R&D involving immersive technology.

For FY 2022, Commerce reported spending approximately $6,434,643 on immersive technology-related activities. Specifically, Commerce provided $5.4 million for its PSIAP-2022 competition winners with immersive technology-related projects; provided a $1 million prize purse for its Command Dashboard Integrating Next-Gen Technology Challenge (see table 7); and spent $34,643 on virtual reality hardware maintenance.

For FY 2023, Commerce reported spending approximately $242,000 on modifications and enhancements to software for immersive visualization.

Commerce also reported spending approximately $30,000 on various immersive hardware, such as virtual reality headsets, from 2016 to 2023.

Commerce reported it was not sure about its planned obligations for immersive technology.

Benefits and Challenges of Immersive Technologies

Commerce reported various benefits and challenges to current use and adoption, and future use of immersive technologies.

Commerce identified the following as the top benefits of adopting or expanding the use of immersive technologies from FY 2022–2023:

- Better understanding of data
- Increased user engagement and learning retention
- Strategic or competitive advantage

Commerce identified the following as the top benefits of adopting or expanding the use of immersive technologies from FY 2024–2028:

- Better understanding of data
- Increased user engagement and learning retention
- Strategic or competitive advantage

Commerce identified the following as the top challenges of adopting or expanding the use of immersive technologies from FY 2024–2028:

- Rapid technology development
- Limited number of workers with necessary immersive technology skills
- User acceptance of immersive technology

Which Commerce Components Contributed to the Survey

The following Commerce components and offices contributed to the agency's survey response:

- National Institute of Standards and Technology
- National Oceanic and Atmospheric Administration

Department of Education

The Department of Education (Education) reported conducting or funding research and development (R&D) involving immersive technologies in fiscal years 2022–2023 and plans to conduct or fund R&D involving immersive technologies for fiscal years 2024–2028.

Source: U.S. Department of Education. | GAO-24-106665

Types of Immersive Technologies Used

Education reported that it does not currently use immersive technologies and that it is not sure about future use of technologies.

Current Uses (FY 2022–2023)

None reported.

Current R&D Activities (FY 2022–2023)

Education reported that it conducted or funded R&D involving immersive technologies for one purpose and provided 15 examples for FY 2022–2023 (see table 8). Education reported that it does not directly fund research on immersive technology, but rather it funds R&D projects that address education needs, some of which may involve immersive technology. Education reported that it conducted or funded applied research and experimental development involving immersive technologies. It also reported that it funds R&D with outside entities through grants or contracts.

Table 8: Department of Education Examples of Research and Development (R&D) Involving Immersive Technologies, Fiscal Years 2022–2023

Education Office	Description	Purpose
Institute of Education Sciences	Project name: Exploring the Affordances of Immersive Virtual Reality for Learning Education's project description: This project will examine the effectiveness of visual and auditory immersive virtual reality design features in enhancing learners' affective state and cognitive processing for science learners in general and for specific subgroups of learners. Award amount: $1,699,922	Real-time assistance, guidance, or inspection

Education Office	Description	Purpose
Institute of Education Sciences	Project name: Reading Together: Building Family Literacy Through AI-Enabled Tutoring Education's project description: This project will develop and test the impact of a scalable, personalized program designed to tackle the intergenerational cycle of reading difficulties and substantially improve the reading abilities of young students, with one component employing an intelligent tutoring system that employs artificial intelligence (AI) to listen to students read aloud, assess mastery, and deliver one-on-one adaptive coaching. Award amount: $2,994,650	Real-time assistance, guidance, or inspection
Institute of Education Sciences	Project name: Kasi Learning System: Accessible Science Diagrams through Multisensory Augmented Reality Education's project description: This project will fully develop a product to support students who are blind or visually impaired as they are learning chemistry. The Kasi system provides audio generated information when scientific images and diagrams are presented during instruction. Award amount: $1,000,000	Real-time assistance, guidance, or inspection
Institute of Education Sciences	Project name: Inclusive Talking Diagrams: Combining Sound Based AR and Tactile Pieces for Accessible Visual Based Science, Technology, Engineering, and Math Communication Education's project description: This project will develop a prototype to provide audio-generated information on scientific images and diagrams used for teaching chemistry using tactile physical manipulatives and software to provide students a more comparable experience of the visualization to their sighted peers. Award amount: $200,000	Real-time assistance, guidance, or inspection
Institute of Education Sciences	Project name: vCoder with AI-assisted Learning Education's project description: This project will fully develop and test vCoder, an immersive virtual reality (VR) game with an artificial intelligence component to customize pathways that optimize how individual middle school students learn to code. Award amount: $900,000	Real-time assistance, guidance, or inspection
Institute of Education Sciences	Project name: Verdant: VR-Enhanced Science Investigations Into Biology and Genetics Education's project description: This project will fully develop and test Verdant, an immersive VR experience for high school students focusing biological science and plant heredity. Award amount: $900,000	Real-time assistance, guidance, or inspection
Institute of Education Sciences	Project name: EdScape XR Education's project description: The project will develop a prototype of a VR escape room for middle and high school biology to engage students in a problem-based, interactive, multi-modal collaborative learning environment, which will also include. a teacher dashboard to monitor student progress. Award amount: $250,000	Real-time assistance, guidance, or inspection
Institute of Education Sciences	Project name: A Quantitative Synthesis of Outcomes of Educational Technology Approaches to K-12 Mathematics Education's project description: The results will provide researchers and education leaders with up-to-date information on effective uses of technology, including computer assisted instruction, games, simulations, VR, and media-infused instruction. Award amount: $599,966	Real-time assistance, guidance, or inspection

Education Office	Description	Purpose
Institute of Education Sciences	Project name: Measuring Prosocial Behavior in Schools through a Virtual Reality Game: vSchool Education's project description: The purpose of this study is to develop and validate a school-friendly, game-based assessment of prosocial behavior for fourth to sixth grade students that can be used to evaluate behavioral and social-emotional learning interventions. Award amount: $1,999,909	Real-time assistance, guidance, or inspection
Institute of Education Sciences	Project name: Exploring Collaborative Embodiment for Learning (EXCEL): Understanding Geometry Through Multiple Modalities Education's project description: This project will develop a platform to explore how the interaction between collaboration and multisensory experiences affects students' geometric reasoning through the use of augmented reality (AR) technology. Award amount: $1,398,245	Real-time assistance, guidance, or inspection
Institute of Education Sciences	Project name: Efficacy Study of the Simulated Instruction in Mathematics Professional Development Education's project description: This project will test the efficacy of the Simulated Instruction in Mathematics Professional Development program, a program that allows teachers to practice implementing research-based mathematics instructional strategies in a mixed-reality environment with support of a coach and teacher colleagues. Award amount: $3,799,68	Real-time assistance, guidance, or inspection
Institute of Education Sciences	Project name: Validation of a Spanish-Language Social Reasoning Assessment for Spanish-Speaking English Language Learners Education's project description: This project will determine whether a Spanish-language version of Virtual Environment for Social Information Processing is valid for use by Spanish-speaking English language learners in third to seventh grade using a simulation format to capture students' skills in challenging social situations. Award amount: $1,399,302	Real-time assistance, guidance, or inspection
Institute of Education Sciences	Project name: Mirror Me - Gamified Movement Therapy in VR for Social-Emotional Education's project description: This project will develop a VR prototype that therapists can use to engage students with Autism spectrum disorder in a dance movement therapy game while embedding occupational therapy practices. Award amount: $250,000	Real-time assistance, guidance, or inspection
Office of Special Education Programs	Project name: Project iKNOW: Increasing Knowledge and Natural Opportunities With Social Emotional Competence Education's project description: Project iKNOW will support social skill development to address social skill delays amongst middle and high school students with Autism and Learning Disabilities, through the use of an extended reality (XR) social skill intervention. Award amount: $2,497,814	Real-time assistance, guidance, or inspection
Office of Special Education Programs	Project name: Virtual reality Opportunities to Integrate Social Skills (VOISS) Education's project description: VOISS is a VR experience that uses social situations and scenarios to effectively teach social skills, such as those used in classrooms, and VOISS Advisor supports teacher professional learning. Award amount: $2,495,311	Real-time assistance, guidance, or inspection

Source: GAO analysis of Department of Education (Education) survey results. | GAO-24-106665

Current Transactions with Nonfederal Entities for Entity's Own Use (FY 2022–2023)

Education officials told us that certain R&D grants enable grantees to purchase or acquire immersive technologies that they can retain for their own use. For non-R&D grants, Education officials said that information indicating whether these grants are used for immersive technology is not available.

Current Regulatory Functions Over Nonfederal Entities That Use Immersive Technologies (FY 2022–2023)

None reported.

Planned Use of Immersive Technologies (FY 2024–2028)

Education plans to adopt or expand the use of immersive technologies but did not provide any examples.

Planned R&D Involving Immersive Technologies (FY 2024–2028)

Education plans to conduct or fund R&D by soliciting field-initiated proposals for research under the programs that have previously supported R&D involving immersive technologies (see table 8). It expects to receive and fund R&D projects involving immersive technologies under these programs in the future.

Planned Regulatory Functions Over Nonfederal Entities That Use Immersive Technologies (FY 2024–2028)

None reported.

Current and Planned Obligations

Education reported its obligations for R&D involving immersive technology were approximately $10.2 million in FY 2022 and $8.2 million in FY 2023.

Benefits and Challenges of Immersive Technologies

Education reported various benefits and challenges to future use of immersive technologies. Because Education did not report using immersive technologies in FY 2022–2023, it did not respond to questions about benefits and challenges of current use. Education also reported that a primary concern is the ability of persons with disabilities to access and use the technologies.

Education identified the following as the top benefits of adopting or expanding the use of immersive technologies from FY 2024–2028:

- Better understanding of data

- Increased user engagement and learning retention
- Time savings

Education identified the following as the top challenges of adopting or expanding the use of immersive technologies from FY 2024–2028:

- High cost to acquire, operate, or maintain
- Technology may not meet the agency's needs
- Ensuring federal cybersecurity and privacy requirements are met[7]

Which Education Components Contributed to the Survey?

The following Education components and offices contributed to the agency's survey response:

- Federal Student Aid
- Institute of Education Sciences
- Office of the Chief Information Officer
- Office of Finance and Operations
- Office of Education Technology
- Office of Special Education and Rehabilitative Services (including the Office of Special Education programs)

[7]For additional information, please refer to footnote 3 of this appendix.

Department of Energy

Source: U.S. Department of Energy. | GAO-24-106665

The U.S. Department of Energy (DOE) reported using immersive technologies and funding immersive technology R&D in FY 2022–2023. DOE also reported that it plans to use immersive technologies and plans to conduct or fund R&D involving immersive technologies for fiscal years 2024–2028.

Types of Immersive Technologies Used

DOE reported that it uses AR, MR, VR, immersive rooms, and simulators. Further, it reported that it currently uses (FY 2022–2023) and has plans to use (FY 2024–2028) different types of simulators—flat screen, one or more screens, immersive environment, and AR or VR-enabled simulators. DOE uses some of these immersive technologies—MR, simulators, and immersive rooms—at least once per week and other technologies—AR and VR—at least once per month.

Current Uses (FY 2022–2023)

DOE reported using at least 11 different systems, programs, or activities for five different purposes in FY 2022–2023 (see table 9).

Table 9: Department of Energy Use of Immersive Technologies, Fiscal Years 2022–2023

DOE Office or Component	Description	Immersive Technology Purpose
Office of Cybersecurity, Energy Security, and Emergency Response (CESER)	Program name: CyberStrike Training Program DOE's program description: Developed in collaboration with Idaho National Laboratory, the purpose of the program is to enhance the ability of energy sector owners and operators to prepare for a cyber incident impacting operational technology. Participants remotely connect to a live operational technology platform that includes a programmable logic controller, human machine interface, and industrial ethernet switch, along with a remotely operable motor and breaker. CESER reported training five employees using immersive technologies FY 2022–2023.	Workforce trainin

DOE Office or Component	Description	Immersive Technology Purpose
Idaho National Laboratory (INL)	Program name: Reactor Control Room Simulation. DOE's program description: INL's Advanced Test Reactor simulates nuclear control room activities for training and scenarios. Program name: Federal Protective Forces Emergency Response Training DOE's program description: INL has multiple human factors and input simulations in place, including cybersecurity scenario simulations. DOE reported that INL does not track data on number of employees trained using immersive technologies.	Workforce trainin
INL	Project name: Technology demonstrations DOE's project description: INL provides immersive room demonstrations, such as environment lidar, reactor design, and other virtual tours. It has used the CAVE for research, public outreach and engagement, and K-12 education tours.	Public outreac
INL	Project name: Reactor and facility engineering and planning DOE's project description: Using an augmented reality system and immersive room, INL performs simulations for a nuclear test reactor and its nuclear fuel cycle research and development testbed.	Design and planning
National Renewable Energy Laboratory (NREL)	NREL performs data visualization and analysis of both computational and experimental data. It designed and built its immersive room, and all software has been written in-house.	Data visualization and analysi
NREL	NREL performs data analysis that supports multiple simultaneous views into a dataset using different immersive technologies.	Remote collaboration
NREL	NREL supports the design and planning of energy systems using immersive technologies.	Design and planning
National Energy Technology Laboratory (NETL)	NETL provides tours and outreach to explain geologic core characterization research.	Public outreach
Office of Science and Oak Ridge Institute for Science and Education (ORISE)	The Office of Science provides virtual tours of a national park area using virtual reality (VR) content published on ORISE's website.	Public outreach
National Nuclear Security Administration (NNSA)	During its Open House in October 2023, NNSA provided demonstrations that depicted a virtual manufacturing floor where multiple users can view and interact with digital twins of advanced manufacturing components.	Public outreach

Source: GAO analysis of Department of Energy (DOE) survey results. | GAO-24-106665

Current R&D Activities (FY 2022–2023)

DOE reported conducting or funding various types of R&D for at least six different systems, programs, or activities in FY 2022–2023 (see table 10). In addition to the four purposes listed in table 10, DOE conducted or funded R&D involving immersive technologies for human factors research and public outreach. DOE conducted or funded basic research, applied research, and experimental development involving immersive technologies. It also reported that it funds R&D with outside entities through contracts and conducts R&D itself.

Table 10: Department of Energy Examples of Research and Development Involving Immersive Technology, Fiscal Years 2022–2023

DOE Office	Description	Immersive Technology Purpose
Idaho National Laboratory (INL)	INL conducted R&D for small, modular reactor design with a digital twin. Augmented reality helps to enable real-time viewing and active design of the facility and infrastructure placement.	Design and planning
INL	Project Name: 435-B Digital Twin DOE's program description: INL has developed an augmented reality 435-B radioactive source transport container to facilitate the training of teams in container operations. These can replace trainings with a physical 435-B, which can cost up to $100,000 per use and require substantial infrastructure and planning.	Workforce training
INL	Project Name: LiDAR System for Source Recovery Planning DOE's program description: INL uses portable LiDAR scanners to perform virtual walkdowns of worksites for radioactive sealed source removals under the Off-Site Source Recovery Program (OSRP). LiDAR allows INL to create a digital twin of the worksite, facilitating planning for safe, efficient removal operations.	Design and planning
National Energy Technology Laboratory (NETL)	Program name: Data Hall and Visualization Center DOE's program description: NETL is constructing its Center for Artificial Intelligence and Machine Learning , which will support researchers across NETL's three campuses to store large datasets and use machine learning and artificial intelligence methods. NETL obligated approximately $700,000 in fiscal years (FY) 2022–2023 for its Data Hall and Visualization Center—specifically, approximately $100,000 in FY 2022 and approximately $600,000 in FY 2023.	Data visualization and analysis
NETL	NETL researched geologic core computerized tomography imaging visualization and analytics with immersive technology for carbon storage and other subsurface resource characterization purposes	Data visualization and analysis
National Nuclear Security Administration (NNSA)	Project name: Virtual Inspection of Advanced Manufacturing via Process-Scale Digital Twins DOE's project description: NNSA uses videogame engines and head-mounted displays to build a multi-user collaborative virtual environment to facilitate cross-site collaboration to analyze additive manufacturing processes. The project used digital twins to represent 3D interaction and visualization methods for datasets, such as 3D surface scans and sensor data. Total project budget: $7.3 million	Design and planning; remote collaboratio

Legend: R&D = research and development

Source: GAO analysis of Department of Energy (DOE) survey results. | GAO-24-106665

Current Transactions with Nonfederal Entities for Entity's Own Use (FY 2022–2023)

DOE reported providing funding to universities and public schools for immersive technologies. It provided the below examples:

Office of Science and Oak Ridge Institute for Science and Education (ORISE):

The Office of Science provided select public schools with virtual reality headsets through ORISE K-12 programs. It also provided funding for the Tremont Experience Virtual Reality Tour, which is a virtual reality

tour of the Great Smoky Mountains Institute at Tremont. This tour was designed to give students and teachers the opportunity to explore the Tremont campus without leaving the classroom.

National Nuclear Security Administration (NNSA):

NNSA entered into an academic subcontract with a 3D interaction group at Virginia Tech to acquire immersive technology via co-development. Virginia Tech and NNSA design and evaluate 3D interaction techniques that are necessary to advance the inspection of digital twins. The contract is worth approximately $150,000 per year over 3 years.

Current Regulatory Functions Over Nonfederal Entities That Use Immersive Technologies (FY 2022–2023)

None reported.

Planned Use of Immersive Technologies (FY 2024–2028)

DOE plans to adopt or expand the use of immersive technology for the following purposes and provided two examples:

- Workforce training
  - The Office of Cybersecurity, Energy Security, and Emergency Response Rural and Municipal Utility Cybersecurity Program anticipates that entities funded by the program will use remote collaboration technologies to conduct simulated cybersecurity exercises for workforce training in utilities that are members of the funded entities.
- Data visualization and analysis
- Human factors research
- Public outreach
- Remote collaboration
- Design and planning
- Real-time assistance or guidance
  - Idaho National Laboratory plans to use immersive technologies for remote camera guidance and assistance.

Planned R&D Involving Immersive Technologies (FY 2024–2028)

DOE plans to conduct or fund R&D involving immersive technology for the following purposes, and it provided one example:

- Workforce training
- Data visualization and analysis

- Similar to its current R&D activities (see table 10), National Energy Technology Laboratory (NETL) plans to use visualization and interrogation tools in its Center for Artificial Intelligence and Machine Learning. It conducted a Phase I demonstration AR and VR systems, and the development of a video deployable on a 270-degree immersive cylinder. If successful, the facility will encourage R&D collaboration amongst various teams at NETL across different site locations. In addition, the immersive Igloo visualization space may be used to generate excitement with key stakeholders in the field of geologic transport and storage, as well as the general public as an educational tool for public-facing site tours.
- Human factors research
- Remote collaboration
- Design and planning

Planned Regulatory Functions Over Nonfederal Entities That Use Immersive Technologies (FY 2024–2028)

None reported.

Current and Planned Obligations

DOE reported that its budget may include funding for future uses of immersive technology. Specifically, the Office of Cybersecurity, Energy Security, and Emergency Response's Rural and Municipal Utility Advanced Cybersecurity Grant and Technical Assistance Program was appropriated funds by the Infrastructure Investment and Jobs Act (IIJA).[8] DOE reported that it anticipates up to $500,000 from its IIJA appropriation might be used by the entities funded by the Program to use remote collaboration technologies.

NETL's Center for Artificial Intelligence and Machine Learning obligated approximately $700,000 in FY 2022–2023 for its Data Hall and Visualization Center—specifically, approximately $100,000 in FY 2022 and approximately $600,000 in FY 2023.

Benefits and Challenges of Immersive Technologies

DOE reported various benefits and challenges to current use and adoption, and future use of immersive technologies.

DOE identified the following as the top current benefits of adopting immersive technologies:

- Better understanding of data
- Error reduction and efficiency improvement
- Time savings
- Increased safety

[8]Infrastructure Investment and Jobs Act, Pub. L. No. 117-58, § 40124, 135 Stat. 429, 953 and 1371 (2021).

- Reconfigurability
- Portability
- Interoperability
- Modularity

DOE identified the following as the top current challenges of adopting or using immersive technologies:

- Ensuring federal cybersecurity and privacy requirements are met[9]
- Limited number of workers with necessary immersive technology skills
- User acceptance of immersive technology

DOE identified the following as the top benefits of adopting or expanding the use of immersive technologies from FY 2024–2028:

- Better understanding of data
- Cost savings
- Decision-making error reduction and efficiency improvement
- Easier access to information
- Increased safety
- Increased user engagement and learning retention
- Portability, interoperability
- Scalability, reconfigurability, modularity
- Strategic or competitive advantage
- Time savings

DOE identified the following as the top challenges of adopting or expanding the use of immersive technologies from FY 2024–2028:

- Access for users with limited resources
- Ensuring federal cybersecurity and privacy requirements are met
- Fall risk, injury, or body sensory experience
- High cost to operate or maintain
- How data are collected, stored, and/or transmitted
- Limited number of workers with necessary immersive technology skills
- Limited understanding of how to use immersive technologies

[9]For additional information, please refer to footnote 3 of this appendix.

- Rapid technology development

Which DOE Components Contributed to the Survey

The following DOE components and offices contributed to the agency's survey response:

- Idaho National Laboratory
- Fossil Energy and Carbon Management
- Golden Field Office
- National Energy Technology Laboratory
- National Nuclear Security Administration
- National Renewable Energy Laboratory
- Oak Ridge Institute for Science and Education
- Office of Cybersecurity, Energy Security, and Emergency Response
- Office of Science
- Office of Technology Transition

Department of Health and Human Services

The U.S. Department of Health and Human Services (HHS) reported using immersive technology and funding immersive technology R&D in FY 2022 and FY 2023. HHS also reported that it plans to use immersive technologies and plans to conduct or fund R&D involving immersive technology for FY 2024–2028.

Source: U.S. Department of Health and Human Services. | GAO-24-106665

Types of Immersive Technologies Used

HHS reported that it uses AR, MR, VR, immersive rooms, and simulators. Further, it reported that it currently uses different types of simulators—flat screen, one or more screens, immersive environment, and VR- and AR-enabled simulators—and has plans to use different types of simulators—flat screen, one or more screens, and immersive environment simulators. HHS uses some of these immersive technologies—MR, simulators, and immersive rooms—at least once a month.

Current Uses (FY 2022–2023)

HHS reported using at least five different systems, programs, or activities for five different purposes in FY 2022 and FY 2023 (see table 11).

Table 11: Department of Health and Human Services Use of Immersive Technology, Fiscal Years 2022–2023

HHS Office	System Name and Description, or Explanation of Use	Purpose
National Institutes of Health (NIH)	Research Knowledge Dissemination Support Tools: NIH uses extended and virtual reality for laboratory and training content delivery.	Workforce trainin
NIH	Biomedical Data Repositories & Analytical Tools: NIH uses virtual reality headsets for scientific data visualization.	Data visualization and analysis
Centers for Disease Control and Prevention (CDC)	Pittsburgh Mining Virtual Reality System: Part of the National Institute for Occupational Safety and Health. It provides worker safety simulation and research to industry partners and mining operators. Virtual tours: A walk-through of the CDC Emergency Operations Center is available for people to take a tour virtually.	Public outreac
CDC	Virtual Reality Lab and Driving Simulator: CDC's National Institute for Occupational Safety and Health supports transportation industry and vehicle planning with the Division of Safety Research Virtual Reality Lab and Driving Simulator.	Design and planning
Food and Drug Administration (FDA)	Regulatory science: FDA reviews the use of immersive technology in medical devices. It also uses immersive technology for developing regulatory science methods that can help with the review process—for example, by evaluating the safety and effectiveness of immersive technologies in submissions from a usability and patient safety perspective.	Othe

Source: GAO analysis of Department of Health and Human Services (HHS) survey results. | GAO-24-106665

Current R&D Activities (FY 2022–2023)

HHS reported that it conducted or funded R&D involving immersive technologies for seven purposes and provided examples from two offices for FY 2022 and FY 2023 (see table 12). In addition to the two purposes listed in table 12, HHS reported that it conducted or funded R&D involving immersive technologies for human factors research, public outreach, design and planning, data visualization and analysis, remote collaboration, and medical assessment or treatment.

