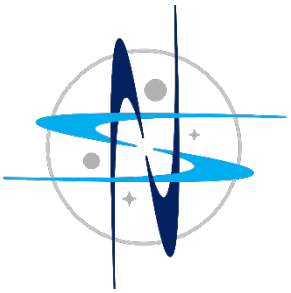
National Aeronautics and

Space Administration



NASA STEM

Launching Tomorrow's Aerospace Workforce

Environmental Scan and FY25 Rapid Research Study

Report Brief

KEY TERMINOLOGY

Recognizing that these terms may be interpreted slightly differently across disciplines, the following key terms and definitions were developed to promote consistency and alignment among NASA OSTEM Teams working on Skilled Technical Workforce research.

KEY TERMS

Apprenticeship	Paid, work-based learning combining classroom and on-the-job training
Badge	Entirely digital credential, signaling mastery of a specific skill, rather than broad achievements or degrees
Career and Technical Education (CTE)	Prepares students for high-demand careers via technical skill development
Career Pathways	Structured progression of education, credentials, and employment opportunities
Certificate	Credentials that demonstrate a level of skill or knowledge needed to perform a specific type of job
Certification	Awarded upon successful completion of a brief course of study
Credential	A documented qualification such as a certificate, badge, or license
Degree	An award or title conferred upon an individual for the completion of a program or courses of study over multiple years at postsecondary education institutions
Externship	Short-term typically unpaid experiential learning opportunity designed to help participants explore more about their chosen field of study
Industry-Recognized Credential (IRC)	A credential that is either developed and offered by or is endorsed by a nationally recognized industry association or organization representing a sizeable portion of the industry sector, or a credential that is sought or accepted by companies within the industry sector for purposes of hiring or recruitment, which may include credentials from product vendors
Internship	A structured program (weeks to 1 year) that allows participants to contribute to the workforce through real projects or tasks. Internships focus on direct and active involvement with the field, where they can gain practical skills and experience
License	Legal permission, typically granted by a government agency, to allow an individual to perform certain regulated tasks or occupations
Micro-credential	Short, focused certification aligned with industry-specific skills that may be stackable / earned for college credit

Micro-internship	Short-term, paid or unpaid, project-based assignments that help students explore different career paths while building portfolios, expanding networks, and developing skills while seeking the right full-time role
Non-Traditional Pathways	Career and technical education, community college programs, apprenticeships, and stackable credential models
Pre-apprenticeship	Unpaid or paid, short-term, work-based learning experience designed to prepare individuals to enter and succeed in an apprenticeship program, registered apprenticeship program, or in another career pathway approach
Registered Apprenticeship (RAP)	A proven model of apprenticeship that has been validated by the Department of Labor (DOL) or State Apprenticeship Agency
Registered Apprenticeship Certificate	A credential or industry-recognized qualification obtained upon completion of a registered apprenticeship program
Stackable Credentials	A credential is considered stackable when it is part of a sequence of industry-informed credentials that can be accumulated over time to expand an individual's competencies and help them advance within a career pathway
Trade School	A secondary or postsecondary educational institution designed to offer hands-on learning and train students for a specific job in a skilled trade career
Traditional Pathways	Academic programs at four-year institutions leading to degrees in STEM fields

LIST OF ACRONYMS

AIA	Aerospace Industries Association
BLS	U.S. Bureau of Labor Statistics
CFO	Chief Financial Officer
CTE	Career Technical Education
DoD	U.S. Department of Defense
DoL	U.S. Department of Labor
FIRST	For Inspiration and Recognition of Science and Technology
IRC	Industry-Recognized Credential
NOAA	National Oceanic and Atmospheric Association
NSB	National Science Board
NSF	National Science Foundation
OMB	Office of Management and Budget
OSTEM	NASA Office of STEM Engagement
RAP	Registered Apprenticeship Program
Space Grant	National Space Grant College and Fellowship Project
STEM	Science, Technology, Engineering, and Mathematics

