Artificial Intelligence Scholarship for Service Initiative

Need, Feasibility, and Implementation

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Executive Summary

The rapid advancement of artificial intelligence (AI)—including powerful Large Language Models (LLM) released in the last 18 months—is having significant impacts on our society, altering the way people live, work, and interact. This technology has the potential to drive innovation, improve efficiency in various sectors, and solve complex problems that have long challenged humanity. AI technologies enhance human abilities to address complex challenges. From healthcare, where AI aids in diagnosing diseases more accurately and swiftly, to environmental protection, where it assists in monitoring and predicting climate change impacts, these contributions are significant and transformative. It is important to recognize that AI is not a singular entity; rather, it operates in tandem with its human creators and users. These advancements also bring challenges, such as societal and ethical concerns and risks to national security.

The Federal Government plays a crucial role in regulating and deploying AI technologies, ensuring their ethical use and overall benefit to society. Both AI and an AI-ready workforce is essential for informed policymaking, regulatory oversight, and the implementation of AI solutions that are transparent, equitable, and accountable. To address these challenges, there is a pressing need to educate more public, service-oriented AI professionals across disciplines, including technology, policy, managerial, procurement, regulatory, ethical, governance, and legal fields.

As required by the Creating Helpful Incentives to Produce Semi-conductors (CHIPS) and Science Act of 2022 (P.L. 117-167) Section 10313(d), this report, developed by the U.S. National Science Foundation (NSF) in coordination with the U.S. Office of Personnel Management (OPM), addresses the need for and feasibility of establishing an artificial intelligence scholarship for service (AI SFS) program. The AI SFS program is intended to recruit and train the next generation of AI professionals to meet the needs of Federal, State, local, and Tribal governments. As statutorily mandated, this report includes (a) recent statistical data on the size, composition, and educational requirements of the Federal AI workforce, including an assessment of current and future demand for additional AI professionals across the Federal Government; (b) an assessment of the capacity of institutions of higher education (IHEs) to produce graduates with degrees, certifications, and relevant skills related to artificial intelligence to meet the current and future needs of the Federal workforce; (c) an evaluation of the need for and (d) feasibility of establishing an AI SFS program as described in Sec. 10313(d) of the CHIPS and Science Act.

THE FEDERAL AI WORKFORCE: CURRENT AND FUTURE

In this report, the Federal AI workforce is defined conceptually as the subset of all Federal workers who have or use AI or machine learning (ML) knowledge, skills, or abilities or who conduct AI/ML tasks as part of their work, independent of job title or occupation and level or field of degree. Given the early stages of Federal Government activities to define, quantify, and characterize the Federal AI workforce, this report used three methods: (a) leveraging AI-relevant Federal occupational series as a proxy; (b) estimating the share and number of workers within each Federal civilian occupational series for whom AI knowledge, skills, abilities, and tasks (KSAT) are a prominent part of their work; and (c) through aggregate statistics of social profiles provided by the private sector labor market analytics firm Lightcast. The data leveraged in this report were obtained prior to the release of Executive Order 14110, and thus do not reflect efforts underway in response to its provisions.

Based on available data and approximations, which rely on several assumptions, it is estimated that on the order of at least 10,000 Federal personnel actively engage with AI or ML or have AI- or ML-specific skills. Evidence suggests that these Federal employees can be found across a range of OPM occupational series and have a variety of technical and non-technical skills. The larger pool of Federal workers with expertise in AI/ML, data, software engineering, and computing (the Federal digital workforce) that lay the foundations for AI work and that likely have the capacity to contribute to aspects of AI work is potentially an order of magnitude larger. More authoritative statistics on the Federal AI workforce will be enabled upon coding of AI and related work roles into Federal personnel systems.

Federal job posting records had on the order of 1,000 Federal AI-focused job postings per year in recent years, and approximately 3,000 AI-focused postings were identified for federally funded research and development centers (FFRDC). Estimating the size of the future Federal AI workforce and need for additional AI professionals requires

making assumptions regarding potential hypothetical growth scenarios, of which two are presented in this report. The moderate growth scenario assumes 17.6%, and the accelerated growth scenario assumes 100%, increase in the Federal AI workforce size in 5 years. Analyses conducted for this report suggest that on the order of 730 to 1,100 (moderate scenario) or 2,300 to 3,400 (accelerated scenario) new AI workers will need to be hired by Federal departments and agencies in 2028. This likely includes between approximately 400 and 600 (moderate) or 1,200 and 1,900 (accelerated) recent graduates hired into Federal civilian positions. Key areas where additional AI professionals are likely needed include roles at the intersection of AI and cybersecurity, policy, governance, ethics, or STEM fields; expert practitioners of AI oversight and safety; data engineers to build enabling infrastructure for AI; PhD-level AI specialists; and, generally, AI, analytics, and data science professionals across degree levels.

U.S. AI EDUCATIONAL CAPACITY FOR FEDERAL WORKFORCE NEEDS

At the time of this writing, at least 118 U.S. IHEs offered a total of 169 AI-related academic programs, including undergraduate majors, minors, concentrations, master's degrees, graduate certificates, and doctoral degrees. A significant portion (54%) of these programs is offered by Very High Research Activity (R1) institutions, highlighting a concentration of AI education within 146 or 3.4% of IHEs.

Depending on the nature of the need for Federal AI workers, the United States risks not graduating enough U.S. citizen or permanent resident master's-level graduates with AI-related degrees. Curricula associated with AI master's programs provide the most preparation in AI development compared to the curricula for other degree types analyzed, with a greater focus on the conceptual understanding of AI and the math that underlies it, such that these AI master's graduates may be more likely able to build new tools and advance the field.

Based on curricular analysis, it appears that most data science master's graduates, who make up half of the total supply of U.S. citizen or permanent resident AI-related master's-level graduates, are being taught a solid foundation of ML and math topics from which they can leverage AI in their work. Additionally, though it was not the focus of this report, there may be other degree programs (e.g.., bioinformatics, econometrics, physics) that include the necessary preparation for applied AI work.

There is a shortfall in the number of U.S. citizen or permanent resident graduates with AI-related degrees entering the Federal service. Particularly, there is a clear gap at the master's and doctoral levels, with demand for AI expertise in the Federal Government well surpassing the projected number of master's degree and doctoral graduates expected to be entering Federal service in 2028. Also, the principal challenge identified by IHEs to expanding their AI educational capacity is hiring and retaining faculty—and the United States risks not graduating enough AI doctorates to meet the needs for future levels of faculty employment in AI. Responses from IHEs also identify course/curriculum development and computing infrastructure availability as significant challenges. Analysis using computer science degrees as a proxy indicates that members of groups traditionally underrepresented in STEM fields are less likely to earn degrees in AI-related fields compared to other areas of study.

THE NEED FOR AN AI SFS PROGRAM

The AI SFS program, as outlined in the CHIPS and Science Act, encompasses three components: (a) scholarship for service, (b) capacity-building efforts, and (c) fellowships. These components are designed to support students in AI-related degree programs, enhance interdisciplinary AI studies, and promote the ethical, social, and legal understanding of AI technologies.

Finding 1: There is a need for an AI SFS program to direct graduates with AI skills into Federal service.

> ***The current Federal and FFRDC workforce need new graduates with AI skills.*** Though job postings do not necessarily map one-to-one with open positions, there were approximately 1,200 Federal or FFRDC job postings per year in 2022 and 2023 that could be filled by AI SFS graduates, and approximately 400 to 600 (moderate) or 1,200 to 1,900 (accelerated) new AI graduates are estimated to be needed in 2028 in Federal positions alone. Most AI graduates pursue employment in the private sector, and interviewees from IHEs (5 out of 11) indicated that an AI SFS would be an important incentive for their students to pursue employment in the Federal Government.

There is a clear need for more U.S. citizens or permanent residents with AI master's degrees and doctorates to meet future Federal AI workforce demand. At the master's and doctoral levels, demand for Federal AI workers is well above the projected number that would enter Federal service. This gap suggests that without a program intended to direct graduates into Federal service, such as an AI SFS, it may be difficult for the Federal Government to recruit the number of new workers required.

Finding 2: There is a need for efforts to build capacity in AI at IHEs.

Additional AI capacity, particularly at non-R1 institutions, is needed. As of the beginning of 2024, 67 U.S. universities and colleges offered AI degree or certificate programs, while 80 IHEs offered AI minors or concentrations/fields of specialization within existing degree programs. These programs are heavily concentrated in R1 institutions. As of the beginning of 2024, not a single Historically Black College and University (HBCU) was offering a degree program or certificate in AI, though two HBCUs (i.e., North Carolina A&T University and Bowie State University) offered a minor or concentration in AI.

The principal barrier to expanding AI capacity is hiring and retaining faculty. Based on the best available data and estimates, IHEs are likely to need a range of additional investments to add capacity to educate and train students in AI-related fields, including availability of AI faculty, course development, and access to computing infrastructure.

An AI SFS would have a positive impact on capacity building for increased student participation in IHE AI programs. Interviewees (4 out of 11) at IHEs with AI degree or academic programs indicated that an AI SFS could help attract students, especially first-generation students, to their programs. Further, an AI SFS program could signal the potential for guaranteed and stable post-graduation employment as well as receiving a higher education degree with significantly reduced financial burden.

Finding 3: There is a need for AI Fellowships.

Federal and FFRDC need. Analyses suggest that approximately twenty percent of Federal job openings for AI-focused positions are for individuals who have just completed research doctorates and approximately half are for individuals who have just completed master's degrees. Fellowships that incentivize U.S. citizens or permanent residents to pursue graduate-level training are a mechanism for increasing the supply of graduates at Federal agencies or the FFRDCs that support them.

IHE AI faculty need. The capacity-building need discussed above implies a specific need to prepare recipients of graduate degrees to be hired at IHEs as faculty. Fellowships, especially at the doctoral level, are mechanisms that, with proper selection, mentoring and networking, have the potential to direct participants toward academic careers and help to increase the supply of future faculty members teaching AI-related subjects. Another approach to address AI faculty shortages is providing funding for professional development for faculty who wish to transition to the field of AI for instruction and research.

FEASIBILITY AND IMPLEMENTATION OF AI SFS PROGRAM

The CHIPS and Science Act of 2022 authorized the Director of NSF to establish an AI SFS program in coordination with the Director of OPM, the Director of the National Institute of Standards and Technology (NIST), and the heads of other agencies with appropriate scientific knowledge. The AI SFS authorization includes consideration for leveraging existing processes and resources associated with administering the CyberCorps® SFS program in standing up the AI SFS program. The CyberCorps® SFS program has been critical for the development of cybersecurity education and government workforce.

This feasibility assessment considers lessons learned from creating a successful ecosystem for cybersecurity education and workforce development during the last 25 years. The assessment addresses scholarships, fellowships, and capacity-building programs; criteria to designate qualified IHEs; and a taxonomy of the Federal AI workforce. Therefore, the AI SFS program would include the aforementioned components as authorized by the statute.

First, a Scholarship component would provide funding to "qualified institutions of higher education" to award scholarships for up to three years to students in degree or concentrations programs in, or related to, AI. All scholarship recipients must work after graduation in the AI mission of an approved government organization for a period equal to the duration of the scholarship. The legislative language of the AI Scholarship component is similar to the CyberCorps® SFS statute.

Second, a Capacity Building component would provide funding to promote integration of AI with other programs of study and support capacity-building education research, including translation to practice, on the next-generation AI workforce, including AI researchers and practitioners. These efforts would be complementary to other NSF AI education initiatives, such as EducateAI and ExpandAI, that address the growing need to develop the next generation of talent for a diverse, well-trained AI workforce. NSF will conduct outreach and encourage applications from rural-located institutions of higher education; rural-serving institutions of higher education; minority-serving institutions such as Historically Black Colleges and Universities, Tribal Colleges and Universities, Asian American and Native American Pacific Islander-Serving Institutions, and Hispanic Serving Institutions; and institutions located in an Established Program to Stimulate Competitive Research (EPSCoR) jurisdiction.

Third, a Fellowship component would provide funding to master's and doctoral students who are pursuing degrees or research in AI and related fields as well as to faculty members on AI professional development, including faculty on a sabbatical leave.

Beyond funding programs, two important elements have contributed to the success of cybersecurity education and workforce development efforts. The National Centers of Academic Excellence in Cybersecurity (NCAE-C) program, maintained by the National Security Agency and partners since 1999, has created a strong community of practice and provided a collection of Knowledge Units (KUs) for validation of academic programs of study.

The National Initiative for Cybersecurity Education (NICE) Cybersecurity Workforce Framework, established by NIST and partner agencies in 2010, has provided a modern taxonomy for the cybersecurity workforce including Work Roles; KSATs; and Competency Levels. An alternative but similar workforce framework is the Department of Defense Cyber Workforce Framework (DCWF), that was expanded in 2023 to include AI work roles.

The AI SFS program can be primarily built on the foundation and lessons learned from the CyberCorps® SFS program. By leveraging established processes, legal frameworks, and resources, the AI SFS program can be efficiently established and maintained by NSF in collaboration with OPM, NIST, and other agencies.

The feasibility assessment addresses the scalability and adaptability of the program. With an initial focus on integrating AI with cybersecurity, the program should be designed to expand to include broader AI technologies and interdisciplinary applications over time. This approach is deemed feasible as it allows the program to start within a familiar context before progressively addressing more complex and wide-ranging aspects of AI technology and its applications in various sectors. There is an increasing need to cultivate public service technologists who have an understanding of the intersection of technology and society, such as technology ethics and the implications of AI on society. AI SFS program will support multi-disciplinary approaches with a special emphasis on societal and ethical aspects of AI and other emerging technologies.

In summary, the feasibility assessment of the AI SFS program suggests a strong potential for success, grounded in proven strategies and a clear understanding of the necessary resources and infrastructure. It highlights the program's ability to adapt to changing technologies and workforce needs, ensuring its relevance and effectiveness in cultivating a well-prepared AI workforce for the Federal Government report.

Acknowledgment

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1. Introduction

BACKGROUND AND CONTEXT

Recent advances in artificial intelligence (AI) are driving significant transformations across multiple domains, showcasing both the rapid pace of AI development and its vast potential. One notable advance is in the realm of Generative AI, exemplified by Large Language Models (LLM), which demonstrate an unprecedented ability to understand and generate human-like content. Another area of significant progress is in machine learning (ML) techniques for image and speech recognition, which are continually improving in accuracy and efficiency, enabling practical applications from autonomous vehicles to real-time translation services. AI is also making strides in predictive analytics, enhancing capabilities in weather forecasting, market trend analysis, and personalized medicine by processing vast datasets at speeds far beyond human capability.

The Federal Government is actively involved in fostering the growth and governance of AI technology to leverage its benefits while mitigating associated risks. Several Federal agencies have initiated programs to integrate AI into their operations and improve public services. For example, the Department of Defense (DoD) has been utilizing AI for autonomous systems and cyber defense, aiming to maintain a technological edge in national security. Additionally, Federal health agencies employ AI to enhance disease diagnosis and treatment personalization. Recognizing the importance of ethical considerations, the U.S. Government has also established guidelines and frameworks to ensure AI development and deployment are conducted responsibly, promoting transparency, accountability, and public trust in AI technologies.

The U.S. National Science Foundation (NSF) plays a crucial role in advancing AI research and development through its support for AI initiatives across the academic and scientific communities. NSF's National AI Research Institutes program exemplifies this support, involving hundreds of millions of dollars of investments to establish institutes that focus on various AI research areas from foundations of ML to AI for agriculture. These institutes not only push the boundaries of AI technology but also address critical societal challenges through AI-driven solutions. Additionally, NSF supports workforce development in AI through initiatives designed to enhance AI education and broaden participation in the field, aiming to prepare a diverse and skilled workforce adept at using AI in a variety of professional contexts.

PURPOSE OF THIS REPORT

As required by the Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act of 2022 (P.L. 117-167) Section 10313(d), this report, developed by NSF in coordination with the Office of Personnel Management (OPM), characterizes the need for and feasibility of establishing an AI scholarship for service (AI SFS) program. This AI SFS program is intended to recruit and train the next generation of AI professionals to meet the needs of Federal, State, local, and Tribal governments. The report is prepared for the Committee on Commerce, Science, and Transportation of the Senate; the Committee on Science, Space, and Technology of the House of Representatives; the Committee on Homeland Security and Governmental Affairs of the Senate, and the Committee on Oversight and Reform of the House of Representatives.

As statutorily mandated, this report includes the following elements:

- Recent statistical data on the size, composition, and educational requirements of the Federal AI workforce, including an assessment of current and future demand for additional AI professionals across the Federal Government;
- The capacity of institutions of higher education (IHEs) to produce graduates with degrees, certifications, and relevant skills related to AI that meet the current and future needs of the Federal workforce; and
- An evaluation of the
    - need for establishing an AI SFS program as described in Sec. 10313(d) of the CHIPS and Science Act; and
    - feasibility and implementation of an AI SFS program.

DATA USED IN THIS REPORT

In compiling this report, information was gathered, reviewed, and analyzed from a variety of sources, including the following:

- Review of recent publications related to AI and AI work and analysis of published Federal Government AI strategies and use cases. (Chapter 2)

- Conversations with individuals engaged in defining AI work roles (including associated knowledge, skills, abilities, and tasks [KSATs] or competencies and tasks) within the Federal Government. (Chapter 2)
- Semi-structured individual and group interviews with Federal personnel with knowledge of agency AI operations and AI workforce issues. (Chapters 2 and 4)
- Publicly available (and anonymized) Federal civilian personnel data maintained and reported through OPM (FedScope/Enterprise Human Resources Integration-Statistical Data Mart [EHRI-SDM]) and downloaded from the OPM website. (Chapters 2 and 4)
- Archived Federal Job Opportunity Announcements (JOAs) from USAJOBS that opened in 2022 or 2023 (through mid-October), provided by USAJOBS database managers. (Chapters 2 and 4)
- Data obtained via contract with Lightcast, a private sector labor market analytics firm. (Chapters 2, 3, and 4)
- Publicly available data on number of degrees awarded by U.S. IHEs from the National Center for Education Statistics Integrated Postsecondary Education Data System (IPEDS). (Chapter 3)
- Publicly available data from the Computing Research Association (CRA) Taulbee survey on the number of computer science (CS), computer engineering and informatics PhDs from North American IHEs with an AI specialization. (Chapter 3)
- A newly generated catalog of AI degree programs at U.S. IHEs developed by NSF based on public information about these degree programs. (Chapter 3)
- Publicly available course descriptions associated with AI and related degree programs. (Chapter 3)
- Semi-structured interviews with individuals associated with AI or CS degree programs at U.S. IHEs. (Chapter 3)
- Responses from representatives at U.S. IHEs to an AI SFS-
- related, NSF-fielded request for information (RFI). (Chapter 3)
- Bureau of Labor Statistics (BLS) workforce projections data published on the BLS public website.

In all cases, analyses were conducted using what was judged to be the best available data and appropriate approximations or assumptions. However, these findings are not necessarily absolute or comprehensive, due to several limiting factors, including lack of comprehensive or authoritative data or definitions; the emerging nature of AI and related research, educational programs, and requirements; and rapidly evolving work and Federal agency AI uses and needs. Details of methods and appropriate qualification of findings are provided in place.

Statutory Definition of Artificial Intelligence Used in the CHIPS and Science Act

The National AI Initiative Act of 2020 (William M. [Mac] Thornberry National Defense Authorization Act for Fiscal Year 2021 Division E, Sec. 5001) - 15 U.S.C. §9401 (3)

The term "artificial intelligence" means a machine-based system that can, for a given set of human-defined objectives, make predictions, recommendations or decisions influencing real or virtual environments. Artificial intelligence systems use machine and human-based inputs to—

(A) perceive real and virtual environments;

(B) abstract such perceptions into models through analysis in an automated manner; and

(C) use model inference to formulate options for information or action.

2. The Federal AI Workforce: Current and Future

NSF was tasked with assessment and evaluation of the need for and the potential role of an AI SFS program in meeting government workforce needs. This chapter provides key background on the Federal workforce, definition of AI, as well as findings from new analyses characterizing the current and likely future importance of AI-specific KSATs within the Federal workforce. These results include proxy or estimated recent statistical data on the size, composition, and educational backgrounds of the Federal AI workforce, as well as estimates of current and future demand for additional individuals with AI-specific competencies in the Federal Government. While this chapter focuses on the Federal workforce and its needs, as called for statutorily, NSF acknowledges the importance of AI professionals in State, local, and Tribal governments.

BACKGROUND AND CONTEXT

THE FEDERAL WORKFORCE DEFINED

The Federal workforce includes civilian employees in the executive, legislative, and judicial branches, and military personnel employed by DoD and the Department of Homeland Security (DHS). As of March 2023, OPM's FedScope/EHRI system included records for a total of 2,191,361 Federal civilian employees.[1] DoD—including the Department of the Army, the Department of the Navy, the Department of the Air Force, the Office of the Secretary of Defense, and other defense agencies and activities—is the largest government employer of civilian personnel recorded in FedScope. DoD civilian personnel represent 34 percent of EHRI-SDM personnel records, followed by the Department of Veterans Affairs (VA; 20 percent), DHS (10 percent), and the Department of Justice (5 percent). The estimated number of DoD military personnel in 2022 exceeded 2 million, nearly two-thirds of which (1.3 million) were active-duty members.[2] There are no official public estimates of the number of U.S. intelligence personnel.

In addition to Federal employees, a variety of professionals employed by other entities provide direct support to the Federal Government, including federally funded research and development centers (FFRDCs) and Federal contractors. As noted in the Federal Acquisition Regulation (FAR 35.017) FFRDCs have a special legal status and are designed to meet a "special long-term research or development need which cannot be met as effectively by existing in-house or contractor resources;" they maintain a trusted relationship with the government and are required to operate in the public interest.[3] According to publicly reported estimates of the number of employees of the 42 FFRDCs or FFRDC operators, this workforce includes on the order of 150,000 personnel.[4,5]

DEFINING ARTIFICIAL INTELLIGENCE

There is no single, widely accepted, and authoritative definition of AI and what it does or does not include. The term is commonly used to refer to a computer-based system capable of completing tasks that require what might otherwise be considered human-level intelligence. It is also commonly used to refer to the theoretical and experimental fields of study or research and development of such systems, and related technologies, capabilities, or functions. AI technologies have been advancing rapidly in recent years, and perspectives on what kinds of capabilities are uniquely human and what are routine for computers are similarly shifting. Today, AI systems are commonly based on ML techniques, especially deep learning (DL); these systems have applications in essentially every industrial or service sector.

The U.S. Congress codified two definitions of AI into law: one in the National Defense Authorization Act (NDAA) for Fiscal Year 2019, and one in the NDAA for Fiscal Year 2021, which is cited in the CHIPS and Science Act of 2022 (P.L. 117-167) Section 10313(d) and presented below. Federal executive branch policy documents and agency personnel cite one or both definitions variously, and Federal agencies and personnel may also have organization-specific definitions of AI. Agency strategies often identify AI as leveraging ML and DL techniques to induce models learned from patterns in data for statistical inference, function approximation, classification, and pattern recognition.

RECENT EFFORTS TO CHARACTERIZE THE U.S. AI WORKFORCE AND LABOR MARKET

The U.S. Department of Labor (DOL) maintains the Standard Occupational Classification System (SOC), a taxonomy for classifying workers across all sectors of the economy into standard occupational categories to use in information gathering, analysis, and reporting.[6] This taxonomy does not include an AI-specific category, but the description for "Data Scientists" (15-2050 and 15-2051, a new category as of 2018), includes "natural language processing" and "machine learning," which are associated with AI, as methods commonly used by workers classified under these codes.

In the absence of authoritative statistics about the U.S. AI labor force, several recent studies have aimed to characterize the U.S. AI workforce using a variety of methods and definitions. For example, researchers from the Center for Security and Emerging Technology (CSET) at Georgetown University, in a series of three reports from 2021,[7] define the AI workforce broadly as including "the set of occupations that include people who are qualified to work in AI or on an AI development team, or have the requisite knowledge, skills, and abilities (KSAs) such that they could work on an AI product or application with minor training."[8] The 2023 AI Index Report released by the AI Index Steering Committee at Stanford's Human-Centered Artificial Intelligence (HAI) Center reports results from analysis of Lightcast job posting data from 2010 to 2022. An Organization for Economic Co-operation and

Development (OECD) report on "The Supply, Demand, and Characteristics of the AI Workforce"[9] examines the workforce across 38 OECD Member countries, leveraging Lightcast job postings and government statistical data. Key findings from these studies are provided in Table 1.

Table 1. Estimated Trends in the AI Workforce or Job Postings Reported in Recent Literature

Organization	Definition of AI Workforce	Method of Estimation	Quantitative Estimate	Recent Growth	Projected Growth
Center for Security and Emerging Technologies (CSET)[a]	Any U.S. workers in occupations that do, can, or have the capacity to engage in any aspect of AI development	Counted number of workers (per the American Community Survey [ACS]) employed in SOCs corresponding to Occupational Information Network (O*NET) occupation titles whose descriptions included specific keywords	14 M (9%) U.S. workers	20% (2015–2019)	8% (2019–2029)
CSET[a]	U.S. workers in the most technical occupations that do or could engage in AI development	Counted number of workers (per ACS) employed in SOCs	4.8 M (3%) U.S. workers	26% (2015–2019)	13% (2019–2029)
AI Index[b]	Job postings that list at least one AI skill	Counted number and share of all U.S. job postings including one or more AI skill	2% of U.S. job postings (2022)	N/A	N/A
Organization for Economic Co-operation and Development (OECD)[c]	Workers that possess at least one AI skill	Identified "within-occupation" share of job postings that name at least one AI skill, add number of current workers scaled by within-occupation share	0.36% of U.S. (0.34 % of OECD nations) workers, 0.7% of U.S. postings in 2019	386% increase in share of OECD nation workers (0.07% to 0.34% from 2011–2019)	N/A

Citations:

[a] Gehlhaus, Diana and Santiago Mutis. 2021. The U.S. AI Workforce: Understanding the Supply of AI Talent. Center for Security and Emerging Technology (CSET). Available online at https://cset.georgetown.edu/publication/the-u-s-ai-workforce/

[b] Stanford HAI. 2023. "AI Index Report 2023 – Artificial Intelligence Index." Stanford Institute for Human-Centered Artificial Intelligence. Available online at https://aiindex.stanford.edu/report/

[c] Green, Andrew and Lucas Lamby. 2023. The supply, demand and characteristics of the AI workforce across OECD countries. Organization for Economic Co-operation and Development (OECD Social, Employment and Migration Working Papers, 287). Available online at https://www.oecd-ilibrary.org/docserver/bb17314a-en.pdf

AI AND THE FEDERAL GOVERNMENT

The Federal Government has long had a role in funding and supporting research and development in the area of AI. In recent years AI technologies have expanded and progressed, along with their potential uses across a variety of application areas for national security and societal benefits. In parallel, concerns have elevated about the potential risks these technologies might pose to individuals and communities. The Federal government has been taking numerous actions to accelerate and harness progress in—and responsible deployment of—AI. As called for in Executive Order (EO) 13960: *Promoting the Use of Trustworthy Artificial Intelligence in the Federal Government*, Federal agencies annually report specific uses of AI in AI use case inventories, which are published online and accessible via ai.gov.[10] On October 30, 2023, the President issued EO 14110: *Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence*. The Order intends to strengthen AI safety and security, protect Americans' privacy, advance equity and civil rights, stand up for consumers and workers, promote innovation and competition, advance American leadership around the world. Federal agencies were assigned actions to be completed by specified deadlines. At the time of finalizing this report, the White House published a list of key AI actions completed 90 and 180 days following the Executive Order.[11]

RECENT CONGRESSIONALLY MANDATED REPORTS ADDRESSING THE FEDERAL AI WORKFORCE

Several recent reports have identified the importance of a strong AI workforce for U.S. competitiveness and national security, including economic security—in particular, the need to strengthen the Federal AI workforce and the broader U.S. AI labor pool.