HHS reported that it conducted or funded basic research, applied research, and experimental development involving immersive technologies. It also reported that it funds R&D with outside entities through grants or contracts and conducts R&D itself.

Table 12: Department of Health and Human Services Examples of Research and Development (R&D) Involving Immersive Technology, Fiscal Years 2022–2023

HHS Office	System Name and Description, or Explanation of R&D	Purpose
Centers for Disease Control and Prevention (CDC)	Project name: Virtual Reality Mine Rescue Training (VR-MRT) Platform HHS's research description: Deliver training that targets mining first responder teams' procedural, collaborative, and problem-solving skills for underground emergency responses.	Public outreach
Food and Drug Administration (FDA)	Project name: Assessment of Safety and Performance Issues with Extended Reality (XR) Tele-mentoring of an Image-Guided, Clinically Important Procedure HHS's research description: FDA supports a research project, the Center of Excellence in Regulatory Science and Innovation, at the University of Maryland, Baltimore and College Park, to assess the safety and performance issues associated with XR tele-mentoring for image-guided, clinically important medical procedures. Award amount: $154,453	Other

Source: GAO analysis of Department of Health and Human Services (HHS) survey results. | GAO-24-106665

Current Transactions with Nonfederal Entities for Entity's Own Use (FY 2022–2023)

HHS reported providing funding to colleges and universities and other nonfederal entities for immersive technologies. For example:

- Food and Drug Administration (FDA):
  - Provided a grant to the University of Maryland in support of a research program.
  - Supports a public-private partnership and working group focused on extended reality through the Medical Device Innovation Consortium.

Regulatory Functions Over Nonfederal Entities That Use Immersive Technology in FY 2022–2023

HHS reported overseeing the use of immersive technology for the purposes of human factors research and medical assessment or treatment. For example:

- FDA:
    - FDA's Center for Devices and Radiological Health regulates immersive technologies that meet the definition of a medical "device" in the Federal Food, Drug, and Cosmetic Act. The center is responsible for assuring that devices are safe and effective for their intended use, which includes premarket, post-market, and compliance reviews. FDA reported reviewing immersive technologies used for medical purposes across several treatment domains, including pediatrics, pain management, mental health, orthopedics, radiology, ophthalmic, and other areas.

Planned Use of Immersive Technologies (FY 2024–2028)

HHS plans to adopt or expand the use of immersive technology for the following purposes and provided one example:

- Workforce Training
    - CDC plans to use immersive technology for the training of inspectors.
- Data Visualization/Analysis
- Remote Collaboration

Planned R&D for Immersive Technology (FY 2024–2028)

HHS plans to conduct or fund R&D involving immersive technology for the following purposes and it provided one example:

- Data Visualization/Analysis
- Remote Collaboration
- Other purposes
    - FDA plans to conduct or fund R&D involving immersive technologies for the purpose of regulatory science.

Planned Regulatory Functions Over Nonfederal Entities That Use Immersive Technology (FY 2024–2028)

HHS reported that it plans to engage in regulatory functions over non-federal entities that use immersive technologies in the next 5 fiscal years (FY 2024–FY 2028).

Current and Planned Obligations

HHS reported that its budget includes funding for the future uses of immersive technology. Specifically, CDC estimated investing $1.2 million annually for worker-safety related immersive research. NIH also reported obligating $238,000 for the use of immersive technology in FY 2022 and FY 2023.

Benefits and Challenges of Immersive Technology

HHS reported various benefits and challenges to current use and adoption, and future use of immersive technologies.

HHS identified the following as the top benefits of adopting or expanding the use of immersive technologies from FY 2022–2023:

- Increased user engagement and learning retention
- Decision-making error reduction and efficiency improvement
- Time savings
- Increased safety
- Reconfigurability
- Strategic or competitive advantage

HHS identified the following as the top challenges of adopting or expanding the use of immersive technologies from FY 2022–2023:

- Acquisition costs
- Limited acquisition options
- Limited standards and/or lack of common definition across industry and/or federal government
- Ensuring federal cybersecurity and privacy requirements are met[10]

HHS identified the following as the top benefits of adopting or expanding the use of immersive technologies from FY 2024–2028:

- Increased user engagement and learning retention
- Decision-making error reduction
- Easier access to information

HHS identified the following as the top challenges of adopting or expanding the use of immersive technologies from FY 2024–2028:

[10]For additional information, please refer to footnote 3 of this appendix.

- High cost to acquire and operate or maintain
- Ensuring federal cybersecurity and privacy requirements are met
- Limited number of workers with necessary immersive technology skills

Which HHS Components Contributed to the Survey

The following HHS components and offices contributed to the agency's survey response:

- Centers for Disease Control and Prevention
- Food and Drug Administration
- National Institutes of Health

Department of Homeland Security

Source: U.S. Department of Homeland Security. | GAO-24-106665

The U.S. Department of Homeland Security (DHS) reported using immersive technologies and conducting and funding immersive technologies R&D in FY 2022 and FY 2023. DHS also reported that it plans to use immersive technologies and plans to conduct or fund R&D involving immersive technologies for FY 2024–2028.

Types of Immersive Technologies Used

DHS reported that it currently uses simulators, immersive rooms, and VR, specifying that it uses simulators daily, immersive rooms at least once a week, and VR at least once per month. Further, it reported that it currently uses different types of simulators—flat screen, one or more screens, and immersive environment—and has plans to use those same types of simulators, as well as AR or VR-enabled simulators in the next 5 fiscal years. DHS additionally reported that, in the next 5 fiscal years, it plans to adopt the use of AR and MR as well as expand its use of current technologies.

Current Uses (FY 2022–2023)

DHS reported using at least 10 different systems, programs, or activities for four different purposes in FY 2022 and FY 2023 (see table 13).

Table 13: Department of Homeland Security Use of Immersive Technologies, Fiscal Years 2022–2023

DHS Component	Description	Purpose
U.S. Customs and Border Protection (CBP)	CBP used law enforcement simulators for use of force proficiency, decision-making, and articulation training.	Workforce training
U.S. Secret Service (USSS)	1) USSS used a simulation laboratory for training Agency and Uniformed Division, including 3D visualization for visualizing major protective events. 2) USSS developed in-house 3D visualization tools for security planning.	1) Workforce training 2) Design and planning
Transportation Security Administration (TSA)	TSA used simulators for 2D and 3D X-ray training to replicate using TSA's technologies and X-ray systems. TSA developed the X-ray images to use in the pre-built software and provided parameters for the design of software mechanics, such as alarm algorithms. TSA used virtual reality (VR) to pilot and explore proof of concept programs for training related to security functions, such as X-ray control panel operation and walk-through metal detector operation.	Workforce trainin

DHS Component	Description	Purpose
U.S. Immigration and Customs Enforcement (ICE)	1) ICE conducted training programs that used a simulator to incorporate law enforcement scenarios and evaluate students' levels of understanding for use of force principles and reasonably responding to scenarios. 2) The Enforcement and Removal Operations Training Division used a simulator in a presentation for Women in Federal Law Enforcement to demonstrate the benefits of using enhanced firearm sights as well as a hiring event to provide information about use of force to potential applicants.	1) Workforce training 2) Public outreach
Federal Emergency Management Agency (FEMA	1) Fire and hazardous material training: The National Fire Academy used simulators for fire and hazardous material training for state, local, tribal, and territorial professionals for fire and emergency medical services. 2) Emergency responder training: FEMA used immersive technologies to assist emergency responders in a training environment to strengthen decision-making and provide insight into the cause and effect of actions in an emergency situation.	1) Workforce training 2) Workforce training; real-time assistance, guidance, or inspection
Federal Law Enforcement Training Centers (FLETC)	FLETC used immersive technologies to deliver law enforcement training to the federal law enforcement community as well as state, local, tribal, territorial, and international law enforcement communities.	Workforce trainin

Source: GAO analysis of Department of Homeland Security (DHS) survey results. | GAO-24-106665

Current R&D Activities (FY 2022–2023)

DHS reported that it conducted or funded R&D involving immersive technologies for three purposes and provided examples from three components for FY 2022 and FY 2023 (see table 14). In addition to the purpose listed in table 14, DHS reported that it conducted or funded R&D involving immersive technologies for human factors research and real-time assistance and/or guidance. DHS reported that it conducted or funded basic research and applied research involving immersive technologies. It also reported that it funded R&D with outside entities through contracts and conducted R&D itself. In addition, it reported that the Transportation Security Administration (TSA) partnered with national laboratories regarding studies and use of immersive technologies.

Table 14: Department of Homeland Security Examples of Research and Development (R&D) Involving Immersive Technologies, Fiscal Years 2022–2023

DHS Component	Description	Purpose
Transportation Security Administration (TSA)	TSA's Training and Development Office is researching universal simulators that provide the ability to incorporate advanced technology X-ray systems and computed tomography X-ray training into the same system. TSA's Training Centers Division is researching the use of virtual reality (VR) goggles to observe simulated airport checkpoints and receive virtual instruction.	Workforce training
Science and Technology Directorate (S&T)	S&T partners with the Uniformed Services University to build an understanding of the effective uses of metaverse technologies within DHS, including a comprehensive assessment of its limitations and its potential to enhance learning and training.	Workforce training
United States Coast Guard (USCG)	Extended Reality (XR) Capabilities for Coast Guard Mission Support will finish in FY 2024 and improves the efficiency and effectiveness of maintenance and training across USCG.	Workforce training

Source: GAO analysis of Department of Homeland Security (DHS) survey results. | GAO-24-106665

Current transactions with Nonfederal Entities for Entity's Own Use (FY 2022–2023)

None reported.

Current Regulatory Functions Over Nonfederal Entities That Use Immersive Technologies (FY 2022–2023)

DHS reported conducting compliance oversight for the use of immersive technologies in research, development, testing, and evaluation. For example:

- DHS Compliance Assurance Program Office (CAPO)
  - DHS CAPO reported that it reviews all DHS-sponsored efforts involving human subjects as well as related activities for nonfederal entities which are submitted for review. CAPO oversees compliance with federal regulations, DHS policies, and if applicable, institutional policies.

Planned Use of Immersive Technologies (FY 2024–2028)

DHS plans to adopt or expand the use of immersive technologies for the following purposes:

- Workforce training
- Data visualization and analysis
- Human factors research
- Public outreach
- Remote collaboration
- Design and planning
- Real-time assistance or guidance

Planned R&D Involving Immersive Technologies (FY 2024–2028)

DHS plans to conduct or fund R&D involving immersive technologies for workforce training and real-time assistance, guidance, or inspection.

Planned Regulatory Functions Over Nonfederal Entities That Use Immersive Technologies (FY 2024–2028)

DHS reported that it plans to engage in regulatory functions over nonfederal entities that use immersive technologies in the next 5 fiscal years.

Current and Planned Obligations

DHS reported that TSA obligated approximately $200,000 for the use and R&D of immersive technologies in FY 2022 and FY 2023.

DHS reported that TSA will fund research and work to support TSA's use of immersive technologies for workforce training.

Benefits and Challenges of Immersive Technologies

DHS reported various benefits and challenges to current use and adoption, and future use of immersive technologies.

DHS identified the following as the top benefits of adopting the use of immersive technologies from FY 2022–2023:

- Easier access to information
- Interoperability
- Modularity
- Portability
- Reconfigurability
- Strategic or competitive advantage
- Better understanding of data
- Cost savings
- Decision-making error reduction and efficiency improvement
- Increased safety
- Increased user engagement and learning retention
- Time savings

DHS identified the following as the top challenges of adopting the use of immersive technologies from FY 2022–2023:

- Acquisition costs
- Ensuring federal cybersecurity and privacy requirements are met[11]
- Limited acquisition options
- Limited number of workers with necessary immersive technology skills

[11]For additional information, please refer to footnote 3 of this appendix.

- Rapid technology development

DHS identified the following as the top benefits of adopting or expanding the use of immersive technologies from FY 2024–2028:

- Better understanding of data
- Cost savings
- Decision-making error reduction and efficiency improvement
- Increased safety
- Increased user engagement and learning retention
- Scalability, reconfigurability, modularity
- Time savings

DHS identified the following as the top challenges of adopting or expanding the use of immersive technologies from FY 2024–2028:

- Dependency on enabling technologies
- Ensuring federal cybersecurity and privacy requirements are met
- High cost to operate or maintain
- How data are collected, stored, and/or transmitted
- Limited acquisition options
- Limited number of workers with necessary immersive technology skills
- Rapid technology development
- Technology may not meet the agency's needs

Which DHS Components Contributed to the Survey

The following DHS components and offices contributed to the agency's survey response:

- Countering Weapons of Mass Destruction Office
- Cybersecurity and Infrastructure Security Agency
- Federal Emergency Management Agency
- Federal Law Enforcement Training Centers
- Science and Technology Directorate
- Federal Protective Service
- Transportation Security Administration
- U.S. Customs and Border Protection

- U.S. Immigration and Customs Enforcement
- U.S. Secret Service
- U.S. Coast Guard

Department of the Interior

The U.S. Department of the Interior reported using immersive technology and funding immersive technology R&D in FY 2022 and FY 2023. Interior also reported that it plans to use immersive technologies and plans to conduct or fund R&D involving immersive technology for FY 2024–2028.

Source: U.S. Department of the Interior. | GAO-24-106665

Types of Immersive Technologies Used

Interior reported that it uses AR, MR, VR, immersive rooms, and simulators. Further, it reported that it is not sure whether it currently uses (FY 2022–2023) or will use (FY 2024–2028) different types of simulators—flat screen, one or more screens, immersive environment, and AR or VR-enabled simulators. Interior uses one of these immersive technologies—MR—at least once per week and other technologies—AR and VR—at least once per month.

Current Uses (FY 2022–2023)

Interior reported using at least three different systems, programs, or activities for three different purposes in FY 2022 and FY 2023 (see table 15).

Table 15: Department of the Interior Use of Immersive Technology, Fiscal Years 2022–2023

Interior Component	Description	Immersive Technology Purpose
Bureau of Ocean Energy Management (BOEM)	3D Visualization Room: Provides more accurate evaluation and validation of geologic resource interpretations, and enhances multidisciplinary teamwork, project review, and data quality assurance, such as 3D seismic data. In addition to its utility for viewing various types of 3D data, the visualization room is also a valuable stakeholder engagement tool. Visualization Platform: Provides a virtualized view of ocean-based wind turbines and the surrounding areas allowing planners, stakeholders, and operators to see what a wind farm will look like once installed. The virtualized view also shows cumulative effects from deployment of multiple offshore wind energy projects, as well as impacts on other resources affected by offshore wind energy development (e.g., historic, recreation and tourism, and underwater resources).	Data visualization and analysis, public outreach, design and plannin
United States Geological Survey (USGS)	Open-source 3D scientific and visualization software: Using virtual reality, this software allows scientists to more finely and intuitively interact and explore multi-parametric models, enabling enhanced qualitative and quantitative analysis.	Data visualization and analysi

Source: GAO analysis of Department of the Interior (Interior) survey results. | GAO-24-106665

Current R&D Activities (FY 2022–2023)

Interior reported that it conducted or funded R&D involving immersive technologies for two purposes and provided one example for FY 2022 and FY 2023 (see table 16). In addition to the purpose listed in table 16, Interior reported that it conducted or funded R&D involving immersive technologies for data visualization and analysis. Interior reported that it conducted or funded basic research and experimental development involving immersive technologies. It also reported that it conducts in-house R&D.

Table 16: Department of the Interior Examples of Research and Development (R&D) Involving Immersive Technology, Fiscal Years 2022–2023

Interior Component	Description	Immersive Technology Purpose
National Park Service (NPS)	Project name: Park Experience Digital Experience / Augmented Reality. Interior's program description: Augmented reality is currently being developed and piloted for use in expanding interpretive media offerings to the public in national parks. For instance, to educate the visitor about what was originally present, the system can label points or drop 3D objects on a landscape.	Public outreach

Source: GAO analysis of Department of the Interior (Interior) survey results. | GAO-24-106665

Current Transactions with Nonfederal Entities for Entity's Own Use (FY 2022–2023)

None reported.

Current Regulatory Functions Over Nonfederal Entities That Use Immersive Technologies (FY 2022–2023)

None reported.

Planned Use of Immersive Technologies (FY 2024–2028)

Interior plans to adopt or expand the use of immersive technology for the following purposes and provided one example:

- Data visualization and analysis
  - USGS plans to leverage Augmented Reality on a mobile device to aid in field operations, specifically through its Augmented Reality High-Water Mark application.
- Public outreach

Planned R&D Involving Immersive Technologies (FY 2024–2028)

Interior plans to conduct unspecified experimental development involving immersive technology in the future (FY 2024–2028).

Planned Regulatory Functions Over Nonfederal Entities That Use Immersive Technology (FY 2024–2028)

None reported.

Current and Planned Obligations

None reported.

USGS reported that its efforts in immersive technology have been funded out of overhead funds.

Benefits and Challenges of Immersive Technology

Interior reported various benefits and challenges to current use and adoption, and future use of immersive technologies.

Interior identified better understanding of data as the top benefit and user acceptance of immersive technology as the top challenge of adopting or expanding the use of immersive technologies from FY 2022–2023.

Interior identified increased user engagement and learning retention as the top benefit of adopting or expanding the use of immersive technologies from FY 2024–2028.

Interior identified the following as the top challenges of adopting or expanding the use of immersive technologies from FY 2024–2028:

- High cost to acquire and operate or maintain
- Rapid technology development
- Access for users with limited resources
- Technology may not meet the agency's needs
- Limited number of workers with necessary immersive technology skills

Which Interior Components Contributed to the Survey

The following Interior components and offices contributed to the agency's survey response:

- Bureau of Ocean Energy Management
- National Park Service
- Office of the Chief Information Officer
- Office of Surface Mining Reclamation and Enforcement
- U.S. Geological Survey

Department of Justice

Source: U.S. Department of Justice. | GAO-24-106665

The U.S. Department of Justice (DOJ) reported using, funding R&D and entering into transactions with nonfederal entities related to immersive technologies in FY 2022–2023. DOJ also reported that it plans to use immersive technologies in FY 2024–2028.

Types of Immersive Technologies Used

DOJ reported that it currently uses VR and different types of simulators—that is, simulators with a flat screen, one or more screens, or immersive environment simulators. DOJ uses simulators at least once per month and projects it will use VR quarterly.

Current Uses (FY 2022–2023)

DOJ reported using at least four different systems, programs, or activities involving immersive technologies for workforce training in FY 2022–2023 (see table 17).

Table 17: Department of Justice Use of Immersive Technologies, Fiscal Years 2022–2023

DOJ Office	Description	Immersive Technology Purpose
Federal Bureau of Investigation (FBI)	1) Aircraft training: The FBI uses flight simulators for annually required aircraft recertification courses. The FBI also uses flight simulators through commercial vendors to meet annual refresher training requirements for the UH-60M and Bell 429 model helicopters. The requirements are dictated by FBI and unit policy and are based on aviation industry practices. 2) Other training: As of April 2024, FBI is developing a Virtual Reality System (VRS) for the purposes of training various job series and enabling the practice of real-world scenarios in a virtual environment. FBI reported that it trained approximately 136 federal employees in FY 2022–2023 using immersive technologies.	Workforce training

DOJ Office	Description	Immersive Technology Purpose
U.S. Marshals Service (USMS)	1) Aircraft training: USMS Justice Prisoner and Alien Transportation System (JPATS) uses immersive technologies for aircraft pilot training in support of its mission to coordinate and transport federal prisoners and detainees. It conducts aircraft pilot training consistent with aviation industry practices. It obligated $405,000 in FY 2022–2023 and $238,000 in FY 2024 for JPATS pilot training. USMS is also in the process of obtaining a non-motion flight simulator to train current and future pilots. It obligated $124,090 in FY 2022–2023 and $64,640 in FY 2024 for pilot training. 2) Firearms training: USMS uses firearms simulators with video-based, branching scenarios for use of force training. USMS reported that the total number of federal employees trained in FY 2022–2023 using immersive technologies are unknown. For JPATS, USMS trained 36 employees in FY 2022 and 20 employees in FY 2023.	Workforce training

Source: GAO analysis of Department of Justice (DOJ) survey results. | GAO-24-106665

Current R&D Activities (FY 2022–2023)

DOJ reported conducting R&D involving immersive technologies for one system, program, or activity for workforce training in FY 2022–2023 and provided the below example. DOJ conducted or funded applied research involving immersive technologies. It funds R&D with outside entities through grants or contracts and conducts R&D itself.

DOJ office: Office of Justice Programs

Project name: Improving Employment and Reducing Recidivism among Prison Offenders via Virtual Reality Job-Interview Training

DOJ's project description: The goal of the project is to evaluate the impact of a virtual reality job interview training (VR-JIT) tool on the likelihood of ex-offenders obtaining and retaining employment when released from prison using a randomized controlled trial. The randomized controlled trial will compare services-as-usual job interview training for offenders with services-as-usual enhanced with VR-JIT. This effort will also include an initial process evaluation of VR-JIT adoption and implementation to assess the acceptability, scalability, generalizability, and affordability of VR-JIT.

Current Transactions with Nonfederal Entities for Entity's Own Use (FY 2022–2023)

DOJ reported providing funding to colleges, universities, and other government entities for immersive technologies, and provided four examples (see table 18).

Table 18: DOJ Transactions with Nonfederal Entities Involving Immersive Technologies, Fiscal Years 2022–2023

DOJ Office	Description	Immersive Technology Purpose
Office of Community Oriented Policing Services (COPS)	Program name: COPS Office Community Policing Development Program—De-escalation Training (sub-topic area) DOJ's program description: Augmented reality and virtual reality technologies are an allowable cost under the de-escalation training program, which is designed to reduce the likelihood that a situation will escalate into a confrontation that could lead to physical injury. Of the $8.6 million available in FY 2022 and $11.5 million available in FY 2023, COPS awarded approximately one-third (36 percent) of this funding in FY 2022–2023 for augmented reality and virtual reality technologies.	Workforce training
COPS	Program name: COPS Technology and Equipment Program (TEP) DOJ's program description: TEP funding is for state, local, tribal, territorial, and other entities to develop and acquire equipment and technologies that improve police effectiveness and the flow of information among law enforcement agencies and the communities they serve. Of the $111,744,000 available in FY 2022 and $177,880,000 available in FY 2023, COPS awarded less than 1 percent of this funding in FY 2022–2023 for the purchase of augmented reality and virtual reality technologies.	Workforce training
Office of Justice Programs (OJP)	Program name: Virtual Reality De-escalation Site-Based Initiative DOJ's program description: This program will enhance training via the utilization of fully immersive virtual reality-based technology. The training should improve responses to individuals in crisis and improve the de-escalation skills of participants. Funding information: FY 2023 = $6,582,822	Workforce training
OJP	Program name: Virtual Reality Training Development for Law Enforcement DOJ's program description: The program will develop, design, and pilot a virtual reality training program designed to improve law enforcement interactions with all individuals, with an emphasis on de-escalation tactics.	Workforce training

Source: GAO analysis of Department of Justice (DOJ) survey results. | GAO-24-106665

Current Regulatory Functions Over Nonfederal Entities That Use Immersive Technologies (FY 2022–2023)

DOJ reported that it was not sure whether it engaged in any regulatory functions over nonfederal entities that use immersive technologies during FY 2022–2023.