Introduction

OSTEM conducted the Environmental Scan and FY25 Rapid Research Study in the Spring of FY 2025 to assess aerospace industry needs and better understand existing career pathways. This two-pronged research effort included a systematic, critical review of 27 existing, publicly accessible relevant sources and a program scan of 62 national, regional, and state programs. The study focused on credentialing models, CTE pathways, and workforce preparation—particularly for students closest to workforce entry. In alignment with the Evidence Act (2018), OMB Circular A-11, and memoranda M-19-23 and M-25-05, OSTEM continues to strengthen its evidence-building infrastructure. The Rapid Research Study and the new OSTEM priorities reflect both OSTEM's internal strategy and federal evidence mandates.

Environmental Scan and FY25 Rapid Research Methodology

This section summarizes the methodology utilized for OSTEM's FY25 Rapid Research Study. This study addressed near-term aerospace workforce needs:

1. How can NASA OSTEM catalyze opportunities and impact the aerospace ecosystem?
2. How can NASA OSTEM support and prepare the future aerospace workforce?

This study was designed using a two-pronged approach to explore how CTE and credentialing pathways support workforce development in the aerospace sector. The focus centered on the secondary and post-secondary levels, as these are critical "two-steps from a job" milestones that prepare individuals to enter the workforce. By conducting a review of literature and a scan of real-world national, regional, and state STEM programs, a comprehensive understanding of current practices, gaps, and opportunities was aligned with NASA OSTEM's mission (see **Figure 1**).

Research Design

The study was structured around two core components:

- A literature scan to identify evidence-based practices and success metrics.
- A program scan to analyze real-world examples of technical STEM workforce development

Literature and Program Scans

Literature Scan

A review of 27 articles and reports was conducted to investigate aerospace career pathways, CTE models, and workforce development initiatives. The focus was to identify outcomes tied to skills development, career readiness, and employability.

Various sources were included in the review:

- 59% peer-reviewed journal articles
- 26% federal agency reports
- 11% conference proceedings and expert commentaries
- 7% industry publications

Program Scan

In a scan of national, regional, and state-level programs, 62 programs were reviewed, with the goal to understand how different initiatives implement workforce pathways and credentialing strategies.

Program Breakdown:

- 18 national programs (e.g., Space Grant, NOAA Sea Grant, FIRST Inspires)
- 9 regional programs (e.g., NSF Engines, regional Space Grant networks)
- 35 state programs (e.g., CTE partnerships, state workforce boards)

Methodological Timing

Phase one: Public sources such as program websites, press releases, federal databases, and institutional reports were examined. Each program's goals, learning pathways, credential types, and measurable outcomes were reviewed. Types of workforce pathways (e.g., internships, apprenticeships, grant-funded programs), integration of credentials (e.g., micro-credentials, industry certifications), and reported success metrics (e.g., number of certifications issued, students placed in jobs, economic impact) were assessed.

Phase two: A synthesis of the literature and program review produced: (1) a comparative matrix that synthesizes program types, skills, success metrics, and connections across workforce development efforts; (2) *A Learning Pathways to the Aerospace Workforce* chart that illustrates how various example students, from CTE learners to veterans, navigate flexible, non-linear routes into the aerospace workforce; and (3) paths of possible credentialing pathways (e.g., apprenticeships-to-credentials, internships-to-credentials) that show how various programs integrate their own industry-recognized credentialing paths.

Figure 1. FY25 Rapid Research Study Methodology

Environmental Scan and FY25 Rapid Research Study Findings

NASA OSTEM's FY25 Rapid Research Study revealed three critical insights: (1) accelerating turnover and rising demand for digital, cybersecurity, and software expertise (AIA, McKinsey, Burning Glass); (2) acute pressure on the skilled technical workforce, particularly in sub-baccalaureate roles (NSB, ILO, BLS); and (3) undersupply of students in CTE and credentialing pathways aligned with aerospace needs.