The National Security Commission on AI (NSCAI), a Federal advisory committee tasked with making recommendations to the government on advancing AI and related technologies for national defense and security, identified improving technical talent in government as among its key recommendations. To bridge what the authors term an "alarming talent deficit," the NSCAI recommended that the government focus on (a) organizing its talent through a specialized talent management system, (b) recruiting individuals, including individuals from industry and academia and recent graduates who already have the skills needed within the Federal Government, (c) building the workforce through training of government employees, and (d) using the digital workforce more effectively so that workers can perform meaningful work in the government. The commission noted that the government faces challenges in recruiting and retaining both AI practitioners and digital talent more broadly. They suggest that, while salaries in the private sector may be higher, the primary obstacle to building an AI workforce is that potential employees do not perceive that there are opportunities in government to conduct meaningful work at the cutting edge of the field.[12]

The NSCAI also noted a need for building the capabilities of the government-employed workforce, rather than solely relying on contractors, and named part-time or temporary civilian service as a key potential area of growth. They also suggested that it would be challenging to recruit new talent within the current labor market, citing 430,000 open positions for computer scientists in 2020 and only 71,000 U.S. graduates in CS each year.[13] While open positions also reflect churn (workers leaving one CS position to take a new CS position), BLS reports the median annual wage for computer and information technology positions in 2022 as $100,530[14] compared to $97,980 for science, technology, engineering, and mathematics (STEM) occupations overall and $44,670 for non-STEM occupations across the U.S. labor market; salary is a useful heuristic for gauging workforce demand.[15]

Similarly, a recent National Institute of Standards and Technology (NIST) study on the state and impact on the U.S. economy of various technologies also found that "the U.S. AI ecosystem will not excel without a robust pool of technical talent for AI research, development, and deployment." The study noted reports of loss of faculty from academia to industry due to the attractiveness of resources afforded by the private sector, with implications for the ability of institutions to yield graduates. The study also found that "[a] lack of diversity in the AI workforce may contribute to the incidence of discrimination, perpetuation of bias, and other harms resulting from the development and use of AI algorithms," and that women and Black or African American and Hispanic workers are underrepresented in the U.S. computing workforce compared to the population at large. Finally, the report noted that many AI-focused graduate students and researchers in the United States are not U.S. citizens and would not be eligible to join the security-

sensitive Federal workforce. Acceleration of progress and U.S. leadership in responsible AI is clearly a national priority, and the AI workforce is the foundation for achieving it.[16]

The National AI Research Resource (NAIRR) Task Force, in its 2023 report to Congress, proposed a vision and implementation plan for creating a research resource to "transform the AI R&D [research and development] landscape in the United States." The NAIRR, currently in pilot stages,[17] is intended to provide researchers and students across scientific disciplines with access to computational resources, high-quality data, educational tools, and training resources, with contributions from and benefits for all sectors. Its four AI-focused goals are to spur innovation, increase diversity of talent for the U.S. workforce writ large, improve research capacity, and advance trustworthy AI.[18]

RECENT EFFORTS WITHIN THE FEDERAL EXECUTIVE BRANCH TO CHARACTERIZE THE FEDERAL AI WORKFORCE

OPM ACTIVITIES

The AI in Government Act of 2020, signed into law in 2021, called on OPM to examine the Federal AI workforce and needs. Specifically, OPM's Director was charged with characterizing skills requirements, considering establishment of a new occupational series, and providing quantitative estimates of current and forecasted numbers of Federal employees in AI-related positions.[19] On July 6, 2023, the OPM Director published a memorandum to Federal Agency Chief Human Capital Officers identifying general and technical AI competencies to help inform agency hiring.[20] OPM also fielded a job analysis survey to AI workers and supervisors in order to validate their skills list and develop a competency model. On April 29, 2024, OPM released three publications: *The Artificial Intelligence Classification Policy and Talent Acquisition Guidance, Skills-Based Hiring Guidance and Competency Model for Artificial Intelligence Work, and Artificial Intelligence (AI) Competency Model for Civil Engineering, 0810.*[21] These documents will help inform AI hiring and position tracking moving forward.

The Federal Government is in the relatively early stages of defining and characterizing its Federal AI workforce and skills and educational requirements, but major efforts are underway

DOD EFFORTS

In February of 2023, DoD updated the Defense Cyber Workforce Framework (DCWF) to include a new AI/data workforce element defining five AI work roles[22] and six data work roles and a software engineering workforce element including eight work roles[23] —along with corresponding KSATs associated with each. Together these three categories are generally described as the DoD's "digital workforce."[24] DoD is at the beginning of its efforts to code the new AI/data and software engineering work roles into billets within personnel management systems to enable identification, analysis, and quantification of its AI and related workforce to support strategic AI workforce planning. This work, spearheaded by DoD's Chief Digital and AI Office, is expected to be a multi-year effort.

OTHER FEDERAL AGENCIES

There is currently no final framework for characterizing or coding non-DoD Federal AI work roles within the Federal Government, though OPM has provided example work roles [25]. At the time of this writing, however, department- or agency-specific frameworks are being developed or explored within several Federal organizations, including the VA and the National Security Agency (NSA).

Federal AI workforce frameworks will help to assess, track, and meet Federal AI talent needs in the future

AI TALENT SURGE PROGRESS REPORT IN RESPONSE TO EXECUTIVE ORDER 14110

On October 30, 2023, the President issued EO 14110: *Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence.* Section 10.2 of this EO called for entities within the Executive Office of the President to identify the highest-priority mission areas where AI talent is needed, as well as priority categories of AI talent and accelerated hiring pathways for bringing this talent into the government. It also established the AI and Tech Talent Task Force to catalyze and accelerate hiring of AI and AI-enabling talent across the Federal Government. The AI and Tech Talent Task Force was convened by the White House Deputy Chief of Staff for Policy, the White House Office of Science and Technology Policy, and the White House

Increasing Federal AI and related talent is a current Federal executive branch priority

Office of Management and Budget with representatives from the Office of Personnel Management, the General Services Administration's Technology Transformation Services, the Chief Human Capital Officers Council, the Presidential Personnel Office, the Chief Data Officer Council, and the Chief AI Officer Council. In April 2024, the AI and Tech Talent Task Force issued a report to the President on AI Talent Surge progress and recommendations.[26] The National AI Talent Surge goal is to build a strong and diverse Federal AI workforce to support the national priorities:

- Leveraging AI in Government - workforce to assess, pilot, and launch use cases for Federal agencies to responsibly leverage AI to improve government services and programs.
- Building AI Regulatory and Policy Capacity - workforce to develop and enforce policies around AI to protect rights, ensure security, safety, and privacy in trustworthy AI systems.
- Strengthening the AI R&D Ecosystem - workforce to build AI infrastructure and oversee Federal R&D to enable the next generation of cutting-edge AI systems.

To assess gaps in Federal AI capacity, including workforce and technical infrastructure, the AI and Tech Talent Task Force ran a survey reaching 161 respondents across 36 agencies. Employees' responses reinforced the need for more AI talent in government—over 50% of employees believe that their organizations do not have the right positions to build, manage, or procure AI. Additionally, employees highlighted the need for additional AI infrastructure at their agencies. The report to the President on AI Talent Surge includes 10 recommendations ranging from increased hiring, additional incentives, and improving the Federal hiring experience to cultivating public service in the technology ecosystem. One of the recommendations calls for creating the AI Scholarship for Service program as excerpted above.

Recommendation: Create a Federal AI Scholarship for-Service Program

To strengthen the pipeline of AI talent into Federal Government service, pending the availability of funds, the U.S. National Science Foundation (NSF) should establish an AI scholarship-for-service program to recruit and train the next generation of AI professionals to work in the Federal Government. This program should build upon the findings of the report that NSF will issue to Congress in response to the CHIPS and Science Act, and utilize the authorities granted to NSF in the CHIPS and Science Act to establish such a program. The program should prioritize training a diverse population for future AI roles.

Federal AI and Tech Talent Task Force

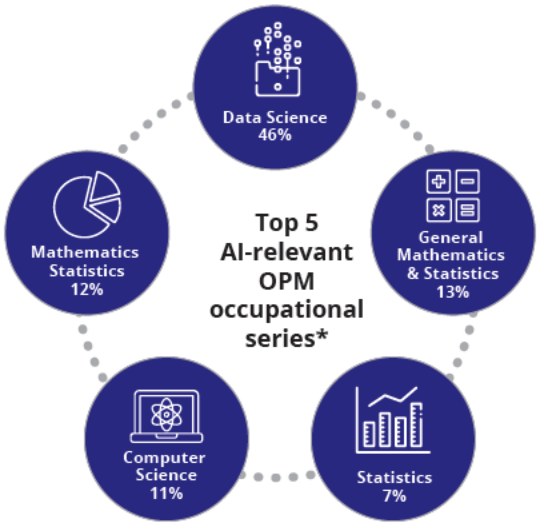
THE CURRENT FEDERAL AI WORKFORCE

Given the early stages of Federal Government activities to identify and quantify the Federal AI workforce, NSF's assessment of the current Federal AI workforce relies on results from analysis of available data, relying on some assumptions. Recent studies have characterized a broad Federal "digital workforce" including individuals in AI, data/analytics, and software work roles as defined in the DCWF.[27,28] This chapter focuses primarily on the subset of the digital workforce in or with the skills required to fill an AI work role or equivalent.

In this report, the AI workforce is defined conceptually as the subset of all Federal workers who have or use AI or ML knowledge, skills, or abilities or who conduct AI/ML tasks as part of their work, independent of job title or occupation and level or field of degree.[29] To approximately characterize the corresponding Federal workforce, this section identifies and provides statistics about relevant cohorts using three methods: (1) leveraging AI-relevant Federal occupational series as a rough proxy, (2) estimating the share and number of workers within each Federal civilian occupational series for whom AI KSATs are a prominent part of their work, and (3) through aggregate statistics of social profile records provided by the private sector labor market analytics firm Lightcast. The data leveraged in this chapter were obtained prior to the release of EO 14110, and thus do not reflect efforts underway in response to its provisions.

PROXY OPM OCCUPATIONAL SERIES FROM FEDSCOPE/EHRI-SDM

AI tools and competencies can be important across a range of Federal occupational series. Federal civilian occupational series are defined by OPM; there are no AI-specific OPM occupational series, and no work roles coded into the anonymized



personnel records made available by OPM through the FedScope platform.[30] To identify the OPM occupational series most likely to involve AI KSATs, recent USAJOBS (a clearinghouse for Federal job postings) JOAs were analyzed. Specifically, 800,000 JOAs from 2022–2023[31] were queried using a list of AI- and ML-specific keywords; 2,372 postings were found to include 1 or more of these keywords in any of the text-based descriptions of the position (including job title, position description, duties, and requirements).[32]

The top five occupational series by share of JOAs with AI/ML keywords were Data Science (46%), General Mathematics and Statistics (13%), Mathematical Statistics (12%), Computer Science (11%), and Statistics (7%); these series are likely the best proxies for AI occupations of all the OPM occupational series, and we consider the demographics of workers in these fields as relevant to the demographics of Federal AI workers; key demographics for these series are plotted in Figures 1, 2 and 3. For comparison, the entire U.S. civilian labor workforce population by sex, race, Hispanic or Latino ethnicity, and disability status is shown in Figure 4.

Lack of diversity in the AI workforce exacerbates the risk of bias in the development, use, and outcomes of AI systems

Based on FedScope civilian personnel records, Figures 1 and 2, the female, Hispanic or Latino, Black or African American, American Indian, or Alaska Native, and Native Hawaiian or other Pacific Islander share of the Federal workforce is each lower than the corresponding U.S. population share for at least four of these five occupational series.[33] This underrepresentation is consistent with findings from recent studies that the broader U.S. AI or AI-relevant workforce is disproportionately white, and male compared to the U.S.

EMPLOYEE RECORDS

Figure 1. Number and Share of FedScope Personnel Records by Gender of Employee for All STEM OPM Occupational Series (Upper Left) and the Five Most AI-Intensive Occupational Series.

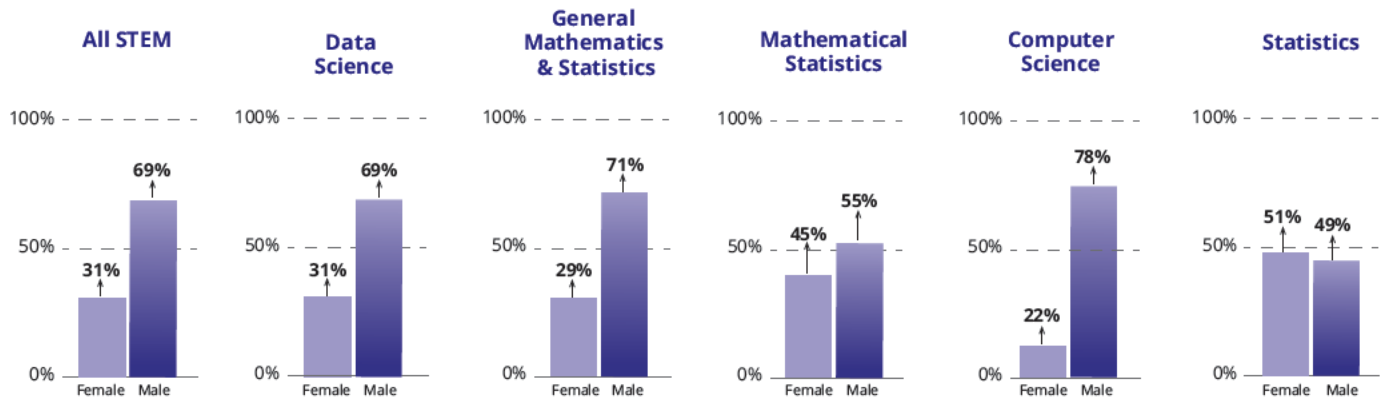


Figure 2. Number and Share of FedScope Personnel Records by Race/Ethnicity of Employee for All STEM OPM Occupational Series (Upper Left) and the Five Most AI-Intensive Occupational Series

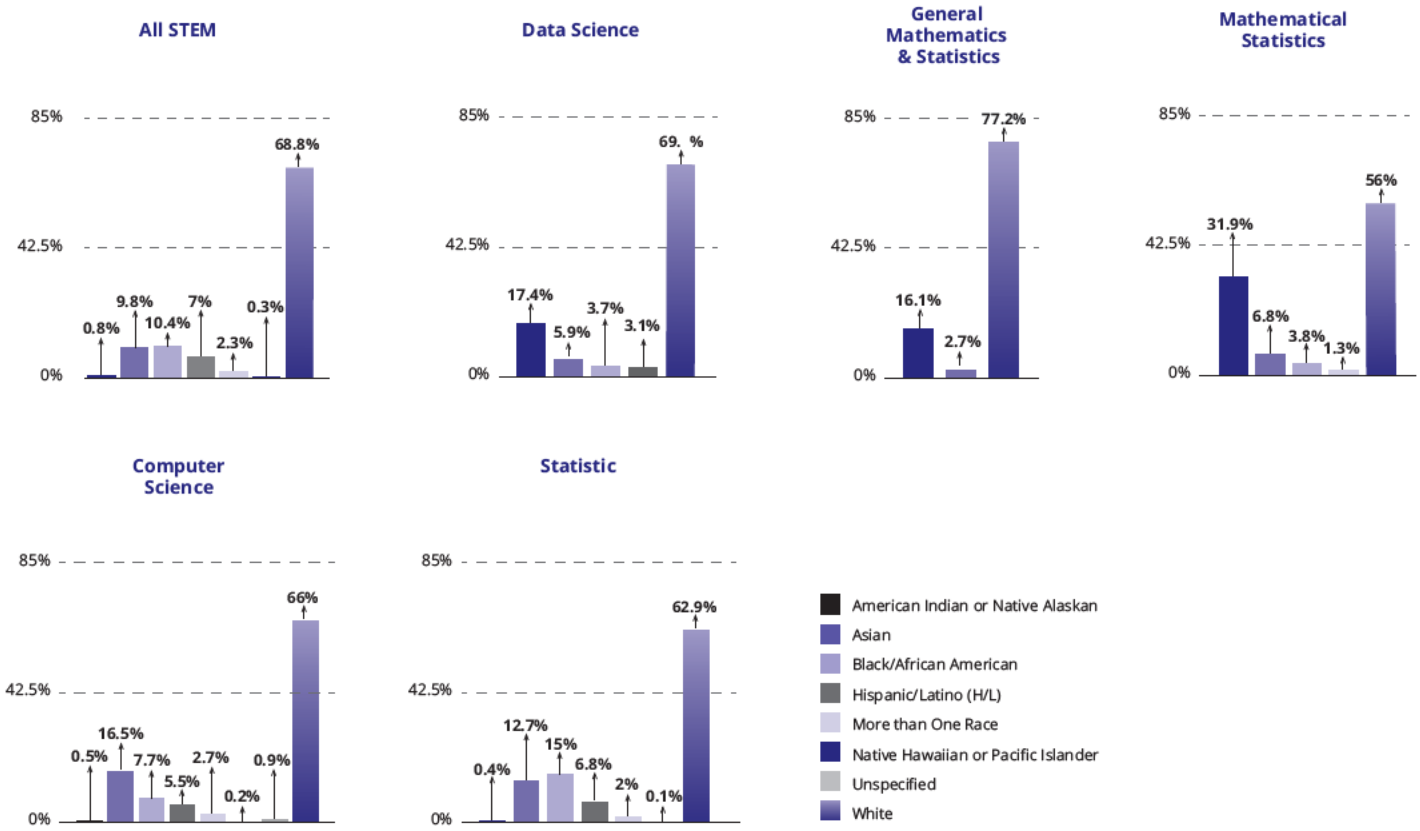
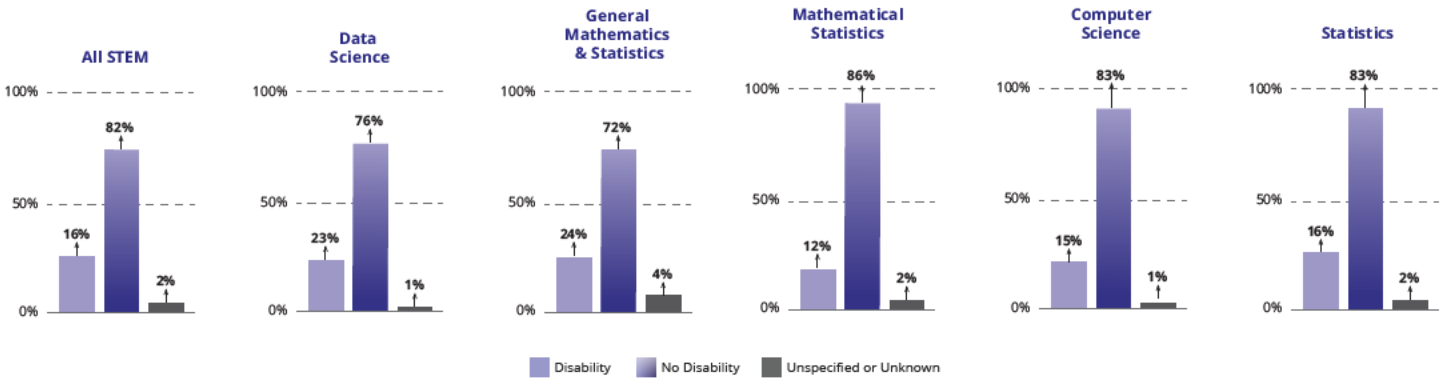


Figure 3. Number and Share of FedScope Personnel Records by Disability Status of Employee for All STEM OPM Occupational Series (Upper Left) and the Five Most AI-Intensive OPM Occupational Series



public at large.[34] Such underrepresentation exacerbates the risk of bias in the development, use, and outcomes of AI systems.

ESTIMATING THE SIZE OF THE CURRENT FEDERAL AI WORKFORCE

Quantitative estimates of the number of workers who are engaged in AI work or who hold AI competencies across all OPM occupational series were derived using two methods. The first leverages the weighted sum of the number of workers currently in each Federal occupation by the "within-occupation share" of recent job postings for that occupation deemed to include associated competencies.[35] Within-occupation shares were computed using USAJOBS JOA AI/ML query results and multiplied by the number of Federal civilian employees in each series reported in FedScope. These estimates are referred to here as the number of "AI workers" or "AI-focused workers" in each occupational series. The total size of the Federal civilian AI workforce is estimated as the corresponding sum across all OPM occupational series. For a rough estimate of the size of broader segments of the workforce, the AI/ML list was augmented successively with data/analytics keywords,[36] and with software and CS keywords, as illustrated conceptually in Figure 5.[37]

Figure 4. U.S. civilian labor workforce population 16 years and older by sex, race, Hispanic or Latino ethnicity, and disability status (Numbers in thousands)

Total	164,287	100.00%
Men	87,421	53.21%
Women	76,866	46.79%
White	125,957	76.67%
Black	21,236	12.93%
Asian	10,921	6.65%
American Indian and Alaska Native	1,826	1.11%
Native Hawaiian and Other Pacific Islander	744	0.45%
Two or More Races	3,603	2.19%
Hispanic or Latino	30,601	18.63%
With a disability	7,528	4.58%

Source: U.S. Bureau of Labor Statistics, 2022 Current Population Survey.
Note: People whose ethnicity is identified as Hispanic or Latino may be of any race.

Figure 5. Schematic of the Digital Workforce and Relevant Subsets, Roughly Corresponding to Combinations of Work Roles in the DCWF (Software, AI, Data)

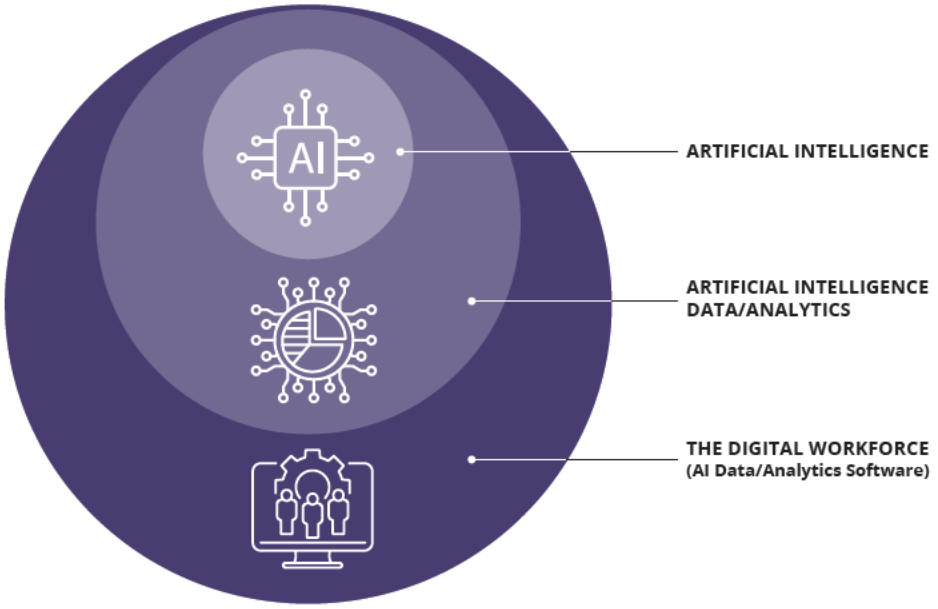


Table 2 presents key results from this approximation method for the most AI-relevant OPM occupational series. It also includes the weighted sum across all OPM occupational series identified in FedScope for each tier of keywords, including those not shown. Additionally, it extrapolates the overall share of the Federal civilian workforce to estimate the workforce size to in the military and intelligence sectors.

Table 2. Estimated Number of Federal Civilian AI, AI+Data, and Digital Workers by OPM Occupational Series

Group	# of Federal workers in Series	Estimated # of Federal AI workers in Series[a]	Estimated # of Federal AI or data workers in Series[b]	Estimated # of Federal digital workers in Series[c]
2210- IT Management	93,377	1,287	4,175	15,760
1560- Data Science	322	148	319	320
1501- General Mathematics and Statistics	149	19	70	74
1529- Mathematical Statistics	1,590	190	367	410
1550- Computer Science	9,957	1,072	1,753	7,989
1530- Statistics	3,626	256	634	672
0301- Miscellaneous Administration and Program	106,770	280	1,506	1,915
0343- Management and Program Analysis	88,348	291	3,355	3,840
…	…	…	…	…
All OPM civilian occupational Series	2,191,361[d]	7,434	28,595	62,734
Active-duty military and intelligence, all occupational series	1,465,000[e]	3,010	10,713	25,397
Total Federal workers	3,656,000	10,444	41,012	88,131

[a] Computed as the number of Federal workers in the group as of March 2023, as reported in FedScope, multiplied by the estimated share that are AI-focused. For Federal civilian occupational series, the share is computed as the prorated share of USAJOBS JOAs opening on or after January 1, 2022 (as obtained on October 17, 2023) that include an AI/ML keyword. For the military and intelligence group, the share is computed as the share of the overall civilian workforce estimated to be AI workers scaled by the ratio of military to civilian personnel in the DoD's cyber workforce (excluding the Army, for which vetted data are not available) as of quarter three of fiscal year 2023, as reported in DoD's Advana system.

[b] Computed as described in note a, except the list of AI/ML keywords was expanded to include data- and analytics-related keywords. This list is likely not comprehensive, and these values are likely underestimates.

[c] Computed as described in note a, except the list of AI/ML keywords was expanded to include data-, analytics-, software-, and computing-related keywords. This list is likely not comprehensive, and these values are likely underestimates.

[d] This number includes 1,274 FedScope/EHRI employee records (out of more than 2 million Federal civilian employee records) that are not indexed with an occupational series. These records are not included in the weighted sum.

[e] Estimated from 2022 DoD workforce demographics data[39] and the estimate of 160,000 civilian and military intelligence workers provided by an interviewee.

The second approach leveraged aggregate statistics from the social profile database private sector labor market analytics The AI share of Federal employees was estimated as the share of individuals identified as employed by the Federal Government holding two or more AI skills from the Lightcast skills taxonomy (by two different definitions named as definition 1 and definition 2 as presented in Appendix B). This share was then extrapolated to the size of the Federal AI workforce. The results of both approaches are summarized in Table 3.