Planned Use of Immersive Technologies (FY 2024–2028)

DOJ plans to adopt or expand the use of immersive technologies for workforce training; it did not provide any examples.

Planned R&D Involving Immersive Technologies (FY 2024–2028)

DOJ reported that it was not sure about its plans to conduct or fund R&D in the next 5 years.

Planned Regulatory Functions Over Nonfederal Entities That Use Immersive Technologies (FY 2024–2028)

DOJ reported that it was not sure about its plans to engage in regulatory functions over nonfederal entities that use immersive technologies for the next 5 years.

Current and Planned Obligations

DOJ reported that it obligated approximately $22,593,000 in FY 2022–2023 and obligated approximately $895,000 for future uses of immersive technology. Specifically, the Federal Bureau of Investigation obligated approximately $4,159,000 in FY 2022–2023 and approximately $592,000 for future use of immersive technologies. The Office of Community Oriented Policing Services obligated approximately $7,323,000 in FY 2022–2023. The Office of Justice Programs obligated approximately $10,583,000 in FY 2022–2023—specifically, $6,583,000 for its Virtual Reality De-escalation Site-Based Initiative and $4,000,000 for its Virtual Reality Training Development for Law Enforcement. The U.S. Marshals Service obligated approximately $529,000 in FY 2022–2023, and approximately $303,000 in FY 2024 for pilot training.

Benefits and Challenges of Immersive Technologies

DOJ reported various benefits and challenges to current use and adoption, and future use of immersive technologies.

DOJ identified the following as the top current benefits of adopting immersive technologies:

- Decision-making error reduction and efficiency improvement
- Increased safety
- Scalability
- Better understanding of data
- Portability

DOJ identified the following as the top current challenges of adopting or using immersive technologies:

- Ensuring federal cybersecurity and privacy requirements are met[12]
- Limited number of workers with necessary immersive technology skills
- User acceptance of immersive technology

DOJ identified the following as the top benefits of adopting or expanding the use of immersive technologies from FY 2024–2028:

- Cost savings

[12]For additional information, please refer to footnote 3 of this appendix.

- Decision-making error reduction and efficiency improvement
- Increased safety
- Increased user engagement and learning retention

DOJ identified the following as the top challenges of adopting or expanding the use of immersive technologies from FY 2024–2028:

- Dependency on enabling technologies
- Ensuring federal cybersecurity and privacy requirements are met
- High cost to operate or maintain
- Limited number of workers with necessary immersive technology skills
- Motion sickness
- User acceptance of immersive technology

Which DOJ Components Contributed to the Survey

The following DOJ components and offices contributed to the agency's survey response:

- Federal Bureau of Investigation
- Office of Community Oriented Policing Services
- Office of Justice Programs
- U.S. Marshals Service

Department of Transportation

The U.S. Department of Transportation (DOT) reported using immersive technology and funding immersive technology R&D in FY 2022 and FY 2023. DOT also reported that it plans to use immersive technologies and plans to conduct or fund R&D involving immersive technology for FY 2024–2028.

Source: U.S. Department of Transportation. | GAO-24-106665

Types of Immersive Technologies Used

DOT reported that it uses AR, MR, VR, immersive rooms, and simulators. Further, it reported that it currently uses and has plans to use different types of simulators—flat screen, one or more screens, immersive environment, and AR or VR-enabled simulators. DOT uses these immersive technologies—AR, VR, MR, simulators, and immersive rooms at least once per week.

Current Uses (FY 2022–2023)

DOT reported using at least six different systems, programs, or activities for six different purposes in FY 2022 and FY 2023 (see table 19).

Table 19: DOT Use of Immersive Technology, Fiscal Years 2022–2023

DOT Office	Description	Immersive Technology Purpose
Federal Aviation Administration (FAA)	FAA uses immersive technologies to support data visualization simulations in which key aircraft data can be superimposed onto a view that is seen through an aircraft simulator window, depicting aircraft trajectories, aircraft separation, and other relevant information to support the development and maintenance of its cockpit simulators. Additionally, FAA develops their own air traffic control simulation systems which are composed of tower simulators, national airspace system automation system simulators, and hardware integration, among others.	Data visualization and analysi
FAA	FAA reviews and gives virtual walkthroughs of proposed changes to facility designs, laboratory configurations/expansions, and tower sites with 3D applications.	Design and planning
FAA	FAA gives virtual tours of the FAA laboratories, provides demonstrations of how VR headsets are used in research and testing, and as part of exhibits and tours for conferences and technical interchange meetings hosted by FAA.	Public outreac

DOT Office	Description	Immersive Technology Purpose
FAA	FAA uses a distributed, integrated laboratory environment with immersive technology to support research, development, and test and evaluation activities in collaboration with partnering organizations, including the Mike Monroney Aeronautical Center (MMAC), other government agencies, (such as the National Aeronautics and Space Administration), industry partners, and academia.	Remote collaboration
Maritime Administration (MARAD)	MARAD operates a ship simulator for bridge resource management, an engine simulator for engine resource management, and Integrated Navigation Labs. Maintenance cost is approximately $100,000 per year.	Data visualization and analysis; design and planning; real-time assistance, guidance, or inspection; and workforce training
U.S. DOT Volpe Center	The Volpe Center develops virtual transportation environments for behavioral research.	Design and planning

Source: GAO analysis of Department of Transportation (DOT) survey data. | GAO-24-106665

Current R&D Activities (FY 2022–2023)

DOT reported conducting or funding various types of R&D for at least 19 different systems, programs, or activities for various purposes in FY 2022 and FY 2023 (see table 20). In addition to the six purposes listed in table 20, DOT reported that it also conducted or funded R&D for remote collaboration. DOT reported that it conducted or funded basic research, applied research, and experimental development involving immersive technologies. It funds R&D with outside entities through grants or contracts and conducts R&D itself. In addition, U.S. DOT's Volpe Center conducts research on a fee-for-service basis, for sponsoring entities.

Table 20: DOT Examples of Research and Development (R&D) Involving Immersive Technology, Fiscal Years 2022–2023

DOT Component	Description	Immersive Technology Purpose
Federal Aviation Administration (FAA)	Project name: Immersive Flight Simulation DOT's project description: FAA is examining technologies such as virtual reality (VR), augmented reality (AR), and mixed reality, as well as simulated air traffic control environments for immersive flight simulation. FAA will develop standards for qualifying these technologies to enable their use as part of pilot training.	Workforce training
FAA	Project Name: Tower Site Assessments DOT's project description: FAA is assessing tower site locations using a 3D virtual environment (both tower/cave as well as VR headset) to recommend new tower placement.	Design and planning
FAA	Project Name: Facility redesign DOT's project description: FAA uses VR to model facility environments in 3D to determine optimal display configurations. It then uses a model of a human to determine the measurements of height, reach, joint stress, etc. of the user as they would interact with the environment.	Design and planning, human factors research
FAA	Project Name: Lab Facility Virtual Tours DOT's project description: FAA creates 3D environments for interactive virtual tours to provide external outreach and inform of the laboratory capabilities to others.	Public outreach

DOT Component	Description	Immersive Technology Purpose
FAA	Project Name: Human Systems Integration DOT's project description: FAA creates simulation environments to facilitate Human-In-The-Loop simulation capabilities to research air traffic control future concepts and technologies. The environments include various simulators of air traffic control systems.	Human factors research
FAA	Project Name: Extended Reality (XR) for Cabin Safety I DOT's project description: A Translational Study of XR Technology in Training and Research: A review of how XR could be used to enhance aviation safety and aviation safety.	Workforce training
FAA	Project Name: Extended Reality (XR) for Cabin Safety II DOT's project description: Flight Attendant Training: A project to see how flight attendant training might be improved using XR.	Workforce training
FAA	Project Name: Extended Reality (XR) for Cabin Safety III DOT's project description: Aircraft Egress and Evacuation: An investigation into the use of XR as an experimental tool to replace certain empirical tests that might expose human subjects to safety risks.	Workforce training
FAA	A cockpit simulator modeling an Airbus A320 to support the NAS Innovation and Emerging Concepts Laboratory.	Design and planning
FAA	FAA uses two virtual reality motion-based helicopter simulators, H125 & R22, for safety research and development	Workforce training
Federal Highway Administration (FHWA)	Project Name: Investigate Key Automated Vehicle (AV) Human Factors Safety Issues Related to Infrastructure DOT's project description: To identify and investigate human factors safety challenges associated with different levels of AV automation, which include interacting with roadway infrastructure, for vulnerable road user interactions, and for mixed-fleet interactions.	Human factors research
FHWA	FHWA utilizes three research tools that use immersive technology, the Highway Driving Simulator, the miniSim, and the Virtual Reality Lab. • The Highway Driving Simulator (HDS) is used to study drivers' reactions in simulated environments. HDS consists of a full automobile chassis surrounded by a projection screen with three digital projectors to provide a 200-degree view. The simulator also utilizes a motion base to simulate pitch, acceleration, braking, and turning, as well as eye-tracking to research what participants are looking at in various scenarios. • The miniSim is a fixed-base quarter-cab driving simulator to conduct research on simulated roadways that do not require the full immersion of the HDS. • The VR Lab is used to study pedestrians' and cyclists' behavior using VR headsets to place participants in immersive, computer-generated, 3D environments with which they can interact.	Human factors research
FHWA	Project Name: Human Factors Issues Related to Truck Platooning Operations DOT's project description: To investigate critical human factors issues involving the behavior of light-vehicle drivers in the presence of groups of trucks, including freeway entry/exit and visual indicators and light vehicle road-user recognition of truck platoons, trucks following each other closely, which can reduce air drag and improve fuel economy.	Human factors research
Federal Railroad Administration (FRA)	Project Name: Augmented Reality for Railroad Operations Using Heads-up Displays DOT's project description: The use of AR heads-up displays for railroad operations in the Cab Technology Integration Lab	Real-time assistance, guidance, or inspection

DOT Component	Description	Immersive Technology Purpose
FRA	FRA uses the Cab Technology Integration Laboratory (CTIL) for research in human interaction with cab controls, displays, and cab systems to improve operations and safety. It also has outreach functions when hosting rail workforce development activities and demonstrating research capabilities. FRA also operates the Behavior and Railroad Crossings Laboratory, a driving simulator, for use in grade crossing research. Current (FY 2022-2023) funding for CTIL is approximately $1 million, which includes simulator support and multiple R&D projects.	Human factors research, public outreach
National Highway Traffic Safety Administration (NHTSA) and U.S. DOT Volpe Center	Project Name: Factors That Influence the Effectiveness of Hazard Perception Training DOT's project description: This project is sponsored by NHTSA and conducted by the Volpe National Transportation Systems Center (Volpe Center) under an interagency agreement. The goal of this project is to investigate the factors that influence the effectiveness of hazard perception training for learning hazard perception skills and improving driving simulator performance. The Volpe Center will test a novice driver training program delivered through a smartphone-like platform and assessed in the lab using a driving simulator. The results of this project can be used by stakeholders to more efficiently deploy hazard perception training and by researchers to design future evaluations of training effectiveness. The project also serves as a critical first step towards delivering free and accessible smartphone-based training to novices who may face barriers accessing traditional driver education.	Human factors research
NHTSA	NHTSA utilizes mixed reality environments and simulators as research tools through the course of project development. Current (FY 2022-2023) funding is approximately $15 million per year for research and development.	Data visualization and analysis
NHTSA	Project Name: Immersive Virtual Reality Training on Impaired Driving for Law Enforcement DOT's project description: A Phase I Small Business Innovative Research project to develop a proof of concept for an interactive technology to be used to provide training approaches for law enforcement officers on drug impaired driving.	Workforce training
U.S. DOT Volpe Center	Project Name: Direct and indirect vision effectiveness for simulated crash avoidance DOT's project description: A study to assess the effectiveness of using integrated bird's eye view cameras to augment mirrors for vehicles with low-vision cabs.	Human factors research

Source: GAO analysis of Department of Transportation (DOT) survey data. | GAO-24-106665

[a]Truck platooning allows trucks to follow each other closely, thereby reducing air drag and improving fuel economy.

Current Transactions with Nonfederal Entities for Entity's Own Use (FY 2022–2023)

DOT reported providing funding for immersive technologies to universities, private research institutions, private companies, and nonfederal government entities, among others, for the purposes of workforce training, data visualization and analysis, human factors research, public outreach, remote collaboration, and design and planning. For example:

- Federal Aviation Administration (FAA)

Supports research to improve aviation through contracts, cooperative agreements, and other transaction authorities. This research may be in different fields, such as weather or the integration of new systems.

Current Regulatory Functions Over Nonfederal Entities That Use Immersive Technologies (FY 2022–2023)

DOT has engaged in regulatory functions over nonfederal entities in FY 2022–2023 and plans to do so through FY 2028. In FY 2022–2023, FAA reported overseeing the use of immersive technology for the approval of simulators used for flight crew training and qualification with their Flight Simulation Training Devices (FSTDs). FSTDs are used in pilot training and qualification and are subject to standards as published in 14 C.F.R. Part 60.[13]

Planned Use of Immersive Technologies (FY 2024–2028)

DOT plans to adopt or expand the use of immersive technology. Specifically, FAA reports that its Technical Center plans to expand its use of immersive technology to support its research and test mission for the following purposes:

- Data visualization and analysis
    - It plans to use immersive technologies to represent data such as aircraft trajectories and flight information where appropriate.
- Public outreach
    - It plans to use immersive technologies to support outreach using virtual tours and VR headsets at various trade shows and conferences.

Planned R&D for Immersive Technology (FY 2024–2028)

DOT plans to conduct or fund R&D involving immersive technology for multiple purposes:

- FAA
    - Immersive Flight Simulation: The FAA's purpose for studying technologies for immersive flight simulation is to develop standards for qualifying these technologies to enable their use as part of pilot training. This activity is examining technologies such as AR, MR, and VR as well as simulated air traffic control environments.
    - FAA's Technical Center plans to expand its use of immersive technology by conducting research into using mixed reality vertical takeoff and land simulators to provide training to pilots.
    - In addition, FAA's Technical Center reported several planned uses for the expansion of the use of immersive technology for various purposes:
        - Human factors research: The Technical Center uses 3D human models to support facility redesigns.

[13]14 C.F.R. Part 60 (2024) includes the relevant text. According to the FAA, the current standards do not address immersive technologies, such as VR. The FAA has been working with several applicants to address deviation or exemption requests to enable the use of such technologies in pilot training. The publication of guidance material to support this work is under consideration.

- Remote collaboration: The Technical Center uses immersive technologies during collaboration and partnerships as appropriate to support research.
- Design and planning: The Technical Center uses immersive technologies to demonstrate new architectural designs and concepts as appropriate.

Planned Regulatory Functions Over Nonfederal Entities That Use Immersive Technology (FY 2024–2028)

DOT reported that it plans to provide regulatory functions over nonfederal entities using immersive technology.

Current and Planned Obligations

DOT reported that its budget may include funding for future uses of immersive technology. Approximate funding amounts reported by DOT agencies are:

- Federal Railroad Administration: $2 million per year, FY 2022–28
- Federal Highway Administration: $397,000, FY 2022–2023
- National Highway Traffic Safety Administration: $15 million per year, FY 2022–2023
- Maritime Administration: $101,214 per year, FY 2022–28

Benefits and Challenges of Immersive Technology

DOT reported various benefits and challenges to current use and adoption, and future use of immersive technologies.

DOT identified the following as the top benefits of using of immersive technologies currently:

- Better understanding of data
- Easier access to information
- Increased user engagement and learning retention
- Interoperability
- Modularity
- Portability
- Reconfigurability
- Scalability
- Strategic or competitive advantage
- Cost savings
- Decision-making error reduction and efficiency improvement
- Increased safety

- Time savings

DOT identified one challenge of using of immersive technologies currently:

- Limited number of workers with necessary immersive technology skills

DOT identified the following as the top benefits of adopting or expanding the use of immersive technologies from FY 2024–2028:

- Better understanding of data
- Cost savings
- Increased safety
- Increased user engagement and learning retention
- Portability, interoperability
- Scalability, reconfigurability, modularity
- Strategic or competitive advantage
- Time savings

DOT identified the following as the top challenges of adopting or expanding the use of immersive technologies from FY 2024–2028:

- Ensuring federal cybersecurity and privacy requirements are met[14]
- High cost to operate or maintain
- Limited number of workers with necessary immersive technology skills
- Limited standards or lack of common definition across industry or federal government
- Rapid technology development
- Technology may not meet the agency's needs

Which DOT Components Contributed to the Survey

The following DOT components and offices contributed to the agency's survey response:

- Federal Aviation Administration
- Federal Highway Administration
- Federal Railroad Administration
- Maritime Administration
- National Highway Traffic Safety Administration

[14]For additional information, please refer to footnote 3 of this appendix.

- U.S. DOT Volpe Center

Department of Veterans Affairs

Source: U.S. Department of Veterans Affairs. | GAO-24-106665

The U.S. Department of Veterans Affairs (VA) reported using immersive technologies and conducting and funding immersive technologies R&D in FY 2022 and FY 2023. VA also reported that it plans to use immersive technologies and plans to conduct or fund R&D involving immersive technologies for FY 2024–2028.

Types of Immersive Technologies Used

VA reported that it currently uses and has plans to use AR, MR and VR. Further, it reported that it currently uses different types of simulators—flat screen and AR- or VR-enabled simulators. VA reported that it uses AR and VR at least once per week, mixed reality at least once per month, and simulators at least once per year.

Current Uses (FY 2022–2023)

VA reported using at least six different systems, programs, or activities for four different purposes in FY 2022 and FY 2023 (see table 21). VA reported that approximately 414 employees had been trained using immersive technologies in FY 2022 or FY 2023.

Table 21: Department of Veterans Affairs Use of Immersive Technologies, Fiscal Years 2022–2023

VA Office	Description	Purpose
Veterans Health Administration (VHA)	VHA participated in the development of several software-based experiences: 1) Empathy training: helps staff understand the lived experience of patients—for example, inpatient discharge and prevention of sexual harassment. VA obligated $1,713,689 in FY 2022 for prevention of sexual harassment training. 2) Firearms safety training: provides lethal means safety counseling for three different firearms.	Workforce trainin
Office of Healthcare Innovation and Learning (OHIL)	VA held demonstration events for veterans, staff, and the public, providing attendees the opportunities to see how immersive technologies can impact physical, emotional, and mental health.	Public outreach
OHIL	VA created digital twins of facilities while planning the building and prior to construction to ensure cost-efficient decisions (e.g., to identify inefficiencies or concerns with space or placement).	Design and planning

VA Office	Description	Purpose
VHA	1) VA uses immersive technologies as an additional clinical tool to support clinical staff by providing physical rehabilitation, mental health, and pain management resources. 2) In virtuo exposure therapy. For example, VA reported obligating $1,398,362 for virtual care for radiology phobias.	Medical assessment or treatment

Source: GAO analysis of Department of Veterans Affairs (VA) survey data. | GAO-24-106665

Current R&D Activities (FY 2022–2023)

VA reported that it conducted or funded R&D for six purposes and provided six examples for FY 2022 and FY 2023 (see table 22). In addition to the purposes listed in table 22, VA reported that it conducted or funded R&D involving immersive technologies for human factors research, remote collaboration, design and planning, and real-time assistance or guidance. VA reported that it conducted or funded basic research, applied research, and experimental research involving immersive technologies. Further, the VA obligated $1,535,792 for R&D in FY 2022–2023, specifying that funding for research primarily focused on physical rehabilitation.

Table 22: Department of Veterans Affairs Examples of Research and Development (R&D) Involving Immersive Technologies, Fiscal Years 2022–2023

VA Office	Description	Purpose
Office of Research and Development (ORD) – Rehabilitation Research and Development	Project name: Priming the Rehabilitation Engine: Aerobic Exercise as the Fuel to Spark Behavioral Improvements in Stroke VA's research description: The VA is using a virtual reality (VR) rehabilitation game to examine the effect of combining aerobic exercise with physical rehabilitation on physical and mental function in stroke survivors. Funds obligated: $361,868	Medical assessment or treatment
ORD – Rehabilitation Research and Development	Project name: Development of a 3D VR Structural Analysis Software Ecosystem for Spinal Cord Injury and Disease Research VA's research description: The VA is using virtual reality to transform 3D imagine analysis processes into a more intuitive workflow. This sets the stage for deeper insights into neurological disorders and more accurate visualizations of brain anatomy. Funds obligated: $140,793	Data visualization and analysis
ORD – Rehabilitation Research and Development	Project name: Spinal Cord Stimulation for Functional Recovery in Humans with Tetraplegia VA's research description: The VA is using virtual reality and smart gloves, as well as spinal stimulation, to study the effects of the combination of treatments on restoring hand and muscle movement in humans with paralysis from the neck down. Funds obligated: $499,681	Medical assessment or treatment
ORD – Rehabilitation Research and Development	Project name: Cognitive-based Rehabilitation Platform of Hand Grasp after Spinal Cord Injury using Virtual Reality and Instrumented Wearables VA's research description: The VA used virtual reality, wearable technologies, and machine learning to provide physical rehabilitation approaches for improving hand grasp after a spinal cord injury. Funds obligated: $116,462	Medical assessment or treatment

VA Office	Description	Purpose
ORD – Rehabilitation Research and Development	Project name: Combined Transcranial Direct Current Stimulation and Virtual Reality for Posttraumatic Stress Disorder VA's research description: The VA used virtual reality as well as noninvasive brain stimulation and exposure therapy to study the effects of the combination of treatments on reducing the symptoms of posttraumatic stress disorder. Funds obligated: $233,776	Medical assessment or treatment
ORD – Rehabilitation Research and Development	Project name: Immersive Virtual Reality to Improve Outcomes in Patients with Stroke: A Pilot Study VA's research description: The VA used virtual reality to allow stroke patients to practice movements in a safe and motivating environment. Funds obligated: $116,195	Medical assessment or treatment

Source: GAO analysis of Department of Veterans Affairs (VA) survey results. | GAO-24-106665

Current Transactions with Nonfederal Entities for Entity's Own Use (FY 2022–2023)

None reported.

Current Regulatory Functions Over Nonfederal Entities That Use Immersive Technologies (FY 2022–2023)

None reported.

Planned Use of Immersive Technologies (FY 2024–2028)

VA plans to adopt or expand the use of immersive technologies for the following purposes:

- Workforce training
- Public outreach
- Remote collaboration
- Design and planning
- Medical assessment or treatment
- Real-time assistance or guidance

Planned R&D Involving Immersive Technologies (FY 2024–2028)

VA plans to conduct or fund R&D involving immersive technologies for data visualization and analysis; real-time assistance, guidance, and/or inspection; and medical assessment or treatment in the next 5 fiscal years. VA reported plans to continue to support projects that use immersive technologies and to develop new or enhance existing devices, algorithms, or systems to improve veteran rehabilitation outcomes, reduce treatment costs, or both.