America's aerospace and defense sector faces a critical workforce transition that requires immediate attention. The industry's 2.2 million workers are experiencing accelerating turnover—from 5.8% to 7.1% in a single year—while job requirements increasingly demand expertise in data science, cybersecurity, and advanced digital systems (Aerospace Industries Association [AIA], 2023). These technical areas represent the largest investment in corporate reskilling budgets, yet companies consistently report difficulty filling these roles (McKinsey & Company, 2023). Recent studies indicate that newly hired engineers frequently require additional training in software development and systems integration, highlighting misalignment between current educational preparation and industry needs (Burning Glass Institute, 2023).

A growing gap in skilled technical talent poses a critical challenge to meeting the rising demands of the aerospace sector. These workforce pressures are particularly acute within the skilled technical workforce—those employed in STEM-intensive roles that do not require a four-year degree. This segment, essential to aerospace and defense operations, is experiencing widening gaps between workforce supply and demand, especially in areas like digital manufacturing, cybersecurity support, and systems maintenance (National Science Board [NSB], 2022). The NSB reports that over 17 million Americans work in these roles, yet employers consistently struggle to find candidates with the right skills. This challenge reflects a broader global pattern: The International Labour Organization (2023) estimates that only half of workers worldwide are employed in jobs aligned with their level of education, underscoring a significant disconnect between education systems and labor market needs (Newsclick, 2023). Without expanded access to industry-aligned training programs—particularly through community colleges and credentialing pathways—the sector will face growing difficulty sustaining the technical capacity needed to meet evolving mission demands.

Broader demographic trends compound these workforce challenges and point to sustained pressure on talent availability. Since 2020, five million workers—predominantly Baby Boomers—have left the workforce, with labor economists projecting a six million-worker national shortfall by 2032 (U.S. Bureau of Labor Statistics [BLS], 2022). Current federal STEM programs, while valuable, operate at

limited scale: the Department of Defense's 54 internship and apprenticeship programs serve approximately 5,000–10,000 participants annually (Department of Defense [DoD], 2023). Addressing this gap between supply and demand for technical talent will require coordinated expansion of training pathways that align educational outcomes with the digital skills essential to maintaining America's aerospace and defense capabilities.

To address these growing workforce gaps, the education-to-employment pathway must focus strategically on students who are closest to entering the workforce. The FY25 Rapid Research Study centers on the critical "two-step" window, or students in secondary (Learning for Work) and post-secondary education (Learning through Work), who are two educational stages away from entering the aerospace workforce. These students are uniquely positioned to build the skilled technical workforce, especially through CTE, credentialing programs, apprenticeships, and partnerships (see **Figure 2**).