Table 3. Estimates of the Share and Size of the Federal Civilian AI-Focused Workforce

Method	AI share of workforce	Estimated number of AI Federal civilian, non-intelligence workers	Estimated number of military and intelligence AI workers	Estimated total number of Federal AI workers*
USAJOBS + FedScope/EHRI-SDM	0.34%	7,434	3,010	10,444
Lightcast 2023 (definition 1)	0.38%	8,328	4,264	12,591
Lightcast 2023 (definition 2)	0.51%	11,160	5,648	16,809

* The estimated total number of Federal AI workers is the sum of the estimated number of civilian AI workers and the estimated number of military or intelligence AI workers. The military and intelligence counts are estimated by multiplying the overall AI workforce share for each method by the estimated size of the military and intelligence workforce. Sum values might not be precise due to rounding.

These approaches to estimating the size of the Federal AI workforce both suggest that there are at least on the order of 10,000 Federal workers with AI/ML-specific competencies. This estimate includes between 7,400 and 11,200 Federal civilian non-intelligence AI workers and between 3,000 and 5,650 military and intelligence AI workers. The broader Federal digital and related workforce (inclusive of individuals in AI, data/analytics, and software work roles) is likely larger by at least an order of magnitude.

NSF estimates that there are at least 10,000 AI-skilled Federal workers and that the broader Federal digital workforce is larger by an order of magnitude

There is substantial uncertainty in these values, given the assumptions and approximations made. For example, the USAJOBS-based approach assumes that the share of job postings in a given occupational series opening in 2022 and 2023 that mention AI/ML keywords is similar to the share of individuals currently employed in those occupations who are in an AI/ML work role. This assumption could lead to overestimation of the current AI workforce size, as AI is likely currently more important than it was when most current Federal employees were hired. On the other hand, the AI/ML keyword list is likely non-comprehensive,[40] which would

25 Most Common Skills in Lightcast Profiles for Federal Workers with Two or More AI-Specific Skills

1. Machine Learning*
2. Data Analysis
3. Python (Programming Language)
4. Artificial Intelligence*
5. Data Science
6. (Programming Language)
7. SQL (Programming Language)
8. Project Management
9. Data Mining*
10. Statistics
11. MATLAB
12. C++ (Programming Language)
13. Java (Programming Language)
14. Algorithms
15. SAS (Software)
16. C (Programming Language)
17. Data Visualization
18. Software Engineering
19. Deep Learning*
20. Big Data
21. Artificial Neutral Networks*
22. Linux
23. Software Development
24. Natural Language Processing*
25. Statistical Modeling

Note: This list yields insights into common competencies among Federal workers that have two or more skills identified as AI-specific (skills on the "core AI" list). All skills listed are from the Lightcast skills taxonomy.

* Indicates a core AI skill from the list of Lightcast skills used to identify AI workers.

mean that some relevant USAJOBS JOAs were missed in the querying protocol. The result would be an underestimation of the number of AI workers. Additional uncertainty is introduced based on numerous limitations associated with the data sources used, such as the absence of records for military and most excepted service positions and postings (FedScope, USAJOBS), missing information or inconsistency in level of detail from record to record (all), incompleteness of data corpus and potential non-representativeness of the sample (USAJOBS, Lightcast), and the possibility of error introduced during indexing of free text records into the standardized form analyzed (Lightcast).

Common fields of degree indicated in Federal AI-skilled worker profiles

- Engineering (CIP 14)
- Computer and Information Science and Support Services
- (CIP 11)
- Mathematics and Statistics (CIP 27)
- Business, Management, Marketing, and Related Support Services (CIP 52)

INSIGHTS FROM FEDERAL WORKER PROFILES

For additional insights on the composition of the Federal AI workforce, aggregate statistics from profile records for AI-skilled Federal workers, provided by Lightcast, were examined. The most common skills appearing in current Federal AI worker profiles are listed om page 20.

Most AI-skilled Federal workers hold a bachelor's degree or higher

Educational backgrounds of Federal AI workers vary by Federal organization and work role. According to professional profile data from Lightcast, the majority of Federal AI workers hold a bachelor's degree or higher across a variety of fields, suggesting that AI-relevant skills are gained in a variety of educational programs, learned independently, or learned on the job. The most common fields of degree indexed in Federal AI worker profiles, as classified using 2-digit Department of Education Classification of Instructional Program (CIP) codes, included Engineering (CIP 14), Computer and Information Science and Support Services (CIP 11), Mathematics and Statistics (CIP 27), and Business, Management, Marketing, and Related Support Services (CIP 52).

INSIGHTS BASED ON INTERVIEWS WITH FEDERAL AND FFRDC PERSONNEL

Mathematics, coding, statistics, ML, DS, and CS skills—and mission-specific expertise—are important for the Federal AI workforce

Semi-structured interviews with 22 Federal agency or FFRDC staff with knowledge of AI work within their organizations yielded key insights about specific workforce characteristics and needs. While interviews were conducted with a relatively small number of individuals or groups and thus are not representative of the full range of Federal and FFRDC workforce, they serve as illustrative anecdotal case studies and provide important context about the AI workforce.

AI-skilled workers have been sought across degree levels at Federal departments and agencies

Federal personnel identified CS and DS as common fields of degrees held by AI workers; mathematics, coding, statistics, ML, DS, and CS skills as relevant; and mission-specific expertise as advantageous for workers in AI work roles.

Interviewees from Federal defense and intelligence organizations (including DoD, NSA, and the National Geospatial Intelligence Agency) reported that individuals have been hired at all degree levels (i.e., bachelor's, master's, and doctoral); one suggested that at least a bachelor's degree is necessary, ideally with a specialization in AI or at least mathematical foundations that would include linear algebra and statistics.

For non-defense/intelligence departments and agencies (i.e., DOL, Internal Revenue Service, VA, Department of Commerce, and U.S. Department of Agriculture), interviewees also reported hiring of individuals at various degree levels. One explicitly noted that a minimum education requirement for their AI workforce has been beneficial to their organization, while also expressing openness to considering individuals with less formal educational experience at lower General Schedule (GS) levels who have completed a relevant "bootcamp." One interviewee noted that some workers with deep knowledge at the doctoral level are necessary to provide expertise on the

Doctorate-holders are especially important to Federal and National Laboratories

strengths and weaknesses of different types of AI tools for specific use cases.

The interviewees working on fundamental research in Federal or National Laboratories (including the National Aeronautics and Space Administration [NASA] Jet Propulsion Laboratory, Oak Ridge National Laboratory, Naval Research Laboratory, and the Air Force Research Laboratory) emphasized the importance of doctoral degree holders among their workforce. Quantitative estimates of the share of a lab's AI workers with doctoral degrees ranged from 25 to 70 percent of workers.

The definition of the AI workforce used here is not inclusive of the entire U.S. digital workforce; AI- and ML-specific keywords or skills were leveraged to identify relevant positions or workers. Many of the AI-related but more general skills identified as important for AI work—such as coding, statistics, data analysis, mathematics, and ethics—are held by a broader cohort of workers than what was defined herein as the AI workforce. Thus, it is likely that there are more Federal employees in the government who are capable of conducting AI work should they be upskilled, than are currently conducting such work. Presumably, those workers already have core work functions that do not include AI.

Between 2018 and 2023, there have been on the order of 1,000 Federal and 3,000 FFRDC job postings annually calling for 2 or more AI skills, the majority of which required a bachelor's degree or higher

CURRENT AND PROJECTED FEDERAL AI WORKFORCE NEEDS

To characterize current Federal AI workforce needs, NSF considered analyses of recent Federal job postings calling for AI-specific skills. While it is difficult to predict future trends with certainty, quantitative estimates of future need are based on hypothetical AI workforce growth scenarios. Additional insights about current and projected Federal AI workforce needs were derived from interviews with Federal and FFRDC personnel and review of Federal agency AI strategies and policy documents.

FEDERAL AI JOB POSTINGS

While job postings do not map one-to-one with positions or new hires in a given year, they are a helpful indicator of current workforce needs. Analysis was conducted to identify (1) Federal Job postings for 2022–2023 from USAJOBS[41] containing one or more AI/ML keyword and (2) Federal job posting records from Lightcast for 2018–2023 requiring two or more AI/ML "skills."[42]

Machine learning and mathematics skills are named in more than 70 percent of recent Federal AI job postings requiring a minimum of a bachelor's degree

Both USAJOBS and Lightcast job posting data included on the order of 1,000 Federal AI-focused job postings per year in recent years, of which approximately 400 per year on average were at the GS 7–13 levels according to USAJOBS records (and thus likely to be open to recent graduates, based on NSF's experience with the CyberCorps® program).

Further analysis of Lightcast job posting records, which are indexed with competencies (referred to by Lightcast as skills) in the Lightcast taxonomy, provides insights into competencies sought by the Federal Government in recent years. The top 10 skills indexed by Lightcast for Federal AI job postings from 2018–2023 are listed in Table 4 by the minimum degree level called for in the posting, along with (in parentheses) the share of postings in each category that are indexed with each skill. The most common job titles (as standardized in the Lightcast database) by minimum level of degree required are listed in Table 5

Recent postings for Federal AI jobs requiring a doctoral degree have been research-focused, and in different areas of science

Table 4. Top 15 Most Frequently Indexed Skills in Lightcast Federal Job Posting Records Calling for Two or More AI-Specific Skills, by Minimum Degree Requirement, 2018–2023*

BACHELOR'S DEGREE (1,969 postings)	MASTER'S DEGREE (227 postings)	PHD OR PROFESSIONAL DEGREE (394 postings)
Mathematics (88%)	Machine Learning (78%)	Research (90%)
Machine Learning (77%)	Research (73%)	Machine Learning (82%)
Computer Science (65%)	Mathematics (57%)	Artificial Intelligence (49%)
Data Science (63%)	Artificial Intelligence (54%)	Communications (42%)
Data Analysis (61%)	Management (48%)	Python (Programming Language) (42%)
Statistics (58%)	Computer Science (46%)	Computer Science (41%)
Python (Programming Language) (57%)	Data Science (42%)	Management (32%)
R (Programming Language) (53%)	Statistics (39%)	Mathematics (32%)
Leadership (53%)	Python (Programming Language) (37%)	Biology (32%)
Management (53%)	Communications (37%)	Data Analysis (31%)
Artificial Intelligence (51%)	R (Programming Language) (36%)	Deep Learning (28%)
Research (49%)	Data Analysis (33%)	Physics (25%)
Data Mining (45%)	Algorithms (30%)	Writing (25%)
Top Secret-Sensitive Compartmented Information (TS/SCI Clearance) (45%)	Writing (29%)	R (Programming Language) (25%)
Top Secret Clearance (42%)	Leadership (24%)	Statistics (24%)

Notes: Parentheticals in column headers indicate the total number of Lightcast Federal AI job postings (defined here as those indexed with two or more AI-specific ["core AI"] skills from the Lightcast taxonomy) with the corresponding minimum degree requirement. Percentages indicate the share of postings in each category that are indexed with a given skill. Possession of, or ability to receive, a security clearance is tagged as a "skill" in the Lightcast records.

*Data for 2023 are only complete through October 31, 2023.

Table 5. Top 10 Most Common Federal AI Position Titles by Minimum Degree Requirement in Lightcast Database, 2018–2023*

BACHELOR'S DEGREE (1,969 postings)	MASTER'S DEGREE (227 postings)	PHD OR PROFESSIONAL DEGREE (394 postings)
Data Scientists (410)	Data Scientists (22)	Unclassified (91)
Programmatic Managers (106)	Fellows (22)	Postdoctoral Fellows (71)
Computer Scientists (105)	Unclassified (21)	Machine Learning Scientists (15)
Research and Development Scientists (103)	Mathematical Statisticians (10)	Staff Scientists (10)
Statisticians/Data Scientists (95)	Fellowship Interns (6)	Environmental Scientists/Biologists (9)
Data Architects (81)	Attorneys and Consultant (5)	Data Scientists (8)
Methodologists (76)	Postdoctoral Fellows (5)	Machine Learning Researchers (8)
Mathematical Statisticians (70)	Research Fellows (4)	Research Associates (7)
Medical Imaging Scientists (68)	Artificial Intelligence/Machine	Fellows (6)
Photogrammetrists (57)	Learning Engineers (3)	Investigators (6)
	Data Science Fellows (3)	

Notes: Analysis of Lightcast Federal AI job postings identified as described in Table 4. Parentheticals in column headers indicate the total number of postings for each title. "Unclassified" job titles are those that did not map to a Lightcast-standardized title.

* Data for 2023 are only complete through October 31, 2023.

FFRDC JOB POSTINGS

Analysis of Lightcast job postings for FFRDCs or the organizations that operate them yielded more than 3,000 AI-focused postings annually in recent years (roughly three times the number for Federal postings), with approximately 800 of these likely open to recent graduates.[43] This count suggests that current need for AI professionals may be higher at FFRDCs than within Federal departments and agencies. Assuming the share of recent FFRDC job postings (3.8 percent) calling for AI or ML skills is a proxy for the share of the FFRDC workforce that requires these skills yields an estimate of approximately 5,700 AI professionals at FFRDCs or FFRDC operators. While these workers are in general not Federal employees, this cohort makes substantial contributions to missions of Federal agencies and augments the Federal workforce.

PROJECTED FUTURE NEED FOR AI PROFESSIONALS

Estimating the size of the future Federal AI workforce and need for additional AI professionals requires making assumptions regarding potential hypothetical growth scenarios, of which two are presented here. The moderate scenario assumes for the Federal AI workforce the 5-year growth projection estimated by BLS for Data Scientists (SOC 15-2051) of 17.6 percent (or 35.2% over 10 years) U.S. workforce-wide, and linear growth over time. In the accelerated scenario, it is projected that the size of the Federal AI workforce will double over 5 years (and triple over 10 years). Applying these two growth scenarios to the range of estimates of the current Federal AI workforce size in 2023 yields the estimated future Federal AI workforce sizes presented in Table 6.

Because graduates of an AI SFS would be most likely to pursue civilian Federal employment (rather than military positions), estimates of future Federal hiring needs for AI professionals presented here are limited to the civilian workforce. To estimate the future need for new AI hires, the projected annual AI workforce growth in 2028 and 2033 for the assumed scenarios was added to the number of separations estimated in those years (based on AI worker separation rates estimated using FedScope data from 2022–2023), inclusive of all GS levels.[44] The number of new AI positions likely to be filled by recent graduates was estimated by repeating the analysis for GS levels 7–13, based on NSF's experience with the CyberCorps® SFS program.

Table 6. Projected Federal AI-Focused Workforce Size and Civilian New Hire Needs in 2028 and 2033 under Moderate and Accelerated Growth Scenarios

	Estimated Total Federal AI Workforce Size			Estimated Number of New, Federal Civilian AI hires needed			
2023–2033 Growth Scenario	**2023**	**2028**	**2033**	**Total in 2028[a]**	**GS 7–13 in 2028[b]**	**Total in 2033[a]**	**GS 7–13 in 2033[b]**
Moderate (17.6% over 5 years) [c]	10,444–16,809	12,282–19,767	14,120–22,726	726–1,082	393–586	1,063–1,585	575–858
Accelerated (100% over 5 years) [d]	10,444–16,809	20,888–33,618	31,332–50,427	2,304–3,437	1,248–1,861	4,220–6,294	2,285–3,408

a. Computed as the estimated net growth in (civilian, including intelligence) AI workforce size in year of projection plus the estimated number of AI separations (workers who leave the Federal workforce and must be replaced) in year of projection (estimated as the 2023 attrition rate, computed using FedScope Employment and Separations data and within-occupation AI shares based on USAJOBS analysis, multiplied by the estimated workforce size in year of projection).

b. Assumes that the estimated GS 7–13 share of new Federal civilian AI hires in 2023 is a reasonable proxy for the share of new Federal civilian AI hires at the GS 7–13 level in 2028 and 2033.

c. Moderate scenario: This scenario assumes for the Federal AI workforce the 5-year growth projection estimated by BLS for data science positions (17.6%), U.S. workforce-wide, and linear growth over time.

d. Accelerated scenario: Assumes a doubling (100% increase) in the Federal AI workforce size in 5 years and a net tripling (200% increase) over 10 years relative to 2023 estimates.

Under both scenarios, the calculations suggest that approximately half of future new hires needed would be at the GS 7–13 levels. Under the moderate linear growth scenario, this approach suggests that 393 to 586 new civilian GS 7–13 AI hires would be needed in 2028. The accelerated growth scenario suggests that 1,248 to 1,861 new civilian GS 7–13 level AI workers would need to be hired in 2028 by the Federal Government. Further estimations show the distribution of those hires by degree level: approximately one-fifth at the doctoral level, one-half at the master's level, and one-third at the bachelor's level (Table 7). These analyses are limited to the Federal workforce, and are underestimates of the collective need across Federal, State, local, and Tribal governments and at FFRDCs. For insights, we may consider that (as of 2021) 235 (7 percent) of approximately 3,400 CyberCorps® SFS graduates were placed at GS 7-13 levels of government. The corresponding share of newly graduated AI workers going to State, local, and Tribal governments in 2028 would amount to on the order of 100.

Workforce projections suggest that between 700 and 3,500 new Federal civilian AI workers will be needed in 2028

Table 7. Projected Number of New Civilian AI Hires in 2028 at Varying Degree Levels and 5-Year Change Assumptions

2023-2028 Growth Scenarios	Estimated # new GS 7–13 civilian AI hires in 2028	New bachelor's-level civilian AI hires	New master's-level civilian AI hires	New doctoral-level hires
Moderate (17.6% over 5 years)	393–586	130–193	188–281	75–112
Accelerated (100% over 5 years)	1,248–1,861	412–614	599–893	237–354

Source: The estimated number of new civilian AI hires at the GS 7–13 level is drawn from Table 6.

Tabulations for each degree level are based on OPM FedScope records on current Federal employment in the 1560 (data science) occupational series in October 2023. For individuals employed in the 1560 occupational series in October 2023 who had specified degree information, 33% held a bachelor's degree or less, 48% held a master's degree, and 19% held a doctoral degree. These percentages were applied to the total new GS 7–13 civilian AI hires to estimate the number of these hires at each degree level.

CURRENT AND FUTURE AI WORKFORCE NEEDS AND CHALLENGES EXPRESSED IN INTERVIEWS WITH FEDERAL AND FFRDC PERSONNEL

Interviews with 22 Federal and FFRDC personnel[45] from defense and intelligence agencies, non-defense agencies, and Federal or FFRDC labs yielded additional context about Federal AI workforce needs as perceived in autumn of 2023. While these findings are qualitative and not necessarily fully representative of all Federal agencies, they provide anecdotal insights into current and anticipated future needs, along with current challenges and potential approaches to overcoming them.[46]

Expertise needed in the Federal Government

- AI for cybersecurity and cybersecurity of AI
- AI for geospatial information systems (GIS) and analyses
- Autonomous systems
- Human-machine teaming
- AI technology in combination with policy
- AI technology and its ethical, legal, and societal implications; civil rights; and potential harms
- AI testing and evaluation of potential harms
- AI in combination with STEM fields
- AI, analytics, and data science in general

Interviewees identified key areas of expertise of current importance or likely to be needed within the Federal Government in the foreseeable future. They pointed not only to the need for core AI-relevant competencies—such as mathematics, statistics, and coding, and deep technical AI expertise at the doctoral level—but also for individuals with AI expertise and subject-matter knowledge and experience across a variety of fields critical to agency missions.

The current Federal and FFRDC workforce need new graduates with AI skills

For example, interviewees from three agencies identified the intersection of AI and cybersecurity— including AI for cybersecurity and the cybersecurity of AI systems— as important for current or future work. Interviewees from eight agencies indicated current or future needs related to AI policy or governance, including ethics and oversight in relation to civil rights and potential harms. Several interviewees also noted the increasing importance of AI applications in STEM fields, such as chemistry and physics (one agency) or materials science (one agency), and interest in candidates with skills in AI and another STEM area, such as GIS (two agencies) and biology or medicine (one agency). As AI systems mature and are increasingly deployed in different Federal work contexts, personnel with expertise in effective human-machine teaming (two agencies); autonomous systems (two agencies); and testing, evaluation, validation, and verification of AI systems (three agencies) will become increasingly important. Interviewees also identified needs for AI workers across a variety of degree levels and fields, including recent graduates; there was no single profile of an AI

U.S. citizens are needed to fill AI positions that are security-sensitive

worker that applied universally to all agencies.

Beyond expertise and competencies, interviewees from four agencies noted that some current and future positions are security-sensitive; three explicitly noted that such positions may only be filled by U.S. citizens. Interviewees from two agencies commented on the importance of diversity, including to help ensure that AI systems are not built by homogenous groups of people, which can lead to unintended bias. An interviewee from an FFRDC commented that it is challenging to hire a diverse workforce; one interviewee highlighted the importance of ensuring equitable access to the resources required to prepare a competitive AI professional for meeting this objective. More broadly, participants pointed to the increasing need not only for technical AI expertise in the Federal workforce, but also for building AI awareness and literacy across the Federal AI workforce; one interviewee described their organization's entire workforce as comprising only two categories: AI professionals and the AI-ready workforce.

Increasing diversity in the AI workforce will help to increase capacity and help ensure that AI systems work well for all

The Federal Government competes with the private sector on salaries and resources in attracting AI talent

Federal personnel identified a range of challenges associated with recruiting, hiring, and retaining AI professionals. Competition with the private sector for AI professionals was noted by individuals from eight agencies, including for diverse candidates (one agency), particularly because industry positions often offer much higher salaries. Two interviewees suggested that the slow pace of the Federal hiring process leads to candidate attrition; one suggested that long timelines associated with realizing the impact of AI work in the Federal Government also poses some challenges with worker retention. One interviewee commented that their organization is also not always visible to potential candidates as they begin their job search. Limitations that reduce AI worker satisfaction could affect recruitment and retention of personnel, including inadequate technical resources for the job (one agency) or insufficient opportunity for expert collaborative work (one agency).

Interviewees also commented on the difficulty of finding qualified workers. In particular, one interviewee suggested that the PhD-holding candidate pool is small, likely because industry salaries are more attractive than graduate stipends and because there are relatively few faculty at academic institutions to serve as graduate mentors. Further, interviewees from three Federal or FFRDC labs reported challenges in discerning which candidates had requisite skills, which are not always easy to assess based on resumes; at least one agency has implemented skills assessments as part of the hiring process.

Key enabling factors for Federal AI work include the establishment of mature technologies, tools, and enabling infrastructures; improved diversity of the professional AI workforce; and AI literacy across the entire Federal workforce

Interviewees identified a variety of factors that could be important for the future of the Federal AI ecosystem. Maturation of the infrastructure necessary to conduct AI work in Federal organizations—such as data pipelines for AI (two agencies), and foundations for AI teams (two agencies) and human-machine teaming (two agencies)—will be needed for achieving agency missions. Interviewees from three agencies also noted the importance of implementing or identifying opportunities to implement AI for business operations. One interviewee suggested that central AI test and evaluation or validation and verification (TEVV) shops with concentrated AI, ethics, and governance expertise could also be made available to advise smaller organizations on AI solutions, implementation, and appropriateness of use for specific applications.

3. U.S. AI EDUCATIONAL CAPACITY

This chapter reports on assessments of the capacity of IHEs to produce graduates with degrees, certifications, and relevant skills related to AI that meet the current and future needs of the Federal workforce. This assessment was done by answering the following questions:

- How many institutions are offering AI degree programs, and how diverse, in terms of research activity, MSI status, and geographic location, are the institutions offering AI degree programs? How many students are graduating from these institutions' AI and related degree programs?
- How does the estimated number of U.S. citizens or permanent residents projected to graduate with AI and related degree programs in 2028 compare with the estimated demand for new graduates in the Federal AI workforce?
- What knowledge and skills are taught in AI degree

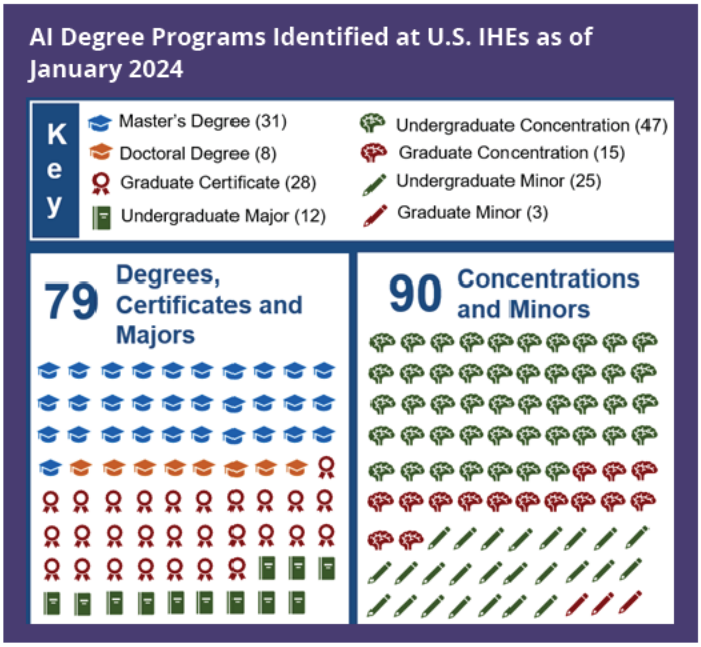
programs, or in other related degree programs (e.g., DS)?

- Are the knowledge and related skills taught by these AI or other related degree programs aligned with Federal AI workforce needs?
- How diverse are the students graduating with CS degrees (as a proxy for diversity of students graduating with AI degrees)?
- Do institutions have the resources necessary to stand up new AI or other related degree programs, grow their current AI or other related degree programs to educate additional students, or refresh the knowledge and skills taught in their AI degree programs?

To answer these questions, available Federal statistical data from IPEDS—which includes information on degree programs and graduates across degree fields, including AI, CS, and DS—were leveraged. Additionally, published reports and analyses of AI or AI-related academic programs were reviewed; however, these prior reports largely did not have the AI-focus nor depth required for this report. Thus, there was a need to conduct significant original data collection for this report. The datasets collected include a catalog of AI degree programs, as well as information on their corresponding curricula including course titles and course descriptions. Other data sources used in this report include an RFI fielded in May 2023 by NSF that asked about the capacity of IHEs "to produce graduates with AI competencies to meet the current and future needs of the Federal workforce." The RFI was framed in the context of planning for an AI SFS program.[47] These data sources were supplemented with qualitative information from semi-structured interviews conducted with representatives from a sample of IHE AI degree programs. To analyze these data, a combination of manual coding and qualitative analysis as well as natural language processing (NLP) techniques was used.