Planned Regulatory Functions Over Nonfederal Entities That Use Immersive Technologies (FY 2024–2028)

None reported.

Current and Planned Obligations

VA obligated $11 million to fund programs, projects, and activities, as well as $1,535,792 for R&D in FY 2022 and FY 2023.

Benefits and Challenges of Immersive Technologies

VA reported various benefits and challenges to current use and adoption, and future use of immersive technologies.

VA identified the following as the top benefits of adopting the use of immersive technologies from FY 2022–2023:

- Better understanding of data
- Cost savings
- Increased safety
- Time savings
- Increased user engagement and learning retention
- Portability
- Scalability
- Strategic or competitive advantage

VA identified the following as the top challenge of adopting the use of immersive technologies from FY 2022–2023:

- Limited standards or lack of common definition across industry or federal government

VA identified the following as the top benefits of adopting or expanding the use of immersive technologies from FY 2024–2028:

- Better understanding of data
- Easier access to information
- Increased user engagement and learning retention

VA identified the following as the top challenges of adopting or expanding the use of immersive technologies from FY 2024–2028:

- Ensuring federal cybersecurity and privacy requirements are met[15]
- Limited standards or lack of common definition across industry or federal government
- Rapid technology development

Which VA Components Contributed to the Survey

The following VA components and offices contributed to the agency's survey response:

- Office of Research and Development – Office of Rehabilitation Research and Development
- Office of Healthcare Innovation and Learning
- VA Office of Information and Technology

[15]For additional information, please refer to footnote 3 of this appendix.

Environmental Protection Agency

The U.S. Environmental Protection Agency (EPA) reported using immersive technology and funding immersive technology R&D in FY 2022 and FY 2023. EPA also reported that it plans to use immersive technologies and plans to conduct or fund R&D involving immersive technology for FY 2024–2028.

Source: U.S. Environmental Protection Agency. | GAO-24-106665

Types of Immersive Technologies Used

EPA reported that it uses AR, MR, VR, and simulators. Further, it reported that it currently uses (FY 2022–2023) different types of simulators—flat screen and AR or VR-enabled simulators. EPA reported using some of these immersive technologies—VR and simulators—at least once per week and other technologies—AR and MR—at least once per month.

Current Uses (FY 2022–2023)

EPA reported using at least two different systems, programs, or activities for two different purposes in FY 2022 and FY 2023 (see table 23).

Table 23: Environmental Protection Agency Use of Immersive Technology, Fiscal Years 2022–2023

EPA Office	Description	Purpose
Office of Research and Development (ORD)	Training: EPA uses a specific virtual reality headset with sampling software loaded to train field responders on sampling strategies and methods. EPA reported training approximately 25–50 employees using immersive technology in FY 2023.	Workforce trainin
ORD	Sampling display: EPA has used augmented reality to demonstrate and display environmental sampling designs and sample locations.	Data visualization and analysis

Source: GAO analysis of Environmental Protection Agency (EPA) survey results. | GAO-24-106665

Current R&D Activities (FY 2022–2023)

EPA reported that it conducted or funded R&D involving immersive technologies for seven purposes and provided three examples for FY 2022 and FY 2023 (see table 24). In addition to the four purposes listed in table 24, EPA reported that it conducted or funded R&D involving immersive technologies for human factors research, remote collaboration, and design and planning. EPA reported that it funds R&D with outside entities through grants or contracts and conducts R&D itself. EPA reported that it conducted or funded applied research and experimental development involving immersive technologies.

Table 24: Environmental Protection Agency Examples of Research and Development (R&D) Involving Immersive Technology, Fiscal Years 2022–2023

EPA Office	System Name and Description, or Explanation of R&D	Purpose
Office of Research and Development (ORD)	Project name: Augmented reality (AR) navigation/sampling EPA's research description: Uses an AR system to serve as a head-mounted support system for navigating complex environments and improving the location and identification of environmental sample locations (through a heads-up display) to clean up environmental contamination.	Real-time assistance or guidance
ORD	Project name: Virtual Reality Training Tools EPA's research description: EPA developed a virtual reality (VR) platform for training responders for the collection of environmental samples for chemical, biological, and radiological (CBR) contaminants by tracking user performance and offers metrics and feedback on their sampling activities. EPA officials stated that while this VR platform is currently used for training (see table 23), the visualization activities associated with it are an R&D effort. Additionally, EPA is developing a VR-based platform for conducting aerial reconnaissance for identifying oil spills and orphaned containers. EPA has also featured its VR training platform at conferences and student engagement programs. Immersive technologies tend to increase audience engagement and generate interest around the content or experience they present, by offering users a more interactive and compelling way to connect with information, stories, and each other. Funds obligated: approximately $100,000 for VR sampling training and $150,000 for aerial observation training in FY 2022 and 2023.	Workforce training, public outreach
ORD	Project name: Trade-off Tool for Sampling EPA's Research description: EPA has used augmented reality to project maps and environmental sampling plans using an iOS-based platform.	Data visualization and analysis

Source: GAO analysis of Environmental Protection Agency (EPA) survey results. | GAO-24-106665

Current Transactions with Nonfederal Entities for Entity's Own Use (FY 2022–2023)

None reported.

Current Regulatory Functions Over Nonfederal Entities That Use Immersive Technologies (FY 2022–2023)

None reported.

Planned Use of Immersive Technologies (FY 2024–2028)

EPA plans to expand its use of immersive technology for the purposes of workforce training and data visualization and analysis.

Planned R&D Involving Immersive Technology (FY 2024–2028)

EPA plans to conduct or fund R&D involving immersive technology for the following purposes, and it provided one example:

- Workforce training
- Data visualization and analysis
- Human factors research
- Public outreach
- Remote collaboration

The Office of Research and Development reported plans to develop an AR platform for the purposes of remote collaboration and design and planning. Specifically, the AR platform will be used for navigating indoor environments and locating environmental samples. Development is planned to begin in FY 2024.

- Design and planning
- Real-time assistance, guidance, or inspection

Planned Regulatory Functions Over Nonfederal Entities That Use Immersive Technology (FY 2024–2028)

EPA reported that it was not sure about its plans to engage in regulatory functions over nonfederal entities that use immersive technologies for the next 5 years.

Current and Planned Obligations

EPA reported obligating $100,000 for its R&D on VR sampling training and $150,000 for R&D on its aerial observation training (see table 24) in FY 2022–2023. EPA reported it was not sure about its planned obligations.

Benefits and Challenges of Immersive Technology

EPA reported various benefits and challenges to current use and adoption, and future use of immersive technologies.

EPA identified the following as the top current benefits of adopting immersive technologies:

- Better understanding of data
- Increased user engagement and learning retention
- Decision-making error reduction and efficiency improvement
- Cost savings
- Time savings

- Increased safety
- Portability
- Strategic or competitive advantage

EPA identified the following as the top current challenges of adopting or expanding the use of immersive technologies: from FY 2024–2028:

- Rapid technology development
- Limited acquisition options

EPA identified the following as the top benefits of adopting or expanding the use of immersive technologies from FY 2024–2028:

- Increased user engagement and learning retention
- Decision-making error reduction and efficiency improvement
- Increased safety

EPA identified the following as the top challenges of adopting or expanding the use of immersive technologies from FY 2024–2028:

- Fall risk, injury, or body sensory experience
- High cost to acquire and operate or maintain
- Limited acquisition options

Which EPA Components Contributed to the Survey

The following EPA components and offices contributed to the agency's survey response:

- Office of Research and Development
- Office of Land and Emergency Management
- Office of Mission Support

National Aeronautics and Space Administration

The National Aeronautics and Space Administration (NASA) reported using immersive technology and funding immersive technology R&D in FY 2022 and FY 2023. NASA also reported that it plans to use immersive technologies and plans to conduct or fund R&D involving immersive technology for FY 2024–2028.

Source: National Aeronautics and Space Administration. | GAO-24-106665

Types of Immersive Technologies Used

NASA reported that it uses AR, MR, VR, immersive rooms, and simulators. NASA also uses other types of immersive technologies, such as brain computer interfaces, holograms, and light-field display technologies. Further, NASA reported that it currently uses (FY 2022–2023) and has plans to use (FY 2024–2028) different types of simulators—flat screen; one or more screens; immersive environments; AR or VR-enabled simulators; multi-degree motion simulators; microgravity simulators; and analog simulation environments to simulate extraterrestrial environments, such large pools, deserts, Mars or lunar rock yards, and enclosed habitat environments. NASA uses all of these immersive technologies—AR, VR, MR, HR, and simulators—daily. NASA reported that its use of immersive technologies has increased over the years due to additional capabilities and a lower cost of entry and usage of the technologies as well as an increasing pace of industry developments.

Current Uses (FY 2022–2023)

NASA reported using at least 65 different systems, programs, or activities for 14 different purposes in FY 2022 and FY 2023 (see table 25).

Table 25: NASA Use of Immersive Technology, Fiscal Years 2022–2023

NASA Office	Description	Immersive Technology Purpose
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project name: Saturn Training Modules NASA's project description: A NASA employee training system with mandatory yearly training modules that include the use of 3D avatars and gamification concepts. NASA trains thousands of employees yearly using this system.	Workforce training
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project name: Astronaut and Pilot Flight Training NASA's project description: Specialized training to include astronaut flight training and flight simulators for pilot training to including technologies such as extended reality (XR) and artificial intelligence.	Workforce training and other purpose(s)

NASA Office	Description	Immersive Technology Purpose
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	System name: Extended Reality Operations Support System NASA's system description: As of November 2023, an XR system is being developed to support multiple collaborative projects for training, Public Affairs Office, education outreach, analysis, and vehicle design support.	Workforce training
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project name: Lunar South Pole visualizations NASA's project description: NASA uses immersive technology, including Mixed Reality Exploration Toolkit (MRET), to visualize Lunar South Pole locations and their lighting. The French Space Agency, Centre National D'Etudes Spatiales, plans to use MRET under a non-reimbursable partnership agreement as part of its Lunar Habitat placement work.	Other purpose(s)
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: Crew Health and Performance Exploration Analog (CHAPEA) XR Environment NASA's Project Description: NASA is using XR to simulate Mars environments to allows test subjects taking part in a simulated analog environment during year-long campaigns to carry out simulated Extravehicular Activities (EVA) in virtual reality (VR) for CHAPEA specific activities.	Medical assessment or treatment
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: Omniverse Eco-System NASA's Project Description: As of November 2023, NASA is investigating the use of NVIDIA Omniverse for 3D visualization and digital twin activities.	Other purpose(s)
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: International Space Station (ISS) Public Outreach (ISS, Lunar, Mars, and other environments). NASA's Project Description: NASA is supporting outreach activities by developing ISS, Lunar, and other VR based experiences.	Public outreach
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: Lunar / Mars EVA and Rover Simulations. NASA's Project Description: Virtual environments are used for simulated EVAs and Rover operations, for design, development, and validation.	Design and planning
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: NASA Spacesuit User Interface Technologies for Students (SUITS) Challenge NASA's Project Description: SUITS is a design challenge in which college students help design user interface design solutions for future spaceflight needs.	Design and planning
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: Metaverse Enabled Digital Twin NASA's Project Description: NASA is studying XR digital twins for ISS flight controllers. As of November 2023, this project has produced a digital twin of ISS gyroscopes and seeking feedback from ISS flight controllers.	Other purpose(s)
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: 3D Model Repository NASA's Project Description: NASA hosts a 3D model sharing repository for use across projects, within and outside of NASA.	Other purpose(s)
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: XR Horizon Scan NASA's Project Description: NASA is investigating the state of XR in industry along with partnerships with various private companies.	Other purpose(s)

NASA Office	Description	Immersive Technology Purpose
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Application Name: Spacecraft Augmented Reality (AR). NASA's Application Description: An augmented reality application that lets you learn about and interact with a variety of spacecraft that explore our solar system, study Earth, and observe the universe.	Public outreach
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: "First Woman" Graphic Novel and AR Experience NASA's Project Description: "First Woman" is an interactive graphic novel and AR experience exploring a fictional story of the first woman on the Moon.	Public outreach
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: Immersive Technology Tools NASA's Project Description: Proof of concept tools have been developed and demonstrated that facilitate multi-user, remote collaboration.	Remote collaboration
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: Propulsion Test AR NASA's Project Description: NASA has used AR capabilities in the propulsion test complex to look at cables and pipe infrastructure underground.	Other purpose(s)
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: Roman Space Telescope (RST) Computer-Aided Design (CAD) with VR NASA's Project Description: Various groups within the Roman Space Telescope integration and testing team implemented VR experiences during key points in the CAD design assisting designers in understanding the context of their designed parts beyond the subsystem level. VR allowed designers to preview their design in a 3D space without the lead time associated with having a prototype or physical model in-hand.	Design and planning
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: RST Integration and Testing with Immersive Technology NASA's Project Description: The RST Spacecraft Bus Harness team implemented VR to allow technicians to preview the harness design and provide feedback during the design process. Technicians were able to measure tight clearances between harness routes and other subsystems and use a 3D avatar to visualize reach and access throughout the Spacecraft Bus and top deck.	Design and planning
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: RST Virtual Mockups NASA's Project Description: Quick-turn delivery time for a full VR model of RST, including the current spacecraft bus harness design, provided the RST Spacecraft Bus Harness team with a 3D visualization of the spacecraft months before the physical mockup for initial harness routing arrived.	Design and planning
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: Mars Sample Return Integration and Testing Lab Design NASA's Project Description: XR is used to design the layout of the hardware I&T lab for the Capture, Containment and Retrieval System project that is part of the Mars Sample Return mission.	Design and planning
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	System Name: Jetpace Simplified Aid For EVA Rescue (SAFER) System NASA's System Description: Immersive technologies are used to train astronauts on how to return to the ISS during spacewalks if they were to become disconnected from the ISS primary structure.	Workforce training

NASA Office	Description	Immersive Technology Purpose
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Application Name: High Efficiency Megawatt Motor (HEMM) Augmented Reality NASA's Application Description: AR allows a user to visualize and interact with a 3D model of a NASA designed and built electric motor used for a NASA concept hybrid electric aircraft, enabling subject matter experts to discuss the motor design and for public outreach events to create awareness and understanding of the project.	Design and planning, remote collaboration, public outreach
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: Hybrid Collaboration Project Using XR Technology NASA's Project Description: Use of XR to improve remote, multi-participant collaboration.	Public outreach
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: Adaptive User Interface with XR NASA's Project Description: Uses XR, artificial intelligence and machine learning, and biometrics to determine a person's cognitive state and adjusts the information or procedure being carried out accordingly. The goal is to use XR as an environment (Mars/Lunar VR scenes) to support the gathering of cognitive/physical assessment data of test subjects during simulated EVAs.	Other purpose(s)
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: Scientific Hybrid Reality Environment (SHyRE) NASA's Project Description: NASA has created a VR environment of the 1974 Hawaii lava flow site that was used by geologists to design tools and train for exploration of Lunar/Mars environments. The system is also designed to allow for outreach activities.	Other purpose(s)
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: Assessment of Physiology and Cognition in Hybrid Reality Environment (APACHE) NASA's Project Description: XR is used to support physiological testing while someone is conducting simulated EVAs on the surface of the Moon, Mars, and other analogs on Earth.	Human factors research
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: Human Exploration Research Analog (HERA) XR Environment NASA's Project Description: NASA is using XR to simulate Mars environments that allows test subjects to take part in HERA campaigns, conducting simulated EVAs in VR for HERA specific activities.	Other purpose(s)
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: Vestibular Sensory Motor Counter Measures NASA's Project Description: VR is used to simulate the illusion of motion encountered by astronauts as they transition between gravity environments to determine if VR can be used as a countermeasure as astronauts transition between gravity environments.	Human factors research
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: Brain Computer Interface using XR and artificial intelligence and machine learning (AI/ML) Project. NASA's Project Description: NASA is investigating brain computer interfaces to determine whether users are able to control buttons to carry out actions inside an extended reality l environment using the brainwaves collected by an electroencephalogram (EEG).	Other purpose(s)
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	System Name: Environment for Data Engineering in Virtual Reality (EnDEVR) NASA's System Description: EnDEVR is a user-extensible system that allows for the execution of custom data science functions in VR.	Data visualization and analysis

NASA Office	Description	Immersive Technology Purpose
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: SciVR - Immersive Earth Science Data Visualization NASA's Project Description: Provides immersive visualization of complex Earth data.	Other purpose(s)
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: ISS Cupola World View NASA's Project Description: Used to support viewing of Earth from the Cupola and can assist in taking picture by annotating locations on earth.	Other purpose(s)
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: Performance Measurement Tools NASA's Project Description: NASA is using eye tracking and XR to support training.	Human factors research
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: Modelling and Optimizing Human Performance Using XR and Redirected Walking NASA's Project Description: Redirected walking allows the physical walking space needed to be reduced by using eye tracking to detect when saccades are occurring to slightly rotate the user's viewpoint in a VR environment. The user is visually directed to walk in curved path, but they perceive that they are walking in a straight path, which means that a user could walk a very large distance in a virtual environment but require a fairly small physical space for the traversal.	Human factors research
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: Creating XR Collaborative Spaces with Rapid Model Import Tool (RMIT) and Virtual Environment Computational Training Resource (VECTR) NASA's Project Description: VECTR is a multi-user virtual reality platform, built with commercial off-the-shelf hardware, designed to augment the way engineers work at NASA by providing a mechanism to carry out remote collaboration. Rapid Model Import Tool (RMIT) is a 3D model import tool that can be used to optimize 3D models to be used in immersive applications by reducing the number of polygons, faces, etc. It can also be used to translate 3D models between different formats.	Data visualization and analysis and remote collaboration
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: Holoportation and Handshake in Space NASA's Project Description: AR Holograms are created and placed on the International Space Station. The system can be used to 'teleport' a doctor that can provide medical information, a family member to provide a more immersive conversation, an engineer to provide repair maintenance information or support.	Other purpose(s)
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: Use of VR to Improve Spacecraft Design NASA's Project Description: NASA is using XR tools to support the development of future spacecraft.	Design and planning
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: VR for Lunar Surface EVA Analysis and Training. NASA's Project Description: Provides an immersive view of the Lunar surface to allow the evaluation of systems being developed by allowing users to don a headset and ambulate within the environment, drive a rover, or carry out other Lunar relevant activities. The system is also being used as part of a Lunar south pole lighting study.	Workforce training
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Application Name: Moon Tycoon Version 2. NASA's Application Description: NASA has developed a 3D Lunar Surface Emulator for Desktops and Virtual Reality	Other purpose(s)

NASA Office	Description	Immersive Technology Purpose
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: Kennedy Space Center Flyover NASA's Project Description: An VR sandbox environment that allows users to navigate and learn more about the Kennedy Space Center and its missions.	Other purpose(s)
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: Metaverse Project Creation of digital versions of various facilities, conference rooms, and labs to allow for more immersive remote collaboration by multiple individuals.	Other purpose(s)
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: Mars XR Challenge NASA's Project Description: Developing assets that can be used in VR applications that would support Mars/Lunar EVAs.	Other purpose(s)
NASA PAO	Project Name: Public Outreach Support ISS Experience NASA's Project Description: NASA has developed ISS and other digital environments to support PAO activities.	Public outreach
Armstrong Flight Research Center	Project Name: Revolutionary Vertical Lift Technology NASA's Project Description: The Revolutionary Vertical Lift Technology project is using virtual reality as a tool to study the passenger ride quality of future electric air taxis. VR, with a motion base creates an immersive experience that allows researchers to gather data on passenger discomfort due to aircraft maneuvers, gust response, external visual cues, and other factors to help inform the design of electric vertical take-off and landing aircraft and operations.	Human factors research, design and planning
Armstrong Flight Research Center	Project Name: Autonomous Systems Certification NASA's Project Description: As of November 2023, Armstrong researchers are collaborating on an effort to build a basis for certification of autonomous systems by defining metrics for trustworthiness and developing a simulation environment in which these concepts are explored.	Design and planning
Armstrong Flight Research Center and Office of Science, Technology, Engineering, and Mathematics (STEM) Engagement	Project Name: Augmented Reality Mobile Application NASA's Project Description: Researchers are working with student interns to develop an augmented reality mobile application to educate the public about NASA's X-planes and aviation research programs.	Public outreach
Stennis Space Center - Autonomous Systems Laboratory	Project Name: Autonomy Voice Assistant (AVA) NASA's Project Description: NASA developed AVA to integrate AR and VR into the NASA Platform for Autonomous Systems (NPAS) to enables development of autonomous applications that can be rapidly deployed, such as for the Gateway space station.	Other purpose(s)
Glenn Research Center	Project Name: Virtual reality digital twin of engine testing facility NASA's Project Description: Users can explore the components and data from a NASA Glenn engine test facility using a VR application.	Other purpose(s)
Glenn Research Center	Application Name: Virtual reality guided tour of engine compressor testing facility NASA's Application Description: A VR application takes the user on a guided tour of a NASA Glenn compressor test facility. Some unique features of this application are the use of an avatar to act as a guide and the ability to see data and models in the facility at both large and small scales.	Public outreach

NASA Office	Description	Immersive Technology Purpose
Glenn Research Center	Project Name: Titan Submarine VR Experience NASA's Project Description: This virtual reality application provides an interactive way to learn more about NASA Glenn's design for a submarine that could be sent to Titan, a moon of Saturn.	Public outreach
Glenn Research Center Graphics and Visualization Lab	Project Name: Subsonic Single Aft Engine (SUSAN) Aircraft visualization in a cave environment NASA's Project Description: Using a large-scale cave environment, users can explore, in VR, the components of the SUSAN aircraft and see the plane in flight.	Other purpose(s)
Goddard Space Flight Center (GSFC)	Project Name: GSFC Design with Immersive Technology NASA's Project Description: XR is used to develop designs in 3D, to communicate design ideas to coworkers, assess access for I&T, and collaboration.	Design and planning, remote collaboration
Jet Propulsion Laboratory (JPL)	Project Name: JPL Multi-Mission Immersive Technologies NASA's Project Description: Several JPL projects use immersive technologies, including the Mars Science Laboratory, Europa Clipper, and the Innovation Foundry. These tools, in the context of mission formulation, design, and operations have revealed several areas that offer strong potential for multi-mission solutions.	Design and planning
Langley Research Center (LaRC)	Project name: Augmented reality wind tunnel data visualization NASA's project description: NASA uses AR to visualize live data over test devices flying in the LaRC vertical wind tunnel. Model and tunnel operators can make real-time adjustments based on virtual data that are overlayed on models under test.	Data visualization and analysis
LaRC	Project Name: LaRC Public Outreach NASA's Project Description: The LaRC public outreach group created VR demonstrations of emerging technologies, including small public air transportation.	Public outreach
LaRC	Project Name: Langley Transformation Initiative's investigation of XR use cases NASA's Project Description: This activity will attempt to enable a handful of cross-center projects to use the existing support network to train employees in the use of AR and apply their knowledge of the technology to their workspaces in new and creative ways.	Workforce training
LaRC and GSFC	System name: Mixed Reality Exploration Toolkit (MRET). NASA's system description: MRET integrates real-time and recorded telemetry data from multiple sources to simulate visualizations that can be used for engineering and simulations which, assists in science-data analysis. It has enabled VR-based engineering design from concept designs for CubeSats to simulated hardware I&T for missions and in-orbit visualizations.	Data visualization and analysis, design and planning
Research Services Directorate	Project Name: Flight Simulators NASA's Project Description: NASA operates flight simulators of differing complexities from single display systems that support general flight control hardware to full motion cockpit simulators. These systems can be tied to simulation facilities at other NASA Centers, Department of Defense facilities, Federal Aviation Administration facilities, commercial facilities, and university facilities to conduct large-scale multi-vehicle simulations.	Remote collaboration

Source: GAO analysis of National Aeronautics and Space Administration (NASA) survey data. | GAO-24-106665

Current R&D Activities (FY 2022–2023)

NASA reported conducting or funding various types of R&D for at least 11 different systems, programs, or activities for various purposes in FY 2022–2023. NASA explained that most of the current uses of immersive technology are in support of R&D efforts. Some examples of NASA's R&D with immersive technology are listed in table 26. In addition to the four purposes listed in the table, NASA also reported that it conducted or funded R&D involving immersive technologies for workforce training, data visualization and analysis, human factors research, public outreach, and remote collaboration. NASA reported that it conducted or funded basic research, applied research, and experimental development involving immersive technologies. It also reported that it funds R&D with outside entities through grants or contracts and conducts R&D itself.

