

Integrating Electric Propulsion Standards into Aerospace Education

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EXECUTIVE SUMMARY

This project, *Integrating Electric Propulsion Standards into Aerospace Education*, funded by the National Institute of Standards and Technology (NIST), Project Number 70NANB22H200, aimed to integrate industry-developed, consensus standards into aerospace and aviation education by developing two instructional modules focused on electric propulsion systems. Recognizing a gap in the inclusion of standards-based content in technical curricula, the project addressed a national need to better prepare students for workforce roles requiring regulatory knowledge, technical documentation skills, and familiarity with consensus standards.

The instructional modules, *Airworthiness Requirements for Electric Propulsion* and *Minimum Design Requirements for Electric Propulsion*, were developed in alignment with ASTM F3239-22 and ASTM F3338-21, respectively. They were also mapped to key FAA regulations, including Title 14 CFR Parts 23, 33, and 35. Each module includes structured lesson plans, professionally created instructional videos (both with and without captions to support accessibility), full transcripts, a bank of multiple-choice assessment questions, and supporting resources, all of which are publicly available through a dedicated website hosted by the Polytechnic Institute at Purdue University.

The curriculum and assessment development part of the project implementation included expert validation, pilot testing with 49 students, and iterative refinement based on quantitative and qualitative evaluation. Assessment tools were validated using Cronbach's Alpha and item-level analysis, while student and faculty feedback supported adjustments to improve instructional clarity and web usability.

The outcomes of the project include a set of modular, standards-aligned educational materials ready for broad adoption. The materials are accessible, learning management system (LMS) compatible, and adaptable for use across associate, bachelor's, and graduate-level courses.

This work contributes to workforce development in the aerospace sector and serves as a scalable, replicable model for integrating consensus standards into STEM education. It supports the modernization of technical education by enhancing student readiness to engage with real-world regulatory environments and certification processes.

1. INTRODUCTION

The aerospace industry is a dynamic and safety-critical sector that demands a multidisciplinary workforce capable of integrating emerging technologies into legacy systems. As the aviation sector transitions toward electric and hybrid-electric propulsion, the need to incorporate consistency, measurability, and compliance becomes increasingly vital. Risks associated with introducing new propulsion technologies into aircraft systems necessitate educational strategies that emphasize standardization, certification, and regulatory alignment.

Consensus standards, including classifications, guides, specifications, terminology standards, and test methods, serve as the foundation for ensuring interoperability and safety across aviation systems. Despite their importance, these standards are often underutilized in academic curricula. The complexity of overlapping standards from organizations such as ASTM, SAE, ISO, and the FAA can be a barrier for students and educators alike. To address this, the project focuses on developing curriculum modules that demystify these standards and embed them into aerospace education.

The overarching goal of this NIST-funded project is to increase student knowledge of the relationship between electric or hybrid-electric propulsion technologies and applicable design and airworthiness standards. This is achieved through the development of two modular, standards-based instructional units.

These lesson modules are designed for undergraduate and graduate-level aerospace and aviation programs. Each module includes structured lesson plans, professionally created instructional videos (both with and without captions to support accessibility), full transcripts, a bank of multiple-choice assessment questions, and supporting resources. The content aligns directly with Federal Aviation Administration (FAA) regulations, including Title 14 CFR Part 23, Part 33, Part 35, and relevant FAA Advisory Circulars.

By embedding consensus-based standards into the academic environment, this project supports the development of a technically proficient, standards-literate aviation workforce. The intended impact is to reduce resistance to using standards in professional practice and to enhance workforce readiness in line with industry and regulatory expectations.

2. THE PROJECT AND ITS IMPORTANCE

At the outset of the project, the team aimed to enhance aerospace education by increasing student knowledge of the relationship between electric propulsion technologies and the applicable standards related to design and airworthiness. Recognizing that aerospace curricula often lack emphasis on consensus-based standards, the project was designed to directly address this gap through the development of two structured lesson modules.

1. Airworthiness Requirements for Electric Propulsion, based on ASTM F3239-22.
2. Minimum Design Requirements for Electric Propulsion, based on ASTM F3338-21.

2.1. Scalability and Broader Impact

From the outset, the project was envisioned as a scalable and replicable model for integrating consensus standards into aerospace curricula. All materials were planned to be shared via:

1. A public website.
2. Conference presentations and journal publications at professional networks such as the American Society of Engineering Education (ASEE), University Aviation Association (UAA), and Aviation Technician Education Council (ATEC).