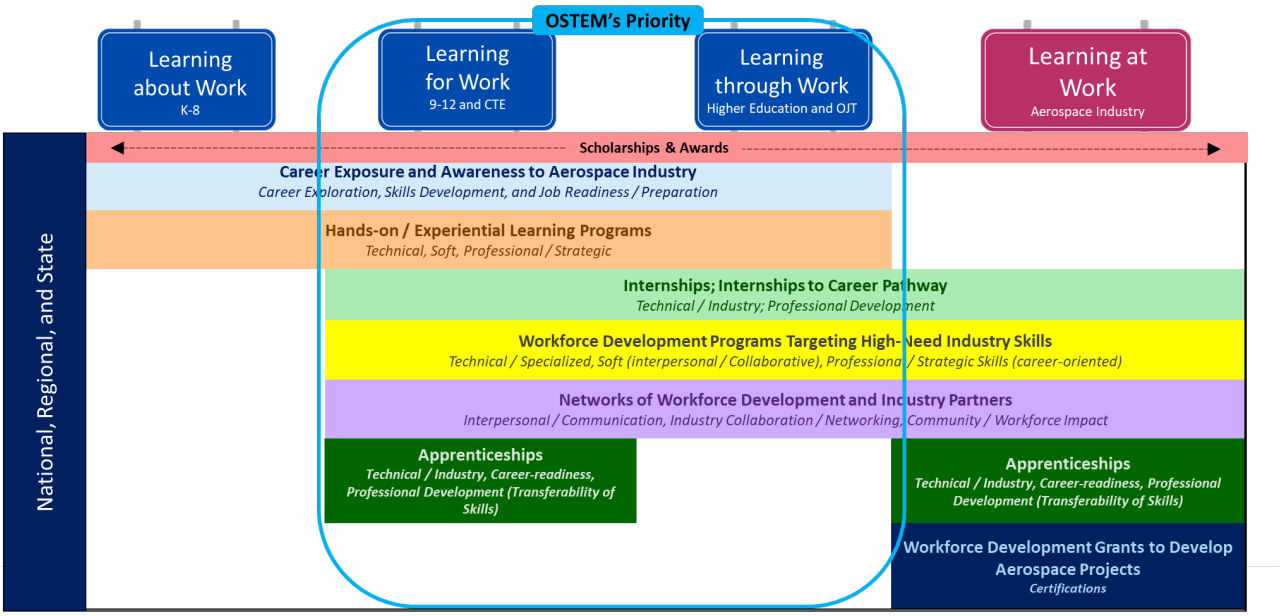


Figure 2. Pathways and Skills (Program Scan)

OSTEM's environmental scan and Rapid Research Study revealed the following:

- A significant skills mismatch exists between education and aerospace workforce needs
- Experiential learning, credentialing pathways, and CTE-aligned programs are critical to readiness

- National programs (e.g., Space Grant, NOAA Sea Grant, FIRST Robotics), regional initiatives (e.g., NSF Engines, regional Space Grant Networks), and state efforts (e.g., CTE partnerships, state workforce boards) offer promising models

Findings from the Rapid Research Study also included:

- Five possible "*Example Learning Pathways*" that illustrate diverse, non-linear routes into the aerospace workforce. Each arrow represents a different journey, whether through community college, military service, or a four-year university (see **Figure 3**)
- A comparative matrix of credentialing models linked to success metrics (see **Appendix A**)
- Evidence-based practices that show the impact of experiential learning, CTE participation, and industry-aligned certifications on workforce outcomes