CURRENT AI ACADEMIC PROGRAMS AT U.S. IHES

An inventory of AI academic programs of study at U.S. IHEs was compiled for both undergraduate and graduate levels—including undergraduate majors, minors, concentrations, master's degrees, professional certificates, and doctoral degrees.[48] At the time of this writing, 169 total AI academic programs, including undergraduate majors, concentrations, graduate degrees, certificates, and minors at 118 U.S. institutions were identified.[49] These AI programs included 12 undergraduate majors, 31 master's degrees, 28 graduate certificates, and 8 doctoral degrees across 67 institutions. Additionally, 47 undergraduate concentrations, 25 undergraduate minors, 15 graduate concentrations, and 3



graduate minors were identified across 80 institutions. Some institutions offer more than one type of AI program.

Some of these AI academic programs were launched as recently as this academic year (2023–2024, at the time of writing), and more have been announced since the time of this report's writing. Through interviews and analysis of an AI RFI conducted by NSF, 20 out of 117 responding to RFI and 5 of 11 interviewed IHEs indicated they plan to launch new AI programs or to spin off an existing AI program into additional programs (i.e., they currently offer an undergraduate major and plan to launch a minor) in the future.

The majority of AI academic programs are offered by R1 institutions

These AI academic programs are offered by IHEs across the range of Carnegie Classifications[50], though the majority (54%) are offered by Doctoral Universities: Very High Research Activity (colloquially known as "Research One" or "R1") institutions. In addition, out of 146 R1 institutions nationally, 44% offer an AI program of any type or level. Approximately 10% of other doctoral-level institutions and about 1 percent of the master's and undergraduate institutions offered AI programs at the time of this writing.

Only two Historically Black College and Universities (HBCUs) offer an academic program in AI: North Carolina Agricultural & Technical State University and Bowie State University, which both offer a graduate concentration in AI. Thirteen

AI academic programs are offered by Hispanic-Serving Institutions (HSI). Half of the HSIs offering AI programs are partners in the NSF-funded Computing Alliance of Hispanic-Serving Institutions (CAHSI)[51]. No HBCU or HSI AI programs offers undergraduate majors. No Tribal Colleges and Universities (TCU) offer AI programs.

The catalog of AI degree programs does not itself contain information on the number of graduates with AI degrees from those programs. No single data source consistently reports the number of AI graduates; therefore, several datasets were leveraged to generate estimates of the number of graduates with different degree types.

Universities report degrees completed in IPEDS, but inconsistent use of the AI-specific CIP code[52] results in an undercount of graduates. Only around half of the AI degrees reported in IPEDS could be validated with an AI degree program of the same type and/or level. Still, a lower bound estimate of the total number of AI degrees granted can be obtained using IPEDS data for the institutions reporting AI degrees for which that particular degree program was validated.

In academic year 2021–2022, 43 bachelor's degrees at three institutions, 285 master's degrees at 16 institutions, and 37 doctoral degrees at five institutions were awarded according to IPEDS records for CIP 11.0102.[53] However, these degrees only reflect the graduates of fewer than half of the AI degree programs included in the catalog of AI degree programs, making this estimate of the number of degrees an underestimation.[54]

Further, IPEDS only tracks "majors" rather than specializations, concentrations, or minors. The CRA Taulbee survey is an annual survey of North American information, CS, and computer engineering PhDs, which tracks PhD specialty areas such as AI and human-computer interaction, among other emerging technology subfields.[55] The 2022 Taulbee Survey reports that there were 2,105 total PhDs awarded in CS, computer engineering, or information programs (Information Science, Information Systems, Information Technology, Informatics, and related disciplines with a strong computing component), of which 436 had a specialty in Artificial Intelligence/Machine Learning. This is an order of magnitude more PhDs with training in AI than reflected by the estimation based on IPEDS data.[56]

Additionally, estimates were generated for the number of CS graduates with AI concentrations (Table 8). Because an AI concentration, unlike a minor, is associated with a particular degree major, typically a CS bachelor's degree, IPEDS data can be used for CS degrees conferred by the universities that were found to have an AI concentration associated with their CS department. In academic year 2021–2022, approximately 11,000 total CS bachelor's degrees[57] were awarded from the 42 institutions with an AI concentration available at this level based on IPEDS data. A share of CS students can be assumed to choose the AI concentration at those institutions, with 10 percent as a lower estimate and 25 percent as an upper estimate of the share of CS students who choose an AI concentration[58]. Assuming only 10 percent of these CS bachelor's students choose an AI concentration, that would mean ~1,000 students are graduating each year with a CS undergraduate degree with an AI concentration. Assuming 25 percent of all CS bachelor's students from these institutions choose an AI concentration, then there would be ~2,800 students graduating with this degree and concentration each year. From institutions with AI concentrations associated with a CS master's degree in IPEDS in 2022, there were ~2,000 CS master's degrees awarded. Again, assuming between 10 to 25 percent of these graduates chose an AI concentration, this figure translates to between ~200 and ~500 CS master's students, respectively, who are graduating with an AI concentration.

Table 8. Estimate of Number of CS Students Choosing an AI Concentration

	CS Bachelor's	CS Master's
Number of institutions with an AI concentration at this degree level	44	12
Total number of CS graduates at this degree level in academic year 2021-2022 from institutions with an AI concentration	11,130	1,980
Assumptions about share of CS students that choose an AI concentration:		
10% of CS students choose an AI concentration	1,113	198
25% of CS students choose an AI concentration	2,783	495

Source: Tabulated based on 2022 IPEDS data.

Additionally, IPEDS was used to determine the number of DS degrees awarded[59]. In 2022, 724 undergraduates earned bachelor's degrees and 1,208 earned master's degrees.[60]

COMPARING PROJECTIONS OF FEDERAL AI WORKER NEEDS WITH PROJECTIONS OF U.S. CITIZENS OR PERMANENT RESIDENTS WITH AI AND RELATED DEGREES

Comparisons were performed to address whether sufficient numbers of students with AI and AI-related degrees will be graduating to meet projected Federal AI worker needs. A series of assumptions were made to generate reasonable estimates of the number of U.S. citizens or permanent residents graduating with these degrees who would be expected to enter Federal service given historical averages (the "supply-side") as presented in Table 9. These estimates are then compared with estimates of the number of Federal AI-focused workers who will need to be hired in the future under the assumed growth scenarios (the "demand-side") as shown in Table 9. If the demand estimate is greater than the supply estimate, that suggests that there will need to be new incentives for U.S. citizens or permanent residents to enter Federal service, such as through an AI SFS program. Those incentives could be to direct graduates toward Federal jobs (e.g., through a scholarship for service) or could increase the number of graduates, on the assumption that some will take Federal positions (e.g., through fellowships).

To compare supply and demand, estimates of the projected number of AI degrees, CS degrees with AI concentrations[61], and DS degrees awarded across all degree levels in 2028 were tabulated first. Historical IPEDS data on the growth in the number of CS bachelor's degrees awarded indicate an ~72% increase in the number of bachelor's degrees awarded over the five-year period from 2017 to 2022. For this analysis, a simplifying and conservative assumption that degree awards for all degree types and levels will increase by 72% between 2022 and 2028 was used.[62]

Next, estimates of the share of students who are U.S. citizens or permanent residents were multiplied by the estimated number of graduates with AI degrees, CS degrees with AI concentrations, and DS degrees, across all degree levels. According to IPEDS, for CS degrees (CIP 11), approximately 90% of bachelor's degrees, 50% of master's degrees and 40% of doctoral degrees are earned by U.S. citizens or permanent residents, and for DS degrees, approximately 80% of bachelor's and 71% of the master's degree recipients were U.S. citizens or permanent residents. It was assumed that the share of graduates with AI degrees who are U.S. citizens or permanent residents matches that of graduates with CS degrees.[63]

Combining this information suggests that ~4,800 bachelor's degrees, ~1,400 master's degrees, and ~300 doctoral degrees in AI and related fields will be awarded to U.S. citizens or permanent residents in 2028 (Table 9).

Finally, using data from the National Survey of College Graduates (NSCG)—which show that of all CS degree holders (at any degree level), approximately 5% were employed in the government sector in 2022—estimates for the number of U.S. citizens or permanent residents graduating with these AI and related degrees that would enter government service were tabulated. Under these sets of assumptions, 244 bachelor's degree recipients (mostly with CS bachelor's degrees with AI concentrations), 70 master's degree recipients (more DS master's degrees than other degree types), and 15 doctoral degree recipients with AI and related degrees will enter Federal service.

Table 9. Estimates of U.S. Citizens or Permanent Residents Graduating in 2028 with AI and Related Degrees Expected to Enter Federal Service

	Total degrees in 2022	Estimated total degrees in 2028[f]	Estimated fraction that are U.S. citizen or permanent resident	Estimated number that are U.S. citizens or permanent residents in 2028	Estimated number of those graduates that will work in government[i]
Total all degrees	5,008	8,614		6,581	329
Total bachelor's degrees	3,188	5,483		4,873	244
AI bachelor's degrees	43[a]	74	90%[g]	67	3
CS bachelor's + AI concentration	2,783[c]	4,787	90%[g]	4,308	215
Half of DS bachelor's degrees d	362[e]	623	80%[h]	498	25
Total master's degrees	1,384	2,380		1,408	70
AI master's degrees	285[a]	490	50%[g]	245	12
CS master's + AI concentration	495[c]	851	50%[g]	426	21
Half of DS master's degrees d	604[e]	1,039	71%[h]	738	37
Total doctoral degrees	436	750		300	15
AI doctoral degrees	436[b]	750	40%[g]	300	15

[a] Based on IPEDS 2022 records from CIP 11.0102 (AI) where a degree of the same type and level were validated.

[b] Based on 2022 Taulbee survey count of computer science, computer engineering and informatics PhDs from North American institutions with a specialty in Artificial Intelligence/Machine Learning.

[c] Based on IPEDS 2022 records from CIP 11.01 (Computer and Information Sciences, General) and 11.07 (CS) for institutions with AI concentrations as identified in the catalog of AI degree programs, and an assumption that 25% of these CS students will choose an AI concentration.

[d] The estimate that half of U.S. citizens or permanent residents earning degrees in DS might be relevant to AI work is based on the finding that 46% of jobs in OPM series 1560 (DS) were AI-focused.

[e] Based on IPEDS 2022 records of degrees in CIP 30.70 (DS)

[f] Based on an assumption that the number of degrees awarded will grow by 72% between 2022 and 2028, based on historical growth of 72% in the number of CS (CIP 11.01 and CIP 11.07) bachelor's degrees awarded from 2017-2022. The number of CS master's degrees awarded over 2017-2022 was relatively flat, however, from 2012-2022, the number of CS master's degrees awarded grew by nearly 120%. For this exercise, a simplifying, and conservative, assumption was made - that the number of CS master's degrees and doctoral degrees awarded will increase at the same rate of 72%. There is not enough historical data on AI or DS degree awards to estimate the growth in degrees awarded, so the estimated growth of 72% of CS bachelor's degrees was used there as well, for both bachelor's and master's degrees. The set of assumptions used here help generate an upper estimate for the number of new graduates with AI-related degrees, which allows for conservative assessment of whether future demand for new AI workers still exceeds this upper estimate for future supply.

[g] Based on IPEDS 2022 records on the number of U.S. citizens and permanent residents awarded CS degrees (CIP 11). There is IPEDS data available on the share of AI degrees (CIP 11.0102) awarded to U.S. citizens and permanent residents, which indicate that 81% of bachelor's degrees, 46% of master's degrees and 24% of doctoral degrees in AI were awarded to U.S. citizens and permanent residents in 2022. However, the IPEDS data on AI degrees (CIP 11.0102) represent only a very small number of institutions (3 for bachelor's degrees, 16 for master's degrees, 5 for doctoral degrees), which may make the shares reported for AI degrees skewed based on a few particular universities reporting these degrees.

[h] Based on IPEDS 2022 records on the number of U.S. citizens and permanent residents awarded DS degrees (CIP 30.70).

[i] Based on custom tabulations of public-use NSCG 2022 data, which show that of all CS degree holders (at any degree level), approximately 5% were employed in the government sector in 2022.

Table 10 compares the projections of the demand for Federal AI-focused workers in 2028 with the projections of the number of new U.S. citizens or permanent residents earning degrees in AI, DS with AI focus, or in CS with an AI concentration in 2028 who would be expected to enter Federal service given historical averages. The first row identifies the number of graduates projected to enter Federal service based on historical averages. The second row shows the range of demand for the two growth scenarios for Federal AI-focused workers at the bachelor's, master's, and doctoral levels.

There is a risk that there will not be enough U.S. citizen or permanent resident graduates with AI bachelor's degrees to meet future Federal AI workforce demand

The comparison suggests that for bachelor's-level graduates, there would likely not be a sufficient number of graduates to meet demand. It is important to note that this analysis does not include FFRDC positions, and if they hire for AI positions at a rate comparable to the Federal Government, then there clearly will be a need for more bachelor's-level graduates with AI and related degrees to meet the combined demand.

At the master's and doctoral level, demand for Federal AI workers is well above the projected number that would enter Federal service. Given that additional AI-focused workers will be required at FFRDCs as well, it is clear that there will not be a sufficient number of master's- or doctoral-level graduates without a program such as an AI SFS to direct them toward Federal service (including at FFRDCs). Presumably, given the small number of U.S. citizens or permanent residents completing doctorates in AI, most Federal or FFRDC AI workers at the doctoral level will need to be drawn from fields that use advanced analytics techniques rather than from AI-specific programs.

There is a clear need for more U.S. citizens or permanent residents with AI master's degrees or doctorates to meet future Federal AI workforce demand

It is clear that there will not be a sufficient number of master's- or doctoral-level graduates without a program such as an AI SFS to direct them toward Federal service (including at FFRDCs).

Table 10. Comparison of Federal AI Workforce in AI SFS-relevant Positions in 2028 Demand Projections with Projected Supply of U.S. Citizen or Permanent Resident Graduates in 2028 with AI-Related Degrees

	2023–2028 Growth Scenario	Bachelor's	Master's	Doctorates	Total
Supply Scenario	Approximate number of U.S. citizens or permanent residents with AI-related degrees projected to enter Federal service based on historical estimates	244	70	15	329
Moderate Demand Scenario	Estimated range of number of new Federal AI-focused workers in AI SFS-relevant positions needed	130–193	188–281	75–112	393–586
Accelerated Demand Scenario	Estimated range of number of new Federal AI-focused workers in AI SFS-relevant positions needed	412–614	599–893	237–354	1,248–1,861
Estimated Shortfall	Gap to be filled by AI SFS Moderate Scenario Accelerated Scenario	0 168–370	118–211 529–823	60–97 222–339	178-308 919–1,532

Sources:

Supply Scenario: Estimates (from Table 9) of AI degrees, DS degrees, and CS degrees with AI concentrations earned by U.S. citizens or permanent residents based on analyses of IPEDS completion data for bachelor's and master's degrees, and Taulbee survey data for AI PhDs. Projections of individuals entering Federal service based on custom tabulations of public-use NSCG 2022 data.

Demand Scenario: Estimates (from Table 7) of the number of new Federal AI workers demanded under the two assumed growth scenarios (17.6% and 100% growth over 5 years). Tabulations for each degree level are based on OPM FedScope records on current Federal employment in the 1560 (data science) occupational series in October 2023. For individuals employed in the 1560 occupational series in October 2023 who had specified degree information, 33% held a bachelor's degree or less, 48% held a master's degree, and 19% held a doctoral degree. These percentages were applied to the total new GS 7–13 civilian AI hires to estimate the number of these hires at each degree level.

KNOWLEDGE AND SKILLS ASSOCIATED WITH AI, CS/AI, AND DS DEGREE PROGRAMS

An understanding of the AI degree programs offered by U.S. IHEs by itself does not answer whether the graduates of these programs have the AI-relevant knowledge and skills needed to meet current or future Federal AI workforce needs. Additionally, DS and CS degree programs may produce graduates with AI-relevant knowledge and skills. However, AI, CS, and DS degree programs do not themselves state the AI-relevant knowledge and skills students will gain across different courses or across the entire degree program.

Therefore, topic modeling of the coursework associated with five different degree types—AI bachelor's and AI master's degrees, CS bachelor's degrees with AI concentrations (CS/AI), and DS bachelor's and DS master's degrees—was conducted to determine whether there are consistent sets of AI knowledge or skills being taught across the AI-related programs.[64] Topics reflected in coursework were considered as a rough proxy for skills, with the acknowledgment that assumptions are needed to translate between the two. Though this analysis focused on coursework as the mechanism by which knowledge and skills are acquired by students, work experience and internships are also important mechanisms, although harder to characterize.

AI bachelor's degrees and CS bachelor's degrees with AI concentrations are generally similar in their computing emphases, and can be thought of as AI-enabling, as they include a solid foundation of CS knowledge through which students can leverage AI in their work. AI bachelor's programs seem to emphasize knowledge and skills in coding and in the broad application of AI, rather than the conceptual foundations to develop AI. Mathematics and statistics are essential elements of this conceptual foundation, and though a few AI bachelor's degrees are math-heavy, most require little to no math coursework to graduate—possibly due to lack of any existing accreditation standards for bachelor's degrees in AI programs. This variation in math coverage potentially indicates the differences between educating AI professionals and AI users. Without knowledge and skills in mathematics and statistics, graduates may be limited in their fundamental understanding of how AI is developed. AI bachelor's degrees have considerable overlap with CS bachelor's degrees with AI concentrations, as the CS bachelor's degree with an AI concentration emphasizes a heavy, practical CS context,

Curricular Emphasis of AI-related Degrees

AI bachelor's degrees and CS bachelor's degrees with AI concentrations: solid computing foundation, ability to leverage AI

AI master's degrees: conceptual foundations of AI and the underlying math, ability to develop new AI

DS bachelor's and master's degrees: solid data science, math and statistics foundation, ability to leverage AI

but also covers a blend of data mining, automata, neural networks, and statistical inference.

AI master's degree curricula seem to have the most preparation in AI development compared to the other degree types analyzed, with focus on the conceptual understanding of AI and the math that underlies it, such that these students may be more likely able to build new tools and advance the field. AI master's degrees have the greatest emphasis on AI topics, including neural networks and NLP, which are not highly emphasized in AI bachelor's degrees. Mathematical foundations and statistical inference topics are also a strong emphasis in AI master's degree programs. Because AI, mathematics, and statistics topics are the focus of AI master's degree curricula, it is likely that students who graduate with this degree type will be best prepared for work in AI development compared to the other degree types analyzed. It is probable that doctoral degree graduates in AI or adjacent fields will have similar preparation but would likely gain such knowledge and skills from hands-on research experiences rather than from coursework.

Both the DS bachelor's and master's degrees can be thought of as AI-enabling degrees, as they emphasize DS, mathematics, and statistics, which provides a solid DS foundation from which to leverage AI. Both the DS bachelor's and master's degrees have a strong emphasis on DS topics (i.e., big data, data analytics). The DS bachelor's degree has the largest emphasis on mathematics and statistics topics of any of the degree types analyzed. This math foundation, and a strong emphasis on data mining, means that DS bachelor's graduates will likely be equipped to fulfill some types of

AI jobs. The DS master's degrees have more emphasis on AI topics than the DS bachelor's degrees. However, the DS master's degrees have less overall overlap (across all topics) with the two AI degree types than the DS bachelor's degree. The DS master's degree has more field-specific topics (i.e., information security and econometrics) emphasized than any other degree type. It seems that DS master's graduates will also likely be equipped to fulfill some types of AI jobs.

Even among degree programs of the same degree type, there is variability in the topics emphasized in their curricula. Though AI master's degrees are the only degree type of those analyzed with strong emphases in AI/ML, mathematics, and statistics topics, there are some AI bachelor's degrees, CS bachelor's degrees with AI concentrations, and DS bachelor's and master's degrees that have exceptionally high emphasis on AI topics, despite the limited average emphasis on these AI topics across their respective degree types. Additionally, there are several AI bachelor's degrees and CS bachelor's degrees with AI concentrations that have field-specific topical emphases (i.e., in robotics or information security).

ALIGNMENT OF AI AND RELATED DEGREES WITH FEDERAL AI JOBS

Given the differences in emphasis across the five degree types—AI bachelor's and AI master's degrees, CS bachelor's degrees with AI concentrations (CS/AI), and DS bachelor's and DS master's degrees, the extent to which the topics covered in these AI or related degree programs align with those described in Federal AI job postings was explored. Alignment was measured as the extent to which terms in Lightcast's taxonomy of skills appeared in certain AI job postings and in course descriptions associated with different degree programs.[65]

This analysis identified the job titles from recent Federal AI job postings with the highest average percent skills overlap with the course descriptions for each type of degree program (Table 11).[66] There is considerable overlap between the top 15 job titles that align with each of the five degree types. The four job titles that have a high degree of skill overlap (i.e., appear in the top 15 job titles) for all five degree types are: Computer Science Engineers, Research Data Scientists, AI/ML Engineers, and ML Researchers (shaded blue in Table 11). This analysis suggests that graduates from DS degree programs at the bachelor's and master's level—not just graduates of AI or CS/AI programs—could possess sufficient skills to meet the qualifications for those jobs.[67] These results should be interpreted as a high-level alignment of job titles and degree programs as the terms that overlap are somewhat general, and furthermore this particular analysis cannot assess the depth of knowledge required for a job nor the importance of that skill to perform the work.

Some Federal AI jobs can be filled by individuals with DS degrees and skills

Table 11. Top-matching Federal AI Job Titles for Each Degree Type, in Terms of Skill Overlap

	AI BACHELOR'S	AI MASTER'S	CS BACHELOR'S + AI CONCENTRATION	DS BACHELOR'S	DS MASTER'S
1	Research Data Scientists	CS Engineers	Research Computer Scientists	Research Data Scientists	Social Science Analysts
2	CS Engineers	AI/ML Engineers	AI/ML Engineers	Social Science Analysts	Research Data Scientists
3	Research Computer Scientists	ML Researchers	CS Engineers	Chief Analytics Officers	Chief Analytics Officers
4	AI/ML Engineers	Research Physical Scientists	Research Data Scientists	DS Analysts	Health Scientists
5	DS Analysts	Research Computer Scientists	Software Engineers	Operations Research Analysts	Federal Employees
6	ML Researchers	Undergraduate Interns	DS Analysts	AI/ML Engineers	DS Analysts
7	Operations Research Analysts	Student Services Administrators	ML Researchers	Mathematical Statisticians	Data Scientists
8	Chief Analytics Officers	ML Scientists	Undergraduate Interns	Federal Employees	DS Managers
9	Software Engineers	Software Engineers	Chief Analytics Officers	ML Researchers	ML Researchers
10	Research Physical Scientists	Unclassified	Operations Research Analysts	Research Computer Scientists	Operations Research Analysts
11	DS Managers	Research Data Scientists	Supervisory IT Specialists	CS Engineers	CS Engineers
12	Undergraduate Interns	R&D Scientists	R&D Scientists	Methodologists	Methodologists
13	Federal Employees	Supervisory IT Specialists	Social Science Analysts	Data Scientists	AI/ML Engineers
14	Supervisory IT Specialists	Health Scientists	IT Specialists/System Administrators	DS Managers	Mathematical Statisticians
15	Defense Analysts	Postdoctoral Fellows	DS Managers	Economists	Data Analysts

DIVERSITY AND REPRESENTATION IN AI-RELATED DEGREES

As Congress has, at least implicitly, incorporated a diversity goal into the AI SFS authorization, analysis was conducted on the representation of women and racial/ethnic groups underrepresented in STEM fields in CS using 2020–2022 IPEDS graduation data as a proxy for AI, since data for AI programs are limited. Gender and racial/ethnic breakdowns of computer and information and support services sciences bachelor's, master's, and doctoral-level degrees (CIP code 11) and of all bachelor's degrees by IHE were computed. A lower percentage of women earn degrees in CS-related fields than in all fields combined across all three degree levels (Table 12). Members of groups underrepresented in STEM are also less likely to earn CS degrees than degrees in other fields, although there is less of a gap by race/ethnicity than there is by gender.

Table 12. Gender and Race/Ethnicity in CS and All Degrees, by Level

Degree Level	Percentage of CS Degrees Earned by Women	Percentage of All Degrees Earned by Women	Percentage of CS Degrees Earned by Members of Groups Under-Represented in STEM	Percentage of All Degrees Earned by Members of Groups Under-Represented in STEM
Bachelor's	22%	58%	27%	32%
Master's	34%	62%	27%	30%
Doctoral	25%	52%	22%	27%

Source: IPEDS 2020-2022, CIP Code 11

Note: "Groups underrepresented in STEM" encompasses Hispanic or Latino, American Indian and Alaska Native, Black, or African American, Native Hawaiian and Other Pacific Islander, and two or more races. Race/ethnicity data are only available for U.S. citizens or permanent residents, and individuals whose race or ethnicity is "Unknown" were excluded from the calculation.

RESOURCE NEEDS TO EXPAND CAPACITY FOR AI EDUCATION AT U.S. IHES

Critical elements of the capacity of IHEs to meet future AI needs of the Federal workforce are the resources necessary to stand up new AI-related degree programs, grow current AI-related programs to educate additional students, and amend the knowledge and skills taught in their AI-related degree or other types of academic programs. Current capacity was characterized using data from 117 responses from U.S. IHEs to an AI SFS RFI[68] and interviews with institutions about challenges to growing institutional capacity, as well as areas of potential opportunity for such growth.

The principal barrier to expanding AI capacity is hiring and retaining faculty

The principal challenge identified by IHEs to expanding their AI educational capacity is hiring and retaining faculty, though a large and diverse number of other challenges were identified. The top three challenges identified in the responses to the RFI included:

- Faculty hiring and retention (65 responses);
- Course/curriculum development (44); and
- Computing/hardware availability (39).

Challenges in hiring and retaining faculty are not unique to AI and extend to other academic specialties, including CS. The 2018 National Academies report, *Assessing and Responding to the Growth of Computer Science Undergraduate Enrollments*, highlights how the rate of faculty hiring in CS has not kept pace with the number of CS majors and enrollment of non-majors in CS courses based on data from 2006–2016.[69] The limited candidate pool for CS faculty is further complicated by competition with industry, which stifles universities' ability to recruit new CS doctoral degree recipients to faculty roles.[70] Competition also exists within academia, where top candidates often receive multiple job offers from different institutions.[71] According to the 2022 CRA Taulbee Survey, the most common reason for unsuccessful hiring of CS teaching faculty was because offers were turned down.[72]

The AI educational capacity of U.S. IHEs likely needs to be expanded to meet future Federal AI workforce needs. Most AI degree programs are at R1 institutions, indicating that doctoral High (R2) and Moderate (R3) Research Activity universities

Additional AI capacity, particularly at non-R1 institutions, is needed as students attending non-R1 IHEs are more likely to enter into Federal employment

as well as master's and undergraduate institutions may need additional resources to also establish AI degree programs. AI degree programs at a broader diversity of institutions can help expand the diversity of students trained. Additionally, in interviews with IHEs, some of the R1 institutions (2 out of 5) interviewed indicated few or none of their graduates typically enter into Federal employment, while a number of the non-R1 institutions interviewed indicated that some or many of their students view Federal employment as an attractive career path. Thus, increasing the capacity of non-R1 institutions to produce AI graduates may help address the challenge of recruiting graduates into public service.

