Bridging the Gap in Aviation Maintenance Education

Identifying Workforce Needs and Opportunities

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Source: https://images.app.goo.gl/bEiFxLHAeR5QJmvM6

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Project Overview

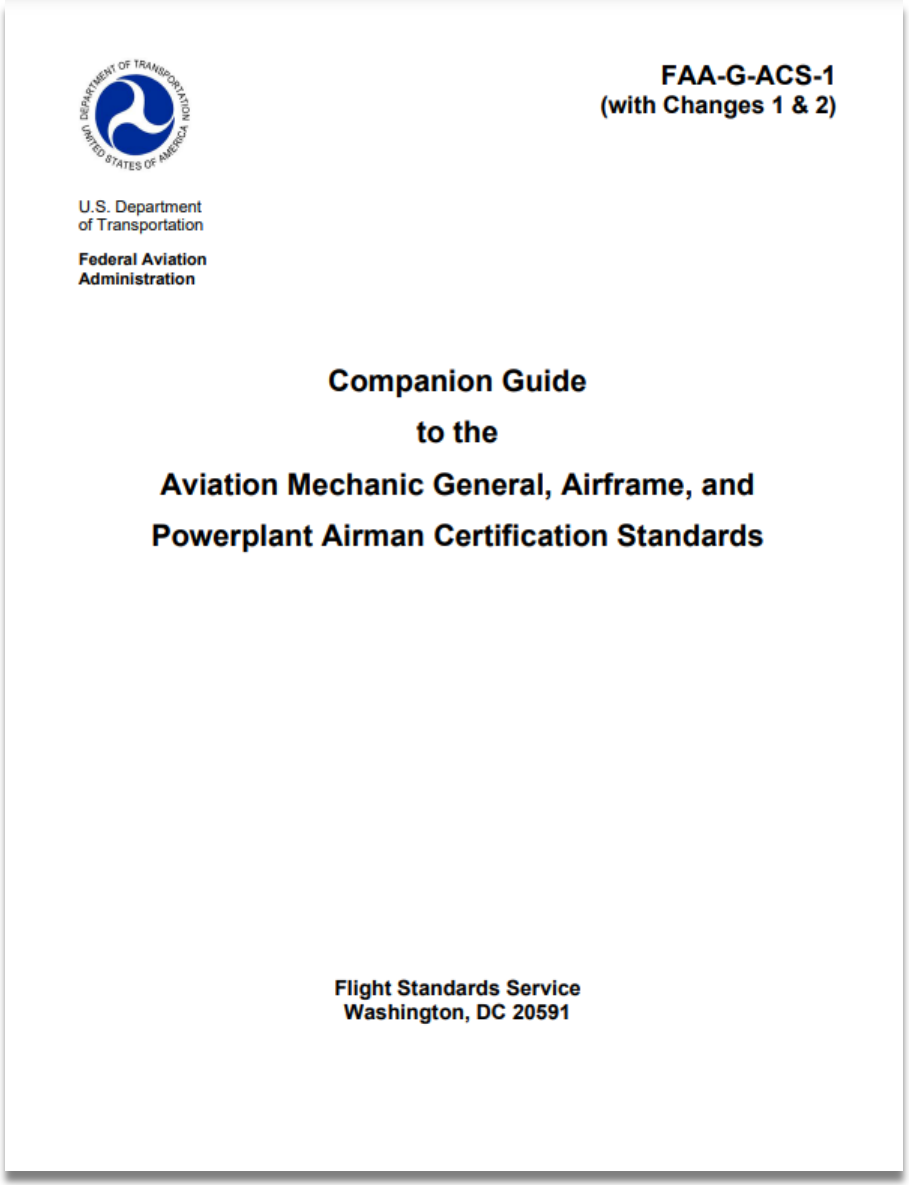
- The aviation maintenance industry faces **challenges** in keeping pace with current in-service aircraft technologies and for future **advanced technology aircraft (ATA)**
- The **competencies** outlined in the Part 147 **Airman Certification Standards (ACS)** are **insufficient** for maintaining ATA, posing **risks to safety** and **hindering industry advancement**
- The main aim is to ensure the **aerospace maintenance workforce** is equipped to meet **evolving industry demands** by developing and implementing a **workforce plan** for maintaining the current ATA

Source: https://images.app.goo.gl/GhgKYf6z23nCHzgT9

What's in the ACS?