Table 26: NASA Examples of Research and Development (R&D) Involving Immersive Technology, Fiscal Years 2022–2023

NASA Office	Description	Immersive Technology Purpose
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: Habitat Module Design NASA's Project Description: An immersive application was developed and used to support the evaluation of Habitat Module designs. The tool is also being used to carry out studies related to the ergonomics and useability of various habitat and pressurized rover designs.	Design and planning
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: Joint AR NASA's Project Description: NASA is developing augmented reality (AR) projection technology for an extra vehicular activity (EVA) helmet bubble. Developing custom interfaces, 3D graphics engine, and testbed	Other purpose(s)
All NASA centers, Office of Technology Policy and Strategy, and Digital Transformation Office	Project Name: Human Factors Research with Immersive Technology NASA's Project Description: NASA is using immersive technologies for training and human factors research, to include: • An immersive procedure system has been developed that guides users how to operate an ultrasound machine and other medical equipment/tools. • Human performance studies related to the effects on the vestibular system during gravity field changes and if XR can be used as a countermeasure. • Physiological/cognitive studies during simulated Lunar/Mars Extravehicular activities.	Medical assessment or treatment
NASA	Project Name: XR Enabled Procedure System for International Space Station (ISS) NASA's Project Description: NASA is evaluating an extended reality (XR) enabled procedure system being evaluated on the ISS that provides guidance on how to maintain certain equipment and could be used for refresher training.	Real-time assistance, guidance, or inspection
NASA	Project Name: Machine Learning (ML) Training Using Synthetic Images NASA's Project Description: Use of synthetic environments to train a computer vision system.	Other purpose(s)
NASA	Project Name: Multi-Modal Human Interfaces NASA's Project Description: NASA is investigating the different modalities that can be used to support XR applications, to include haptics, eye-tracking, gesture recognition / motion capture, and others	Other purpose(s)

NASA Office	Description	Immersive Technology Purpose
NASA	Project Name: Augmented Reality Sensorimotor Assessment for Astronaut Readiness Evaluation NASA's Project Description: This effort is to determine if AR can be used for Sensorimotor assessment, determining risk of planetary EVA after microgravity exposure.	Other purpose(s)
Ames Research Center	Project Name: Vertical Motion Simulator (VMS) NASA's Project Description: The VMS at NASA Ames is the world's largest motion flight simulator, moving within a 10-story tower. The motion of the VMS is based on aircraft models developed using real data from actual aircraft, wind tunnels, and computational fluid dynamic analysis allowing the VMS to generate precise accelerations that result in a near-flight-like experience for pilots and passengers.	Design and planning
Armstrong Flight Research Center	Project Name: Immersive Technology for Flight Testing NASA's Project Description: Investigation of how virtual and augmented reality systems can make it easier for pilots to receive and visualize critical information during flight testing.	Design and planning
Earth Science Technology Office	Project Name: Earth Science Research with Immersive Technologies NASA's Project Description: Developing a scientific exploration and analysis mixed augmented and virtual reality tool with integrated Lagrangian dynamics to help scientists identify, track, and understand the evolution of Earth Science atmospheric phenomena in the NASA Earth Science climate model, the Goddard Earth Observing System.	Other purpose(s)
Langley Research Center (LaRC) and Research Services Directorate	Project Name: Flight Simulators NASA's Project Description: LaRC operates flight simulators that are high-performance, state-of-the-art human-in-the-loop flight simulators for all classes of aircraft and spacecraft. These hardware and software systems are used to conduct research for advanced flight deck design and vehicle operations for crew and cargo space missions, advanced air vehicles, uninhabited aircraft systems, and Next Generation Air Transportation System.	Design and planning
LaRC	Project Name: Langley Autonomous Integrated System Research NASA's Project Description: NASA is researching the use of AR with autonomous systems including the ability to create 3D meshes of external environments and mapping them into Unity and creating path planning and trajectory algorithms that can be visualized in a virtual environment.	Other purpose(s)
Planetary Science and Technology from Analog Research (PSTAR)	Project Name: AR data visualization in low-angle lighting NASA's Project Description: XR technologies are being developed to assess the use of AR data visualization in both rover and astronaut planetary analog missions using low-angle lighting conditions similar to those present at the lunar south pole, where 'astronauts' using AR on lunar planetary analogs such as the Cinder Lake Apollo-era Crater Fields in Arizona and VR 'mission ops' of the same area at Goddard Space Flight Center. The findings will contribute to data visualization methods and concept of operations for future Artemis missions to the lunar surface.	Other purpose(s)

Source: GAO analysis of National Aeronautics and Space Administration (NASA) survey data. | GAO-24-106665

Current Transactions with Nonfederal Entities for Entity's Own Use (FY 2022–2023)

NASA reported providing funding to colleges and universities and private entities for immersive technologies in the forms of internal innovation funds, independent research and development, small business innovation research, small business technology transfer, and human research program funds, among others. They

reported collaborating with industry, other government agencies, and academia to develop software that supports astronaut training, engineering design and analysis, teleoperation, complex data visualization, public outreach, procedure execution, collaboration, health and human performance, among others.

Current Regulatory Functions Over Nonfederal Entities That Use Immersive Technologies (FY 2022–2023)

None reported.

Planned Use of Immersive Technologies (FY 2024–2028)

NASA plans to adopt or expand the use of immersive technology for data visualization and analysis, human factors research, public outreach, remote collaboration, design and planning, medical assessment or treatment, real-time assistance, guidance, or inspection.

Planned R&D for Immersive Technology (FY 2024–2028)

NASA plans to conduct or fund R&D involving immersive technology for data visualization and analysis, human factors research, public outreach, remote collaboration, design and planning, medical assessment or treatment, real-time assistance, guidance, or inspection.

Planned Regulatory Functions Over Nonfederal Entities That Use Immersive Technology (FY 2024–2028)

None reported.

Current and Planned Obligations

NASA reported that it was not sure of the total of current and planned obligations.

Benefits and Challenges of Immersive Technology

NASA reported various benefits and challenges to current use and adoption, and future use of immersive technologies.

NASA identified the following as the top benefits of using of immersive technologies currently:

- Better understanding of data
- Cost savings
- Decision-making error reduction and efficiency improvement
- Easier access to information
- Increased safety

- Increased user engagement and learning retention
- Interoperability
- Modularity
- Portability
- Reconfigurability
- Scalability
- Strategic or competitive advantage
- Time savings

NASA identified the following as the top challenges of using of immersive technologies currently:

- Ensuring federal cybersecurity and privacy requirements are met[16]

NASA identified the following as the top benefits of adopting or expanding the use of immersive technologies from FY 2024–2028:

- Decision-making error reduction and efficiency improvement
- Increased safety
- Increased user engagement and learning retention
- Scalability, reconfigurability, modularity

NASA identified the following as the top challenges of adopting or expanding the use of immersive technologies from FY 2024–2028:

- Ensuring federal cybersecurity and privacy requirements are met[17]
- High cost to operate or maintain
- How data are collected, stored, or transmitted
- Rapid technology development

Which NASA Components Contributed to the Survey

The following NASA components and offices contributed to the agency's survey response:

- Ames Research Center
- Armstrong Flight Research Center
- Center Chief Technologists from all NASA Centers

[16]For additional information, please refer to footnote 3 of this appendix.

[17]For additional information, please refer to footnote 3 of this appendix.

- Office of Technology Policy and Strategy
- Digital Transformation Office
- Glenn Research Center
- Goddard Space Flight Center
- Jet Propulsion Laboratory
- Johnson Space Center
- Langley Research Center
- Stennis Space Center

General Services Administration

Source: U.S. General Services Administration. | GAO-24-106665

The U.S. General Services Administration (GSA) reported using immersive technologies and funding immersive technology R&D in FY 2022 and FY 2023. GSA also reported that it plans to use immersive technologies and plans to conduct or fund R&D using immersive technology for FY 2023–2028.

Types of Immersive Technologies Used

GSA reported that it currently (FY 2022–2023) uses augmented reality, mixed reality, and virtual reality, and plans to continue the use of these types of immersive technologies through FY 2028. GSA has and continues to conduct pilot activities with immersive technologies since at least 2020, with a recent pilot conducted on using immersive virtual workspaces for telepresence. GSA uses augmented reality and virtual reality at least once a year, while using mixed reality technologies at least once a week.

Current Uses (FY 2022–2023)

GSA reported using immersive technologies for design and planning and public outreach in FY 2022 and FY 2023 (see table 27).

Table 27: GSA Uses of Immersive Technology, Fiscal Years 2022–2023

GSA Office	Description	Immersive Technology Purpose
Public Buildings Service, Office of Architecture and Engineering	GSA has used building information modeling and 3D building modeling techniques since 2009. These technologies have been used for flat-screen, visual-headgear, and immersive rooms for design of office spaces, courtroom mock-up and design refinement, and for mechanical room layout and re-engineering.	Design and plannin
Public Buildings Service, Office of Architecture and Engineering	For historic preservation purposes, GSA has documented historic buildings scheduled for renovation, adaptive reuse and demolition with photographic “fly-throughs” to ensure the physical sense of the original buildings could be captured for public experience.	Public outreach

Source: GAO analysis of General Services Administration (GSA) survey data. | GAO-24-106665

Current R&D Activities (FY 2022–2023)

GSA reported conducting one R&D activity in FY 2022–2023 (see table 28). GSA reported that it conducted in-house R&D for basic and applied research involving immersive technologies.

Table 28: GSA Example of Research and Development (R&D) Involving Immersive Technology, Fiscal Years 2022–2023

GSA Office	Description	Immersive Technology Purpose
Office of the Chief Technology Officer	Project name: Virtual Presence Pilot GSA's research description: This completed pilot used virtual reality headsets to explore Virtual Presence in an immersive workspace with hopes to enable GSA organizations to better interact and collaborate with one another, beyond the telepresence representation in a two-dimensional space, but rather "feel" and "respond" in an immersive 3D virtual environment. Funds obligated: Approximately $9,500 for FY 2022–2023[a]	Human factors research, remote collaboration

Source: GAO analysis of General Services Administration (GSA) survey data. | GAO-24-106665

[a]GSA reported that funds may be in abeyance due to compliance challenges with Section 508 of the Rehabilitation Act of 1973. Section 508 of the Rehabilitation Act of 1973 requires federal agencies to make their electronic and information technology (EIT) accessible to people with disabilities. The law applies to all federal agencies when they develop, procure, maintain, or use electronic and information technology. 29 U.S.C § 794d. Under Section 508, agencies must give federal employees with disabilities and members of the public access to information comparable to the access available to others.

Current Transactions with Nonfederal Entities for Entity's Own Use (FY 2022–2023)

None reported.

Current Regulatory Functions Over Nonfederal Entities That Use Immersive Technologies (FY 2022–2023)

None reported.

Planned Use of Immersive Technologies (FY 2024–2028)

GSA plans to adopt or expand the use of immersive technology for remote collaboration, design and planning, and real-time assistance or guidance. GSA plans to adopt enhanced visualization technologies that will enable faster and more efficient design, construction, maintenance, and space management of their inventory.

Planned R&D for Immersive Technology (FY 2024–2028)

None reported.

Planned Regulatory Functions Over Nonfederal Entities That Use Immersive Technology (FY 2024–2028)

None reported.

Current and Planned Obligations

GSA reported that its budget includes approximately $2 million, provided through operational funds, to support personnel enabling the use of immersive technologies. No funding for hardware or software has been authorized.

Benefits and Challenges of Immersive Technologies

GSA reported various benefits and challenges to current use and adoption, and future use of immersive technologies.

GSA identified the following as the top benefits of using of immersive technologies currently:

- Better understanding of data
- Cost savings
- Decision-making error reduction and efficiency improvement
- Interoperability
- Reconfigurability
- Time savings

GSA identified the following as the top challenges of using of immersive technologies currently:

- Limited acquisition options
- Rapid technology development
- Ensuring federal cybersecurity and privacy requirements are met[18]
- Limited number of workers with necessary immersive technology skills

GSA identified the following as the top benefits of adopting or expanding the use of immersive technologies from FY 2024–2028:

- Better understanding of data
- Cost savings
- Time savings

GSA identified the following as the top challenges of adopting or expanding the use of immersive technologies from FY 2024–2028:

- Ensuring federal cybersecurity and privacy requirements are met
- Limited number of workers with necessary immersive technology skills
- User acceptance of immersive technology

Which GSA Components Contributed to the Survey

The following GSA components and offices contributed to the agency's survey response:

[18]For additional information, please refer to footnote 3 of this appendix.

- Office of the Chief Technology Officer
- Public Buildings Service, Office of Architecture and Engineering

National Science Foundation

The U.S. National Science Foundation (NSF) reported funding R&D involving immersive technologies in FY 2022–2023.

Source: U.S. National Science Foundation. | GAO-24-106665

Types of Immersive Technologies Used

None reported.

Current Uses (FY 2022–2023)

None reported.

Current R&D Activities (FY 2022–2023)

NSF reported conducting or funding R&D for at least 507 systems, programs, or activities for various purposes in FY 2022–2023, and it provided 17 examples (see table 29). It funded basic research and experimental development involving immersive technologies. It also reported that it funds R&D with outside entities through grants.

Table 29 NSF Examples of Research and Development Involving Immersive Technologies, Fiscal Years 2022–2023

NSF Division[a]	Description	Immersive Technology Purpose
Division of Computer and Network Systems (CNS)	Project name: Industry–University Cooperative Research Centers Program: Center for Visual and Decision Informatics (CVDI) Site at SUNY Stony Brook NSF's research description: SUNY Stony Brook is added to the CVDI, which seeks to conduct multi-disciplinary, cross-institutional, pre-competitive research and develop the next generation technologies in data science, big data, analytics, data acquisition and management, and data visualization. Funds obligated: None in FY 2022–2023	Basic research

NSF Division[a]	Description	Immersive Technology Purpose
CNS	Project name: Development of iCAVE2 (Instrument for Connected and Autonomous Vehicle Evaluation and Experimentation) NSF's research description: iCAVE2 consists of multiple driving simulators, a traffic simulator, a network simulator, and other systems to address research challenges in surface transportation systems where statistics on accidents and fatalities, congestion, fuel consumptions, and emissions have raised serious concerns. Funds obligated: None in FY 2022–2023	Basic research
CN	Project name: Support for Interactive AR/VR Video: Learning and Optimizing at the Network Edge NSF's research description: This project seeks to improve user experience with AR/VR applications by using compute capability in edge cloud nodes located close to the user with a goal of implementing a system for real-time streaming and analysis of AR/VR videos that jointly uses the network efficiently while maintaining a high user quality of experience. Funds obligated: None in FY 2022–2023	Basic research
CN	Project name: Networked Multi-User Augmented Reality for Mobile Devices NSF's research description: This project seeks to address poor user experience issues (such as high latency or inconsistent views of the virtual objects by different users) by developing the network capabilities of the underlying AR platform, to support future multi-user AR applications. Funds obligated: FY 2022 = $107,723; FY 2023 = $110,021	Basic research
CN	Project name: Rhythmic Pixel Region Interface Systems for Efficient, Performant, and Precise Augmented Reality NSF's research description: The project aims to reduce the sensing data rate of visual computing, enabling more compact augmented reality devices with smaller battery sizes, and higher precision placement of virtual objects in the physical spaces, which could improve performance and reduce energy consumption. Funds obligated: FY 2022 = $90,584; FY 2023 = $192,974	Basic research
CN	Project name: miVirtualSeat: Semantics-aware Content Distribution for Immersive Meeting Environments NSF's research description: This project will research, build, and evaluate a distributed system, called miVirtualSeat, that more closely simulates the immersive experience of in-person meetings, including physical and virtual participants in a physical meeting space. Funds obligated: None in FY 2022–2023	Basic research
CN	Project name: CoMIC: A Collaborative Mobile Immersive Computing Research Infrastructure for Multi-user XR Research description: Currently, the research and development of multi-user extended reality (XR) have been hindered because the underlying infrastructure with essential building blocks is still missing. This project aims to design and develop the infrastructure for Collaborative Mobile Immersive Computing (CoMIC), which fills this critical gap and lays the technical foundation for realizing the grand vision of the Metaverse. Funds obligated: FY 2023 = $1,500,000	Basic research

NSF Division[a]	Description	Immersive Technology Purpose
CNS	Project name: Modeling and Defense of Cyber Attacks for Improving Social Virtual Reality Resilience Research description: This project's goal is to investigate how Social VR Learning Environments can be improved for geo-distributed users by examining how networked systems need to be properly designed for performance and resilience to prevent unique cyber-attacks. Funds obligated: None in FY 2022–2023	Basic research
Division of Information and Intelligent Systems (IIS)	Project name: Data-Mediated Communication with Proximal Robots for Emergency Response NSF's research description: This project will explore how see-through augmented reality head-mounted displays might offer an intuitive and powerful medium for analysis of robot-collected data that allows emergency responders to interact with robot-collected information, such as in environments that may be dangerous or inaccessible for human responders, such as in wildfire fighting, search and rescue, or hurricane response. Funds obligated: None in FY 2022–2023	Basic research
IIS	Project name: First Person View and Augmented Reality for Airborne Embodied Intelligent Cognitive Assistants NSF's research description: Through the careful integration of AR with first-person-view operator interfaces this research will explore the use of intelligent airborne drones to help ground-based operators in the inspection of highway bridges. Funds obligated: None in FY 2022–2023	Basic research
IIS	Project name: DataWorld: Externalizing Hidden Data Flows for Situated Analytics NSF's research description: This project will build a framework called DataWorld on a university campus that uses AR to help students, faculty, and visitors understand the university's events, alerts, and historical background. Funds obligated: None in FY 2022–2023	Basic research
IIS	Project name: Integrative Wide-Area Augmented Reality Scene Modeling NSF's research description: The goal of this project is to develop and evaluate new methods for creating, maintaining, and improving large-scale scene models to enable wide-area AR. AR and VR user interfaces will be developed and evaluated to allow remote users to virtually navigate through modeled spaces and to provide guidance to the local AR users. Funds obligated: None in FY 2022–2023	Basic research
IIS	Project name: Improved Situation Awareness of Unknown Environments through a Robotic Augmented Reality Virtual Window NSF's research description: This project will develop a robot that police officers can send into a room before they enter. The police officers wear AR headsets that allow them to see the room through the robot's cameras. In addition, the combination of AR and the robot allows the police to see the room as though they had x-ray vision, giving them a virtual window through an otherwise solid wall. Funds obligated: None in FY 2022–2023	Basic research
IIS	Project name: Cybertechnology Development and Exploration of Learning Processes in Augmented Reality Team Environments (CyberlearnAR) NSF's research description: The CyberLearnAR project at Middle Tennessee State University in Murfreesboro Tennessee, will explore how wearable AR technology when combined with best classroom practices affects the learning process of college-level science, technology, engineering, and math (STEM) students. Groups of students will view and manipulate 3D holographic objects in a collaborative learning environment. Funds obligated: None in FY 2022–2023	Basic research

NSF Division[a]	Description	Immersive Technology Purpose
IIS	Project name: A Virtual Reality simulator to train first responders involved in health care efforts related to the COVID-19 virus outbreak NSF's research description: This project involves the creation of a VR based simulation environment to support training of first responders including nurses in hospitals, communities, and cities in the U.S. in order to respond more effectively to the recent COVID-19 outbreak. The simulator's training modules will also be used to introduce university students to the process of designing and building such Virtual Reality simulators for medical and health care contexts. Funds obligated: None in FY 2022–2023	Basic research
IIS	Project name: Adaptive Driver Assistance Systems and Personalized Training for Law Enforcement Officers (ADAPT-LEO) NSF's research description' This project will model law enforcement officers' driving workload and performance in high-demand situations and use those models to develop in-vehicle technology and training solutions that adapt to officers' workload in order to reduce the risk of crash-related harms in police operations. Funds obligated: FY 2022 = $299,728	Basic research
IIS	Project name: Adaptive Digital Twinning: An Immersive Visualization Framework for Structural Cyber-Physical Systems NSF's research description: This project will explore an approach to modernizing infrastructure systems using artificial intelligence-informed digital twins to form a collaborative feedback loop between the measurable data of the physical world and simulated processes in the virtual world, providing a domain-specific adaptation of the broader cyber-physical system framework necessary to inform decision-making. Funds obligated: None in FY 2022–2023	Basic research

Legend: FY = fiscal year

Source: GAO analysis of National Science Foundation (NSF) survey responses. | GAO-24-106665

[a]Both NSF divisions—Computer and Network Systems and Information and Intelligent Systems—fall under NSF's Directorate for Computer and Information Science and Engineering.

Current Transactions with Nonfederal Entities for Entity's Own Use (FY 2022–2023)

None reported.

Current Regulatory Functions Over Nonfederal Entities That Use Immersive Technologies (FY 2022–2023)

None reported.

Planned Use of Immersive Technologies (FY 2024–2028)

NSF reported it was not sure about its plans for using immersive technologies in the next 5 years.

Planned R&D Involving Immersive Technologies (FY 2024–2028)

NSF reported it had plans for funding R&D in the next 5 years.

Planned Regulatory Functions Over Nonfederal Entities That Use Immersive Technologies (FY 2024–2028)

None reported.

Current and Planned Obligations

NSF obligated approximately $378.94 million in FY 2022–2023 for R&D involving immersive technologies. Specifically, it obligated approximately $213.366 million in FY 2022 and approximately $165.574 million in FY 2023.[19]

Benefits and Challenges of Immersive Technologies

Because NSF did not report any current or planned use of immersive technologies, it did not respond to GAO's questions about benefits and challenges.

Which NSF Components Contributed to the Survey

The following NSF component or office contributed to the agency's survey response:

- Directorate for Computer and Information Science and Engineering

[19]According to NSF, these obligations do not include research projects that were identified using the search term "simulator," because it provided too many results that did not include immersive elements.

Nuclear Regulatory Commission

Source: U.S. Department of Education. | GAO-24-106665

The U.S. Nuclear Regulatory Commission (NRC) reported using immersive technology and funding immersive technology R&D in FY 2022 and FY 2023. NRC also reported that it is unsure of its plans to use immersive technologies and plans to conduct or fund R&D involving immersive technology for FY 2024–2028.