Many IHEs indicated that an AI SFS would have a positive impact on their AI degree programs and would incentivize employment in the Federal Government. In the RFI responses, 17 respondents indicated that student scholarships would help their programs produce additional AI graduates, which a scholarship for service, if established, would address. Interviews with IHEs with AI degree programs indicated (4 out of 11) that an AI SFS could help attract students, especially first-generation students, to their degree programs, as an AI SFS program could signal the potential for guaranteed and stable post-graduation employment. Additionally, IHEs reported (5 out of 11) that most AI graduates pursue employment in the private sector, and that an AI SFS would be an important incentive for their students to pursue employment in the Federal Government.

An AI SFS program would have a positive impact on AI education capacity

4. Need for an AI SFS Program

The need for rapid development of the Federal AI workforce is imperative in a landscape where technological advancements rapidly outpace the development of the workforce required to manage, improve, and ethically guide their implementation. This chapter explores the need to establish the AI SFS program, addressing emerging demands within the Federal Government.

AI holds the promise of transforming public sector operations by enhancing efficiency, uncovering insights from data, and effectively delivering services to meet the growing expectations of the public. However, the potential of AI can only be fully realized through a well-prepared, ethically informed, and technologically adept workforce. The urgency of developing the Federal AI workforce is further underpinned by EO 14110, which outlines a comprehensive strategy for the safe, secure, and trustworthy development and use of AI. This EO not only reiterates the necessity of a skilled workforce, but it also sets forth directives for expanding AI capabilities within the government. The AI SFS program would address this challenge by providing targeted scholarships, fostering capacity building in IHEs, and offering fellowships to develop a cadre of professionals committed to public service and within the Federal workforce in 2028 and beyond.

This chapter outlines the quantitative and qualitative data illustrating the supply/demand gap, including a detailed analysis of current and projected workforce needs that span various Federal agencies and FFRDCs. This examination highlights the need for programmatic support to enhance educational offerings that align with Federal needs, focusing on interdisciplinary approaches that integrate ethical considerations with technical training. The findings point to the need to establish an AI SFS program to direct graduates with AI skills into Federal service; to accelerate capacity-building efforts at IHEs, particularly at non-R1 institutions, to educate more U.S. citizens; and to address the shortage of AI faculty.

KEY PROVISIONS FROM THE LEGISLATIVE AUTHORIZATION FOR AN AI SFS

The full text of the legislative authorization within the CHIPS and Science Act (42 U.S. Code § 18993(d)) can be found in Appendix A of this report. Most of the provisions describing the AI SFS relate to the administration of the program and the roles and responsibilities of NSF and OPM, but five paragraphs are especially relevant for assessing the need for an AI SFS program.

PROGRAM DESCRIPTION AND COMPONENTS

Paragraph 5 of Section 10313(d) "Program Description and Components" of the CHIPS and Science Act (42 U.S. Code § 18993(d)) describes the activities NSF is authorized to undertake. The stipulated activities include three components:

1. ***Scholarships for Service.*** Subsections A–C authorize NSF to provide scholarships to students enrolled in degree programs or concentrations related to AI through "qualified institutions of higher education." The legislation also directs scholarship recipients to be provided with Federal internship opportunities related to AI and be

prioritized for hiring opportunities.

2. ***Capacity-building efforts.*** Subsections D–F authorize NSF to fund efforts to promote multi-disciplinary programs of AI study (e.g., integrating AI training with other fields or integrating ethical, social, and legal studies); to support education research programs, including translation to practice, that will enable colleges and universities to build their capacity to train the future AI workforce; and to create courses or training modules related to "technology ethics."
3. ***Fellowships.*** Subsection G authorizes NSF to support, in addition to the AI SFS described in subsections A–C, fellowships at the master's or doctoral level to students pursuing AI degrees or research, including in technology ethics.

The program will also support AI professional development of prospective or current faculty members who are interested in expanding their research and teaching into AI, including faculty on sabbatical leave.

SCHOLARSHIPS FOR SERVICE

Paragraph 6 of Section 10313(d) indicates that participating students should have their tuition and fees paid for up to three years of schooling and should receive a stipend. Paragraph 7 states that in exchange, scholars are required to provide service once they graduate equal to the number of years of support they received. They can work at a Federal agency (including legislative and independent agencies as well as executive branch organizations; organizations such as FFRDCs that support the mission of an executive branch agency are also included) or can work for a State, local, or Tribal government—including as a teacher who engages in AI-related instructional activities in public school settings.

"QUALIFIED" IHES

The AI SFS described in paragraph 5 must be conducted through "qualified" IHEs. Paragraph 4 authorizes the NSF Director (in coordination with other relevant agencies not defined in the legislation) to set criteria that identify which institutions can participate. The authorization gives the NSF Director discretion in defining "qualified," but two minimum criteria are specified:

- Demonstrated excellence in educating students in the field of AI; and
- Institutional success in attracting and retaining a diverse and nontraditional student population in STEM fields.

ELIGIBILITY

Paragraph 9 of Section 10313(d) describes the eligibility requirements for AI SFS. All AI SFS participants must be U.S. citizens or permanent residents. They also must "demonstrate a commitment to a career in advancing the field of AI." Participants must either be students enrolled in degree programs at a qualified IHE or be a faculty member on AI professional development, including faculty on a sabbatical leave.

DEFINING NEED

FEDERAL AI WORKFORCE AND CAPACITY OF IHES FOR AI EDUCATION

Assessing the need for and capacity of the AI workforce is challenging because AI is such a new field and the education landscape and the understanding of the workforce required to fill AI jobs is continuously evolving. OPM has identified AI competencies and tasks needed for AI work and developed AI classification policy and guidance. Some Federal agencies have been working to define AI work roles and associated KSATs. However, final taxonomies were still pending as of the time of this report. Universities are still developing their approaches to teaching "artificial intelligence" as a field of study. Some have created AI departments or degree programs, while others are teaching "artificial intelligence" as a specialization with an existing degree program or department or offering a limited number of AI-related courses.

DEFINING "NEED" IN THE CONTEXT OF EXECUTIVE ORDER 14110

On October 30, 2023—the Administration released EO 14110: *Executive Order on the Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence.*[73] This EO lays out Administration policy with respect to AI, including a section related to AI research and development (Section 5); a section related to the national workforce and how it might be influenced by the growing use of AI (Section 6), and the need to expand the Federal Government's AI workforce (Section 10.2).

Some of the language in the EO is directly relevant to elements of the AI SFS program as described in Section 10313(d) of the CHIPS and Science Act. Specific examples of where requirements laid out in the EO align with the results of the analyses presented in Chapters 2 and 3 are included on the following page.

ADMINISTRATION PRIORITIES

There are a range of contextual factors that help to illuminate facets of the needs assessment. One is the goal of increasing access to programs. Demonstrated success in the recruitment and retention of a diverse student population is one of the two criteria for "qualified" IHEs, highlighting the importance of broadening participation.

EO 14110 lays out a set of specific actions to be taken by executive branch agencies in response to Administration priorities. Most of the actions relevant to the needs assessment concern the AI workforce, both inside the Federal Government and more broadly. EO 14110 (building on other Administration documents), also speaks to the need for diversity in the AI workforce.

AI WORKFORCE NEEDS, BOTH FEDERAL AND NON-FEDERAL

The Administration is prioritizing the discussion of assessing the AI Workforce needs at the federal and non-federal sector through new taskforces like the AI and Tech Talent Taskforce and the Office of the National Cyber Director (ONCD) Federal Cyber Workforce Working Group in which NSF participates. Some of these working groups are further defined below.

Section 10.2 of EO 14110 calls for a "national surge in AI talent in the Federal Government."[74] The EO does not explicitly discuss the need for an AI SFS as a specific tool for expanding AI hiring in the Federal Government. Instead, it calls for the Director of the Office of Management and Budget, and the Director of the White House Office of Science and Technology Policy, in consultation with other stakeholders in the Executive Office of the President, to "identify priority mission areas for increased Federal Government AI talent, the types of talent that are highest priority to recruit and develop to ensure adequate implementation of this order and use of relevant enforcement and regulatory authorities to address AI risks, and accelerated hiring pathways" within 45 days of the issuance of the EO.[75]

In parallel, the Assistant to the President and Deputy Chief of Staff for Policy is tasked to convene an AI and Technology Talent Task Force, which is charged with making recommendations for increasing Federal AI workforce capacity and coordinating the use of "fellowship programs and agency technology-talent programs and human-capital teams to build hiring capabilities, execute hires, and place AI talent to fill staffing gaps."[76] Existing Federal programs for recruiting AI-related workers, including the U.S. Digital Corps, are tasked with developing "plans to support the rapid recruitment of individuals as part of a Federal Government-wide AI talent surge to accelerate the placement of key AI and AI-enabling talent in high-priority areas and to advance agencies' data and technology strategies."[77] The Director of OPM is also tasked with conducting a range of studies regarding hiring and workplace flexibilities that could be applied to AI-related Federal employment.[78]

While NSF is not identified specifically in any of the activities described in Section 10.2 of EO 14110, the NSF Director is tasked in other sections with two AI workforce-related efforts that are not specific to the Federal Government:[79]

- "To support activities involving high-performance and data-intensive computing, the Secretary of Energy, in coordination with the Director of NSF, shall, in a manner consistent with applicable law and available appropriations, establish a pilot program to enhance existing successful training programs for scientists, with the goal of training 500 new researchers by 2025 capable of meeting the rising demand for AI talent"[80] ; and
- "To foster a diverse AI-ready workforce, the Director of NSF shall prioritize available resources to support AI-related education and AI-related workforce development through existing programs. The Director shall additionally consult with agencies, as appropriate, to identify further opportunities for agencies to allocate resources for those purposes. The actions by the Director shall use appropriate fellowship programs and awards for these purposes."[81]

DIVERSITY OF FEDERAL AI WORKFORCE

EO 14110's statements of policy and principles include a sub-section regarding the Federal Government's AI use and capacity. That section makes explicit reference to attracting and retaining a diverse AI Federal workforce:

> It is important to manage the risks from the Federal Government's own use of AI and increase its internal capacity to regulate, govern, and support responsible use of AI to *deliver better results for Americans. These efforts start with people, our Nation's greatest asset. My Administration will take steps to attract, retain, and develop public service-oriented AI professionals, including from underserved communities,* across disciplines—including technology, policy, managerial, procurement, regulatory, ethical, governance, and legal fields—and ease AI professionals' path into the Federal Government to help harness and govern AI.[82]

As noted above, the section on NSF's role in AI-related workforce development includes fostering diversity. In addition, in Section 10.2 of EO 14110, the AI and Technology Talent Task Force is tasked with "identifying and circulating best practices for agencies to attract, hire, retain, train, and empower AI talent, including diversity, inclusion, and accessibility best practices."[83]

INSIGHTS FROM FEDERAL AND FFRDC INTERVIEWEES

Federal agency and FFRDC personnel interviewed expressed support for an AI SFS program across agencies and FFRDCs, indicating that an AI SFS could help to address the challenges associated with the hiring of AI-skilled workers in an increasingly competitive market. More specifically: individuals from 10 organizations said that the program would (6) or could potentially (4) be helpful for meeting workforce needs (interviewees from the other 4 organizations did not address this topic). Many interviewees noted a need for a larger pool of AI-trained graduates and concern regarding the retention of junior professionals with AI skills, with two interviewees citing issues related to team members leaving for industry opportunities with much higher pay. Industry was mentioned by interviewees from 8 organizations as a major competitor for AI talent.

Federal agency and FFRDC personnel interviewed expressed support for an AI SFS program

In conjunction with the broad support for an AI SFS program, there was substantial variability in the specific nature of AI skills or degrees desired, which is as expected given the applicability of AI across a wide spectrum of areas. A range of degree fields and levels and types of skills were mentioned as relevant to agency work. Two interviewees emphasized a need for disciplinary scientists with AI skills and tools to pursue AI-enabled scientific discovery, and three prioritized AI ethics, governance, management, or procurement, which require AI "soft skills" paired with technical knowledge to assess products, models, and tools. Additionally, four agencies mentioned that the need for security clearances for AI workers creates additional constraints on AI recruitment and hiring.

Three interviewees said it was sometimes difficult to assess candidates' skill levels or AI KSAs based on grades and transcripts alone during the hiring process. While Federal programs such as *Pathways* require a strict adherence to the hiring procedure with little flexibility, four interviewees mentioned the benefits of assessing internships, experience, coding approaches and skills (through a real-time coding test or other interview activity), and training lineage in hiring skilled employees. Additionally, four interviewees from organizations with research or science missions described a need for PhD-level candidates and two identified an interest in faculty pursuing sabbaticals in addition to bachelor's- and master's-level candidates. Interviewees from two other agencies suggested that individuals with PhDs would be needed for governance, evaluation, or supervisory roles.

NEED FOR AI SFS PROGRAM

THERE IS A NEED FOR AI SCHOLARSHIPS FOR SERVICE PROGRAM

Using the best available data, it is estimated that the Federal civilian non-intelligence executive branch workforce includes between 7,400 and 11,200 AI-focused workers and that the AI workforce at FFRDCs includes approximately 5,700 AI-focused workers.[84] The quantitative results, however, have significant limitations because these data are not comprehensive or complete, and due to the fact that AI and AI work are evolving concepts lacking clear consensus definitions (and authoritative datasets do not label data by these categories).

The analyses further suggest that AI workers are distributed across many Federal departments, agencies, and OPM classification codes; they also are educated in a range of degree fields. Federal agency experts interviewed for this report pointed to challenges in identifying and hiring individuals with appropriate skills.

Most important for an AI SFS is the demand for newly graduated workers who would enter Federal service upon the completion of their degrees, most likely at entry-levels (i.e., GS-7 through GS-13 levels). These are the jobs that participants in an AI SFS program would be expected to fill. Based on analyses of the percentage of new hires into Federal service at those levels, it is estimated that in 2022 and 2023 there were approximately 1,200 job postings per year that were potentially relevant to AI SFS graduates between the Federal Government and FFRDCs. Approximately two-thirds of those were for FFRDC positions.

Projections were made for the number of U.S. citizens or permanent residents receiving AI degrees, DS degrees, and CS

degrees with AI concentrations in 2028, at both the bachelor's and master's level. It is estimated that there will be thousands of bachelor's graduates and hundreds to a few thousand master's graduates who are U.S. citizens or permanent residents. Using historical trends, only a small fraction of these graduates is anticipated to opt to work for the Federal Government as shown in Table 10. More specifically, estimates indicate that approximately 244 bachelor's, 70 master's, and only 15 doctoral graduates will seek employment with the Federal Government in 2028. The number of new Federal AI-focused workers projected to be needed in 2028 ranges from hundreds at each the bachelor's and doctoral level (moderate growth scenario) to nearly a thousand at the master's level (accelerated growth scenario). While similar analyses were not run for FFRDC AI workers, given the large number of AI-focused jobs identified at FFRDCs currently, were they to have been included the number of workers projected in 2028 would have been considerably higher. Comparing these two estimates suggests that it may be difficult for the Federal Government to recruit a sufficient number of new AI-focused workers at all three levels without some sort of policy intervention, such as an AI SFS that directs participants toward government service.

AI master's degrees are the degree type from among the bachelor's and master's programs studied that best prepare students to develop AI tools and advance the field of AI. While CS/AI and DS degrees may provide sufficient training for some types of jobs, no other degree type has as much emphasis on the most relevant combination of topics. Graduates of AI master's or doctoral degree programs will be best prepared to meet the future needs of the Federal Government for AI talent. The Federal Government will almost certainly need to recruit AI talent at the doctoral level from graduates of a wide range of fields given the small number of U.S. citizens or permanent residents receiving AI-focused doctoral degrees.

Finding 1: There is a need for an AI SFS program intended to direct graduates with AI skills into Federal service. That need encompasses:

- ***The current Federal and FFRDC workforce need new graduates with AI skills.*** Though job postings do not necessarily map one-to-one with open positions, the analyses shown in Chapter 2 identified approximately 1,200 Federal or FFRDC job postings per year in 2022 and 2023 that could be filled by AI SFS graduates, with the majority at FFRDCs. Interviews with Federal agency personnel indicated that implementing an AI SFS would be valuable in helping to recruit trained personnel. Most AI (and CS or DS) graduates pursue employment in the private sector, and interviewees (5 out of 11) indicated that an AI SFS would be an important incentive for students to pursue employment in the Federal Government. Interviews specifically with Federal and FFRDC personnel working in research positions (e.g., at National Laboratories) identified a need for doctoral-level scientists.
- ***There is a risk that there will not be enough U.S. citizen or permanent resident graduates with AI-related bachelor's degrees to meet future Federal AI workforce demand.*** Of the number of graduates at the bachelor's level from AI, DS, and CS/AI programs, only a small fraction chooses to work for the Federal Government. Comparing this to the need for bachelor's-level Federal AI workers as quantified in Table 10, indicates that a program intended to direct graduates into Federal service, such as an AI SFS, is necessary for the Federal Government to recruit the number of new workers required, under the accelerated growth scenario in Federal AI-focused employment. Given that additional AI-focused workers will be required at FFRDCs as well, it appears unlikely that there will be a sufficient number of bachelor's level graduates even under the moderate growth scenario.
- ***There is a clear need for more U.S. citizens or permanent residents with master's degrees or doctorates in AI and related fields to meet future Federal AI workforce demand.*** At the master's and doctoral levels, demand for Federal AI workers is well above the projected number who would enter Federal service (Table 10). Specifically, the Federal Government is projected to need 4-fold (moderate growth scenario) or 12-fold (accelerated growth scenario) more AI workers than the estimated number of U.S. citizens or permanent residents graduating with AI and related master's or doctoral degrees who are expected to enter Federal service.

At the master's and doctoral levels, demand for Federal AI workers is well above the projected number entering Federal service

Furthermore, projections suggest that in 2028 there will be only 300 U.S. citizens or permanent residents completing doctorates in AI, while the Federal Government is projected to need a similar number of new workers per year at doctoral entry-level positions. This analysis does not account for FFRDC demand for AI workers at the master's and doctoral levels, which will only widen the gap between the number of such workers needed and available. Presumably, given the small number of U.S. citizens or permanent residents completing doctorates in AI, and the even smaller fraction opting to work for the Federal Government, most Federal or FFRDC AI workers at the doctoral level will need to be drawn from fields that use advanced analytics techniques rather than from AI-specific programs.

THERE IS A NEED FOR THE AI SFS PROGRAM TO INCLUDE CAPACITY BUILDING AT IHES

The analyses in Chapter 3 identified gaps in current AI education capacity at IHEs. Analyses were heavily focused on degree or other academic programs—and therefore on bachelor's-level and master's-level programs, which are more heavily dependent on course-based training than doctoral programs. Nevertheless, these analyses suggest that additional capacity is required. Furthermore, additional capacity may be needed to train students who meet specific requirements in EO 14110.

To meet projected Federal AI workforce demand, additional capacity at U.S. IHEs is needed

While EO 14110 does not explicitly discuss the need for developing capacity at IHEs, many of the actions assume that substantial current capacity exists. For example, Section 10.2's call for an AI hiring talent surge in the Federal Government suggests that there is a pool of already-trained personnel either in the workforce (who, presumably, were once university educated) or who are currently working toward degrees at IHEs. While some of these individuals' AI-related skills may be self-taught, the call for a hiring surge suggests that there is an existing pool of talent that can be readily tapped. Similarly, EO 14110 calls for the NSF Director to prioritize AI-related training efforts in the service of building the U.S. AI workforce generally and to coordinate with the Department of Energy to "establish a pilot program to enhance existing successful training programs for scientists, with the goal of training 500 new researchers by 2025 capable of meeting the rising demand for AI talent."[86] The analyses in Chapter 3 suggest, however, that there likely will need to be additional capacity development at U.S. IHEs in order to expand the number of AI programs (and the number of U.S. citizens or permanent residents graduating from those programs) to meet projected Federal AI workforce demand, especially at the master's and doctoral level.

Finding 2: There is a need for efforts to build capacity in AI at IHEs. That need encompasses:

- ***Additional AI capacity, particularly at non-R1 institutions, is needed.***

  More non-R1 universities will need capacity to train or educate AI professionals

  As of the beginning of 2024, 67 U.S. universities offered AI degree or certificate programs, while 80 IHEs offered AI minors or concentrations/fields of specialization within existing degree programs. These programs are heavily concentrated in IHEs classified as Research 1 (R1) institutions. Twenty-eight percent of R1 institutions offered AI majors or certificates while 34 percent of R1 institutions offered AI minors or concentrations, as compared with approximately 10 percent of other doctoral universities and approximately 1 percent of other 4-year colleges and universities. As of the beginning of 2024, not a single HBCU offered a degree program or certificate in AI and only two (North Carolina A&T and Bowie State) offered a minor or concentration in AI. For the Federal Government to accelerate its hiring of AI professionals, opportunities to pursue AI-related training or education will need to be available nationwide. More universities—especially universities that are not elite research institutions—will need to have the capacity to train or educate AI professionals.

- ***The principal barrier to expanding AI capacity is hiring and retaining faculty.*** Based on analysis of the AI SFS RFI and interviews discussed in detail in Chapter 3, IHEs will require a range of additional investments in order to add capacity to train students in AI-related fields. Analysis of the RFI responses identified faculty recruitment, course development, and hardware/computing access as their three most prevalent needs. These common responses in the RFI—and in the

interviews conducted with IHE representatives—are not explicitly included in the authorization of capacity-building activities. One finding from the Federal agency and FFRDC personnel interviews was that few AI specialists have knowledge/experience in ethics/governance/legal/policy issues (3 out of 10 interviewed). A second finding (2 out of 10) was an increasing need for scientists in various fields to have AI-related skills.

- ***An AI SFS would have a positive impact for capacity building for increased student participation in IHE AI programs.*** Interviewees (4 out of 11) at IHEs with AI degrees or academic programs indicated that an AI SFS could help attract students, especially first-generation students, to their programs, as an AI SFS program could signal the potential for guaranteed and stable post-graduation employment as well as receiving a higher education degree with significantly reduced financial burden. In 17 out of the 117 RFI responses, student scholarships were identified as a mechanism that would help their programs produce additional AI graduates, which a scholarship for service, if established, would address.

An AI SFS could help attract students, especially first-generation students, to AI degree or academic programs

THERE IS A NEED FOR FELLOWSHIPS FOR MASTER'S AND DOCTORAL STUDENTS IN AI-RELATED PROGRAMS

CS and DS fields offer the highest capacity for quick production of AI-educated graduates at all levels given the substantial commonality of academic coursework between AI and CS or DS degrees, particularly at the undergraduate level. It is relatively easier and quicker, as compared to creating a new AI degree, to incorporate a minor or specialization/concentration in AI in a BS/BA in CS or DS degree program, or to deliver AI courses without any other prerequisites for master's or doctoral students who already have a BS/BA in a CS or DS degree. Currently, approximately half of the master's degrees granted in CS-related fields are earned by U.S. citizens or permanent residents. The share of doctorates in CS-related fields earned by U.S. citizens or permanent residents is lower—approximately 40 percent. For the United States to have a vibrant AI ecosystem—in industry, in academia, and in the Federal Government and FFRDCs—more U.S citizens or permanent residents will need to acquire AI-relevant skills and earn AI-related degrees and certifications, especially at graduate levels (master's and doctoral). Fellowships and research traineeships are a mechanism for incentivizing U.S. citizens or permanent residents to pursue such advanced study.

CS and DS fields offer the highest capacity for quick production of AI-educated graduates at all levels in the short term

Finding 3: There is a need for fellowships for master's and doctoral students in AI-related programs. That need encompasses:

- ***Federal need:*** Analyses suggest that two-thirds of Federal job postings for AI-focused positions are for individuals who have just completed research doctorates (e.g., GS-12 or GS-13 level) and one-sixth are for individuals who have just completed master's degrees. AI SFS activities would complement other Federal agencies' actions intended to increase the AI workforce, such as EO 14110's direction to the Department of Energy and NSF to pilot a training program for doctoral students in high-performance computing (Section 5.2(b)) and NSF to prioritize AI-related education and workforce activities in existing grant and fellowship programs (Section 6(c)). Students who are funded through other fellowship programs beyond the AI SFS can help to contribute to the future Federal workforce.
- ***FFRDC need:*** As with Federal AI-focused jobs, many future positions at FFRDCs are projected to require advanced training. Fellowships that incentivize U.S. citizens or permanent residents to pursue master's and doctoral training are a mechanism for increasing the supply of graduates who might pursue employment in the FFDRCs that support Executive Branch agencies.
- ***IHE AI faculty need:*** There is a specific need to train recipients of doctoral degrees to be hired at IHEs as

Fellowships are mechanisms that could help to direct participants toward faculty careers and help to increase the supply of future professors teaching AI-related subjects

faculty. Fellowships, with proper selection, mentoring and networking, could help direct participants toward faculty careers and help to increase the supply of future professors teaching AI-related subjects. Another potential source to address AI faculty shortage is through providing funding support for retraining of existing faculty in a closely related area (such as CS, mathematics with discrete math and CS or DS focus or computer engineering) to AI and who wishes to transition to the field of AI for instruction and research through a professional development opportunity, including a sabbatical leave.

ADDITIONAL FINDINGS

Finding 4: Several identified areas of need may not fit clearly within the legislative authorization in the CHIPS and Science Act Section 10313(d):

- ***Finding 4A: There may be value in construing "the field" of AI broadly. There are three types of AI training:***

    1. "Core AI" training that focuses on the development and validation of AI methods, tools, and algorithms, as well as AI implementation, governance, and oversight;
    2. "AI + X" training that blends training in core AI skills with the application of those skills to a particular field (e.g., health care, climate science); and
    3. "X + AI" training in a particular field or discipline that incorporates some training in AI-related methods and tools.[87]

    Information gleaned from interviews suggests that individuals with all three types of training are sought by Federal agencies, although the value of "X+AI" training may still be emerging as compared with "AI" and "AI+X" skills. Therefore, there would be value—especially in the absence of a recognized definition—in construing "the field" of AI broadly to incorporate the full range of AI-related training types, including "X+AI" training, for the purpose of implementing programs under Section 10313(d).

- ***Finding 4B: There would be value in construing the capacity-building authorization broadly.*** Section 10313(d) includes three provisions related to capacity-building activities: (1) promoting multi-disciplinary programs of AI study including social and ethical implications of AI; (2) building educational research capacity to improve teaching and learning AI; and (3) supporting the development of technology ethics courses and training programs.[88] The first and third of these activities were mentioned explicitly by some respondents to the AI SFS RFI, although these were not the most-mentioned activities (31 and 9 responses, respectively, out of 117). While the second activity was not mentioned specifically in the RFI responses, it is likely that increasing capacity to teach AI would be beneficial to universities working to improve AI programs. Furthermore, several common responses in the RFI—and in the interviews with faculty members described in Chapter 3—are not explicitly included in the authorization of capacity-building activities. These include hiring faculty (65 out of 117 responses), providing access to computational capacity (39), and student preparation (28) and outreach activities (29). Another common response (26), internships and industry partnerships, is authorized solely for AI SFS participants.[89] Limiting capacity-building support to the elements authorized in Section 10313(d), including limiting at least part of that support to IHEs providing AI SFS would run the risk of missing important categories of IHE needs as they strengthen their AI education capacity.