In summary, the original project goals focused on creating high-impact, standards-based instructional content that could be adopted by academic programs nationwide to improve workforce readiness in the rapidly evolving field of electric aircraft propulsion.

3. ORIGINAL PROJECT GOAL

The implementation of the project began in October 2022, with the goal of increasing student knowledge of the relationship between electric propulsion technologies and the applicable standards related to design and airworthiness. The approach was designed to be both rigorous and adaptable, ensuring that the instructional materials would be relevant to undergraduate and graduate-level courses and aligned with evolving consensus standards in electric aircraft propulsion.

3.1. Team Structure and Roles

The project was led by two faculty members from the School of Aviation and Transportation Technology who coordinated the overall planning, content development, and outreach. These faculty project leads were responsible for developing the lesson modules and overseeing alignment with relevant ASTM and FAA standards.

In addition, a graduate student from Purdue's Computer and Information Technology program was brought to design and build the website that would host and disseminate the modules and related resources.

Regular internal meetings were held to monitor progress, align development tasks, and review drafts of instructional content and assessments. The faculty also maintained ongoing communication with NIST via quarterly updates and informal check-ins to ensure that the project met its educational and technical objectives.

3.2. Development Approach

The project followed a systematic and collaborative development process that prioritized both academic integrity and practical usability. The development began with the identification of two core topic areas that reflect emerging areas of interest and regulatory focus in aviation.

Each module was carefully designed to highlight the relationships between standards and real-world engineering applications. The modules were structured to serve as instructional supplements, intended to be embedded into existing courses rather than function as standalone content. To support this integration, the materials included detailed lesson plans, scripted instructional content, visual media, and assessment tools.

The project team utilized Purdue's internal curriculum development resources and collaborated with experienced aviation faculty to refine module outcomes. The lesson plans incorporated clearly defined goals, reference standards, target student characteristics, delivery methods, and outcomes-based assignments. Content development was supported by internal review and iterative feedback from educational and industry experts.

4. PROJECT DEVELOPMENT

4.1. Module and Assessment Development

Following internal content development and SME review, a pilot implementation phase was carried out. The lesson modules were piloted with a sample of students enrolled in the aeronautical engineering technology program. Feedback from both students and faculty informed final refinements to the instructional materials before dissemination.

To enhance accessibility and engagement, each module included the following instructional components:

1. A lesson plan document outlining instructional objectives, aligned standards, student engagement strategies, and content structure.
2. A scripted narrative to accompany instructor delivery or self-paced study.
3. Short instructional videos to reinforce core concepts and provide visual explanations.
4. A bank of at least ten assessment questions per module, formatted as multiple-choice, allowing instructors flexibility in classroom use or remote learning.

5. A printable and digital lesson module card with key topic highlights and a link to supporting resources.
6. Supporting linked resources for students and faculty.

Purdue University's video and multimedia services collaborated with the project team to film and edit the instructional videos, ensuring clarity, conciseness, and alignment with lesson plan narratives. These multimedia elements were intentionally kept short to facilitate repeat viewing and higher retention.

Two fully developed instructional modules were completed:

1. Airworthiness Requirements for Electric Propulsion: This module was based on ASTM F3239-22 (*Standard Specification for Aircraft Electric Propulsion Systems*) and emphasized airworthiness criteria across core system categories such as energy distribution, control and indication, hazard mitigation, and powerplant installation.
 - a. Introduction to Airworthiness Requirements for Electric Propulsion (with and without captions): 2:57 minutes with 10 assignment questions.
 - b. Terminology in ASTM F3239 (with and without captions): 3:56 minutes with 10 assignment questions.
 - c. Requirements in ASTM F3239 (with and without captions): 5:15 minutes with 10 assignment questions.
2. Minimum Design Requirements for Electric Propulsion: Built around ASTM F3338-21 (*Design of Electric Engines for General Aviation Aircraft*), this module focused on engineering design considerations and certification pathways.
 - a. Introduction to Minimum Requirements for Electric Propulsion (with and without captions): 4:56 minutes with 10 assignment questions
 - b. Terminology in ASTM 3338 (with and without captions): 3:34 minutes and 10 assignment questions.
 - c. Requirements and Ratings in ASTM F3338-24 (with and without captions): 5:03 minutes and 10 assignment questions.
 - d. Endurance and Durability Testing in ASTM F3338 (with and without captions): 3:37 minutes and 10 assignment questions.