Types of Immersive Technologies Used

NRC reported that it currently uses (FY 2022–2023) different types of simulators—flat screens and immersive environments. NRC reported using these simulators at least once per month.

Current Uses (FY 2022–2023)

NRC reported using at least two different systems, programs, or activities for two different purposes in FY 2022 and FY 2023 (see table 30).

Table 30: NRC Use of Immersive Technology, Fiscal Years 2022–2023

NRC Office	Description	Immersive Technology Purpose
Office of the Chief Human Capital Officer	Program Name: Reactor Operations Demonstrations NRC's Program Description: Simulators are used for demonstrating reactor operations as part of NRC public outreach efforts.	Public outreac
Office of the Chief Human Capital Officer	Program Name: Training Simulators NRC's Program Description: NRC uses simulators to provide technical training focused on reactor design and operations, enabling agency staff to gain necessary knowledge and skills. These simulators were used to train approximately 300 staff in FY 2022–2023.	Workforce training

Source: GAO analysis of Nuclear Regulatory Commission (NRC) survey results. | GAO-24-106665

Current R&D Activities (FY 2022–2023)

NRC reported conducting or funding various types of R&D for at least two different systems, programs, or activities for various purposes in FY 2022 and FY 2023 (see table 31). In addition to the two purposes listed in table 31, NRC reported that it conducted or funded R&D involving immersive technologies for data visualization and analysis and other purposes. NRC reported that it conducted or funded applied research. It also reported that it funds R&D with outside entities through grants or contracts and conducts R&D itself.

Table 31: NRC Examples of Research and Development (R&D) Involving Immersive Technology, Fiscal Years 2022–2023

	Description	Immersive Technology Purpose
Office of Nuclear Regulatory Research	Project Name: Enabling Technologies for Plant Modernization and Applications of Digital Twins Project Description: NRC is examining the viability of digital twin-enabling technologies, such as advanced sensors, condition monitoring and related data analytics, and advanced modeling using artificial intelligence to reduce uncertainties and risk and enhance operational safety and security. This effort has been funded $600,000 for FY 2023-25.	Data visualization and analysis
Office of Nuclear Regulatory Research	Project Name: Research and Development of Assessment Tools and Methodologies for Condition Monitoring of Component Performance Project Description: NRC is using virtual simulators to demonstrate applications of advanced modeling for condition monitoring and prognostics of system performance for reactor sub-systems.	Data analysis and intelligence

Source: GAO analysis of Nuclear Regulatory Commission (NRC) survey results. | GAO-24-106665

Current Transactions with Nonfederal Entities for Entity's Own Use (FY 2022–2023)

NRC reported providing funding to universities through R&D grants and have also funded other government entities (such as state and local governments) for immersive technologies. NRC reported funding $1 million for these projects in FY 2022. The projects funded supports multiple purposes, including workforce training, data visualization and analysis, human factors research, and design and planning. For example:

- NRC Grant to North Carolina State University:

Project Purpose: Trustworthiness of Digital-Twin-based Automation Technology in Nuclear Power Plant Operation

Project Description: NRC provided a grant to North Carolina State University to establish a technical basis for the development and demonstration of a trustworthiness assessment framework for automation enabled by digital twin technology for nuclear reactor operation and maintenance procedures.

- NRC Grant to University of Illinois, Urbana-Champaign

Project Purpose: Integrated Modeling of Human Interactions with Hardware and Software in Digital Twins to Support Risk-Informed Regulation for Existing Plants and Advanced Reactors

NRC's Project Description: NRC provided a grant to the University of Illinois, Urbana-Champaign to develop a first-of-its-kind methodology for modeling human interactions with digital twins in nuclear power plants and to quantify the safety risk impacts of human and digital twin interactions.

Current Regulatory Functions Over Nonfederal Entities That Use Immersive Technologies (FY 2022–2023)

None reported.

Planned Use of Immersive Technologies (FY 2024–2028)

None reported.

Planned R&D Involving Immersive Technologies (FY 2024–2028)

None reported.

Planned Regulatory Functions Over Nonfederal Entities That Use Immersive Technology (FY 2024–2028)

None reported.

Current and Planned Obligations

NRC reported that it has funded $600,000 for immersive technology efforts from FY 2023–2025.

Benefits and Challenges of Immersive Technology

NRC reported various benefits and challenges to current use and adoption, and future use of immersive technologies. Because NRC did not report any planned adoption or expansion of the use of immersive technologies in FY 2024–2028, it did not respond to questions about adoption or expansion benefits and challenges.

NRC identified the following as the top benefits of using of immersive technologies currently:

- Better understanding of data
- Decision-making error reduction and efficiency improvement
- Increased safety
- Increased user engagement and learning retention

NRC identified the following as the top challenges of using of immersive technologies currently:

- Ensuring federal cybersecurity and privacy requirements are met[20]
- Limited number of workers with necessary immersive technology skills
- Limited standards or lack of common definition across industry or federal government

[20]For additional information, please refer to footnote 3 of this appendix.

Which NRC Components Contributed to the Survey

The following NRC components and offices contributed to the agency's survey response:

- Office of the Chief Human Capital Officer
- Office of Nuclear Regulatory Research

Appendix II: Objectives, Scope, and Methodology

This report addresses (1) which federal civilian agencies had programs or activities involving immersive technologies in the past 2 fiscal years (FY) 2022 and FY 2023, including the purpose and reported benefits of using the technologies; (2) how federal civilian agencies plan to increase their programs or activities involving immersive technologies over the next 5 fiscal years (FY 2024–2028), including anticipated benefits; and (3) what challenges federal civilian agencies reported on the use and adoption of immersive technologies.

To address these objectives, we conducted a survey of the 23 civilian agencies listed in the Chief Financial Officers Act (CFO Act) of 1990, as amended.[1] These departments and agencies (hereafter referred to as agencies) are as follows:

- Department of Agriculture
- Department of Commerce
- Department of Education
- Department of Energy
- Department of Health and Human Services
- Department of Homeland Security
- Department of Housing and Urban Development
- Department of the Interior
- Department of Justice
- Department of Labor
- Department of State
- Department of Transportation
- Department of the Treasury
- Department of Veterans Affairs
- Environmental Protection Agency
- National Aeronautics and Space Administration
- Agency for International Development
- General Services Administration
- National Science Foundation
- Nuclear Regulatory Commission

[1]The 23 agencies are those identified in the Chief Financial Officers Act of 1990 (CFO Act), Pub. L. No. 101-576, 104 Stat. 2838 (1990), as amended, codified at 31 U.S.C. § 901(b), which are generally the largest federal agencies. Although the Department of Defense is a CFO Act agency under 31 U.S.C. § 901(b)(1)(C), it is not a civilian agency, and, therefore, outside the scope of this review.

- Office of Personnel Management
- Small Business Administration
- Social Security Administration

We emailed the survey to each of the 23 civilian CFO Act agencies from September 2023 and closed the survey in November 2023.[2] We sent the survey to points of contact identified during initial meetings with each agency and instructed them to provide responses for all their components, bureaus, and offices in a consolidated response. We received responses from all 23 agencies.

To develop the survey questions, we used information from prior GAO reports; relevant literature; interviews with agency officials, industry, and other groups; and site visits. We conducted site visits to inform our understanding of the technologies. We visited federal sites including the Department of Transportation's Turner-Fairbank Highway Research Center, the National Aeronautics and Space Administration's Goddard Space Flight Center, and the Department of Energy's National Renewable Energy Laboratory. We also visited the Maryland Blended Reality Center. At these locations, we interviewed officials about their uses and experiences with immersive technologies and observed demonstrations of their systems. We also met with an industry organization, the XR Association, and attended the 2023 XR Symposium at Johns Hopkins University's Applied Physics Laboratory

To ensure that agencies had a common understanding of immersive technology terminology, we identified and defined a set of common concepts for agencies to use when answering survey questions and describing their activities, including definitions for immersive technologies, types of immersive technologies, purposes, benefits, and challenges. To develop these definitions, we analyzed interviews with agencies and industry, prior GAO reports, reports identified by agency and industry officials, and other background documentation. We defined immersive technologies as any technology that integrates the physical environment with digital content to support user engagement. In the survey, we included a glossary of these terms and instructed agencies to refer to it when responding to the survey.[3] Further, we identified and defined five types of immersive technologies: (1) Augmented reality (AR), (2) mixed reality (MR), (3) virtual reality (VR), (4) simulator; and (5) immersive room.

We determined that immersive technologies could be used for a variety of purposes, such as training individuals to operate equipment or displaying complex information. We grouped these uses into nine purposes: (1) Workforce training, (2) data visualization and analysis, (3) human factors research, (4) public outreach, (5) remote collaboration, (6) design and planning, (7) medical assessment or treatment, (8) real-time assistance, guidance, or inspection, and (9) other purposes not already listed.

We identified and defined 13 benefits associated with the use or adoption of immersive technologies: (1) Better understanding of data; (2) increased user engagement and learning retention; (3) decision-making error reduction and efficiency improvement; (4) cost savings; (5) time savings; (6) increased safety; (7) scalability;

[2]These dates cover the submission of surveys from all 23 civilian agencies. They do not include updated or additional responses received because of follow-up activities.

[3]Several of the survey's multiple-choice questions included an "other" option. Agencies selecting "other" were asked to provide more details on their answer in writing.

(8) reconfigurability; (9) portability; (10) interoperability; (11) modularity; (12) easier access to information; and (13) strategic or competitive advantage.

Finally, we identified and defined 16 challenges associated with the use or adoption of immersive technologies: (1) Acquisition costs; (2) high cost to operate or maintain; (3) rapid technology development; (4) limited acquisition options; (5) limited standards or lack of common definition across industry or federal government; (6) technology may not meet the agency's needs; (7) dependency on enabling technologies; (8) ensuring federal cybersecurity and privacy requirements are met; (9) limited number of workers with necessary skills; (10) user acceptance of immersive technology; (11) motion sickness; (12) fall risk, injury, or body sensory experience; (13) access for users with limited resources; (14) access for users with disabilities; (15) limited understanding of which immersive technologies to use or how to use them; and (16) how data are collected, stored, or transmitted.

In the survey, we asked agencies to report any current (FY 2022–2023) and planned (FY 2024–2028) activities involving immersive technologies, including (1) the agency's use of immersive technologies; (2) the agency's research and development (R&D) activities involving immersive technologies; and (3) the agency's activities with nonfederal entities involving immersive technologies, such as entering into transactions with nonfederal entities[4] and regulatory functions involving nonfederal entities.[5]

We asked agencies that reported current or planned activities to answer additional questions about the type(s) of immersive technologies involved in these activities and the nature of these activities. For example, agencies that reported using immersive technologies were asked to select which technologies they used, for what purposes they used them, how often they used them, and to provide written descriptions of each purpose, among other questions. We asked agencies to identify any obligations and expenditures related to their activities with immersive technologies. We also asked agencies to identify the benefits, challenges, and barriers they faced in adopting or using immersive technology.

We asked agencies several background questions related to their overall approach to immersive technologies, such as how they defined immersive technology, whether they had established internal policies, strategic plans, or working groups related to immersive technology, and how, if at all, the agency connected immersive technology to a network or the internet. Finally, we asked if agencies conducted activities with immersive technologies that they did not identify in the survey because they were classified, but no agencies reported such activities.

[4]By "entered into transactions with nonfederal entities" we mean that the agency awarded grants, entered into contracts, leases, or cooperative agreements, provided direct loans or loan guarantees, or entered into any other transactions using any other transactional authority that would enable nonfederal entities to develop, purchase, or use immersive technologies for their own uses. We only asked agencies about this type of activity for current (FY 2022–23) use.

[5]In our survey we asked agencies if they engaged in or planned to engage in any "regulatory functions" over nonfederal entities. For the purposes of this survey, we explained that "regulatory functions" includes, but is not limited to, investigatory and inspection activities, taking enforcement actions, prescribing requirements or guidance, conducting oversight, and maintaining performance standards. We also explained that for the purposes of this survey, nonfederal entities include state, local or tribal governments or agencies, or private companies—for example, technology companies, universities, police departments, banks, or airports.

To answer questions regarding the benefits and challenges they faced in adopting or using immersive technology, and to report the likelihood of performing certain activities with immersive technology in the future, we asked agencies to select their answers from a five-point Likert scale:

Benefit, Likelihood, and Challenge Values

Extremely	Very	Moderately	Slightly or Somewhat	Not at All
4	3	2	1	0

For certain benefits and challenges questions, if an agency had multiple components or offices contributing responses to the survey, to provide a consolidated response for the agency, it was instructed to generate an average value across all responding offices. See appendix III for all survey questions and terms used in the survey.

After determining the areas of inquiry and terms used in the survey, we conducted pretests with three agencies—the Departments of Commerce, Transportation, and Veterans Affairs—to ensure that our survey questions were complete, understandable, and elicited the types of responses needed to answer our reporting objectives. We chose these agencies because they represented a range of immersive technology types used and different levels of adoption of immersive technology, according to information provided by officials during initial interviews. We focused our pretests on the subjects and questions in the survey that were most relevant to each agency. For example, Department of Commerce officials told us in an initial meeting that it uses immersive technology for R&D, so we focused that pretest on the survey's R&D questions. We revised our survey based on the results of these pretests.

Once the survey design process was completed, we administered the survey by email to the 23 civilian CFO Act agencies via the agency liaisons, or their designees, for an agency-level response. To do this, we asked the liaisons to disseminate the survey to relevant officials at the agency that had knowledge about immersive technology, such as subject matter experts, at the sub-agency, component, bureau, or office levels. We provided additional instructions to the liaisons in writing and in the survey itself. We instructed each agency that responses to 14 of the survey's 36 questions were required. We asked the liaisons to consolidate all responses from sub-agencies, components, bureaus, or offices into a single survey for the agency.[6] We also followed up with the agency liaisons by email and phone, when appropriate, to ensure that the agency received the questionnaire and to answer any questions they had.

After each agency submitted its completed survey, we reviewed the survey for completeness, inconsistencies, or logical errors. We asked agencies to resubmit or clarify responses if necessary. In some cases, we updated the agency's completed survey or moved its response to a question—for example, if an agency answered a question in section that clearly applied to another section, we moved the response. In these cases, we documented the actions we took and the reasons.

[6]The Department of Justice and the Department of Health and Human Services did not provide consolidated responses to the survey. For both agencies, we consolidated the component responses into a single agency-level survey response in alignment with the survey instructions sent to each agency and used these consolidated surveys in our analysis.

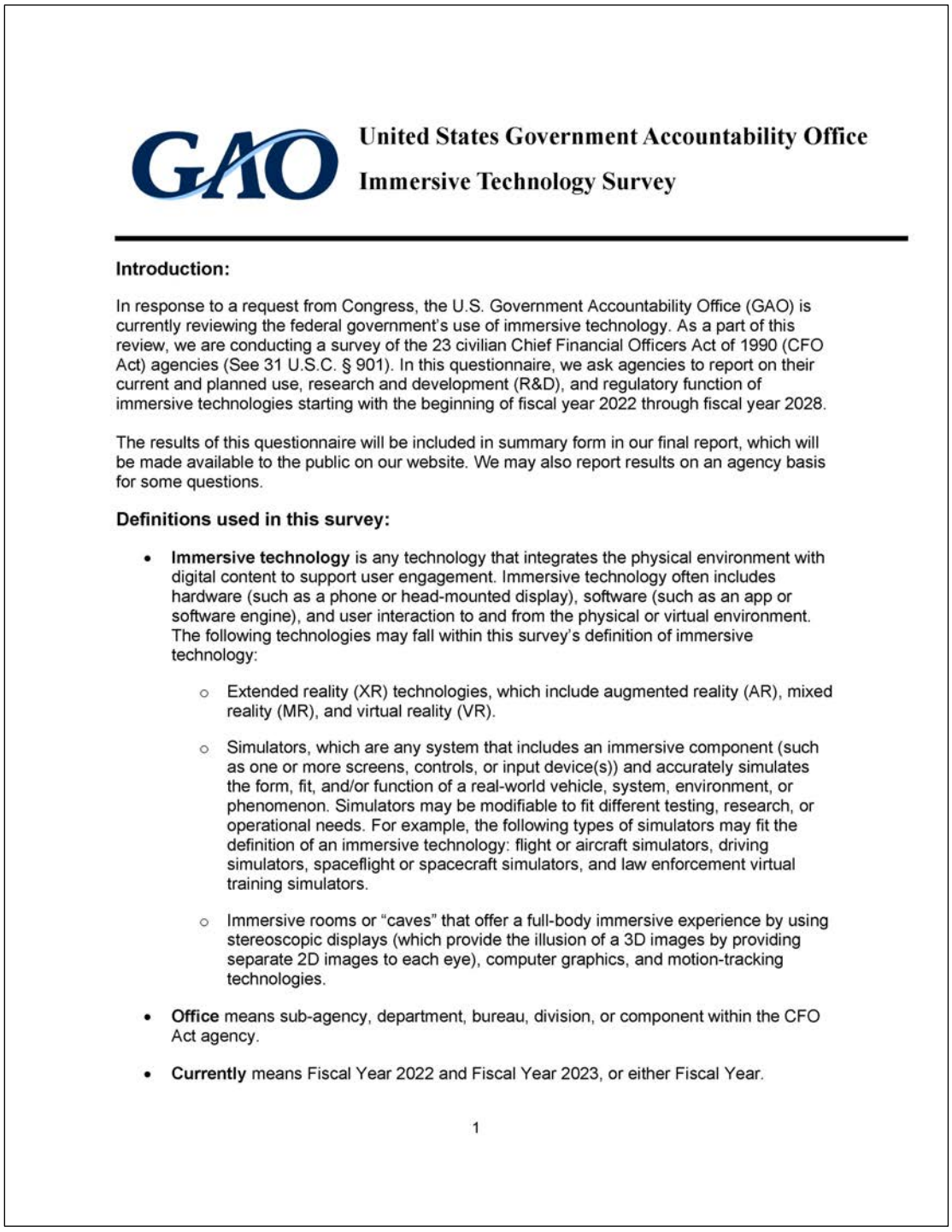
Because we surveyed and obtained responses from all 23 civilian agencies in the population defined by our scope, the summary results describing this group are not subject to errors from sampling and nonresponse. However, the practical difficulties of conducting any survey may introduce other errors, such as:

- Difficulties in how particular questions or terms are interpreted by respondents. To mitigate differences in interpretation, we instructed agencies to use the common definitions listed by GAO in the survey's instructions and glossary of terms when considering their response. Nonetheless, different interpretations of some definitions still occurred. In cases where it appeared that agencies might have interpreted a question or term differently than was intended, we followed up with the agencies to clarify their answer(s).
- Sources of information that are available to respondents differ across agencies. For example, while some agencies provided specific obligation amounts for immersive technologies, other agencies were unable to specify specific obligation amounts related to immersive technologies. For some questions, agencies specifically selected "not sure" as an option instead of a definitive "yes" or "no." Further, we relied on agency liaisons to distribute the surveys and collect answers from relevant sub-agencies, components, bureaus, and offices across the agency. To help ensure all relevant stakeholders contributed to the survey, we instructed liaisons to distribute the survey to the necessary personnel—for example, subject matter experts—within the agency. In cases where agencies did not provide an answer, selected "not sure" as an answer, or provided seemingly incomplete information, we made a note of this and followed up with the agency as appropriate to ensure that the agency-level responses were comprehensive.
- Agencies provided varied levels of detail in their responses. While we requested that agencies include complete information in their survey responses, some agencies provided more details than others. For example, some agencies provided single-sentence descriptions of R&D activities, while other agencies provided full paragraphs. Further, because not all questions on the survey were required, some agencies answered questions and provided information that other agencies did not. For example, one optional question asked agencies to estimate the number of workers it trained using immersive technology. While some agencies answered this question, others did not, and we were therefore not able to report on this question for some agencies. In cases where agencies provided relatively little information or did not answer an optional question, we followed up with the agency as appropriate to ensure we could report specific information.

We took steps in the development and administration of the survey to minimize these potential errors and to help ensure the accuracy of the answers obtained, such as pretesting, data collection, and data analysis, including follow up interviews and information requests as noted above. After we consolidated responses for the Departments of Health and Human Services and Justice—separately for each agency—we took quality control steps to ensure that the consolidated responses were accurate and complete. Based on these quality assurance and control actions we determined that, for the purposes of this report, the information provided is an accurate and valid representation of the extent of immersive technology use across the 23 civilian CFO Act agencies.

We conducted this performance audit from February 2023 to August 2024 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix III: Copy of GAO's Survey Instrument



United States Government Accountability Office

Immersive Technology Survey

Introduction:

In response to a request from Congress, the U.S. Government Accountability Office (GAO) is currently reviewing the federal government's use of immersive technology. As a part of this review, we are conducting a survey of the 23 civilian Chief Financial Officers Act of 1990 (CFO Act) agencies (See 31 U.S.C. § 901). In this questionnaire, we ask agencies to report on their current and planned use, research and development (R&D), and regulatory function of immersive technologies starting with the beginning of fiscal year 2022 through fiscal year 2028.

The results of this questionnaire will be included in summary form in our final report, which will be made available to the public on our website. We may also report results on an agency basis for some questions.

Definitions used in this survey:

- **Immersive technology** is any technology that integrates the physical environment with digital content to support user engagement. Immersive technology often includes hardware (such as a phone or head-mounted display), software (such as an app or software engine), and user interaction to and from the physical or virtual environment. The following technologies may fall within this survey's definition of immersive technology:
    - Extended reality (XR) technologies, which include augmented reality (AR), mixed reality (MR), and virtual reality (VR).
    - Simulators, which are any system that includes an immersive component (such as one or more screens, controls, or input device(s)) and accurately simulates the form, fit, and/or function of a real-world vehicle, system, environment, or phenomenon. Simulators may be modifiable to fit different testing, research, or operational needs. For example, the following types of simulators may fit the definition of an immersive technology: flight or aircraft simulators, driving simulators, spaceflight or spacecraft simulators, and law enforcement virtual training simulators.
    - Immersive rooms or "caves" that offer a full-body immersive experience by using stereoscopic displays (which provide the illusion of a 3D images by providing separate 2D images to each eye), computer graphics, and motion-tracking technologies.
- **Office** means sub-agency, department, bureau, division, or component within the CFO Act agency.
- **Currently** means Fiscal Year 2022 and Fiscal Year 2023, or either Fiscal Year.

1

- **Planned** and/or **future** means Fiscal Years 2024 through 2028.
- **Use** means your agency:

  (1) owned and/or operated immersive technologies for internal agency purposes,

  (2) accessed another federal or non-federal entity's (including local government or private company) immersive technologies under an agreement or arrangement as part of an agency program or activity, or

  (3) tested immersive technologies as part of a pilot, proof of concept, trial, or evaluation for potential agency use.

Additional definitions can be found in the glossary at the end of the survey.

Completing and Returning the Questionnaire:

Please complete this questionnaire within two weeks of receipt. In testing the questionnaire, we found that it took about 60 to 90 minutes to complete. We appreciate your time and effort in completing this questionnaire.

The agency liaison or designated point of contact should distribute the survey to the necessary personnel—for example, subject matter experts—within your agency to complete.

The agency's liaison or designated point of contact should consolidate responses so that they represent the entire agency's response.