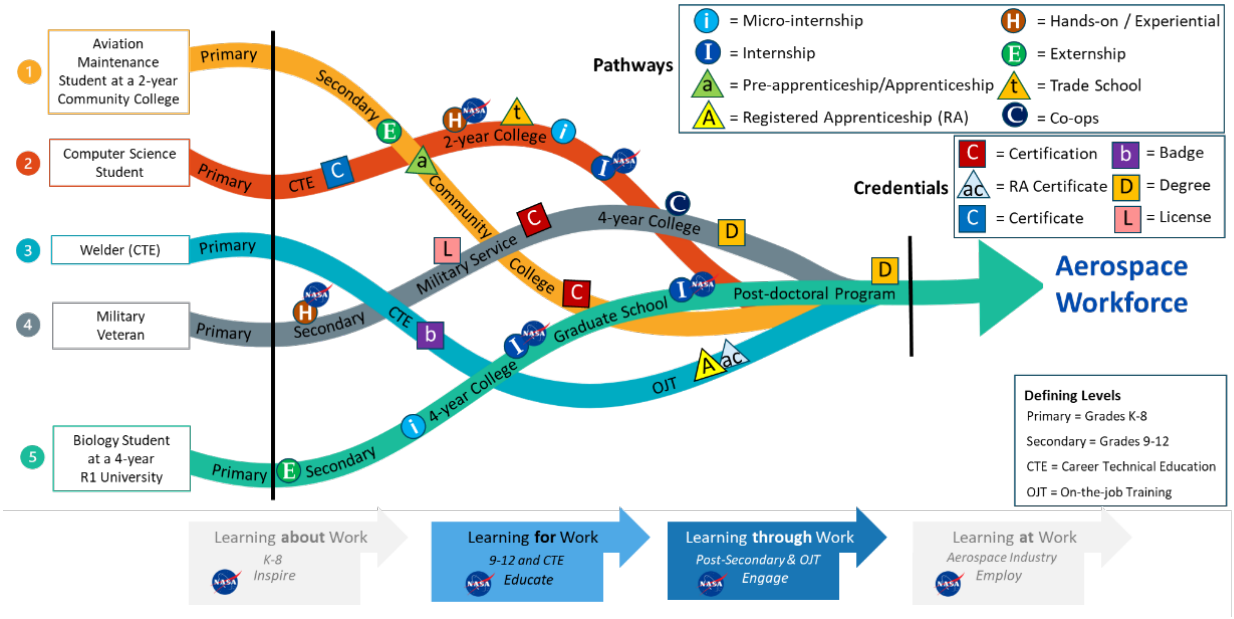


Figure 3. Example Learning Pathways to the Aerospace Workforce

Conclusion / Next Steps

Now, OSTEM has the opportunity to move toward deeper alignment with workforce outcomes. The FY25 Rapid Research Study filled key knowledge gaps left by prior agendas—particularly around short-term student impacts, external industry relationships, and the effectiveness of credentialing pipelines.

NASA's STEM Engagement function is able to leverage internships and student work experiences, competitive grants and awards, student challenges and competitions, and high school and community college engagement as mechanisms for cultivating a technically skilled aerospace workforce.

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APPENDIX A: COMPARATIVE MATRIX OF WORKFORCE DEVELOPMENT MODELS

Superscript Key:
N: National Program, **R:** Regional Program, **S**: State Program, **L:** Literature

Pathways	Definition	Skills	Connections to the Literature (Evidence-Based Pathways)	Success Metrics* (Literature and Program)	NASA-related Examples
Career Exposure and Awareness to Aerospace Industry (Primary, Secondary, Post-Secondary)	Programs connect with students about future careers in aerospace and provide mentorship for aerospace career pathway development	• **Career exploration:** access to growing occupations and career pathways • **Skill development:** learning skill-based certifications • **Job readiness/preparation:** interviewing skills	1. Formal and Informal Engineering-based STEM Activities[L34-25, 57-59, 71-77] 2. Informal Hands-on STEM Activities[L34-67-70,78-81] 3. Formal Problem-based STEM Activities[L34-60]	1. STEM interest, STEM career interest, Critical thinking and Problem solving, STEM achievement[L34-25, 57-59, 71-75] 2. STEM career interest, Learning motivation[L34-67-70,78-81] 3. STEM career interest, Learning motivation[L34-60] 4. Graduates hired in field of interest[N4] 5. Number of 2-year students advancing to a 4-year STEM university program[S7]	
Hands-on / Experiential Learning Programs (Primary, Secondary, Post-Secondary)	Programs provide STEM competitions, hands-on design challenges, and applied research projects for students	• **Technical:** lab skills, knowledge from flight, space, and tech courses, drone operations skills, flight hours, and knowledge readiness for FAA exams, Aviation Maintenance, & Drone Engineering • **Soft skills:** mastering 21st century skills, communication, teamwork, and leadership) • **Professional / Strategic:** professional development, mentoring, and coaching to build strategic communication and entrepreneurial skills	1. Formal and Informal Engineering-based STEM Activities[L34-25, 57-59, 71-77] 2. Informal Hands-on STEM Activities[L34-67-70,78-81] 3. Formal Problem-based STEM Activities[L34-60] 4. Formal socio-scientific activities[L34-86] 5. Informal STEM Support Programs and Near Peer Mentorship[L31, L32, L33] 6. Challenge-based Learning in Engineering Education[L39, L40]	1. STEM interest, STEM career interest, Critical thinking and Problem solving, STEM achievement[L34-25, 57-59, 71-75] 2. STEM career interest, Learning motivation[L34-67-70,78-81] 3. STEM career interest, Learning motivation[L34-60] 4. 21st Century Skills[L34-86] 5. STEM self-identification, STEM self-perception, STEM self-efficacy, STEM interest, Scientific Practices[L31, L32 L33] 6. Quality of Solutions, transversal skills (collaboration & innovation), Problem solving skills, Technical skills, Networking skills [L39, L40] 7. STEM knowledge, STEM identity, and STEM career interest[N18] 8. Students prepared for research[R6] 9. Pursuing STEM pathway in college (majors and coursework)[N18, R6] 10. Program alumni persistence in STEM employment [N18] 11. Number of students with increased problem-solving skills, accepting input / feedback from others, and who persevere through challenges[N18] 12. Number of students who enter the aerospace workforce[S2, S11] 13. Number of 2-year students advancing to a 4-year STEM university program[S7] 14. Number of students reached with no previous STEM experience[S31]	
Scholarships and Awards (Primary, Secondary, Post-Secondary)	Programs provide scholarships and awards to assist students in their continued STEM studies. • **Undergraduate scholarships =** Sophomores, Juniors, and Seniors in Science / Engineering programs) (N11) • **Graduate awards =** excellent research in the air / space sciences (N11)		1. Young Entrepreneur and Scholar (YES) program [L8]	1. Persistence to graduation, Time for degree completion[L8]	