Each lesson module was accompanied by a bank of multiple-choice assessment items, purposefully aligned with that module's specific learning objectives and tied directly to industry-developed, consensus standards and FAA regulatory references. The assessments aimed to measure not only knowledge retention but also students' ability to recognize, interpret, and apply technical standards to realistic aerospace scenarios. All questions were constructed to test fundamental understanding of terminology, design constraints, certification requirements, and system-level relationships between standards and regulatory frameworks. The materials and assessments were built for integration into a variety of aviation and aerospace courses, including those focused on propulsion systems, aircraft design, certification processes, and safety engineering.

4.2. Pilot Testing

Pilot testing was carried out at Purdue's School of Aviation and Transportation Technology (SATT), targeting undergraduate students with a Bachelor of Science in Aeronautical Engineering Technology (BSAET). The pilot phase involved 49 students across multiple course sections. Data was collected through:

1. Student responses to assessment items.
2. Feedback surveys regarding instructional clarity, engagement, content relevance, and the website.
3. In-class performance and participation metrics.

The pilot testing process involved a complete instructional walk-through with participants.

1. Students were directed to the project website, where they explored the digital layout, navigational flow, and embedded instructional content.
2. They watched the module's YouTube videos hosted on the site, which introduced the topic and explained standards-based concepts using scripted narration and visual aids.
3. After viewing, students were provided paper Scantrons and answered a set of multiple-choice assessment questions for each module.
4. Following completion of the assessments, students provided feedback through a structured questionnaire, addressing the clarity, relevance, and ease of use of both the content and the website platform.

This combined approach allowed the team to gather both test performance data and experiential feedback. The evaluation of learning outcomes focused on content alignment and instrument reliability. The project team analyzed internal consistency using Cronbach's Alpha and reviewed item discrimination and difficulty indices to ensure content validity. This review confirmed that the assessments were well-targeted to the intended learning outcomes and provided actionable diagnostic feedback to both instructors and students.

Minor refinements were made to:

1. Improve the clarity of specific assessment items.
2. Increase alignment with the specific language used in ASTM standards and FAA rulemaking documents.
3. Improve the website's layout for better usability and navigation, ensuring that educators can quickly locate and integrate lesson materials into their course platforms.

4.3. Validation of Assessment Tools

To ensure the reliability and accuracy of the assessment items, the project team followed an evaluation model based on Waugh and Gronlund (1998), which emphasizes content-related evidence of validity. Student responses to the module assessments were analyzed to evaluate reliability and clarity, including the use of Cronbach's Alpha and other internal consistency metrics. This process confirmed that the assessments were representative of key instructional concepts and suitable for evaluating understanding of standards-based electric propulsion content. Validation steps included:

1. Mapping each item to a clearly defined learning outcome, linked to a specific FAA regulation or ASTM standard.
2. Designing assessment questions that directly reflect those outcomes, avoiding ambiguity or misinterpretation.

4.4. Dissemination

A dedicated, public-facing website is developed, deployed, and hosted by the Purdue Polytechnic that supports wide public access and educational reuse. The URL is <https://polytechnic.purdue.edu/aircraft-electric-propulsion>. The digital platform includes:

1. Lesson plans and transcripts to provide instructor guidance for implementation and adaptation.
2. Embedded YouTube videos with and without captions and transcripts for the YouTube videos for accessibility.
3. Assessment items that can be imported into common Learning Management Systems (LMS).
4. A modular layout to support expansion with future standards-based modules.

The central focus of the implementation was to ensure the final outputs would be publicly accessible and reusable by other academic institutions. The project team gathered perspectives, presented work-in-progress results, shared outcomes, and resources through professional associations and journal publications such as:

1. University Aviation Association (UAA)
Yother, T., & Johnson, M. (in review). Perceptions of the inclusion of electric propulsion curriculum in collegiate aviation maintenance programs by faculty and industry professionals. *Collegiate Aviation Review International*.
2. Aviation Technician Education Council (ATEC)
Yother, T., & Johnson, M. E. (2024, March) *Elevate A&P coursework with electric engine standards*. Oral Presentation. Aviation Technician Education Council Annual Conference, Tucson, AZ, United States.