If any information or responses are considered Sensitive but Unclassified (SBU), Controlled Unclassified Information (CUI), or law enforcement sensitive, please advise GAO so that we may discuss how to receive the survey responses in a secure manner. When responding, please indicate which responses are considered SBU, CUI, or law enforcement sensitive, as applicable.

By law, GAO is required to protect such information with a level of protection at least equal to the level of protection afforded the same information by the source agency. 31 U.S.C.§ 716(e).

Your agency should only submit one copy of the questionnaire.

Every agency should answer, at minimum, the questions highlighted in [Blue], which are Questions 1, 2, 11, 15, 17, 20, 26, 29 - 34, and 36.

When you have completed the consolidation of the questionnaire, attach it to an email and send to ImmersiveTech_Survey@gao.gov.

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1. Does your agency have a common, working, or formal definition of immersive technology?

   ☐ Yes

☐ No → If No, please skip to question 2.

☐ Not Sure

1a. What is your agency's definition of immersive technology?

To help ensure we receive consistent responses across agencies and departments, when answering the questions in this survey, please use the definition on page 1 of this questionnaire.

2. Does your agency currently (FY22 and/or FY23) use immersive technologies?

Please refer to the definition for "use" on page 1.

☐ Yes

☐ No → If No, please skip to question 11.

☐ Not Sure

3. Does your agency currently use any of the following immersive technologies?

Definitions of the following terms can be found under "technology" in the glossary at the end of the survey.

	Yes	No	Not sure
Virtual Reality	☐	☐	☐
Augmented Reality	☐	☐	☐
Mixed Reality	☐	☐	☐
Simulator	☐	☐	☐
Immersive room or "cave"	☐	☐	☐
Other *(please specify in space below)*	☐	☐	☐

3a. If you agency said "Yes" to Simulator in question 3, does your agency use simulator(s) with any of the following characteristics:

Please answer for all of your agency's simulators.

3

	Yes	No	Not sure
a flat screen (*for example, a computer or projector screen*)	☐	☐	☐
one or more screens or displays that provide a wider field of view than a flat screen (*for example, a semi-circle of screens surrounding the user*)	☐	☐	☐
Immersive environment with multiple input devices *(for example, a flight simulator with a cockpit)*	☐	☐	☐
Virtual Reality (VR) or Augmented Reality (AR) headset or head mounted display	☐	☐	☐
Other *(please specify in space below)*	☐	☐	☐

3b. If your agency used immersive technologies, how often does your agency use any of the following?

If your agency uses any of the technologies with different frequencies of use, please report the highest frequency of use.

Definitions of the following terms can be found in the glossary under "technology" at the end of the survey.

	At least once a week	Less than once a week but at least once a month	Less than once a month but at least once a year	Less than once a year	Other frequency – please describe	Not Applicable
Virtual Reality	☐	☐	☐	☐		☐
Augmented Reality	☐	☐	☐	☐		☐
Mixed Reality	☐	☐	☐	☐		☐
Simulator	☐	☐	☐	☐		☐
Immersive room or "cave"	☐	☐	☐	☐		☐
Other *(please specify in space below)*	☐	☐	☐	☐		☐

3b(i). Has your agency's frequency of use of immersive technology changed since its adoption?

4

☐ No

☐ Yes → Please explain how and why.

4. Does your agency currently use immersive technology for any of the following purposes (excluding R&D)?

Definitions of the following terms can be found under "purposes" in the glossary at the end of the survey.

	Yes	No	Not sure
Workforce training	☐	☐	☐
Data visualization/analysis	☐	☐	☐
Public outreach (*for example, public education campaigns or stakeholder engagement*)	☐	☐	☐
Remote collaboration	☐	☐	☐
Design and planning	☐	☐	☐
Medical assessment and/or treatment	☐	☐	☐
Real-time assistance, guidance, and/or inspection	☐	☐	☐
Other purpose(s) *(please specify in space below)*	☐	☐	☐

4a. For each purpose listed below, describe how your agency uses immersive technology. Please include the system name and description for each under the applicable purpose. *Please write out all acronyms.*

If your agency uses an immersive technology system for more than one purpose, please indicate this by including the system name under each applicable purpose.

Workforce training

Data visualization/analysis

5

Public outreach

Remote collaboration

Design and planning

Medical assessment and/or treatment

Real-time assistance, guidance, and/or inspection

Other purpose(s)

4b. If your agency uses immersive technology for workforce training, please provide the approximate number of federal employees that have been trained in FY22 and/or FY23.

6

5. Since adopting immersive technology, how beneficial, if at all, have the following been to your agency?

Definitions of the following terms can be found in the glossary under "benefits" at the end of the survey.

	Extremely beneficial	Very beneficial	Moderately beneficial	Slightly beneficial	Not at all beneficial	Not Applicable
Better understanding of data	☐	☐	☐	☐	☐	☐
Increased user engagement and learning retention	☐	☐	☐	☐	☐	☐
Decision making error reduction and efficiency improvement	☐	☐	☐	☐	☐	☐
Cost savings	☐	☐	☐	☐	☐	☐
Time savings	☐	☐	☐	☐	☐	☐
Increased safety	☐	☐	☐	☐	☐	☐
Scalability	☐	☐	☐	☐	☐	☐
Reconfigurability	☐	☐	☐	☐	☐	☐
Portability	☐	☐	☐	☐	☐	☐
Interoperability	☐	☐	☐	☐	☐	☐
Modularity	☐	☐	☐	☐	☐	☐
Easier access to information	☐	☐	☐	☐	☐	☐
Strategic and/or competitive advantage	☐	☐	☐	☐	☐	☐
Other(s) *(please specify in space below)*	☐	☐	☐	☐	☐	☐

6. How challenging, if at all, have the following been to your agency's adoption of immersive technology?

Definitions of the following terms can be found in the glossary under "challenges" at the end of the survey.

7

	Extremely Challenging	Very Challenging	Moderately Challenging	Slightly Challenging	Not at all Challenging	Not Applicable
Acquisition costs	☐	☐	☐	☐	☐	☐
Rapid technology development	☐	☐	☐	☐	☐	☐
Limited acquisition options	☐	☐	☐	☐	☐	☐
Limited standards and/or lack of common definition across industry and/or federal government	☐	☐	☐	☐	☐	☐
Technology may not meet the agency's needs	☐	☐	☐	☐	☐	☐
Dependency on enabling technologies (e.g., 5G and or Artificial Intelligence)	☐	☐	☐	☐	☐	☐
Ensuring federal cybersecurity and privacy requirements are met	☐	☐	☐	☐	☐	☐
Limited number of workers with necessary immersive technology skills	☐	☐	☐	☐	☐	☐
User acceptance of immersive technology	☐	☐	☐	☐	☐	☐

7. How challenging, if at all, have the following been to your agency's use of immersive technology?

   Definitions of the following terms can be found in the glossary under "challenges" at the end of the survey.

	Extremely Challenging	Very Challenging	Moderately Challenging	Slightly Challenging	Not at all Challenging	Not applicable
Motion sickness	☐	☐	☐	☐	☐	☐

8

	Extremely Challenging	Very Challenging	Moderately Challenging	Slightly Challenging	Not at all Challenging	Not applicable
Fall risk, injury, and/or body sensory experience	☐	☐	☐	☐	☐	☐
High cost to operate or maintain	☐	☐	☐	☐	☐	☐
Access for users with limited resources *(for example, those with limited or no broadband internet service)*	☐	☐	☐	☐	☐	☐
Access for users with disabilities (*for example, those with vision impairment*)	☐	☐	☐	☐	☐	☐
Limited understanding of how to use immersive technologies	☐	☐	☐	☐	☐	☐
How data are collected, stored, and/or transmitted	☐	☐	☐	☐	☐	☐
Ensuring federal cybersecurity and privacy requirements are met	☐	☐	☐	☐	☐	☐
User acceptance of immersive technology	☐	☐	☐	☐	☐	☐

8. How does your agency acquire immersive technology software and/or hardware?

	Yes	No	Not sure
Developed by the agency *(technology and/or software developed or produced mostly or entirely by federal employees.)*	☐	☐	☐
Acquired by a third party/contractor	☐	☐	☐

9

	Yes	No	Not sure
Co-developed by the agency and a third party contractor	☐	☐	☐
Other *(please specify in space below)*	☐	☐	☐

8a. If your agency develops software or hardware, please provide a brief description of the hardware and/or software developed by your agency. *Please write out all acronyms.*

8b. If your agency acquires immersive technology from a third party contractor or through co-development, please provide the contractor name, approximate dollar value, date, and a brief description.

9. How, if at all, does your agency connect immersive technology to a network or the Internet?

	Yes	No	Not sure
Connected to agency network	☐	☐	☐
Connected to external (nongovernmental) network	☐	☐	☐
Non-networked, siloed, or standalone	☐	☐	☐
Other *(please specify in space below)*	☐	☐	☐

10. During fiscal years 2022 and/or 2023, did your agency use immersive technologies that are not identified in your answers above because the details regarding its use are Sensitive but Unclassified (SBU), Controlled Unclassified Information (CUI), law enforcement sensitive, or classified?

☐ Yes

☐ No

☐ Not Sure

10

11. Does your agency currently (during FY22 and/or FY23) conduct or fund R&D involving immersive technology?

The questions below are based on the OMB Circular No. A-11 (2022) R&D definitions.

☐ Yes

☐ No → If No, please skip to question 15

☐ Not Sure → If Not sure, please skip to question 15

The R&D terms below are defined in OMB Circular No. A-11 (2022):

- ***Basic research*** *means experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts.*
- ***Applied research*** *is directed primarily towards a specific practical aim or objective.*
- ***Experimental development*** *involves creative and systematic work, drawing on knowledge gained from research and practical experience, which is directed at producing new products or processes or improving existing products or processes.)*

12. Does your agency conduct R&D in any of the following ways?

	Yes	No	Not sure
Internal: conducts in-house R&D	☐	☐	☐
External: enters into a contract under which an outside entity conducts R&D	☐	☐	☐
External: awards a grant under which an outside entity conducts R&D	☐	☐	☐
Other *(please specify in space below)*	☐	☐	☐

If your agency selected "Yes" to either or both External R&D items in question 12, please answer question 13, otherwise skip to question 14.

13. Does your agency currently (FY22 and/or FY23) provide funding to non-federal entities to conduct R&D involving immersive technologies?

☐ Not sure

☐ No

11

☐ Yes → If Yes, what kinds of entities receive funding?

	Yes	No	Not sure
Universities	☐	☐	☐
Private research institutions (including, but not limited to federally funded research and development centers (FFRDCs))	☐	☐	☐
Private companies (excluding private research institutions)	☐	☐	☐
Government entities (including state and/or local entities)	☐	☐	☐
Other *(please specify in space below)*	☐	☐	☐

14. Does your agency conduct R&D internally and/or enter into a contract, grant, or other agreement under which an outside entity conducts R&D involving immersive technology for any of the following purposes?

	Yes	No	Not sure
Basic research	☐	☐	☐
Applied research	☐	☐	☐
Experimental development	☐	☐	☐
Other *(please describe in space below)*	☐	☐	☐

If your agency selected "No" or "Not sure" for all items in question 14, please skip to question 15.

14a. For which of the following purposes does your agency conduct R&D involving immersive technology?

Definitions of the following terms can be found under "purposes" in the glossary at the end of the survey.

	Yes	No	Not sure
Workforce training	☐	☐	☐

12

	Yes	No	Not sure
Data visualization/analysis	☐	☐	☐
Human factors research	☐	☐	☐
Public outreach	☐	☐	☐
Remote collaboration	☐	☐	☐
Design and planning	☐	☐	☐
Medical assessment and/or treatment	☐	☐	☐
Real-time assistance and/or guidance	☐	☐	☐
Other purpose(s) *(please specify in space below)*	☐	☐	☐

14b. Please describe recent examples of funded R&D. Include the R&D title, purpose, and description. *Please write out all acronyms.*

15. At any time during Fiscal Years 2022 or 2023, did your agency engage in any regulatory functions over non-federal entities that use immersive technologies?

"Regulatory functions" includes, but is not limited to, investigatory and inspections activities, taking enforcement actions, prescribing requirements or guidance, conducting oversight, and maintaining performance standards. Non-federal entities (defined under general definition in the glossary) could include police departments, banks, or airports.

☐ Yes

☐ No → If No, please skip to question 17.

☐ Not sure

16. Does your agency oversee the use of immersive technology for any of the following purposes?

Definitions of the following terms can be found under "purposes" in the glossary at the end of the survey

	Yes	No	Not sure
Workforce training	☐	☐	☐

13

	Yes	No	Not sure
Data visualization/analysis	☐	☐	☐
Human factors research	☐	☐	☐
Public outreach	☐	☐	☐
Remote collaboration	☐	☐	☐
Design and planning	☐	☐	☐
Medical assessment and/or treatment	☐	☐	☐
Real-time assistance and/or guidance	☐	☐	☐
Other purpose(s) *(please specify in space below)*	☐	☐	☐

16a. For each purpose you answered "Yes" to in question 16, please list the program name, its purpose and short description. *Please write out all acronyms.*

17. Did your agency award grants, enter into contracts, leases, or cooperative agreements, provide direct loans or loan guarantees, or enter into any other transactions using any other transactional authority that would enable non-federal entities to develop, purchase, or use immersive technologies for their own uses?

☐ Yes

☐ No → If No, please skip to question 20.

☐ Not Sure → If Not sure, please skip to question 20.

17a. What kind of financial awards or assistance (as described above) did your agency provide or enter into in fiscal years 2022 or 2023 (e.g. grants, contracts, loans, etc.)?

18. Does your agency fund private entities or other government entities for the use of immersive technology?

14

	Yes	No	Not sure
Colleges and universities	☐	☐	☐
Private entities	☐	☐	☐
Other government entities (including other federal agencies, state entities, and/or local entities)	☐	☐	☐
Other *(please specify in the space below)*	☐	☐	☐

19. Does your agency fund the use of immersive technology for any of the following purposes?

Definitions of the following terms can be found under "purposes" in the glossary at the end of the survey.

	Yes	No	Not sure
Workforce training	☐	☐	☐
Data visualization/analysis	☐	☐	☐
Human factors research	☐	☐	☐
Public outreach	☐	☐	☐
Remote collaboration	☐	☐	☐
Design and planning	☐	☐	☐
Medical assessment and/or treatment	☐	☐	☐
Real-time assistance and/or guidance	☐	☐	☐
Other purpose(s) *(please specify in space below)*	☐	☐	☐

19a. For each purpose selected, please provide the program name, purpose, and a description. *Please write out all acronyms.*

19b. Please provide the approximate funding amount for FY22 and/or FY23.

15

20. How likely is it that your agency will adopt or expand the use (excluding R&D) of immersive technology in the next 5 fiscal years (FY 2024 – FY 2028)?

- ☐ Extremely likely
- ☐ Very likely
- ☐ Moderately likely
- ☐ Somewhat likely
- ☐ Not at all likely → If No, answer question 20a.
- ☐ Not sure → If Not sure, answer question 20a.

If your agency answered "Extremely likely", "Very likely", "Moderately likely" or "Somewhat likely" to question 20, please skip to question 21.

20a. How important, if at all, were each of the following to your agency's decision to not use immersive technology in the next 5 fiscal years?

Definitions of the following terms can be found under "challenges" in the glossary at the end of the survey.

	Extremely important	Very important	Moderately important	Slightly important	Not at all important	Not applicable
Acquisition costs	☐	☐	☐	☐	☐	☐
Rapid technology development	☐	☐	☐	☐	☐	☐
Limited acquisition options	☐	☐	☐	☐	☐	☐
Limited standards and/or lack of common definition across industry and/or federal government	☐	☐	☐	☐	☐	☐
Technology may not meet the agency's needs	☐	☐	☐	☐	☐	☐
Dependency on enabling technologies (e.g., 5G and/or Artificial Intelligence)	☐	☐	☐	☐	☐	☐

16

	Extremely important	Very important	Moderately important	Slightly important	Not at all important	Not applicable
Ensuring federal cybersecurity and privacy requirements are met	☐	☐	☐	☐	☐	☐
Limited number of workers with necessary immersive technology skills	☐	☐	☐	☐	☐	☐
User acceptance of immersive technology	☐	☐	☐	☐	☐	☐

If your agency answered "Not at all likely" or "Not sure" to question 20, please skip to question 26.

21. Does your agency plan to adopt or expand the use immersive technology for any of the following purposes in the next 5 fiscal years (FY 2024 – FY 2028)?

Definitions of the following terms can be found under "purposes" in the glossary at the end of the survey.

	Yes	No	Not sure
Workforce training	☐	☐	☐
Data visualization/analysis	☐	☐	☐
Human factors research	☐	☐	☐
Public outreach	☐	☐	☐
Remote collaboration	☐	☐	☐
Design and planning	☐	☐	☐
Medical assessment and/or treatment	☐	☐	☐
Real-time assistance and/or guidance	☐	☐	☐
Other purpose(s) *(please specify in space below)*	☐	☐	☐

Please answer 21a ONLY if your agency plans use immersive technologies for new purposes.

17

21a. Please describe each new planned use, including the program name, purpose, and a description as applicable. *Please write out all acronyms.*

22. Does your agency plan to adopt or expand the use any of the following immersive technologies in the next 5 fiscal years (FY 2024 – FY 2028)?

Definitions of the following terms can be found under "technology" in the glossary at the end of the survey.

	Yes	No	Not sure
Virtual Reality	☐	☐	☐
Augmented Reality	☐	☐	☐
Mixed Reality	☐	☐	☐
Simulator	☐	☐	☐
Immersive room or "cave"	☐	☐	☐
Other *(Please describe in the space below)*	☐	☐	☐

If your agency said "Yes" to Simulator in question 22, please answer question 22a, otherwise skip to question 23.

22a. If your agency plans to adopt or expand the use of a simulator, does the simulator have any of the following characteristics?

	Yes	No	Not sure
a flat screen	☐	☐	☐
one or more screens or displays that provide a wider field of view than a flat screen (*for example, a semi-circle of screens surrounding the user*)	☐	☐	☐
Immersive environment with multiple input devices *(for example, a flight simulator with a cockpit)*	☐	☐	☐
Virtual Reality (VR) or Augmented Reality (AR) headset or head mounted display	☐	☐	☐
Other (*Please describe in the space below)*	☐	☐	☐

18

	Yes	No	Not sure

23. Does your budget include funding for future uses of immersive technology?

☐ Yes → Please enter the approximate amount for the program, project, or activity (as applicable).

☐ No

☐ Not sure

24. Please select your agency's top three benefits to adopting/expanding the use of immersive technology in the next 5 fiscal years (FY 2024 – FY 2028). *(Please only select 3 items)*

Definitions of the following terms can be found under "benefits" in the glossary at the end of the survey.

Better understanding of data	☐
Increased user engagement and learning retention	☐
Decision-making error reduction and efficiency improvement	☐
Cost savings	☐
Time savings	☐
Increased safety	☐
Software features: scalability, reconfigurability, and/or modularity	☐
Hardware features: portability and/or interoperability	☐
Easier access to information	☐
Strategic and/or competitive advantage	☐

25. Please select your agency's top three challenges to adopting/expanding the use of immersive technology in the next 5 fiscal years (FY 2024 – FY 2028). *(Please only select 3 items)*

Definitions of the following terms can be found under "challenges" in the glossary at the end of the survey.

19

Motion sickness	☐
Fall risk, injury, and/or body sensory experience	☐
High cost to acquire and operate or maintain	☐
Rapid technology development	☐
Limited acquisition options	☐
Limited standards and lack of common definition across industry and/or the federal government	☐
Access for users with limited resources *(for example, those with limited or no broadband service)*	☐
Access for users with disabilities *(for example those with vision impairment)*	☐
Limited understanding of which immersive technologies to use or how to use them	☐
Technology may not meet the agency's needs	☐
Dependency on enabling technologies (e.g., artificial intelligence and 5G) which may not be mature	☐
How data are collected, stored, and/or transmitted	☐
Ensuring federal cybersecurity and privacy requirements are met	☐
Limited number of workers with necessary immersive technology skills	☐
User acceptance of immersive technology	☐

26. Does your agency plan to conduct or fund R&D involving immersive technology in the next 5 fiscal years (FY 2024 – FY 2028)?

☐ Yes

☐ No → If No, please skip to question 31.

☐ Not sure → If Not sure, please skip to question 31.

27. Does your agency plan to conduct or continue R&D in any of the following ways in the next 5 years (FY24 – FY28)?

20

	Yes	No	Not sure
Internal: conducts in-house R&D	☐	☐	☐
External: enters into a contract under which an outside entity conducts R&D	☐	☐	☐
External: awards a grant under which an outside entity conducts R&D	☐	☐	☐
Other (*Please describe in the space below)*	☐	☐	☐

28. Does your agency plan to conduct R&D internally and/or enter into a contract, grant, or other agreement under which an outside entity conducts R&D involving immersive technology for any of the following purposes in the next 5 years (FY24 – FY28)?

	Yes	No	Not sure
Basic research	☐	☐	☐
Applied research	☐	☐	☐
Experimental development	☐	☐	☐
Other (*Please describe in the space below)*	☐	☐	☐

If your agency selected "No" or "Not sure" for all items in question 28, please skip to question 29.

28a. Does the agency plan to conduct R&D internally and/or enter into a contract, grant, or other agreement under which an outside entity conducts R&D involving immersive technology for any of the following purposes in the next 5 years?

Definitions of the following terms can be found under "purposes" in the glossary at the end of the survey.

	Yes	No	Not sure
Workforce training	☐	☐	☐
Data visualization/analysis	☐	☐	☐
Human factors research	☐	☐	☐
Public outreach	☐	☐	☐

21

	Yes	No	Not sure
Remote collaboration	☐	☐	☐
Design and planning	☐	☐	☐
Medical assessment and/or treatment	☐	☐	☐
Real-time assistance, guidance, and/or inspection	☐	☐	☐
Other purpose(s) (*please specify in space below)*	☐	☐	☐

Please only answer 28b if these efforts are planned R&D, not expansions of current projects.

28b. Please describe examples of planned R&D. Include the R&D title, purpose, and description. *Please write out all acronyms.*

29. Can your agency provide funding information for immersive technologies?

☐ Yes

☐ No → If No, please skip to question 30

☐ Not sure → If Not sure, please skip to question 30

☐ Not applicable → If Not applicable, please skip to question 30

29a. Approximately, how much funding for the program, project or activity (as applicable) for the use (not including R&D) of immersive technology has the agency obligated in FY 22 and FY 23 (as applicable)?

29b. Approximately, how much funding for program, project or activity (as applicable) for R&D involving immersive technology has the agency obligated in FY 22 and FY 23 (as applicable)?

29c. Please provide any comments about your answers, as applicable.

22

30. Does your agency plan to engage in any regulatory functions over non-federal entities that use immersive technologies in the next 5 fiscal years (FY 2024 – FY 2028)?

- ☐ Yes
- ☐ No
- ☐ Not sure

31. Does your agency have a strategic plan that includes the use of immersive technology?

- ☐ Yes
- ☐ No
- ☐ Not sure

32. Does your agency have internal guidance related to the use of immersive technology?

- ☐ Yes
- ☐ No
- ☐ Not sure

33. Are there possible use cases for immersive technology that are not in current use or planned for future use?

- ☐ No
- ☐ Not sure
- ☐ Yes → If Yes, please describe.

34. Does your agency have organizational support, such as a community of interest or interagency working group, on the use of immersive technology?