AI SFS AND ADMINISTRATION PRIORITIES RELATED TO DIVERSITY

EO 14110 lays out a set of specific actions to be taken by executive branch agencies in response to Administration AI priorities.[90] EO 14110's statements of policy and principles include a sub-section regarding the Federal Government's AI use and capacity. That section makes explicit reference to attracting and retaining a diverse AI Federal workforce (Section 2(g)). This emphasis on supporting a diverse Federal AI workforce aligns with the emphasis on diversity in the planned institutional eligibility criteria for the AI SFS, as well as with other Administration EOs regarding the importance of diversity and equity.[91] Similarly, the NAIRR Task Force emphasized the importance of increasing access to AI research infrastructure and increasing diversity of AI researchers to enable a diversity of perspectives in developing AI systems in their report to Congress.[92]

DIVERSITY AND REPRESENTATION IN AI-RELATED ACADEMIC PROGRAMS

As Congress has, at least implicitly, incorporated a diversity goal into the AI SFS authorization, the needs assessment explored the representation of women and racial/ethnic groups traditionally underrepresented in STEM fields in CS as a proxy for AI since the data for AI programs are limited. IPEDS 2020–2022 graduation data were used to collect gender and racial/ethnic breakdowns for computer and information and support services sciences for bachelor's-, master's-, and doctoral-level degrees (CIP code 11) and for all bachelor's degrees by IHE. The analysis was limited to institutions granting at least 50 bachelor's degrees in CS over the three-year period to detect variations in racial/ethnic and gender makeup of graduates.

The analysis used only two measures of diversity, namely overall percentage of CS graduates who are female or are from underrepresented racial/ethnic groups.[93] This approach provides a simple-to-interpret measure. As might be expected, the institutions with the highest percentage of CS-related graduates who are from racial/ethnic underrepresented groups are all HBCUs. While some MSIs also graduate a large number of students from underrepresented groups in CS, some of the institutions that graduate the largest number of CS-related graduates from underrepresented groups are large public IHEs. IHEs whose CS-related programs graduate a high percentage of women are women's colleges. The institutions that graduate the largest number of women in CS tend to be research-intensive public institutions.

At the same time, this count-based approach does not account for the underlying demographics of the IHE itself. Measures that normalize demographics of particular programs or fields against the overall demographics of IHEs have also been proposed.[94] The representation metric used compares the percentage of graduates in a field with particular demographic characteristics at the same IHE (e.g., percentage of degrees in CS earned by women) with the overall percentage of graduates with those demographic characteristic (e.g., percentage of total degrees earned by women). So, if 50% of the graduates of an IHE are women, while 25% of the CS graduates are women, then the representation metric would be 0.5. The metric is expressed on a log2 scale, centered at 1. Approximately one-quarter of IHEs graduate underrepresented students with CS bachelor's degrees proportional to or greater than their overall representation in bachelor's degrees (Table 13). In 4% of IHEs, the percentage of underrepresented students earning CS degrees was half of the percentage of overall students receiving degrees or less.

Women are underrepresented in CS at the bachelor's level in 98% of IHEs

~70% of IHEs do not graduate underrepresented students with CS bachelor's degrees proportional to their overall representation in bachelor's degrees

Table 13. Relative Representation of Women and Students from Underrepresented Groups in CS-related Bachelor's Degrees, 2020–2022

Percentage of IHEs	Underrepresented groups	Women
Representation metric of 1 or greater	237 (30.3%)	15 (1.9%)
Representation metric between 0.8 and 1	297 (38.0%)	16 (2.0%)
Representation metric between 0.8 and 0.5	218 (27.9%)	126 (16.1%)
Representation metric below 0.5	29 (3.7%)	623 (80.0%)

Source: Analysis of IPEDS 2020–2022 degree data

Note: Analysis limited to 781 IHEs with 50 or more bachelor's degrees between 2020 and 2022 in CIP code 11

This analysis suggests that when considering universities' success in attracting and retaining students in AI/CS-related fields, there may be value in considering not only the overall share of degrees earned but also representation relative to the demographics of the IHEs themselves. It also suggests that there may be value in focusing on women in AI/CS-related fields as well as on representation based on race and ethnicity.

5. FEASIBILITY AND IMPLEMENTATION OF AI SFS PROGRAM

The CHIPS and Science Act of 2022 authorized the Director of NSF to establish the AI SFS program in coordination with the Director of OPM, the Director of NIST, and the heads of other agencies with appropriate scientific knowledge.

NSF is an independent Federal agency created by Congress in 1950 "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes." NSF achieves its mission primarily by creating programs that issue limited-term grants to fund specific proposals that have been judged the most promising by a rigorous and objective merit review system. This review process ensures that proposals are reviewed in a fair, competitive, transparent, and in-depth manner. If established, the AI SFS program, like other programs at NSF, would issue a solicitation inviting proposals from U.S.-based IHEs. Proposals submitted in response to AI SFS solicitations would be reviewed by independent reviewers who lack conflicts of interest with the proposals. Reviewers would be selected from a national pool of experts in AI education, research and practice, and reviewer identity would not be disclosed.

The AI SFS authorization includes consideration for leveraging existing processes and resources associated with administering the CyberCorps® SFS program in standing up the AI SFS program. The CyberCorps® program has been a critical element in the development of high-quality cybersecurity education programs in the U.S. and in strengthening the government cybersecurity workforce. The first cohort of 31 CyberCorps® SFS students enrolled in fall 2001. Over the years, the program has grown to 104 higher education institutions located in 43 States, the District of Columbia, and Puerto Rico. As of January 2024, 5,573 students have enrolled since its inception.

The AI SFS program would include three components as authorized by statute. First, a Scholarship component would provide funding to "qualified institutions of higher education" to award scholarships for up to three years to students in undergraduate or graduate degree programs or concentrations in, or related to, AI. All scholarship recipients would need to work after graduation in the AI mission of an approved government organization for a period equal to the duration of their scholarship. The legislative language of the AI Scholarship component is similar to the CyberCorps® SFS statute. Second, a *Capacity Building* component would provide funding to promote integration of AI with other programs of study and support education research and translation to practice related to the development of AI researchers and practitioners. Third, a *Fellowship* component would provide funding to graduate students in AI and related fields who are pursuing research-based master's and doctoral degrees, and to prospective or current faculty members who are interested in expanding their research and teaching into AI.

Beyond funding programs, two important elements have contributed to the success of cybersecurity education and workforce development efforts. The National Centers of Academic Excellence in Cybersecurity (NCAE-C) program, maintained by NSA and partners since 1999, has created a strong community of practice and provided a collection of Knowledge Units (KUs) for validation of academic programs of study. The National Initiative for Cybersecurity Education (NICE) Cybersecurity Workforce Framework, established by NIST and partners in 2010, has provided a modern taxonomy of cybersecurity workforce including Work Roles; KSATs; and Competency Levels. An alternative but similar workforce framework is the DCWF.

This feasibility study considers lessons learned from creating a successful ecosystem for cybersecurity education and workforce development in the last 25 years and aims to apply them to the creation of an AI SFS program. It includes scholarships, fellowships, and capacity-building programs; criteria to designate qualified IHEs; and a taxonomy of the Federal AI workforce.

SCHOLARSHIPS

The AI SFS program would provide funds to qualified IHEs to award scholarships to students who commit to work after graduation in the AI mission of a government organization. The AI SFS scholarships would consist of stipends, tuition, education-related fees, and other allowances. Scholarships are not based on student financial need. It is expected that AI scholarships will be similar to those provided by the CyberCorps® SFS program, which is currently offering academic-year stipends of $27,000 per year for undergraduate students and $37,000 per year for graduate students; full tuition and education-related fees

(not including items such as meal plans, housing, or parking); and a professional allowance of $6,000 per academic year to be used for attending AI SFS Job Fairs and other travel, conferences, research materials, books and supplies including a one-time purchase of a computer, professional training and certifications, etc.

ELIGIBILITY AND SELECTION

The AI SFS program would solicit proposals from IHEs accredited in, and having a campus located in the United States, to establish an AI scholarship program. All proposals submitted to NSF are assessed on their intellectual merit and broader (societal) impacts. An NSF program can add additional program-specific criteria, which are listed in the program's solicitation. In addition, NSF can specify additional eligibility criteria for academic institutions. As required by the AI SFS statute, NSF, in coordination with other agencies with appropriate scientific knowledge, would establish such additional eligibility criteria to designate qualified IHEs that would be eligible to participate in the AI SFS program. The criteria would include measures of the institution's demonstrated excellence in AI education, with special emphasis on Federal workforce needs; ability to attract, retain and graduate a diverse STEM student population; and other criteria as established by NSF and government partners. In addition to technical aspects of AI, one of the selection criteria would be the institution's ability to graduate AI scholarship and fellowship recipients with an understanding of the intersection of technology and society, such as technology ethics and the social impacts of AI.

Scholarship awards to academic institutions would be continuing grants extending over a five-year period with a typical budget of $2 to $4 million (total) to support four student cohorts. A proposing institution would provide a description of its scholarship recipient selection criteria and process. To be eligible for consideration for an AI SFS scholarship, a student will need to be a citizen or lawful permanent resident of the United States and demonstrate a commitment to a career in advancing the field of AI. In addition, the student would be required to be a full-time student in a coherent formal program that is focused on AI with sophomore standing in an associate's degree program; with junior or senior standing in a bachelor's degree program; enrolled in a master's degree program; or enrolled in a research-based doctoral program. Second-year students at community colleges would be eligible for one year of support if there is a formal agreement between their community college and a four-year institution which will allow students to transfer for two additional years, with support, to complete a bachelor's degree. A supported student at a community college would be allowed to enroll on a less than full-time basis, but not less than a half-time basis with prorated scholarship amounts.

The diverse talents and perspectives of various underrepresented groups in STEM, including women, Blacks and African Americans, Hispanic Americans, American Indians, Alaska Natives, Native Hawaiians, Native Pacific Islanders, and persons with disabilities, offer significant potential to increase and enhance the AI professional community. Tapping into a vast pool of diverse talent will require a range of measures, including institutional programs and activities as well as culture change across colleges, departments, classes, and research groups. Institutions submitting AI SFS proposals would be required to describe their current demographics, existing initiatives intended to broaden participation, and plans for recruitment, mentoring, and retention of AI SFS scholars who are members of underrepresented racial and ethnic minority groups, women, first-generation/low-income students, persons with disabilities, members of rural communities, or veterans. NSF will conduct outreach and encourage applications from rural-located institutions of higher education; rural-serving institutions of higher education; minority-serving institutions such as Historically Black Colleges and Universities, Tribal Colleges and Universities, Asian American and Native American Pacific Islander-Serving Institutions, and Hispanic Serving Institutions; and institutions located in an Established Program to Stimulate Competitive Research (EPSCoR) jurisdiction.

SCHOLARSHIP AGREEMENT

Each AI SFS scholarship recipient would sign an agreement to meet the service obligation or repay the scholarship. The service obligation is the time period the recipient would be required to work in the AI mission of a Federal executive agency; Congress (including any agency, entity, office, or commission established in the legislative branch); an interstate agency; a State, local or Tribal government, which may include instruction in AI-related skill sets in a public school system; or government-affiliated nonprofit considered to be critical infrastructure. The recipient must also obtain prior approval of employment to ensure that it will count toward completion of the service obligation. Each institution would be required to have AI SFS scholarship recipients complete an

initial counseling session before receiving the scholarship and an exit counseling session before graduation. The initial counseling informs prospective scholarship recipients about the AI SFS scholarship program and service obligation requirements, the circumstances under which the scholarship needs to be repaid, and when it will be treated as a Direct Unsubsidized Loan for repayment purposes. The exit counseling provides information about fulfilling the scholarship service obligation, options for temporarily deferring the completion of the service obligation, and terms and conditions surrounding scholarship repayments. To demonstrate that a scholarship recipient is performing service in accordance with the agreement to serve, each scholarship recipient would be required, within 30 days of the beginning of the service and upon completion of each year of such service, to provide documentation of that service. Recipients who fail to complete their service obligation may be required to repay part or all of their scholarships.

INTERNSHIPS AND SERVICE OBLIGATION

AI SFS students would be required to participate in meaningful government internships during the summer between their first and second year of scholarship study and would be encouraged to take additional internships in subsequent years. Summer internships typically are paid for by the hiring agency. Doctoral students may be allowed to substitute their summer internship with a research activity following a recommendation from their academic advisor.

The AI SFS authorization requires the AI SFS program to prioritize the employment placement of scholarship recipients in the Federal Government's executive branch. This would be accomplished by limiting the number of students that may be placed in a non-executive Federal agency; State, local or Tribal government organizations, which may include instruction in AI-related skills in public schools; or FFRDCs.

Internship placements and final job placements in government organizations usually require security clearances, and scholarship recipients would need to undergo the background investigation necessary to obtain such clearances as part of the job and/or internship application process.

DEFERRAL OF SERVICE OBLIGATION

A scholarship recipient may request a deferral of the completion of the service obligation based on enrollment in a program of study or engagement in approved professional activity that would improve the scholar's AI workforce readiness. The deferral may be also granted in exceptional circumstances significantly affecting the scholarship recipient's ability to serve, including a qualifying reason for leave based on the Family and Medical Leave Act or active service in the National Guard and Reserve.

WAIVER OF SERVICE OBLIGATION

A scholarship recipient may request a partial or total waiver or suspension of any service or repayment obligation whenever compliance with the obligation is impossible or would involve extreme hardship, or if enforcement of such obligation with respect to the scholarship recipient would be unconscionable. Extreme hardship could include but is not limited to financial or economic burden, permanent disability, and other circumstances.

SCHOLARSHIP REPAYMENT

A scholarship recipient who fails to complete their service obligation would need to repay the scholarship to the United States. If not repaid, the scholarship will be treated as a Direct Unsubsidized Loan. If the full amount is not repaid, any remaining balance plus any applicable fees will be referred to the U.S. Treasury for collection. A scholarship recipient whose scholarship is treated as a Direct Unsubsidized Loan, is granted a six-month grace period prior to entering repayment.

HIRING AUTHORITY AND JOB FAIRS

The AI SFS authorization includes special hiring authorities, allowing Federal organizations to noncompetitively appoint scholarship graduates. In addition, upon fulfillment of their service term, AI SFS recipients may be converted noncompetitively to a term, career-conditional or career appointment. If converted to a term appointment, an agency may later noncompetitively convert such employee to a career-conditional or career appointment before the term appointment expires.

Agencies interested in recruiting from the pool of AI SFS scholars would be able to use a web portal to browse the student pool. While scholarship recipients are responsible for their own job searches, the AI SFS program would provide several tools to help scholarship recipients find employment, including annual job fairs. Closed hiring events specifically for the AI SFS students would be held twice a year to give agencies an opportunity to interview and even hire students on the spot.

CAPACITY BUILDING

The statutory language includes capacity-building efforts to promote multi-disciplinary programs of study that integrate basic or advanced AI training with other fields of study, including those that address the social, economic, legal, and ethical implications of human interaction with AI systems; to support education research programs that will enable postsecondary educational institutions to expand their ability to train the next-generation AI workforce, including AI researchers and practitioners; and to create courses or training modules in technology ethics. The AI SFS program would support these efforts in a larger context of capacity-building strategies as described in the NSF-funded report on Expanding Capacity and Diversity in Lifelong AI Education.[95] A short description of major findings is included below.

QUALITY AI EDUCATION

Strategies for establishing guidelines for quality AI education across all levels of education are being addressed by organizations such as TeachAI.org and the ACM/AAAI Committees for curriculum guidelines. A gap in the development of curriculum guidelines exists for public AI literacy and the need to enhance the offerings and effectiveness of adult AI education. Strategies to address this gap may leverage existing "continuing education" mandates in professions like nursing; exploit online education for adult learning; advocate for public-private partnerships to deliver education, while addressing integration challenges with existing academic policies; engage public libraries, community, and senior citizen centers to promote lifelong learning; and prioritize personalized learning experiences for varied demographics.

INCREASING CAPACITY IN AI

Increasing capacity in AI requires a comprehensive approach to AI education, including curricular development, teacher training, and public awareness initiatives across various educational levels. Enhancing AI capacity requires a combination of revised educational approaches, informed partnerships, and a commitment to fostering an inclusive and adaptable AI understanding across disciplines. The implementation of these strategies, along with adequate funding support, will enhance AI knowledge and skills among learners of all ages and backgrounds and help promote widespread adoption and understanding of AI in education and society. Creating trusted information sources and utilizing public resources and organizations to share information is essential. It is important to note that rapid advancement is often fragile. Consideration of how efforts can be sustained over time is critical.

INCREASING DIVERSITY IN AI

The complex challenge of promoting diversity and inclusivity in AI education across various educational levels requires more focus, investments, and research. Strategies and metrics should encompass demographic representation, accessibility, teacher training, interdisciplinary collaboration, and the contextualization of materials. The overarching goal should be to create inclusive AI education that addresses the unique needs and backgrounds of learners and educators at all levels while considering the intersecting factors that shape experiences. A holistic and data-driven approach is essential for fostering diversity and equity in AI education and ensuring that it is accessible and beneficial to all. Collaboration between academia and industry, hands-on experiences, and the incorporation of real-world contexts and ethical considerations are key themes. Additionally, tracking diversity metrics and promoting lifelong learning are recognized as essential for creating a skilled and inclusive AI workforce for the future.

Strategies for enhanced engagement and inclusion in AI education span a wide range, including creating multiple pathways to AI, collaborating with Special Education Teachers, providing nurturing peer support, varying tasks, utilizing a variety of tools, tailoring problems to students' local interests, considering the scope of inclusivity appropriate for the learning context, avoiding technical terms when introducing AI concepts, and drawing from diverse datasets. These strategies aim to make AI education more inclusive and engaging for a broad range of students, including those with diverse backgrounds and abilities. Ultimately, leaders need to champion and align these values and practices to achieve true universal inclusion in AI education, rather than occasional inclusion. They also need to assess how well current practices are aligned with the values and practices to which they aspire and to address misalignments when they are identified.

INTEGRATING AI IN EDUCATION

The integration of AI in education and the profession of teaching is poised to redefine the equilibrium between theoretical understanding and skill acquisition. As AI automates certain tasks and challenges traditional learning pathways, the educational community must reassess the primary objectives of learning to ensure holistic development of learners.

AI SFS capacity-building efforts would be complementary to other NSF AI education initiatives. NSF's EducateAI Initiative addresses the growing need to develop the next generation of talent for a diverse, well-trained AI workforce by creating new pathways and educational experiences that provide the knowledge, skills, and dispositions necessary for current and future AI careers. The ExpandAI program aims to significantly broaden participation in AI research, education, and workforce development through capacity-development projects and through partnerships within the National AI Research Institutes[96] ecosystem.

A critical factor for success of capacity-building efforts as well as democratization of the AI education ecosystem is access to needed resources. Led by NSF in partnership with 10 other Federal agencies and 25 non-governmental partners, the NAIRR pilot[97] will support educators to train students on responsible use and development of AI technologies by providing access to infrastructure and training resources. When fully functional, NAIIR could provide students with an interactive learning environment integrating electronic notebooks and computational content with textbooks developed by the instructor.

FELLOWSHIPS

The main goal of AI Fellowship would be to increase the number and diversity of domestic graduate students pursuing research, teaching, and innovation careers in AI and related fields. The program would recognize and support (1) outstanding graduate students in AI and related fields who are pursuing research-based master's and doctoral degrees at accredited U.S. institutions and (2) prospective or current faculty members who are interested in expanding their research and teaching into AI.

To be eligible, an applicant would have to be a U.S. citizen, national, or permanent resident and (1) intend to enroll or be enrolled in a research-based master's or doctoral degree program in an AI or AI-related field; or (2) a faculty member on AI professional development, including faculty on a sabbatical leave.

PROGRAM MANAGEMENT

As outlined in the AI SFS statute, oversight and administration of the program are entrusted to NSF in collaboration with OPM, NIST, and other agencies with appropriate scientific knowledge. This collaborative approach will ensure the program's effectiveness and alignment with national AI objectives. OPM already partners with NSF for the CyberCorps® SFS program by aiding scholarship recipients, coordinating students' transition into government employment, and monitoring students' compliance with program requirements. This model as well as the existing resources and processes would be extended to the scholarship component of the AI SFS program.

U.S. NATIONAL SCIENCE FOUNDATION

NSF's AI SFS Program Office would play a central role in overseeing the three components of the program. This role encompasses a broad spectrum of responsibilities, ranging from issuing program solicitations, overseeing the merit review process, conducting pre-award site visits, and post-award management of awards. Review of annual and final reports submitted by AI SFS awardees ensures that projects adhere to program objectives. Beyond these administrative functions, the Program Office would manage financial aspects of the program and represent the program in interactions with Federal agencies and the academic and scientific communities.

The Scholarship component management will be shared with OPM as described below. Capacity Building and Fellowship components will be managed entirely by NSF with other government partners serving in an advisory role.

OFFICE OF PERSONNEL MANAGEMENT

OPM's AI SFS Management Office would support the scholarship component via a reimbursable interagency agreement. The Management Office would create and disseminate program documents, including Student Service Agreements, policy directives, and general guidance. These documents form a framework for the administration of the scholarships. The Management Office would also facilitate the onboarding process for new scholarship recipients. It would

track scholarship recipients from program entry through the completion of the post-graduation service obligation, which includes monitoring academic progress in collaboration with participating institutions during the scholarship phase.

The Management Office would review and approve student job offers, ensuring alignment with program objectives, and monitor the service obligations reported by scholars. Finally, the Management Office would manage annual Job Fair events. The Management Office would maintain an online portal where scholarship recipients can access program-related information, post resumes, and connect with registered and approved organizations seeking AI talent. The portal will also provide consolidated and user-friendly online resources for prospective scholarship recipients, including searchable database of participating institutions, AI-related job opportunities, and an up-to-date description of AI careers.

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY AND OTHER FEDERAL PARTNERS

For the last six months, NSF has been actively collaborating on the AI SFS Initiative with partner agencies including NIST, DoD, NSA, OPM and the Cybersecurity and Infrastructure Security Agency (CISA). The current collaboration focuses on discussing how 25-years of cybersecurity education and workforce development experiences can be translated into corresponding AI domains. In particular, the Federal frameworks that are being assessed are the NICE Cybersecurity Workforce Framework maintained by NIST; the DCWF; and the Center of Academic Excellence in Cybersecurity (CAE-C) maintained by NSA and CISA. Both NICE and DCWF are being extended by adding AI and DS elements. NSF and NSA will support a series of workshops leading to the addition of the AI Program of Study validation to the CAE-C designation by September 2024. These collaborative efforts will identify Federal AI Work Roles and their associated KSATs and map those to KUs that could be used for assessing curricular guidelines.

NSF and Federal partners will develop criteria to designate qualified IHEs that would be eligible to participate in the AI SFS program. They will serve on AI SFS advisory board, bringing diverse perspectives to build a successful AI SFS program and contribute to AI SFS leadership and vision to increase the number of highly skilled AI professionals entering the Federal workforce.

MONITORING AND EVALUATION

Program monitoring for the AI SFS program would involve ongoing review of awardee's annual reports submitted to NSF coupled with continued monitoring of the progress of AI SFS scholarship recipients during the scholarship and commitment phases by the OPM Management Office.

All NSF projects are required to submit annual reports that document progress and findings of the project. These reports enable program officers to monitor the progress of projects towards their specific goals. Financial tracking also enables NSF to examine if a project is spending its funds in a timely and approved manner. If an AI SFS project is not progressing as planned, NSF can defer disbursement of annual budget increments.

The OPM Management Office would conduct continuous monitoring of AI SFS students including registration of new students, monitoring continuing students' academic status, approving internships and post-graduation placement, and processing annual employment verification until the end of the obligation phase. In addition, in cases in which a student does not fulfill their obligation, necessary information would be collected and/or generated to support processing waiver requests, repayment agreements, or collection by the U.S. Treasury.

Every five years, NSF will conduct independent evaluations lasting approximately two years. The evaluations would examine the effectiveness of the program through a rigorous, multi-method approach, involving multiple data sources, focus groups, annual surveys, college site visits, agency site visits, interviews, and internal data spanning multiple years. The evaluation would use a logic model representing program inputs, program initiatives, intended intermediate outcomes, ultimate outcomes, unintended outcomes, and contextual factors of the AI SFS program.

Evaluation efforts will be supported by annual surveys to monitor program implementation and outcomes for the purposes of accountability, program management, and improvement of the program. The annual scholar surveys would be administered beginning the year that a scholar enters into the AI SFS program and conclude eight years after the service commitment end date. Additional surveys and focus groups would include academic faculty and agency representatives involved in the recruitment and hiring of interns and graduates. The evaluators would visit several

agencies each year to shadow and interview AI SFS scholars and their supervisors. This information would be used to create a competency gap analysis.

In addition to the evaluation discussed above, as for all NSF programs, the primary mechanism used to determine program strengths and weaknesses is the quadrennial review by an external group of experts known as the Committee of Visitors (COV). The COV conducts a systematic review of all programs in a given division and presents its report to the Directorate Advisory Committee, which also reviews and comments on the Division's plans for any needed programmatic adjustments. Strengths and weaknesses are also identified via the examination of projects recommended for award or declination. Program officers likewise examine the program as a whole with respect to the goal of a balanced portfolio, considering multiple factors including geographic distribution and diversity in institution type.

PUBLIC INFORMATION AND REPORTS TO CONGRESS

As required by the AI SFS legislation, the Director of NSF in coordination with the Director of OPM, would annually evaluate and make public information on the success of recruiting individuals for scholarships under this section and on hiring and retaining those individuals in the public sector AI workforce, including information on placement rates; where students are placed; salary ranges; how long after graduation students are placed; how long students stay in the positions they enter upon graduation; how many students are released from obligations; and what, if any, remedial training is required.

Every three years, a report including the information listed in the preceding paragraph—together with any recent statistics regarding the size, composition, and educational requirements of the Federal AI workforce—would be submitted to the Committee on Homeland Security and Governmental Affairs of the Senate; the Committee on Commerce, Science, and Transportation of the Senate; the Committee on Science, Space, and Technology of the House of Representatives; and the Committee on Oversight and Reform of the House of Representatives.

PROGRAM REFRESH

NSF updates its solicitations periodically to adapt to new legislatively mandated requirements, recommendations received from the community, and challenges encountered generally by grantees. As required by the legislative language, the AI SFS program would be updated not less than once every two years to reflect advances in technology. It could take the form of updating a solicitation, creating special emphasis themes, or issuing Dear Colleague Letters to the community.

IMPLEMENTATION PLAN

The AI SFS program would publish one or more solicitations for scholarships, capacity building and fellowships. As required by the AI SFS statute, NSF in coordination with other agencies with appropriate scientific knowledge, would establish additional eligibility criteria to designate qualified IHEs that would be eligible to participate in the AI SFS program and apply for the scholarship grants. The capacity building grants would help academic institutions to meet designation criteria.