Presentations, working group sessions, and email outreach helped promote awareness and foster adoption across the aviation education community. After Purdue University Institutional Review Board approval (IRB-2023-180), data were collected. The results of academic and industry perspectives are in review for publication by the Collegiate Aviation Review International and are expected to be published in 2025.

The project successfully met its goal of developing and disseminating structured, standards-based instructional content that supports the integration of electric propulsion system standards into higher education curricula. The final deliverables reflect a multi-layered effort that produced high-quality, accessible learning materials aligned with national and international standards, FAA regulations, and best practices in aerospace education.

5. EVALUATION AND ASSESSMENT RESULTS

A structured evaluation plan was implemented to assess the educational effectiveness, content validity, and usability of the two standards-based lesson modules developed under this project. The evaluation process combined both quantitative and qualitative feedback mechanisms to determine whether the instructional materials met their intended learning outcomes and practical application goals.

5.1. Statistical Analysis of Results

The completed assessments were evaluated using standard educational measurement tools. These analyses affirmed the technical soundness of the assessment instruments and informed improvements to the instructional materials. Analysis focused on the following indicators:

1. Cronbach's Alpha was calculated to assess the internal consistency and reliability of the multiple-choice assessments. Evaluation was completed on all of the questions together, so an overall CA was calculated to be 0.80.
2. Item analysis techniques (e.g., mean score, standard deviation, and Point Biserial Correlation) were applied to ensure the assessment items effectively distinguished between varying levels of student understanding and were free of technical or wording flaws.

5.2. Statistical Analysis of Results

The assessments were statistically evaluated using established educational measurement techniques to ensure their reliability, validity, and effectiveness. Key indicators such as Cronbach's Alpha, Mean Score, Standard Deviation, and Point Biserial Correlation (PBS) were applied to validate item quality and internal consistency across both modules.

For Assessment #1, completed by 49 students, the following summary statistics were recorded:

1. Cronbach's Alpha (Internal Consistency): 0.80, indicating a strong level of reliability
2. Overall Mean Score: 27.33 out of 30 points (91.1%)
3. Standard Deviation: 3.15 points

To evaluate the quality and discrimination power of individual questions, a detailed item analysis was conducted. Questions were grouped under their respective module topics and subtopics and analyzed for their ability to differentiate student performance and align with learning objectives, see Table 1. These values were based on results from data provided by the Purdue University Center for Instructional Excellence.

Each item consistently demonstrated acceptable PBS values (> 0.15), indicating that questions effectively distinguished between high- and low-performing students. Mean scores ranged between 0.67 and 0.94, with 24 out of 30 mean scores over 0.90.

These results affirm the technical soundness of the assessment instruments and confirm that the instructional materials were successful in meeting their educational goals. The insights obtained through this analysis informed improvements to both content clarity and assessment design in subsequent versions of the modules.