Figure 5. Matrix of Findings, Page 1 of 3

Superscript Key:
N: National Program, **R:** Regional Program, **S**: State Program, **L:** Literature

Pathways	Definition	Skills	Connections to the Literature (Evidence-Based Pathways)	Success Metrics* (Program and Literature)	NASA-related Examples
Internships; Internships to Career Pathways (Secondary, Post-Secondary, Aerospace Industry)	Programs offer internship opportunities that provide hands-on experiences, research experiences tied to a mentor. In some cases, internship programs (e.g., NASA Pathways and National Space Intern Program), provide an infrastructure for interns to transition into the workforce.	• **Technical / Industry**: Real-world STEM experiences, develop STEM and research skill sets • **Professional Development**: Critical thinking, problem solving, and mentorship	1. Internships[L17]	1. Confidence, competence, and creativity in STEM[L17] 2. Number of interns[N14] 3. Number of intern conversions[N14] 4. Development of technical, communication, project management, and leadership skills during internship experiences[S8]	
Workforce Development Programs Targeting High-Need Industry Skills (Secondary, Post-Secondary, Aerospace Industry)	Programs provide industry-recognized aerospace and manufacturing education and training for high-need in-demand jobs. This involves CTE-focused conferences, dual enrollment for college credit, and CTE-aligned coursework leading to industry-recognized certification.	• **Technical / Specialized:** Industry certifications (e.g., Aviation Maintenance, Drone Engineering, Programming and Digital Technology, Robotic Manufacturing), and pre-pilot and drone pilot certifications, earning pilot licenses through Delta Airlines • **Soft (Interpersonal / Collaborative):** Master the 21st century skills & industry collaboration • **Professional / Strategic Skills (career-oriented):** Identifying new ideas and networks, proper job-searching techniques, & alumni networking	1. Career and Technical Education Programs [L34-83,84,L4, L9, L11, L14, L21] 2. Workforce Development Programs [L1, L12] 3. Micro-credentials [L20]	1. STEM skills, STEM interest, STEM Achievement, Career identity, Graduation rates, College enrollment, Career goals, Career awareness, Employment, College credits earned[L34-83,84,L4, L9, L11, L14, L21] 2. STEM interest, Early Career Growth, Employment, Earnings, Lack of unemployment benefits[L1, L12] 3. Aerospace enrollment data for undergraduate and graduates[N14] 4. New jobs created[S34] 5. Number of technical aerospace jobs filled[S3, S5] 6. Number of individuals who receive training[S3, S13, S34] 7. Number of training hours completed[S34] 8. Number of individuals who receive career assistance[S3] 9. Creation and development of new and complementary support industries[S4] 10. Number of individuals who engage in learning experiences[S9, S13] 11. Number of individuals to engaged in dual enrollment and CTE courses[S6] 12. Number of certifications and/or degrees[S5, S34] 13. Number of school districts who adopted CTE programs [S17]	