- ☐ No
- ☐ Not sure
- ☐ Yes → If Yes, please describe.

23

35. Do you have any additional explanations of your answers or comments on any of the topics in this questionnaire?

☐ No

☐ Not sure

☐ Yes → If Yes, please include your explanations/comments in the space below.

36. Please list a point of contact. Include their name, title, Office, email address, and phone number below. *Please write out all acronyms.*

Note: GAO will use this information to follow up with agencies, as needed. Contact information will not be included in the final report.

Name:

Title:

Office:

Email address:

Phone number:

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Glossary

General Definitions

For the purposes of this survey, **regulatory functions** includes, but is not limited to, investigatory and inspections activities, taking enforcement actions, prescribing requirements or guidance, conducting oversight, and maintaining performance standards.

In this survey, **non-federal entities** includes state, local or tribal governments or agencies, or private companies, including, for example, technology companies, universities, police departments, banks, or airports.

Purposes

Immersive technology systems are used for a variety of purposes across the federal government. Please refer to the definitions below. This is not an exhaustive list; agencies may identify additional purposes that are not listed here.

1. **Workforce training**: Increase, maintain, or improve worker knowledge, skills, or performance to achieve organizational goals.
2. **Data visualization and analysis:** Describe, illustrate, analyze, or synthesize data and other information for users to grasp difficult concepts and identify patterns.
3. **Human factors research:** Observe, test, or evaluate physical and cognitive human traits and behaviors that influence the function of technological systems.
4. **Public outreach:** Inform the general public, coordinate dialogue with members of the public, or otherwise increase or maintain awareness about a given subject.
5. **Remote collaboration:** Coordinate and execute activities at multiple locations and/or with multiple users.
6. **Design and planning:** Generate, prototype, test, evaluate, or synthesize a concept of an object, process, or system.
7. **Medical assessment and/or treatment:** Assess, treat, or otherwise manage a disease, injury, mental health condition, or other condition.
8. **Real-time assistance, guidance, and/or inspection**: Increase, maintain, or improve one or more users' functional capabilities by using information instantaneously generated, previously stored, or transmitted on-site in real-time.
9. **Other purpose(s):** Any agency use(s) that does/do not fit into the categories above.

Technology

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1. **Augmented reality (AR):** AR overlays digital content onto representations of the real environment, using smartphones, tablets, or AR glasses.
2. **Mixed reality (MR):** In MR, a dedicated headset recognizes its environment and enables the interaction between digital content and the real world in multiple dimensions.
3. **Virtual reality (VR):** VR completely obscures the real world, immersing users in digital environments using head-mounted displays.
4. **Simulator:** Any system that includes an immersive component (such as one or more screens, controls, or input device(s)) and accurately simulates the form, fit, and/or function of a real-world vehicle, system, environment, or phenomenon. Simulators may be modifiable to fit different testing, research, or operational needs. For example, the following types of simulators may fit the definition of an immersive technology: flight or aircraft simulators, driving simulators, spaceflight or spacecraft simulators, and law enforcement virtual training simulators.

Benefits

1. **Better understanding of data:** Allow engineers, researchers, scientists, etc. to better understand their data, discover features in data, and make spatial judgments regarding data that may not be possible with traditional desktop computers or 2D displays.
2. **Increased user engagement and learning retention:** Help foster engagement with training and other content. Immersive technologies may also help users better retain information or skills.
3. **Decision-making error reduction and efficiency improvement:** Improve efficiency or reduce errors through increased situational awareness and access to information earlier in the R&D process.
4. **Cost savings:** Compared to other technologies or approaches (such as traditional training), immersive technologies may allow agencies to reduce or avoid costs such as travel or retrofitting existing training facilities, operations, or designs.
5. **Time savings:** Compared to other technologies or approaches (such as traditional training), immersive technologies may save time by, for example, reducing design time, training time, or time to complete a medical procedure.
6. **Increased safety:** Immersive technologies may provide safer alternatives to medical therapies or provide a safer simulated training environment that models dangerous real-world environments.
7. **Scalability:** Immersive technologies' software and hardware architecture may lend themselves to scale up more easily than other technologies or approaches (such as traditional training).
8. **Reconfigurability:** Immersive technologies may allow training or other content to be adjusted without creating an entirely new product or content.

9. **Portability:** Immersive technologies may be more portable than other technologies or may not require additional hardware or internet access.

10. **Interoperability:** Immersive technologies may be used in various hardware configurations, such as a tablet or a headset.

11. **Modularity:** Immersive technology software may allow software developers to develop content within the immersive platform or allow immersive content to be used on other platforms.

12. **Easier access to information:** Immersive technology may allow for easier access to information, greater access to institutional knowledge, and could increase access to services for rural or otherwise hard-to-reach communities. Immersive technologies could also allow users to download lessons onto a device that can be accessed at a later time without broadband. In a medical setting, providers may be able to better access a patient's information without diverting attention away from the patient, such as during a surgery for example. For users with visual impairments or other sensory barriers, immersive technologies may provide a means to more easily access information.

13. **Strategic and/or competitive advantage:** Immersive technologies may provide a strategic and/or competitive advantage. For example, the U.S. could be seen as a leader in this space and be able to set the standards, norms, and rules for future immersive technology use.

Challenges

1. **Motion sickness:** Immersive technologies may cause users to feel motion sickness (similar to feeling car sick or seasick).

2. **Fall risk, injury, and/or body sensory experience:** While using the immersive technologies, there may be a risk of a user losing their balance and/or falling over, due to a disconnect between the immersive experience and the user's physical locomotor sensory response. While using immersive technologies, users may also experience a sense of disembodiment.

3. **Acquisition costs:** Immersive technologies may have a large upfront cost to acquire the hardware, software, or other components, and may have ongoing costs to update or maintain licensing requirements.

4. **High cost to operate or maintain:** Once acquired, immersive technologies may have high costs to operate or maintain the hardware, software, or other system components. There may also be ongoing costs to update or maintain licensing requirements.

5. **Rapid technology development:** Because this technology area is evolving quickly, agencies' development time may not be able to keep pace. For example, an agency may take 6 to 12 months to develop an immersive technology system, after which time the technology could be out of date or obsolete.

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6. **Limited acquisition options:** Procurement officials may not know how to classify immersive technology equipment when purchasing or acquiring it. Additionally, there may be a limited number of vendors approved to sell immersive technologies to the federal government.

7. **Limited standards and/or lack of common definition across industry and/or the federal government**: Because immersive technologies are an emerging and rapidly evolving technology area, there may be limited standards for their use. Additionally, there may not be a common or agreed-upon definition of the term "immersive technology" across the federal government, industry, or academia.

8. **Access for users with limited resources:** Immersive technology may be difficult to use or access for certain users, such as those with limited or no broadband internet service.

9. **Access for users with disabilities:** Immersive technology used by or provided by federal agencies must be accessible to all users, regardless of disability. For example, Section 508 of the Rehabilitation Act of 1973, requires federal agencies to make their electronic and information technology, such as an immersive technology system, accessible to people with disabilities – See 29 U.S.C. § 798.

10. **Limited understanding of which immersive technologies to use or how to use them:** There may not be a clear understanding of which immersive technologies to use for a given application or task, or how to use them for the application or task. Additionally, there may be a limited number of studies examining the feasibility of immersive technologies for certain areas.

11. **Technology may not meet the agency's needs:** Immersive technology may not meet the operational or functional requirements of an agency due to technological factors such as size, weight, and power; compute power; image quality; and field of view.

12. **Dependency on enabling technologies:** Certain technologies necessary for immersive technologies to achieve their full potential are not yet mature, including artificial intelligence and 5G.

13. **How data are collected, stored, and/or transmitted:** To provide an immersive experience, immersive systems may collect a variety of data about a user, which may be extremely personal, such as details about the user's hand, eye, body, or voice data. How federal agencies collect, store, and/or transmit such data may be a challenge.

14. **Ensuring federal cybersecurity and privacy requirements are met:** GAO has previously reported on the cybersecurity challenges across the federal government, including how federal agencies protect privacy and sensitive data. How federal agencies incorporate immersive technologies into their cybersecurity and privacy protection policies may be a challenge.

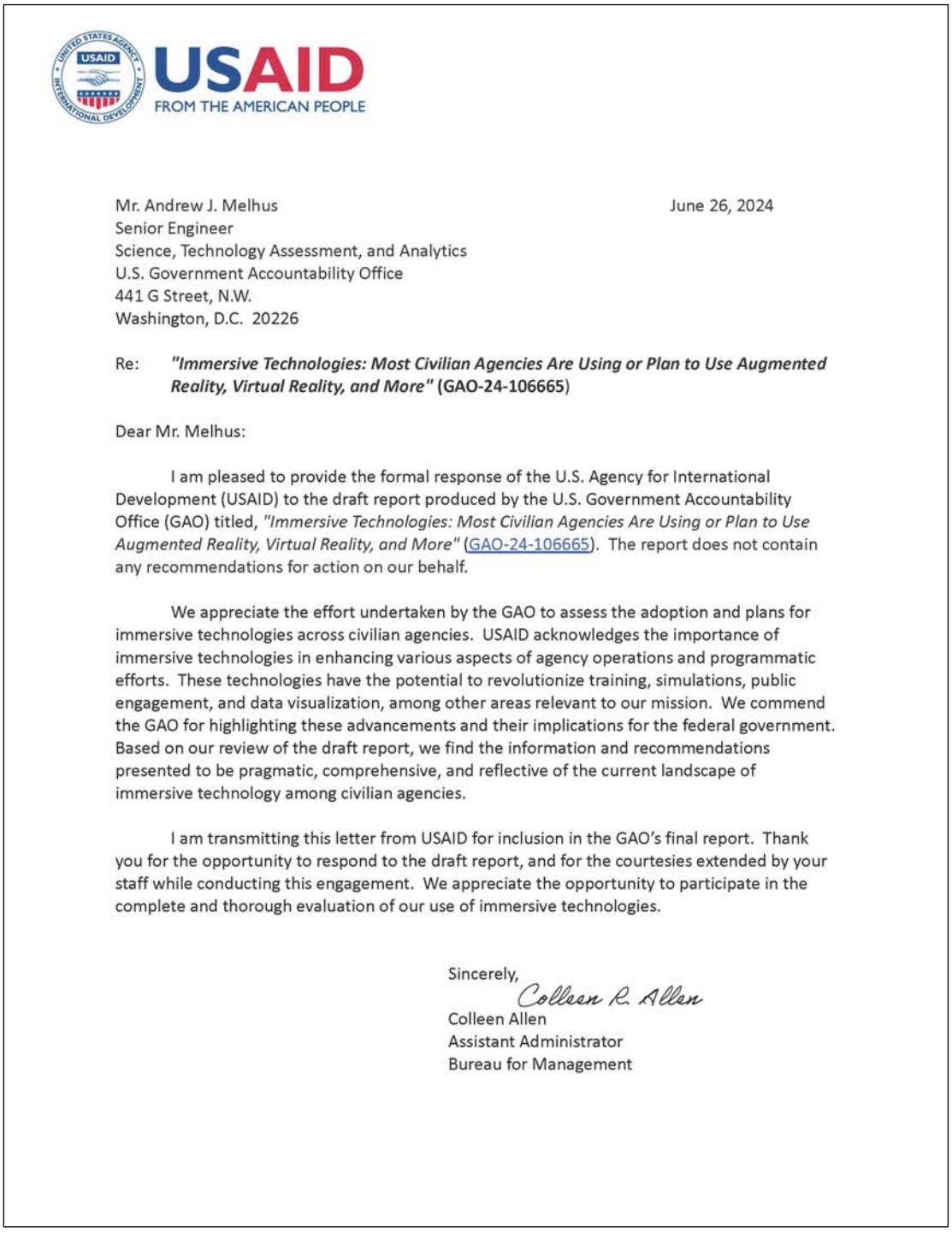
15. **Limited number of workers with necessary immersive technology skills**: Since immersive technologies are an emerging technology, it may be difficult for the federal government to attract and/or retain workers with the necessary skills to develop and use the technologies.

28

16. **User acceptance of immersive technology:** Some users may be hesitant or opposed to adopting and using new systems or technologies.

29

Appendix IV: Comments from the U.S. Agency for International Development



USAID
FROM THE AMERICAN PEOPLE

Mr. Andrew J. Melhus
Senior Engineer
Science, Technology Assessment, and Analytics
U.S. Government Accountability Office
441 G Street, N.W.
Washington, D.C. 20226

June 26, 2024

Re: ***"Immersive Technologies: Most Civilian Agencies Are Using or Plan to Use Augmented Reality, Virtual Reality, and More"*** **(GAO-24-106665)**

Dear Mr. Melhus:

I am pleased to provide the formal response of the U.S. Agency for International Development (USAID) to the draft report produced by the U.S. Government Accountability Office (GAO) titled, *"Immersive Technologies: Most Civilian Agencies Are Using or Plan to Use Augmented Reality, Virtual Reality, and More"* (GAO-24-106665). The report does not contain any recommendations for action on our behalf.

We appreciate the effort undertaken by the GAO to assess the adoption and plans for immersive technologies across civilian agencies. USAID acknowledges the importance of immersive technologies in enhancing various aspects of agency operations and programmatic efforts. These technologies have the potential to revolutionize training, simulations, public engagement, and data visualization, among other areas relevant to our mission. We commend the GAO for highlighting these advancements and their implications for the federal government. Based on our review of the draft report, we find the information and recommendations presented to be pragmatic, comprehensive, and reflective of the current landscape of immersive technology among civilian agencies.

I am transmitting this letter from USAID for inclusion in the GAO's final report. Thank you for the opportunity to respond to the draft report, and for the courtesies extended by your staff while conducting this engagement. We appreciate the opportunity to participate in the complete and thorough evaluation of our use of immersive technologies.

Sincerely,

Colleen R. Allen

Colleen Allen
Assistant Administrator
Bureau for Management

Accessible Text for Appendix IV: Comments from the U.S. Agency for International Development

June 26, 2024

Mr. Andrew J. Melhus
Senior Engineer
Science, Technology Assessment, and Analytics
U.S. Government Accountability Office
441 G Street, N.W.
Washington, D.C. 20226

Re: “Immersive Technologies: Most Civilian Agencies Are Using or Plan to Use Augmented Reality, Virtual Reality, and More” (GAO-24-106665)

Dear Mr. Melhus:

I am pleased to provide the formal response of the U.S. Agency for International Development (USAID) to the draft report produced by the U.S. Government Accountability Office (GAO) titled, "Immersive Technologies: Most Civilian Agencies Are Using or Plan to Use Augmented Reality, Virtual Reality, and More" (GAO-24-106665). The report does not contain any recommendations for action on our behalf.

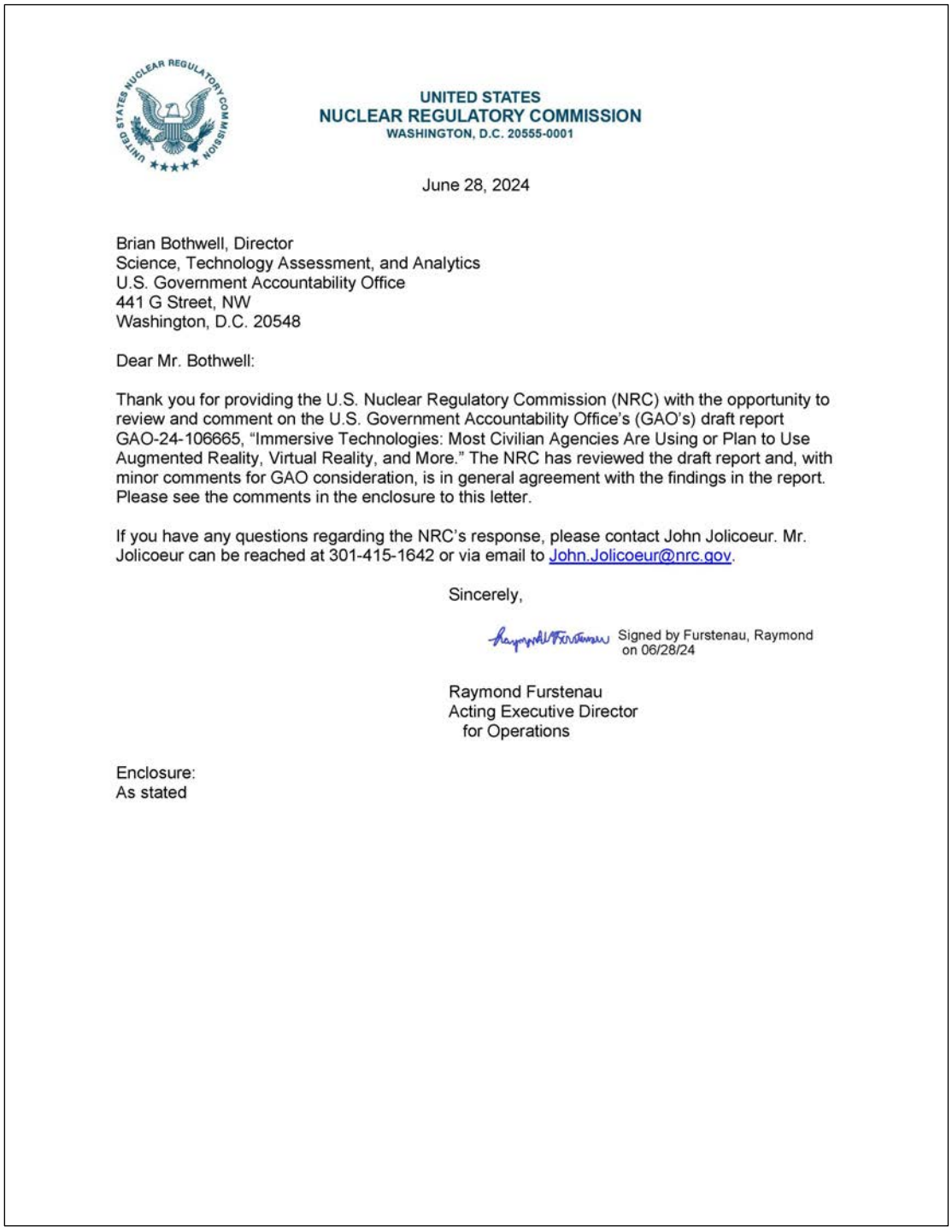
We appreciate the effort undertaken by the GAO to assess the adoption and plans for immersive technologies across civilian agencies. USAID acknowledges the importance of immersive technologies in enhancing various aspects of agency operations and programmatic efforts. These technologies have the potential to revolutionize training, simulations, public engagement, and data visualization, among other areas relevant to our mission. We commend the GAO for highlighting these advancements and their implications for the federal government. Based on our review of the draft report, we find the information and recommendations presented to be pragmatic, comprehensive, and reflective of the current landscape of immersive technology among civilian agencies.

I am transmitting this letter from USAID for inclusion in the GAO’s final report. Thank you for the opportunity to respond to the draft report, and for the courtesies extended by your staff while conducting this engagement. We appreciate the opportunity to participate in the complete and thorough evaluation of our use of immersive technologies.

Sincerely,

Colleen Allen
Assistant Administrator
Bureau for Management

Appendix V: Comments from the Nuclear Regulatory Commission



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

June 28, 2024

Brian Bothwell, Director
Science, Technology Assessment, and Analytics
U.S. Government Accountability Office
441 G Street, NW
Washington, D.C. 20548

Dear Mr. Bothwell:

Thank you for providing the U.S. Nuclear Regulatory Commission (NRC) with the opportunity to review and comment on the U.S. Government Accountability Office's (GAO's) draft report GAO-24-106665, "Immersive Technologies: Most Civilian Agencies Are Using or Plan to Use Augmented Reality, Virtual Reality, and More." The NRC has reviewed the draft report and, with minor comments for GAO consideration, is in general agreement with the findings in the report. Please see the comments in the enclosure to this letter.

If you have any questions regarding the NRC's response, please contact John Jolicoeur. Mr. Jolicoeur can be reached at 301-415-1642 or via email to John.Jolicoeur@nrc.gov.

Sincerely,

Signed by Furstenau, Raymond on 06/28/24

Raymond Furstenau
Acting Executive Director
for Operations

Enclosure:
As stated

Accessible Text for Appendix V: Comments from the Nuclear Regulatory Commission

June 28, 2024

Brian Bothwell, Director
Science, Technology Assessment, and Analytics
U.S. Government Accountability Office
441 G Street, NW
Washington, D.C. 20548

Dear Mr. Bothwell:

Thank you for providing the U.S. Nuclear Regulatory Commission (NRC) with the opportunity to review and comment on the U.S. Government Accountability Office's (GAO's) draft report GAO-24-106665, "Immersive Technologies: Most Civilian Agencies Are Using or Plan to Use Augmented Reality, Virtual Reality, and More." The NRC has reviewed the draft report and, with minor comments for GAO consideration, is in general agreement with the findings in the report. Please see the comments in the enclosure to this letter.

If you have any questions regarding the NRC's response, please contact John Jolicoeur. Mr. Jolicoeur can be reached at 301-415-1642 or via email to John.Jolicoeur@nrc.gov.

Sincerely,

Signed by Furstenau, Raymond on 06/28/24

Raymond Furstenau
Acting Executive Director
for Operations

Enclosure:
As stated

Appendix VI: Comments from the Social Security Administration

SOCIAL SECURITY
Office of the Commissioner

July 12, 2024

Brian Rothwell
Director
United States Government Accountability Office
441 G Street, NW
Washington, DC 20548

Dear Director Rothwell,

Thank you for the opportunity to review the draft report "IMMERSIVE TECHNOLOGIES: Most Civilian Agencies Are Using or Plan to Use Augmented Reality, Virtual Reality, and More" (106665). We have reviewed the report and reaffirm that we are not using immersive technology. Although there may be applications for immersive technology in our operations, we do not have the adequate funding or staffing to pursue these options.

Please contact me at (410) 965-2611 if I can be of further assistance. Your staff may contact Hank Amato, Director of the Audit Liaison Staff, at (407) 765-9774.

Sincerely,

Dustin Brown
Acting Chief of Staff

Accessible Text for Appendix VI: Comments from the Social Security Administration

July 12, 2024

Brian Rothwell
Director
United States Government Accountability Office
441 G Street, NW
Washington, DC 20548

Dear Director Rothwell,

Thank you for the opportunity to review the draft report "IMMERSIVE TECHNOLOGIES: Most Civilian Agencies Are Using or Plan to Use Augmented Reality, Virtual Reality, and More" (106665). We have reviewed the report and reaffirm that we are not using immersive technology. Although there may be applications for immersive technology in our operations, we do not have the adequate funding or staffing to pursue these options.

Please contact me at (410) 965-2611 if I can be of further assistance. Your staff may contact Hank Amato, Director of the Audit Liaison Staff, at (407) 765-9774.

Dustin Brown
Acting Chief of Staff

Appendix VII: GAO Contact and Staff Acknowledgments

GAO Contact

Brian Bothwell at (202) 512-6888 or bothwellb@gao.gov

Staff Acknowledgments

In addition to the contact named above, Richard Hung (Assistant Director), AJ Melhus (Analyst-in-Charge), Aubrey Anderson, Jenn Beddor, Hunter Graff, Anne Kolesnikoff, Jean Lee, Matt Metz, Kelly Rubin, and Daniel Xue made key contributions to this report. Also contributing were Jehan Chase, Louise Fickel, Curtis Martin, and Andrew Stavisky.

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