Table 1. Item analysis for module assessment questions

Question	Mean Score	Standard Deviation	PBS
TITLE: AIRWORTHINESS REQUIREMENTS FOR ELECTRIC PROPULSION			
Topic 1: Introduction to Airworthiness Requirements for Electric Propulsion			
1. Why are industry standards important in making air travel safer?	0.92	0.02	0.26
2. Who certifies the safety of civilian aircraft in the United States?	0.92	0.10	0.30
3. What types of flights fall under 'general aviation' in the United States?	0.80	0.00	0.36
4. How does the FAA share information about safety updates and recommendations?	0.93	0.09	0.50
Topic 2: Terminology in ASTM F3239			
5. Why must each engine on an electric aircraft have an independent energy source?	0.91	0.11	-0.08
6. What is one important requirement for an energy system on an electric aircraft?	0.91	0.10	0.00
7. What types of hazards must electric aircraft systems be protected against?	0.81	0.14	0.39
8. Which part of the aircraft must be carefully controlled and monitored according to the standards?	0.91	0.10	0.00
Topic 3: Requirements in ASTM F3239			
9. Why are standards and FAA guidelines compared to 'pieces of a puzzle'?	0.92	0.10	0.19
10. What is the main purpose of the 'Terminology' section in the standards?	0.91	0.10	0.25
11. What does an electric propulsion system mainly do?	0.91	0.10	0.00
12. What is the energy storage system most like in a regular gasoline aircraft?	0.91	0.10	0.00
13. Why do we need standard definitions like 'capacity' and 'quantity'?	0.91	0.10	0.00
Question	Mean Score	Standard Deviation	PBS
TITLE: MINIMUM DESIGN FOR ELECTRIC PROPULSION			
Topic 1: Introduction to Minimum Requirements for Electric Propulsion			
14. What is the main purpose of endurance and durability testing?	0.92	0.09	0.53
15. What does the over torque test check for?	0.92	0.09	0.45
16. What happens in a rotor locking test?	0.93	0.09	0.47
17. What is the purpose of the final teardown inspection?	0.91	0.11	0.02
18. Why are electric aircraft considered to be more environmentally friendly?	0.67	0.08	0.60
Topic 2: Terminology in ASTM F3338			
19. Which organization in the U.S. is responsible for certifying electric aircraft?	0.67	0.08	0.62
20. What is the purpose of the "special conditions" created by the FAA for electric engines?	0.80	0.10	0.26
21. Which of the following is an example of an electric aircraft used for pilot training?	0.94	0.09	0.47
22. Why is there pressure to create more specific rules for electric aircraft certification?	0.92	0.09	0.48
Topic 3: Requirements and Ratings in ASTM F3338			
23. Why is it important for engine parts to have defined limits and ratings?	0.87	0.09	0.49
24. What does 'overspeed protection' ensure in an electric engine?	0.94	0.07	0.64
25. What are the critical parts in an electric engine?	0.92	0.09	0.53
26. Why is safety analysis important in electric engine design?	0.92	0.10	0.39
Topic 4: Endurance and Durability Testing in ASTM F3338-24			
27. Why is using common definitions important in aviation?	0.93	0.09	0.55
28. What is the main difference between an electric engine and a motor?	0.93	0.09	0.42
29. What is 'takeoff power' in simple terms?	0.92	0.09	0.43
30. Which of the following is an example of periodic duty?	0.94	0.09	0.56

5.3. Continuous Improvement Based on Evaluation

Evaluation results and student feedback informed targeted refinements across the instructional modules. Key revisions incorporated into the deliverables:

1. Rewording multiple-choice questions to enhance clarity and better reflect the terminology used in FAA and ASTM documentation.
2. Improving the website layout for better usability and navigation, ensuring that educators can quickly locate and integrate lesson materials into their learning management systems.

These revisions increased the pedagogical strength, technical accuracy, and ease of implementation of the final module packages.

6. FINDINGS AND LESSONS LEARNED

The project yielded several key findings related to the integration of industry-developed, consensus standards into aerospace education, as well as important lessons for future efforts involving curriculum design, instructional media, and stakeholder engagement.

6.1. Key Findings

1. Standards-based instruction improves student awareness of regulatory frameworks. Students demonstrated increased familiarity with specific standards (ASTM F3239-22 and F3338-21) and their connection to FAA regulations (e.g., 14 CFR Parts 23, 33, and 35). Post-assessment results and qualitative feedback indicated improved understanding of how standards apply to electric propulsion system design and certification.
2. Concise, modular content supports flexibility in instruction. Students and faculty who piloted the modules reported that the short video format, structured lesson plans, and adaptable assessments allowed for seamless integration into existing courses without requiring significant restructuring. The modular design supports both in-class instruction and independent student learning.
3. Assessment reliability was strong, and content validity was confirmed. Statistical analysis of pilot testing confirmed internal consistency (Cronbach's Alpha > 0.70) and alignment between learning objectives and assessment items. Subject Matter Experts validated the technical accuracy and standards alignment of the questions and scripted content.
4. The project confirmed the value of early and iterative expert engagement. SME input during the planning and validation phases led to improved instructional clarity, alignment with industry expectations, and better integration of FAA Advisory Circulars and ASTM terminology. This input ensured that materials remained technically sound while being pedagogically accessible.

6.2. Lessons Learned

1. Clear alignment between learning outcomes and standards references is essential. Early mapping of instructional content to ASTM standards and FAA regulations streamlined the development of assessment items and enhanced student comprehension of regulatory relevance.

2. Even highly structured lesson plans benefit from feedback-informed iteration. Student and instructor feedback during pilot testing led to key refinements in question phrasing, resource formatting, and the flow of the scripted narratives. Future modules will incorporate formative checkpoints during pilot phases to enable earlier feedback loops.
3. Standardized formats increase reusability and portability. Packaging content in formats compatible with common Learning Management Systems (PDF, MP4) and providing clear metadata (titles, topics, standards referenced) enabled easier adoption by instructors outside the project team.
4. Dissemination platforms must be designed with instructor workflows in mind. In response to pilot feedback, the website's layout was revised to prioritize usability, allowing instructors to quickly access and deploy specific components of the lesson modules. Navigation and searchability were identified as critical for long-term adoption.