Figure 6. Matrix of Findings, Page 2 of 3

Superscript Key:
N: National Program, **R:** Regional Program, **S**: State Program, **L:** Literature

Pathways	Definition	Skills	Connections to the Literature (Evidence-Based Pathways)	Success Metrics* (Program and Literature)	NASA-related Examples
Networks of Workforce Development and Industry partners (Secondary, Post-Secondary, Aerospace Industry)	Program develops partnerships with the federal government, private and public industry partners, states, institutions, and nonprofit organizations. These networks provide workforce development pathways for in-demand jobs and tailor services to meet critical needs, ranging from process improvement and workforce development to specialized business practices, including supply chain integration, innovation, and technology transfer.	• **Interpersonal / Communication:** Personal communication skills, teamwork, and leadership • **Industry Collaboration / networking:** Building relationships in aerospace, advanced manufacturing, construction, cybersecurity/IT, & semiconductors • **Community / Workforce Impact:** Addressing specific issues will manufacturing, personal protective equipment, medical supplies, & working directly with state governments	1. Partnerships between industry, universities, and government[L5] 2. Aligning academic curricula with workforce needs[L10]	1. Student satisfactions, Completion of Internships, Employment[L5] 2. Number of jobs created / retained[N17, R7, R9, S17] 3. Number of students and workers prepared for workforce opportunities[R7, S3] 4. Number of new aerospace companies as partners[S17] 5. Total dollars of new and retained sales[N17] 6. Dollars of new client investments[N17] 7. Dollars of cost savings[N17] 8. Dollars into the economy[R7] 9. Dollars to support research projects, partnerships, and grants[S17]	
Apprenticeships (Secondary, Aerospace Industry)	A program model where individuals combine learning with on-the-job training, with the end goal of transitioning to an industry position. This umbrella term includes Pre-apprenticeships (i.e., a short-term apprenticeship that prepares an individual to feed into a registered program), Registered Apprenticeships (i.e., formal agreement with apprentice, employers, and state in which instruction and OJT are combined), and Co-ops (i.e., cooperative education job, gaining practical work experience, pursing academic studies)	• **Technical / Industry:** Industry skills in Aerospace, Aviation, Advanced Manufacturing,& IT/Cybersecurity • **Career-readiness:** career assessments & resume writing • **Professional Development:** 21st century skills & soft skills	Grants for increasing Pre-Apprenticeships, Apprenticeships, Registered Apprenticeships[L6]	1. Number of apprenticeships[L6] 2. Number of students who enter the aerospace workforce[S2]	
Workforce Development Grants to Develop Aerospace Projects (Aerospace Industry)	Program provides grant opportunity for current NASA employees to develop proposals to develop aerospace technology projects, leveraging industry and academic partners to develop the skills required to manage and transition transformative concepts into future NASA missions.	• **Certifications in Aerospace fields**			

***Success Metrics Across the Continuum**: Total dollars invested[N4, S17]; Programs Created[N4]; Peer-reviewed publications[N4]; Number of people engaged in education program[N4]; Number of K-12 STEM students reached[N14, N18, S22] ; Number of classrooms reached [S22]; Number of events [N18], Number of countries with program presence [N18] ; Projects in pipeline [S17]

Figure 7. Matrix of Findings, Page 3 of 3