YEAR 0: DEVELOPING A FEDERAL AI SFS ECOSYSTEM

Collaboration with NIST, DoD, NSA, OPM, and CISA will focus on translating Federal cyber education and workforce development frameworks to AI. In particular, the Federal frameworks that are being assessed are the NICE Cybersecurity Workforce Framework maintained by NIST; DCWF maintained by DoD; and CAE-C maintained by NSA and CISA. NSF and NSA have supported a series of workshops leading to the addition of the AI Program of Study validation to the CAE-C designation by September 2024. NSF and Federal partners will develop criteria to designate qualified IHEs that would be eligible to participate in the AI SFS program.

YEAR 1: AI SFS COHORT FOCUSING ON SECURITY OF AI AND AI IN CYBERSECURITY

In Year 1, the Scholarship focus will be on using AI in cybersecurity as well as on security and resilience of AI systems, and the ecosystems in which they are deployed. Common security concerns relate to adversarial examples, data poisoning, and the exfiltration of models, training data, or other intellectual property through AI system endpoints. Capacity building and Fellowship focus would be open to all AI and AI-related areas.

YEARS 2–7: AI SFS COHORTS FOCUSING ON CORE AI, AI ENABLERS, AND AI + X

In subsequent years, the Scholarship focus will be on preparing core AI professionals broadly trained in ML,

generative models, large language models etc., and AI-enablers such as data scientists or data engineers. In addition, there could be a specific focus X preparing experts in domain X to implement AI solutions. Capacity building and Fellowship focus would be open to all AI and AI-related areas.

6. Conclusion

AI is widely considered a disruptive technology because of its ability to reshape societal norms, transform industries, create new markets and products, integrate into daily life, accelerate innovation, and more. While AI presents numerous opportunities, it also poses challenges including job displacement due to automation and the need for significant investment in AI governance to address ethical, privacy, and security concerns. The Federal Government's role in using, regulating, and promoting ethical AI deployment will be rapidly increasing. It will require a well-informed AI-ready workforce to implement AI solutions effectively and ethically. The AI SFS program will develop the next generation of AI professionals equipped to serve Federal, State, local, and Tribal governments.

Key findings of this report suggest a growing demand within the Federal sector for AI-skilled professionals across a variety of roles, from technical to managerial and policy-oriented positions. Despite the advancement in AI education at IHEs, there is a notable gap in the alignment of these programs with Federal workforce requirements, particularly at the doctoral and post-doctoral levels. The report analyzed the current and projected needs of the Federal AI workforce and identified a shortfall in AI-educated U.S. citizens entering Federal service, which the AI SFS program aims to address through targeted scholarships, capacity-building efforts, and fellowships. The report highlights the broader benefits of AI SFS program, including the promotion of diversity in AI education and the Federal AI workforce. By fostering a more diverse pool of AI professionals, the program aims to bring a wide range of perspectives and solutions to the challenges posed by AI technologies, ensuring that its benefits are widely and equitably distributed.

Establishing the AI SFS program will supply the Federal AI workforce and help maintain national security, economic competitiveness, and ethical governance in the AI domain. The AI SFS program's structure is set to mirror the successful elements of the CyberCorps® SFS program that proved to be a critical contributor to building the Federal cybersecurity workforce over the last 20 years. The program will provide financial support and educational opportunities designed to attract top talent into AI roles within the government, ensuring that the United States remains at the forefront of global AI innovation and application.

APPENDIX A. Creating Helpful Incentives to Produce Semiconductors Act Section 10313(d)

(d) AI SCHOLARSHIP-FOR-SERVICE

(**1) DEFINITION OF EXECUTIVE AGENCY.** In this subsection, the term "executive agency" has the meaning given the term "Executive agency" in section 105 of title 5.

(2) AI SCHOLARSHIP-FOR-SERVICE INITIATIVE REPORT Not later than 1 year after August 9, 2022, the Director, in coordination with the Office of Personnel Management, shall submit to the Committee on Commerce, Science, and Transportation of the Senate, the Committee on Science, Space, and Technology of the House of Representatives, the Committee on Homeland Security and Governmental Affairs of the Senate, and the Committee on Oversight and Reform of the House of Representatives a report on the need and feasibility, and if appropriate, plans to implement a program to recruit and train the next generation of artificial intelligence professionals to meet the needs of Federal, State, local, and Tribal governments.The report shall include—

(A) recent statistical data on the size, composition, and educational requirements of the Federal AI workforce, including an assessment of current and future demand for additional AI professionals across the Federal Government;

(B) an assessment of the capacity of institutions of higher education to produce graduates with degrees, certifications, and relevant skills related to artificial intelligence that meet the current and future needs of the Federal workforce; and

(C) an evaluation of the need for and feasibility of establishing a scholarship-for-service program to recruit and train the next generation of artificial intelligence professionals to meet the needs of Federal, State, local, and Tribal governments, including opportunities for leveraging existing processes and resources for administering the Federal Cyber Scholarship-for Service Program established under section 7442 of title 15 in standing up such a program.

(3) PROGRAM ESTABLISHMENT
Upon submitting the report required in paragraph (2), the Director, in coordination with the Director of the Office of Personnel Management, the Director of the National Institute of Standards and Technology, and the heads of other agencies with appropriate scientific knowledge, is authorized to establish a Federal artificial intelligence scholarship-for service program (referred to in this section as the Federal AI Scholarship-for-Service Program) to recruit and train artificial intelligence professionals to lead and support the application of artificial intelligence to the missions of Federal, State, local, and Tribal governments.

(4) QUALIFIED INSTITUTION OF HIGHER EDUCATION The Director, in coordination with the heads of other agencies with appropriate scientific knowledge, shall establish criteria to designate qualified institutions of higher education that shall be eligible to participate in the Federal AI Scholarship-for-Service program. Such criteria shall include—

(A) measures of the institution's demonstrated excellence in the education of students in the field of artificial intelligence; and

(B) measures of the institution's ability to attract and retain a diverse and nontraditional student population in the fields of science, technology, engineering, and mathematics, which may include the ability to attract women, minorities, and individuals with disabilities.

(5) PROGRAM DESCRIPTION AND COMPONENTS The Federal AI Scholarship-for-Service Program shall—

(A) provide scholarships through qualified institutions of higher education to students who are enrolled in programs of study at institutions of higher education leading to degrees or concentrations in or related to the artificial intelligence field;

(B) provide the scholarship recipients with summer internship opportunities or other meaningful temporary appointments in
the Federal workforce focusing on AI projects or research;

(C) prioritize the employment placement of scholarship recipients in executive agencies;

(D) identify opportunities to promote multi-disciplinary programs of study that integrate basic or advanced AI training with other fields of study, including those that address the social, economic, legal, and ethical implications of human interaction with AI systems;

(E) support capacity-building education research programs that will enable postsecondary educational institutions to expand their ability to train the next-generation AI workforce, including AI researchers and practitioners;

(F) create courses or training programs in technology ethics for students receiving scholarships; and

(G) award fellowships to masters and doctoral students who are pursuing degrees or research in artificial intelligence and related fields, including in the field of technology ethics.

(6) SCHOLARSHIP AMOUNTS

Each scholarship under paragraph (5) shall be in an amount that covers the student's tuition and fees at the institution for not more than 3 years and provides the student with an additional stipend.

(7) POST-AWARD EMPLOYMENT OBLIGATIONS

Each scholarship recipient, as a condition of receiving a scholarship under the program, shall enter into an agreement under which the recipient agrees to work for a period equal to the length of the scholarship, following receipt of the student's degree, in the AI mission of—

(A) an executive agency;

(B) Congress, including any agency, entity, office, or commission established in the legislative branch;

(C) an interstate agency;

(D) a State, local, or Tribal government, which may include instruction in AI-related skill sets in a public system; or

(E) a State, local, or Tribal government-affiliated nonprofit entity that is considered to be critical infrastructure (as defined in section 5195c(e) of this title).

(8) HIRING AUTHORITY

(A) Appointment in excepted service

Notwithstanding any provision of chapter 33 of title 5, governing appointments in the competitive service, an executive agency may appoint an individual who has completed the eligible degree program for which a scholarship was awarded to a position in the excepted service in the executive agency.

(B) Noncompetitive conversion

Except as provided in subparagraph (D), upon fulfillment of the service term, an employee appointed under subparagraph (A) may be converted noncompetitively to term, career-conditional, or career appointment.

(C) Timing of conversion

An executive agency may noncompetitively convert a term employee appointed under subparagraph (B) to a career-conditional or career appointment before the term appointment expires.

(D) Authority to decline conversion

An executive agency may decline to make the noncompetitive conversion or appointment under subparagraph (B) for cause.

(9) ELIGIBILITY TO BE ELIGIBLE TO RECEIVE A SCHOLARSHIP UNDER THIS SECTION, AN INDIVIDUAL SHALL—

(A) be a citizen or lawful permanent resident of the United States;

(B) demonstrate a commitment to a career in advancing the field of AI;

(C) be—

(i) a full-time student in an eligible degree program at a qualified institution of higher education, as determined by the Director;

(ii) a student pursuing a degree on a less than full-time basis, but not less than half-time basis; or

(iii) an AI faculty member on sabbatical to advance knowledge in the field; and

(D) accept the terms of a scholarship under this section.

(10) CONDITIONS OF SUPPORT

(A) In general
As a condition of receiving a scholarship under this section, a recipient shall agree to provide the qualified institution of higher education with annual verifiable documentation of post-award employment and up-to-date contact information.

(B) Terms A scholarship recipient under this section shall be liable to the United States as provided in paragraph (12) if the individual—

(i) fails to maintain an acceptable level of academic standing at the applicable institution of higher education, as determined by the Director;
(ii) is dismissed from the applicable institution of higher education for disciplinary reasons;
(iii) withdraws from the eligible degree program before completing the program;
(iv) declares that the individual does not intend to fulfill the post-award employment obligation under this section; or
(v) fails to fulfill the post-award employment obligation of the individual under this section.

(11) MONITORING COMPLIANCE AS A CONDITION OF PARTICIPATING IN THE PROGRAM, A QUALIFIED INSTITUTION OF HIGHER EDUCATION SHALL—

(A) enter into an agreement with the Director to monitor the compliance of scholarship recipients with respect to their post-award employment obligations; and

(B) provide to the Director, on an annual basis, the post-award employment documentation required under paragraph (10) for scholarship recipients through the completion of their post-award employment obligations.

(12) AMOUNT OF REPAYMENT

(**A)** Less than 1 year of service If a circumstance described in paragraph (10) occurs before the completion of 1 year of a post-award employment obligation under this section, the total amount of scholarship awards received by the individual under this section shall—

(i) be repaid; or
(**ii)** be treated as a loan to be repaid in accordance with paragraph (13).

(B) 1 or more years of service If a circumstance described in clause (iv) or (v) of paragraph (10)(B) occurs after the completion of 1 or more years of a post-award employment obligation under this section, the total amount of scholarship awards received by the individual under this section, reduced by the ratio of the number of years of service completed divided by the number of years of service required, shall—

(i) be repaid; or
(ii) be treated as a loan to be repaid in accordance with paragraph (13).

(13) REPAYMENTS A LOAN DESCRIBED IN PARAGRAPH (12) SHALL—

(A) be treated as a Federal Direct Unsubsidized Stafford Loan under part D of title IV of the Higher Education Act of 1965 (20 U.S.C. 1087a et seq.); and

(B) be subject to repayment, together with interest thereon accruing from the date of the scholarship award, in accordance with terms and conditions specified by the Director (in consultation with the Secretary of Education).

(14) COLLECTION OF REPAYMENT

(A) In general, in the event that a scholarship recipient is required to repay the scholarship award under this section, the qualified institution of higher education providing the scholarship shall—

(i) determine the repayment amounts and notify the recipient and the Director of the amounts owed; and
(ii) collect the repayment amounts within a period of time as determined by the Director, or the repayment amounts shall be treated as a loan in accordance with paragraph (13).

(B) Returned to Treasury
Except as provided in subparagraph (C), any repayment under this subsection shall be returned to the Treasury of the United States.

(C) Retain percentage
A qualified institution of higher education may retain a percentage of any repayment the institution collects under this subsection to defray administrative costs associated with the collection. The Director shall establish a fixed percentage that will apply to all eligible entities, and may update this percentage as needed, in the determination of the Director.

(15) EXCEPTIONS
The Director may provide for the partial or total waiver or suspension of any service or payment obligation by an individual under this section whenever compliance by the individual with the obligation is impossible or would involve extreme hardship to the individual, or if enforcement of such obligation with respect to the individual would be unconscionable.

(16) PUBLIC INFORMATION

(A) Evaluation The Director, in coordination with the Director of the Office of Personnel Management, shall annually evaluate and make public, in a manner that protects the personally identifiable information of scholarship recipients, information on the success of recruiting individuals for scholarships under this section and on hiring and retaining those individuals in the public sector AI workforce, including information on—

(i) placement rates;
(ii) where students are placed, including job titles and descriptions;
(iii) salary ranges for students not released from obligations under this section;
(iv) how long after graduation students are placed;
(v) how long students stay in the positions they enter upon graduation;
(vi) how many students are released from obligations; and
(vii) what, if any, remedial training is required.

(B) Reports
The Director, in coordination with the Office of Personnel Management, shall submit, not less frequently than once every 3 years, to the Committee on Homeland Security and Governmental Affairs of the Senate, the Committee on Commerce, Science, and Transportation of the Senate, the Committee on Science, Space, and Technology of the House of Representatives, and the Committee on Oversight and Reform of the House of Representatives a report, including the results of the evaluation under subparagraph (A) and any recent statistics regarding the size, composition, and educational requirements of the Federal AI workforce.

(C) Resources The Director, in coordination with the Director of the Office of Personnel Management, shall provide consolidated and user-friendly online resources for prospective scholarship recipients, including, to the extent practicable—

(i) searchable, up-to-date, and accurate information about participating institutions of higher education and job opportunities related to the AI field; and
(ii) a modernized description of AI careers.

(17) REFRESH
Not less than once every 2 years, the Director, in coordination with the Director of the Office of Personnel Management, shall review and update the Federal AI Scholarship-for-Service Program to reflect advances in technology.

APPENDIX B. AI Skills from the Lightcast Taxonomy

In analysis of Lightcast job posting and social profile records, two skills-based definitions were leveraged. Definition 1 includes any record indexed with two or more skills from a list of core AI/ML skills identified in the Lightcast taxonomy, listed in Table 14. Definition 2 includes definition 1 augmented with any record indexed with one core AI/ML skill and one or more skills from the list of field-specific skills from the Lightcast taxonomy (Table 15). The two-skills requirement is used to reduce the number of false hits.

Table 14. Core AI/ML Skills List Derived from Lightcast Skills Taxonomy

Activity Recognition
AdaBoost (Adaptive Boosting)
Adversarial Machine Learning
AIOps (Artificial Intelligence For IT Operations)
Apache MADlib
Apache Mahout
Apache MXNet
Apache SINGA
Apache Spark
Applications Of Artificial Intelligence
Artificial General Intelligence
Artificial Intelligence
Artificial Intelligence Development
Artificial Intelligence Markup Language (AIML)
Artificial Intelligence Systems
Artificial Linguistic Internet Computer Entity (ALICE)
Artificial Neural Networks
Association Rule Learning
Autoencoders
Automated Machine Learning
Autonomic Computing
Autonomous System
AWS SageMaker
Azure Cognitive Services
Azure Machine Learning
Baidu
Bayesian Networks
BERT (NLP Model)
Boolean Networks
Boosting
Caffe
Caffe2
Chainer (Deep Learning Framework)
Chatbot
Chi-Squared Automatic Interaction Detection (CHAID)
Classification And Regression Tree (CART)
Cluster Analysis
Cognitive Automation
Cognitive Computing
Cognitive Robotics
Collaborative Filtering
Component Analysis
Computational Intelligence
Computational Linguistics
Computer Vision
Confusion Matrix
Constraint Logic Programming
Contextual Image Classification
Convolutional Neural Networks
Cudnn
Cyber-Physical Systems
Data Classification
Data Mining
Dbscan
Decision Models
Decision Tree Learning
Deep Learning
Deeplearning4j
DeepSpeech
Dialog Systems
Dimensionality Reduction
Dlib (C++ Library)
Ensemble Methods
Evolutionary Programming
Expert Systems
fastText
Feature Engineering
Feature Extraction
Feature Learning
Feature Selection
Fuzzy Logic
Gaussian Process
Genetic Algorithm
Google AutoML
Google Cloud ML Engine
Gradient Boosting
Greedy Algorithm
H2O.ai
Hidden Markov Model
Hugging Face (NLP Framework)
Hugging Face Transformers
Hyperparameter Optimization
Image Segmentation
Imagenet
Inference Engine
Intelligent Agent
Intelligent Control
Intelligent Systems
Intelligent Virtual Assistant
Kaldi
Keras (Neural Network Library)
Kernel Methods
K-Means Clustering
Knowledge-Based Configuration
Knowledge-Based Systems
Kubeflow
Latent Dirichlet Allocation
LexalyticsLinear Regression
Logistic Regression
Long Short-Term Memory (LSTM)
Machine Learning
Machine Learning Algorithms
Machine Learning Methods
Machine Translation
Machine Vision
Markov Chain
Markov Decision Process (Optimal Decisions)
Markov Process
Matrix Factorization
Meta Learning
Microsoft Cognitive Toolkit (CNTK)
Microsoft LUIS
MLflow
MLOps (Machine Learning Operations)
mlpack (C++ Library)
Montecarlo
Motion Planning
Multi-Agent Systems
Multiple Linear Regression
Naive Bayes Classifier
Natural Language Generation
Natural Language Processing
Natural Language Programming
Natural Language Toolkits
Natural Language Understanding
Natural Language User Interface
Nonlinear Regression
Nvidia Jetson
Open Neural Network Exchange (ONNX)
OpenAI Gym
OpenCV
OpenVINO
Optical Character Recognition (OCR)
Ordinary Least Squares (Regression Analysis)
PaddlePaddle
Particle Swarm Optimization
Path Analysis
Path Finding
Perceptron
Poisson Regression
Polynomial Regression
Pose Estimation
Predictive Modeling
Principal Component Analysis
Principal Component Regression
Pybrain
PyTorch (Machine Learning Library)
Q Learning
Random Forest Algorithm
Reasoning Systems
Recommender Systems
Recurrent Neural Network (RNN)
Regression Analysis
Reinforcement Learning
Ridge/LASSO Regressions
Robot Framework
Robot Operating Systems
Robotic Automation Software
Robotic Programming
Robotic Systems
Robust Regression
Semantic Analysis
Semantic Interpretation For Speech Recognition
Semantic Parsing
Semantic Reasoner
Semantic Search
Semi-Supervised Learning
Sentiment Analysis
Seq2Seq
SLAM Algorithms (Simultaneous Localization And Mapping)
Soft Computing
Sorting Algorithm
Spectral Clustering
Statistical Language Acquisition
Stochastic Optimization
Supervised Learning
Support Vector Machine
Swarm Intelligence
Symbolic Computation
TensorFlow
Test Datasets
Text Mining
Time Series
Tokenization
Torch (Machine Learning)
Training Datasets
Transfer Learning
Unsupervised Learning
Vowpal Wabbit
Watson Conversation
Watson Studio
Weka
Word Embedding
Word2Vec Models
Xgboost

Table 15. Field-Specific AI Skills List Derived from Lightcast Skills Taxonomy

Algorithmic Trading	Clinical Informatics	Financial Forecasting	Operations Research
Advanced Robotics	Clinical Research Informatics	Financial Risk Modeling	Predictive Analytics
Autonomous Vehicles	Data-Driven Decision-Making	Health Informatics	Psychometrics
Bioinformatics	Econometrics	Informatics	Quantum Information
Cheminformatics	Electronic Design Automation		

APPENDIX C. Abbreviations

ACS	American Community Survey
AI	artificial intelligence
BLS	Bureau of Labor Statistics
CAHSI	Computing Alliance of Hispanic-Serving Institutions
CHIPS	Creating Helpful Incentives to Produce Semi-conductors
CIO	Chief Information Officers
CIP	Department of Education Classification of Instructional Programs
CISA	Cybersecurity and Infrastructure Security Agency
COV	Committee of Visitors
CRA	Computing Research Association
CS	computer science
CS/AI	computer science bachelor's degrees with AI concentrations
CSET	Center for Security and Emerging Technology
DHS	Department of Homeland Security
DCWF	DoD Cyber Workforce Framework
DL	deep learning
DoD	Department of Defense
DOL	Department of Labor
DS	Data Science
EHRI-SDM	Enterprise Human Resources Integration-Statistical Data Mart
EO	Executive Order
FFRDC	Federally Funded Research and Development Center
GIS	geospatial information systems
GRFP	U.S. National Science Foundation Graduate Research Fellowship Program
GS	Office of Personnel Management General Schedule
HAI	Stanford University's Stanford's Human-Centered Artificial Intelligence Center
HBCU	Historically Black Colleges and Universities
IHE	institution of higher education
IPEDS	U.S. Department of Education Integrated Postsecondary Education Data System
JOA	job opportunity announcement
KSA	knowledge, skills, and abilities
KSAT	knowledge, skills, abilities, and tasks
KU	knowledge unit
ML	machine learning
MSI	Minority-Serving Institution
NAIRR	National AI Research Resource
NASA	National Aeronautics and Space Administration
NCAE-C	National Centers of Academic Excellence in Cybersecurity
NDAA	National Defense Authorization Act
NICE	National Initiative for Cybersecurity Education
NIST	National Institute of Standards and Technology
NLP	natural language processing
NSA	National Security Agency
NSCAI	National Security Commission on AI
NSCG	National Survey of College Graduates
NSF	U.S. National Science Foundation
OECD	Organization for Economic Co-operation and Development
ONCD	Office of the National Cyber Director
OPM	U.S. Office of Personnel Management
R&D	Research and Development
R1	Carnegie Classification: "Doctoral Universities: Very High Research Activity"
R2	Carnegie Classification: "Doctoral Universities: High Research Activity"
R3	Carnegie Classification: "Doctoral/Professional Universities"
RFI	request for information
SFS	scholarship for service
SOC	DOL Standard Occupational Classification System
STEM	science, technology, engineering, and mathematics
TEVV	test and evaluation and validation and verification
VA	U.S Department of Veterans Affairs

APPENDIX D. Notes

[1] OPM makes available to the public anonymized statistical data about the Federal civilian workforce via its FedScope/EHRI-SDM data system Data used in this report were drawn from the March 2023 data release, the most current dataset available at the time of analyses conducted in development of this report. EHRI-SDM data cover most of the non-Postal Federal executive branch, excluding most intelligence agencies; the Government Printing Office and six commissions from the legislative branch; and the U.S. Tax Court from the judicial branch. For more information about inclusions or exclusions, visit:

[2] U.S. Department of Defense. 2022. "Total Defense Department Military Community." 2022 Demographics Profile. DoD. Available online at https://download.militaryonesource.mil/12038/MOS/Infographic/2022-demographics-total-dod-militarycommunity.pdf

[3] Federal Acquisition Regulations. "Federally Funded Research and Development Centers." FAR 35.017. Available online at https://www.acquisition.gov/far/35.017

[4] National Science Foundation. 2023. "Master Government List of Federally Funded R&D Centers." Available online at https://www.nsf.gov/statistics/ffrdclist/

[5] Includes a sum of estimates from the following sources: Aerospace Corporation. 2023. "Aerospace by the Numbers" The Aerospace. Available online at https://aerospace.org/video/aerospace-numbers; Ames National Laboratory. 2024. "About Ames National Laboratory." Ames National Laboratory. Available online at https://www.ameslab.gov/about-ames-laboratory; RAND. 2024. "RAND at a Glance." RAND. Available online at https://www.rand.org/about/glance.html Argonne National Laboratory. 2024. "Argonne Employee Demographics." Argonne National Laboratory. Available online at https://www.anl.gov/hr/argonne-employee-demographics; Brookhaven National Laboratory. 2024. "About Brookhaven National Laboratory." Brookhaven National Laboratory. Available online at https://www.bnl.gov/about/; MITRE. 2024. MITRE Connects | Impact Report. MITRE. Available online at https://www.mitre.org/impact-report; Southwest Research Institute. 2024. "Center for Nuclear Waste Regulatory Analyses." Southwest Research Institute. Available online at https://www.swri.org/sites/default/filesbrochures/cnwra-support-services.pdf; Fermilab. 2024. "About Fermilab." Fermi National Accelerator Laboratory. Available online at https://www.fnal.gov/pub/about/index.html; Zippia. 2020. "Working at Associated University: Employee Reviews and Culture." Zippia. Available online at https://www.zippia.com/associated-university-careers-15582/; INL. 2023. "About INL." Idaho National Laboratory. 5/8/2023. Available online at https://inl.gov/about-inl/; MITRE. 2024. *MITRE Connects | Impact Report*. MITRE. Available online at https://www.mitre.org/impact-report; JPL. 2024. "Who We Are." NASA Jet Propulsion Laboratory. Available online at https://www.jpl.nasa.gov/who-we-are; LBNL. 2024. "Our Story." Lawrence Berkeley National Laboratory. Available online at https://www.lbl.gov/about/; https://kb.lightcast.io/en/articles/6957504-profiles-methodology; LLNL. 2024. "Diversity - Our Workforce." Lawrence Livermore National Laboratory. Available online at https://www.llnl.gov/diversity/our-workforce; LANL. 2024. "About the Lab." Los Alamos National Laboratory. Available online at https://about.lanl.gov/; Batelle. 2024. "About Us." Batelle. Available online at https://www.battelle.org/about-us; NCI. 2024. "About NCI Frederick." National Cancer Institute Frederick. Available online at https://www.cancer.gov/about-nci/organization/nci-frederick/about; AURA Astronomy. 2023. "About - AURA Astronomy." AURA Astronomy. Available online at https://www.aura-astronomy.org/about/; Zippia. 2022. "National Radio Astronomy Observatory Number of Employees, Statistics, Diversity, Demographics, and Facts - Zippia." Available online at https://www.zippia.com/national-radio-astronomy-observatory-careers-32414/demographics/; NREL. 2024. "Diversity, Equity, Inclusion, and Accessibility." National Renewable Energy Laboratory. Available online at https://www.nrel.gov/about/diversity.html; ORNL. 2024. "FrequentlyAsked Questions | ORNL." Oak Ridge National Laboratory. Available online at https://www.ornl.gov/content/frequently-asked-questions; PNNL. 2023. "PNNL Creates Center for Artificial Intelligence." Pacific Northwest National Laboratory. Available online at https://www.pnnl.gov/news-media/pnnl-creates-center-artificial-intelligence; Sandia. 2024. "About Sandia. Facts & Figures." Sandia NationalLaboratory. Available online at https://www.sandia.gov/about/facts-figures/; Thomas Jefferson National Accelerator Facility. 2024. "ThomasJefferson National Accelerator Facility."Available online at https://www.jlab.org/; MIT Lincoln Laboratory. 2022. Facts 2022. MIT Lincoln Laboratory. Available online at https://www.ll.mit.edu/sites/default/files/page/doc/2022-02 Facts_book_2022_FINAL.pdf

[6] Bureau of Labor Statistics. 2022. "SOC home: U.S. Bureau of Labor Statistics." Available online at https://www.bls.gov/soc/

[7] Gehlhaus, Diana and Santiago Mutis. 2021. *The U.S. AI Workforce: Understanding the Supply of AI Talent*. Center for Security and Emerging Technology. Available online at https://cset.georgetown.edu/publication/the-u-s-ai-workforce/

Gehlhaus, Diana and Ilya Rahkovsky. 2021. *U.S. AI Workforce Labor Market Dynamics.* Center for Security and Emerging Technology. https://cset.georgetown.edu/wp-content/uploads/CSET-U.S.-AI-Workforce-Labor-Market-Dynamics.pdf

Gehlhaus, Diana, Luke Koslosky, Kayla Goode, and Claire Perkins. 2021. *U.S. AI Workforce: Policy Recommendations*. Center for Security and Emerging Technology. Available online at https://cset.georgetown.edu/publication/u-s-ai-workforce-policy-recommendations/

[8] Gehlhaus, Diana and Santiago Mutis. 2021. *The U.S. AI Workforce: Understanding the Supply of AI Talent.* Center for Security and Emerging Technology. Available online at https://cset.georgetown.edu/publication/the-u-s-ai-workforce/

[9] Green, Andrew and Lucas Lamby. 2023. *The supply, demand and characteristics of the AI workforce across OECD countries*. Organization for Economic Co-operation and Development (OECD Social, Employment and Migration Working Papers, 287). Available online at https://www.oecd-ilibrary.org/docserver/bb17314a-en.pdf

[10] This reporting requirement excludes AI use cases that are classified, sensitive, defense- or intelligence-specific, included in common commercial products, or used solely for AI research and development.