7. POTENTIAL FOR BROADER ADOPTION

The instructional modules developed through this project were intentionally designed with scalability, modularity, and accessibility in mind, making them highly suitable for adoption across a diverse range of educational institutions. By aligning the content with widely recognized industry-developed, consensus standards, ASTM F3239-22 and ASTM F3338-21, and key FAA regulatory frameworks such as 14 CFR Parts 23, 33, and 35, the modules offer clear relevance for preparing students in fields such as aerospace engineering, aviation maintenance, systems integration, and flight operations.

These modules are adaptable across multiple levels of instruction. They can be embedded into associate-level aviation maintenance programs, particularly those aligned with FAA Part 147 certification requirements. At the bachelor's level, the content is relevant for programs in Aeronautical Engineering Technology, Aviation Management, and Aerospace Engineering, or other similarly technical programs. Additionally, the modules provide value in master's level or continuing education settings where industry professionals are seeking to update their knowledge on electric propulsion standards and regulatory compliance.

The project team emphasized portability by designing the instructional materials in standard digital formats that are compatible with a wide range of instructional environments. All module content is hosted on a publicly accessible website that includes lesson plans, assessment banks, and instructional videos. Each video is available in two formats, with captions and without captions, and is accompanied by a full transcript to support accessibility and learner preferences. The assessment materials consist of multiple-choice questions (MCQs) that align directly with the module objectives, allowing instructors to easily deploy them for both formative and summative evaluation.

Although the primary focus of the project was aerospace education, the instructional framework is highly transferable to other disciplines that rely on the integration of technical standards. Fields such as automotive engineering, electric vehicle development, mechatronics, energy systems, and industrial automation can benefit from a similar educational structure. Even in non-STEM fields, such as workplace safety, quality assurance, and infrastructure planning, the standards-based instructional model used in this project can inform approaches to compliance education and technical documentation training.

Informal instructor feedback during pilot testing and professional presentations further confirmed the potential for broader adoption. Faculty from multiple institutions expressed strong interest in incorporating the modules into their own curricula. They emphasized the value of concise, video-based delivery, alignment with industry-recognized standards, and the availability of pre-built assessment tools that could be used in both in-person and asynchronous learning environments. This early validation reinforces the project's suitability for national dissemination and long-term integration across a wide spectrum of educational and training contexts.

8. CONCLUSION

This project successfully designed, validated, and disseminated two comprehensive instructional modules that embed industry-developed, consensus standards into aerospace and aviation education, with a specific emphasis on electric propulsion systems. Grounded in ASTM F3239-22 and F3338-21 and aligned with key FAA regulatory frameworks (14 CFR Parts 23, 33, and 35), the modules provide a rigorous, industry-relevant foundation for teaching emerging propulsion technologies.

The results of this initiative demonstrate that standards-based education can be meaningfully integrated into STEM curricula through structured, multimedia-supported, and outcomes-driven instruction. The modular design, concise video content, and standards-aligned assessments make the materials accessible and adaptable for a wide range of educational institutions, from technical colleges to research universities.

Pilot implementation and evaluation confirmed both the reliability of the assessment instruments and the educational value of the instructional content. Student performance data and faculty feedback led to refinements that improved technical accuracy, user experience, and instructional clarity. The public-facing website, featuring lesson plans, captioned and uncaptioned videos, and multiple-choice assessments, enhances the accessibility and usability of the modules across diverse instructional environments.

Importantly, this project contributes to national efforts to modernize technical education and strengthen the pipeline of workforce-ready professionals in the aerospace sector. By fostering standards literacy and connecting students with real-world regulatory practices, the modules support the development of critical competencies needed in aviation, engineering, and advanced manufacturing fields.

Looking forward, the project team remains committed to expanding the reach of these materials through publications, conference presentations, and strategic partnerships. The framework developed here offers a scalable and replicable model for integrating consensus standards into STEM education, one that can be adapted across disciplines and institutions to advance both technical excellence and workforce preparedness in an evolving technological landscape.