[11] The White House. 2024. Fact Sheet: Biden-Harris Administration Announces Key AI Actions Following President Biden's Landmark Executive Order. Available online at https://www.whitehouse.gov/briefing-room/statements-releases/2024/01/29/fact-sheet-biden-harris-administration-announces-key-ai-actions-following-president-bidens-landmark-executive-order/
The White House. 2024. Fact Sheet: Biden-Harris Administration Announces Key AI Actions Following President Biden's Landmark Executive Order. Available online at https://www.whitehouse.gov/briefing-room/statements-releases/2024/04/29/biden-harris-administration-announces-key-ai-actions-180-days-following-president-bidens-landmark-executive-order/

[12] NSCAI. 2021. *Final Report.* National Security Commission on Artificial Intelligence. Available online at https://www.nscai.gov/wp-content uploads/2021/03/Full-Report-Digital-1.pdf

[13] Ibid.

[14] Bureau of Labor Statistics. 2023. "Computer and Information Technology Occupations: Occupational Outlook Handbook: U.S. Bureau of Labor Statistics." Bureau of Labor Statistics. Available online at https://www.bls.gov/ooh/computer-and-information-technology/home

[15] Bureau of Labor Statistics. 2023. "Employment in STEM occupations." Bureau of Labor Statistics. Available online at https://www.bls.gov/emp/tables/stem-employment.htm

[16] GCR, NIST. "American Competitiveness Of a More Productive Emerging Tech Economy Act (The American COMPETE Act)." (2023). Available online at: https://nvlpubs.nist.gov/nistpubs/gcr/2023/NIST.GCR.23-039.pdf

[17] National Science Foundation. 2024. "National Artificial Intelligence Research Resource Pilot." National Science Foundation. Available online at National Artificial Intelligence Research Resource Pilot | NSF - National Science Foundation.
NAIRR Pilot. 2024. "The National Artificial Intelligence Research Resource (NAIRR) Pilot." NAIRR Pilot. Available online at: https://nairrpilot.org/

[18] NAIRR TF. 2023. Strengthening and Democratizing the U.S. Artificial Intelligence Innovation Ecosystem: An Implementation Plan for a National Artificial Intelligence Research Resource. Available online at https://www.ai.gov/wp-content/uploads/2023/01/NAIRR-TF-Final-Report-2023.pdf

[19] 116th Congress. 2021. AI in Government Act. Title I Sec. 105 of the Consolidated Appropriations Act of 2021, P.L. 116-68.

[20] U.S. Office of Personnel Management. 2023. "The AI in Government Act of 2020 – Artificial Intelligence Competencies." Available online at https://chcoc.gov/sites/default/files/The%20AI%20in%20Government%20Act%20of%202020%20Memo.pdf

[21] U.S. Office of Personnel Management. 2024. "The Artificial Intelligence Classification Policy and Talent Acquisition Guidance." Available online at https://chcoc.gov/content/artificial-intelligence-classification-policy-and-talent-acquisition-guidance-ai-government
U.S. Office of Personnel Management. 2024. " Skills-Based Hiring Guidance and Competency Model for Artificial Intelligence Work." Available online at https://chcoc.gov/content/skills-based-hiring-guidance-and-competency-model-artificial-intelligence-work
U.S. Office of Personnel Management. 2024. "Artificial Intelligence (AI) Competency Model for Civil Engineering, 0810." Available online at https://chcoc.gov/content/artificial-intelligence-ai-competency-model-civil-engineering-0810

[22] Department of Defense. 2023. "AI/Data – DoD Cyber Exchange." Available online at https://public.cyber.mil/wf-element-sub/ai-data/

[23] Department of Defense. 2023. "Software Engineering – DoD Cyber Exchange." Available online at https://public.cyber.mil/wf-element-sub/software-engineering/

[24] Gehlhaus, Diana, Ron Hodge, and Jonathan Rotner. 2023. *DOD's Emerging Digital Workforce. A Follow-on Report to the DOD's Hidden AI Workforce*. Center for Security and Emerging Technology; MITRE.

[25] U.S. Office of Personnel Management. 2024. "The Artificial Intelligence Classification Policy and Talent Acquisition Guidance." Available online at https://chcoc.gov/content/artificial-intelligence-classification-policy-and-talent-acquisition-guidance-ai-government

[26] Executive Office of the U.S. President. 2024. The AI and Tech Talent Task Force Report to the President "Increasing AI Capacity Across the Federal Government: AI Talent Surge Progress and Recommendations." Available online at https://ai.gov/wp-content/uploads/2024/04/AI-Talent-Surge-Progress-Report.pdf

[27] U.S. Office of Personnel Management. 2024. "The Artificial Intelligence Classification Policy and Talent Acquisition Guidance." Available online at https://chcoc.gov/content/artificial-intelligence-classification-policy-and-talent-acquisition-guidance-ai-government

[28] Department of Defense. 2024. "DoD Cyber Workforce Framework." Available online at https://public.cyber.mil/wid/dcwf/

[29] Throughout this report, AI is defined as inclusive of ML, and "AI" and "AI/ML" are used interchangeably.

[30] U.S. Office of Personnel Management. 2014. "FedScope Data Definitions and About EHRI-SDM." https://www.fedscope.opm.gov/datadefn DataDefinitions.pdf; OPM. 2023. "About our Data (EHRI-SDM)." Available online at https://www.fedscope.opm.gov/datadefn/aehri_sdm.asp

[31] The 800,000 USAJOBS JOAs analyzed included all openings for 2022 and 2023 as of mid-October 2023.

[32] The keywords used in this AI/ML USAJOBS JOA query include artificial intelligence, machine learning, statistical learning, supervised learning, deep learning, neural network, reinforcement learning, computer vision, natural language processing, knowledge representation, responsible AI, trustworthy AI, explainable AI, cognitive system, intelligent system, generative AI, large language model, MLOps, neuromorphic, AI/ML, statistical reasoning, and expert system.

[33] The top five occupational series by number of USAJOBS JOAs with AI keywords include IT Management, Data Science, Computer Science, Miscellaneous Administration and Program, and Management and Program Analysis.

[34] See, for example: Gehlhaus, Diana and Santiago Mutis. 2021. The U.S. AI Workforce: Understanding the Supply of AI Talent. Center for Security and Emerging Technology. Available online at https://cset.georgetown.edu/publication/the-u-s-ai-workforce/ and Green, Andrew and Lucas Lamby. 2023. The supply, demand and characteristics of the AI workforce across OECD countries. Organization for Economic Co-operation and Development (OECD Social, Employment and Migration Working Papers, 287). Available online at https://www.oecd-ilibrary.org/docserver/bb17314a-en.pdf.

[35] Because USAJOBS JOAs are not cleanly indexed with AI competencies or tasks as a basis for identifying AI-focused and non-AI-focused jobs for each occupational series—and the data leveraged predate the USAJOBS category of "AI or AI-enabling jobs"—this analysis instead relies on the assumption that if a Federal agency is seeking job candidates with AI/ML knowledge, skills, or abilities—or to fill a role that involves tasks related to AI—then "artificial intelligence," "machine learning," or other closely related terms or common techniques will appear somewhere in the text of a job posting. This method is analogous to the one leveraged by Green and Lamby (2023) in their OECD working paper (highlighted earlier in Chapter 2). Green and Lamby's corresponding estimates for the size of the full U.S. AI workforce are substantially smaller than other estimates because they aim to capture the positions for which AI competencies are core to the job, rather than positions held by individuals who likely have the capacity to engage in any aspect of AI work or product cycles, or who have the capacity to develop AI competencies, whether or not they currently do.

Because this assumption is not easy to validate, and due to other limitations of the approach, it is important to emphasize that these estimates are approximations reasonably derived from available data and should not be taken as absolute ground truth—rather, they are the best available estimates at the time of writing this report. For example, because job postings are written by different individuals and include different levels of detail from job to job, it is possible that there are job postings that require AI competencies or involve AI tasks that might not include these keywords. In addition, while these keywords were validated, it is possible that they do not capture all of the specific AI terms mentioned in Federal job postings, though these postings tend to include relatively high-level descriptions rather than highly technical jargon. On the other hand, the share of postings referencing AI KSATs in recent postings is likely to be higher than the current share of the workforce conducting AI work due to the trend in increasing demand for these KSATs over time.

There are additional limitations associated with the underlying dataset. Some JOAs in the corpus, including approximately 10 percent of those returned in the AI/ML query results, reflect positions that were "canceled." This could mean a variety of things—for example, an agency changed its mind about an opening, the position was filled directly by the agency (rather than via USAJOBS), the position parameters were changed, resulting in the need for an updated JOA, or the position went unfilled. In addition, a single JOA may be used to fill multiple positions; while JOAs are often tagged as representing "one," "few," "many" or a specific number of openings, specific numbers are not as a rule included in the records, and there is no way to determine from these data how many positions were filled. The analysis thus leverages the assumption that one JOA of any status corresponds to approximately one open position, another assumption that cannot be fully validated. Finally, some positions could feasibly be coded with more than one OPM occupational series based on the position duties and requirements. There might be inconsistency in how hiring managers choose to code a given position. In some cases, positions are tagged with more than one occupational series. To avoid overcounting, this method thus uses "prorated counts" by distributing the count for one posting fractionally across all occupational series with which it is tagged with equal weights.

[36] These include data science, data scientist, data engineer, data infrastructure, data manager, data steward, data architecture, data architect, data analytics, data analyst, and data officer.

[37] These include computer engineer, computer scientist, computer architect, software engineer, software developer, software design, software architect, software test & evaluation, software test and evaluation.

[38] Based on share of USAJOBS JOAs that included an AI/ML keyword.

[39] U.S. Department of Defense. 2022. "Total Defense Department Military Community." 2022 Demographics Profile. DoD. Available online at https://download.militaryonesource.mil/12038/MOS/Infographic/2022-demographics-total-dod-military-community.pdf

[40] This list was designed to exclude irrelevant results and thus is likely under-inclusive rather than over-inclusive.

[41] Included records for JOAs opening in 2022 and 2023 available as of October 17, 2023.

[42] Includes Lightcast-indexed records for postings opening from 2018-2023 available as of October 31, 2023.

[43] This analysis included 12 of the 16 DOE National Labs and 24 of the other 26 FFRDC operators.

[44] FedScope's Accessions and Separations DataCubes for FY 2022 and roughly the first half of FY 2023 (as reported in March 2023) were used to estimated total AI accessions (number of individuals entering new positions as new hires or transfers from other positions) and separations (people leaving a Federal government position). The number of accessions and separations for each OPM occupational series included in FedScope was multiplied by with estimated within-occupation AI share of workers computed through analysis of USAJOBS JOAs. This approach yielded estimates of approximately 600 new hires into Federal civilian non-intelligence AI positions per year on average in 2022 and 2023. A loss of 280 Federal civilian non-intelligence AI workers per year corresponds to an attrition rate of approximately 5 percent, assuming the Federal, civilian non-intelligence estimated AI workforce size derived using the same data sources (USAJOBS and FedScope).

[45] These interviews were held prior to October 30, 2023.

[46] It is possible that views and needs have shifted since the release of EO 14110, which is expected to accelerate Federal AI deployment, oversight, and workforce development and could represent transition into a new Federal AI workforce paradigm.

[47] National Science Foundation. 2023. "Dear Colleague Letter: Request for Information on the Capacity of Institutions of Higher Education to Produce Graduates with Degrees, Certifications, and Relevant Skills Related to Artificial Intelligence." https://www.nsf.gov/pubs/2023/nsf23099/nsf23099.jsp

[48] To identify AI degree programs, general web searches were conducted to identify institutions with such degrees and cross-checked with institutions reporting IPEDS degree awards using the AI CIP code, and institutions that responded to the AI SFS RFI.

[49] These totals represent a lower bound estimate of the number of AI degree programs at IHEs. Based on the method used to identify AI degree| programs, the list may not be complete.

[50] The Carnegie Classification of Institutions of Higher Education is a framework for classifying colleges and universities in the United States. See: https://carnegieclassifications.acenet.edu/

[51] CAHSI is an NSF National INCLUDES Alliance (https://cahsi.utep.edu/). The HSIs with AI programs that are CAHSI participating institutions are: New Mexico State University, University of Bridgeport, University of North Texas, Florida International University, and San Jose State University.

[52] CIP code 11.0102 is titled "Artificial Intelligence" and is defined as "A program that focuses on the symbolic inference, representation, and simulation by computers and software of human learning and reasoning processes and capabilities, and the computer modeling of human motor control and motion. Includes instruction in computing theory, cybernetics, human factors, natural language processing, and applicable aspects of engineering, technology, and specific end-use applications." (https://nces.ed.gov/ipeds/cipcode/cipdetail.aspx?y=55&cipid=87243)

[53] For this analysis, first and second majors in CIP 11.0102 were counted. A much larger number of bachelor's and master's degrees in AI are being counted in IPEDS. Across all institutions reporting AI degrees in IPEDS, in 2022, there were 104 bachelor's degrees and 485 master's degrees reported.

[54] Some degree programs in the catalog of AI degree programs were launched too recently to have produced any graduates that would have been reported in IPEDS, so it is not unreasonable that the catalog of AI degree programs includes a larger range of universities and degree programs than is reflected in IPEDS.

[55] Zweben, Stuart and Betsy Bizot. 2022. "2022 Taulbee Survey Record Doctoral Degree Production; More Increases in Undergrad Enrollment Despite Increased Degree Production." Available online at https://cra.org/crn/wp-content/uploads/sites/7/2023/05/2022-Taulbee-Survey-Final.pdf

[56] AI/ML was the largest specialty area reported (436). Other AI-related specialty areas include Human-Computer Interaction (88), Software Engineering (110), and Robotics/Vision (79).

[57] In this analysis, both first and second degrees reported in IPEDS for CIP 11.01 (computer and information sciences) and 11.07 (computer science) were counted.

[58] These estimates were based on information from two interviews where estimates were shared for the number of students in their AI concentration. For one university, they shared that over a third of their CS undergraduate majors choose the AI concentration (the most popular of all their available concentrations). For another university, they shared that around 10 percent of their CS master's degree students choose the AI concentration.

[59] The degrees tagged with CIP code 30.70 (Data Science) were analyzed.

[60] Unlike for the AI degree program, no validation of the DS degrees reported in IPEDS was conducted at this time.

[61] For this analysis, the upper estimate is used, with the assumption that 25% of the CS graduates will choose an AI concentration.

[62] Historical IPEDS data on the growth in the number of CS bachelor's degrees (specifically CIP 11.01 and CIP 11.07) awarded indicate an ~12% annual increase in the number of bachelor's degrees awarded from ~50,000 in 2017 to ~80,000 in 2022. Thus, if this trend continues, when projecting forward from 2022 to 2028, the increase from 2022 to 2028 would be 72%. The number of CS master's degrees awarded over 2017-2022 was relatively flat, however, from 2012-2022, the number of CS master's degrees awarded grew by nearly 120%. For this exercise, a simplifying, and conservative, assumption was made - that the number of CS master's degrees and doctoral degrees awarded will increase at the same rate of 72%. There is not enough historical data on AI or DS degree awards to estimate the growth in degrees awarded, so the estimated growth of 72% of CS bachelor's degrees was used there as well, for both bachelor's and master's degrees. It is also assumed that the number of AI doctoral degrees will increase by 72% by 2028, even though the size of doctoral cohorts may be unlikely to increase by that large an amount, so this estimate may be an overestimate for AI doctoral degrees. The set of assumptions used here help generate an upper estimate for the number of new graduates with AI-related degrees, which allows for conservative assessment of whether future demand for new AI workers still exceeds this upper estimate for future supply.

[63] There are IPEDS data available on the share of AI degrees (CIP 11.0102) awarded to U.S. citizens and permanent residents, which says that 81% of bachelor's degrees, 46% of master's degrees and 24% of doctoral degrees in AI were awarded to U.S. citizens and permanent residents in 2022. However, the IPEDS data on AI degrees (CIP 11.0102) represent only a very small number of institutions (3 for bachelor's degrees, 16 for master's degrees, 5 for doctoral degrees), which may make the shares reported for AI degrees skewed based on a few particular universities reporting these degrees.

[64] Course descriptions for all of the required courses were compiled for nearly all (11) AI bachelor's degrees, for nearly all (18) AI master's degrees, and for a sample of (22) CS bachelor's degrees with AI concentrations, (25) DS bachelor's degrees, and (22) DS master's degrees. Cosine similarity topic modeling method of these course descriptions was pursued, specifically to characterize the agreement of degree programs about inclusion of a variety of selected topics in their required coursework. 52 topics were chosen to represent types of courses that appear in the required coursework for the degree programs analyzed with the heuristic that each topic needed to reflect at least 4 representative classes across all 98 program descriptions. From these representative courses associated with each topic, a bag-of-words associated with that topic was created. The topics were also grouped within four primary categories (artificial intelligence & machine learning, computer science, data science, and mathematics & statistics) or a field-specific category (biology, cybersecurity, economics, engineering, humanities, human imitation) to help demonstrate the relationships between topics. The cosine similarity analysis generated a similarity score between each of the 98 degree programs and a set of 52 topics. The method is able to pick up topics covered in the course description that are not necessarily apparent from the course title. The results of the topic modeling were validated with input from interviews with IHEs, responses to the NSF AI SFS RFI, and with blinded manual qualitative analyses of the coursework.

[65] Lightcast assigns each job posting a standardized job title. Each Lightcast job posting is tagged with a collection of skills from a Lightcast taxonomy of skills. The Lightcast skills are split into common skills and technical skills, but only the technical skills were analyzed here. A set of core and field-specific AI job postings from 2018 to October 31, 2023, were used as the "Federal AI job postings" for this analysis. To ensure that this analysis does not weight job titles that might have very high overlap due to there being only a few job postings, meaning fewer skills listed in the job postings, only standardized job title to have a minimum of nine job postings were analyzed.

[66] There are several important caveats to this analysis that are important to the interpretation of the results. A major limitation of these results is that they do not contain information on the depth of knowledge or experience needed in any particular skill/topic area. By matching on skill terms that appear in job postings and in course descriptions, the analysis is not capturing information on the proficiency levels required or gained in this skill—likely because many job postings and course descriptions lack these details on depth of knowledge/experience in a topic. Also, the appearance of a skill term in a job posting does not indicate the relative importance of that skill to perform the work—some skills listed may be critical, need-to-have skills for an application and others may be nice-to-have skills. This analysis, therefore, cannot inform whether the overlap between degree programs and job postings is on need-to-have or nice-to-have skills. For these reasons, numerical overlap on the number of skills that appear in a job description and degree program can be misleading. A score of 30 percent overlap between a particular job title and a degree program alone lacks the context needed to determine this degree program is exceptional, sufficient, or insufficient preparation for a particular job. Instead, the relative rankings of the job titles with highest overlap for each degree program were used.

[67] It is important to note that the skill keywords that are being measured as overlapping between the job postings and degree programs are broad. For example, skill keywords of machine learning, artificial intelligence, research, computer science, algorithms, data analysis, are responsible for some of the highest overlaps between job postings and degree programs. Thus, this approach is measuring a somewhat crude and high-level alignment of job titles and degree programs.

[68] Specifically, the answers to two questions on the RFI "What factors are critical for increasing AI education and workforce development capacity at your institution? What are the current barriers?" and "What factors are critical for increasing the number of graduates with AI skills, knowledge, and competencies? What are the current barriers?" were coded and analyzed. Of the 113 institutions that responded to these questions of the RFI, over half (54) were associated with R1 institutions, 33 were from R2/R3 institutions, 19 were from master's or baccalaureate institutions, 5 were from community colleges and 2 had no university affiliations. No interesting correlations, however, were identified when responses were cross tabulated by Carnegie Classification.

[69] National Academies of Sciences, Engineering, and Medicine. 2018. Assessing and Responding to the Growth of Computer Science Undergraduate Enrollments. Consensus study report. Washington, District of Columbia: The National Academies Press. https://nap.nationalacademies.org/catalog/24926/assessing-and-responding-to-the-growth-of-computer-science-undergraduate-enrollments

[70] National Academies of Sciences, Engineering, and Medicine. 2018. Assessing and Responding to the Growth of Computer Science Undergraduate Enrollments. Consensus study report. Washington, District of Columbia: The National Academies Press. https://nap.nationalacademies.org/catalog/24926/assessing-and-responding-to-the-growth-of-computer-science-undergraduate-enrollments

[71] Singer, Natasha. 2019. "The Hard Part of Computer Science? Getting into Class." The New York Times, January 24, 2019. https://www.nytimes.com/2019/01/24/technology/computer-science-courses-college.html

[72] Computing Research Association. 2023. "2022 Taulbee Survey Record Doctoral Degree Production; More Increases in Undergrad Enrollment Despite Increased Degree Production." https://cra.org/crn/wp-content/uploads/sites/7/2023/05/2022-Taulbee-Survey-Final.pdf. Accessed December 28, 2023

[73] Executive Office of the President. 2023. Executive Order 14110: *Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence*. Federal Register. Available online at https://www.federalregister.gov/documents/2023/11/01/2023-24283/safe-secure-and-trustworthy-development and-use-of-artificial-intelligence

[74] Ibid., Section 10.2(a)

[75] Ibid.

[76] Ibid., Section 10.2(b)(iii)

[77] Ibid., Section 10.2(c)

[78] Ibid., Section 10.2(d)

[79] NSF is also tasked with several research-related activities in Sections 5.2 and 9(c) of EO 14110 that could also contribute to training AI-related researchers and workers.

[80] Ibid., Section 5.2(b)

[81] Ibid., Section 6(c)

[82] Ibid., Section 2(g). Italics added for emphasis.

[83] Ibid., Section 10(b)(ii)

[84] See Chapter 2: The Federal AI Workforce for a description of the methodology underlying these estimates.

[85] While similar analyses were not run for similar computations for FFRDC AI workers, given the large number of AI-focused jobs identified at FFRDCs currently, were they to have been included the number of workers projected in 2028 would have been considerably higher.

[86] Executive Office of the President. 2023. Executive Order 14110: *Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence*. Sections 5.2(b) and 6(c). Federal Register. Available online at https://www.federalregister.gov/documents/2023/11/01/2023-24283/safe-secure and-trustworthy-development-and-use-of-artificial-intelligence

[87] AI literacy by workers who interact with and make use of AI systems was also touched upon in interviews as a potential need but is considered to be outside of any reasonable definition of "the field" of AI.

[88] Section 10313(d) Paragraph 5(D): "identify opportunities to promote multi-disciplinary programs of study that integrate basic or advanced AI training with other fields of study, including those that address the social, economic, legal, and ethical implications of human interaction with AI systems";

Paragraph 5(E): "support capacity-building education research programs that will enable postsecondary educational institutions to expand their ability to train the next-generation AI workforce, including AI researchers and practitioners";

Paragraph 5(F): "create courses or training programs in technology ethics for students receiving scholarships"

[89] Section 10313(d) Paragraph 5(B).

[90] Executive Office of the President. 2023. Executive Order 14110: *Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence*. Federal Register. Available online at https://www.federalregister.gov/documents/2023/11/01/2023-24283/safe-secure-and-trustworthy-development and-use-of-artificial-intelligence

[91] For example, Executive Order 13985 of January 20, 2021 (*Advancing Racial Equity and Support for Underserved Communities Through the Federal Government*), Executive Order 14035 of June 25, 2021 (*Diversity, Equity, Inclusion, and Accessibility in the Federal Workforce*), and Executive Order 14091 of February 16, 2023 *(Further Advancing Racial Equity and Support for Underserved Communities Through the Federal Government*)

[92] National AI Research Resource Task Force. 2023. "Strengthening and Democratizing the U.S. Artificial Intelligence Innovation Ecosystem: An Implementation Plan for a National Artificial Intelligence Research Resource." Available online at https://www.ai.gov/wp-content/uploads/2023/01/NAIRR-TF-Final-Report-2023.pdf

[93] IPEDS data merge race and ethnicity. IPEDS also does not collect race/ethnicity data for non-resident graduates and reports individuals for whom race/ethnicity is unknown, so percentage of graduates "underrepresented" in STEM is defined as (total graduates – white – Asian – unknown – non-U.S. residents) divided by (total graduates – unknown – non-U.S. residents).

[94] Tokita, Christopher K., William E. J. Doane, and Brian L. Zuckerman. 2015. "Reframing Participation in Postsecondary STEM Education with a Representation Metric." Bulletin of Science, Technology & Society 35 (5-6): 125–33 Available online at https://doi.org/10.1177/0270467616645222

[95] Mary Lou Maher, Razvan Bunescu, Stephanie August, Eric Eaton, Douglas Fisher, Christina, Gardner-McCune, Ashok Goel, Yolanda Gil, Mehran Sahami, Reid Simmons, David Touretzky, Pat Yongpradit, 2023. Expanding Capacity and Diversity in Lifelong AI Education. (NSF Award #2330257.) Available online at https://sites.google.com/uncc.edu/ai-education-workshop/

[96] https://new.nsf.gov/funding/opportunities/national-artificial-intelligence-research

[97] https://new.nsf.gov/focus-areas/artificial-intelligence/nairr