- Core Sections:
  - Knowledge
  - Skills
  - Risk Management
- Purpose: Ensures aviation maintenance education meets foundational standards
- Challenge: Does not address key competencies to support modern workforce demands

Federal Aviation Administration


FAA-G-ACS-1
(with Changes 1 & 2)

U.S. Department of Transportation

Federal Aviation Administration

Companion Guide

to the

Aviation Mechanic General, Airframe, and Powerplant Airman Certification Standards

Flight Standards Service
Washington, DC 20591

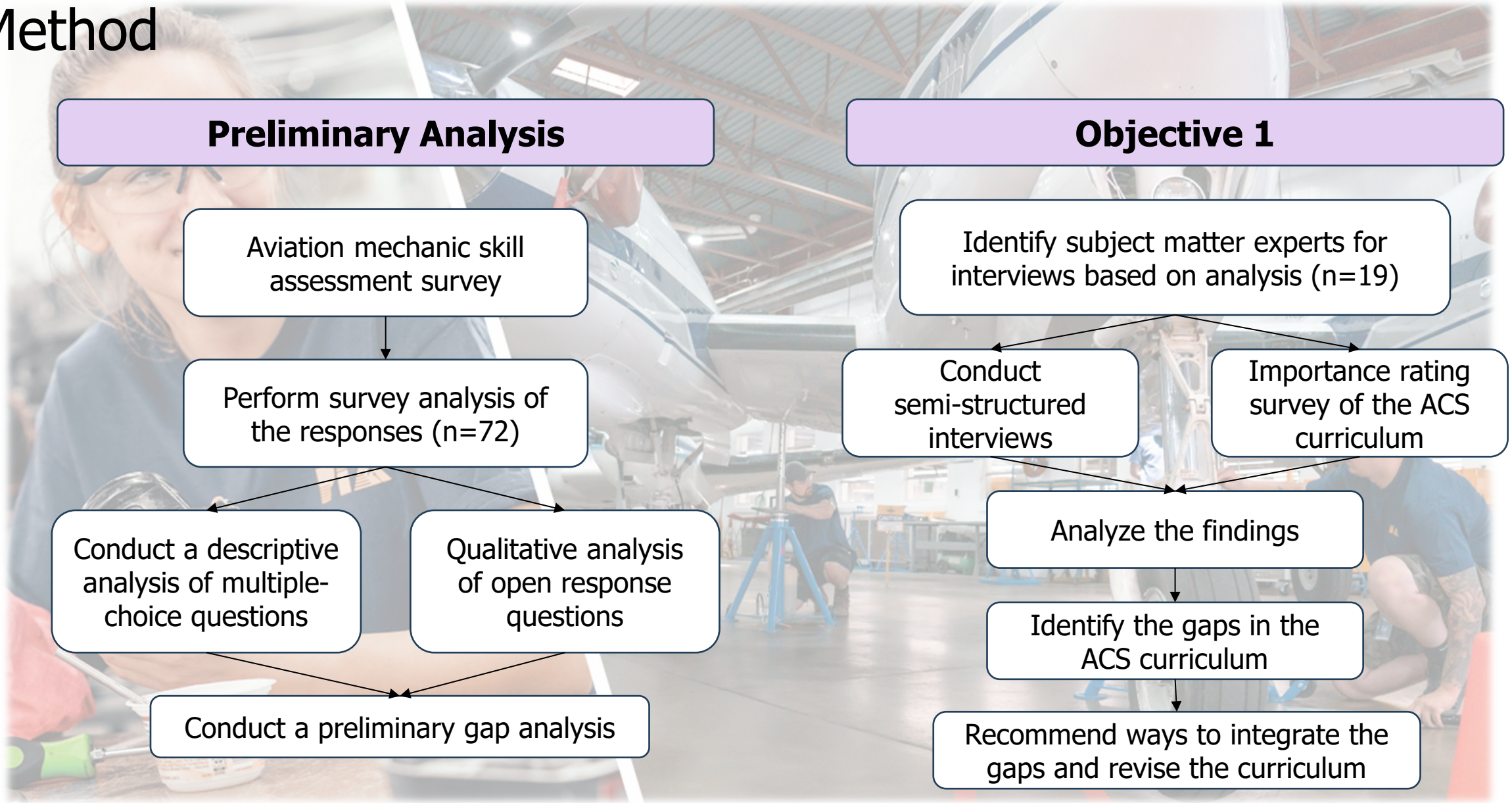
Source: https://www.faa.gov/training_testing/testing/acs/amt_acs_companion_guide.pdf; https://images.app.goo.gl/o77WV3NFq7Epzani8

Objectives

- **Objective 1:** Identify current education and workforce requirements and conduct gap analysis
  - Conduct a thorough review of the aviation mechanic ACS to identify gaps between current standards and the required competencies for current aviation maintenance professionals
- **Objective 2:** Identify future aviation technical education and workforce requirements and conduct gap analysis
  - Analyze future workforce and technical education needs by examining emerging trends in aviation, focusing on new ATA maintenance requirements
- **Objective 3:** Build stakeholder networks and share aviation technical standards, credentials, and education information
  - Develop a stakeholder network and share project findings, gathering feedback from academics, industry professionals, and regulatory bodies to address identified skills gaps

Source: https://images.app.goo.gl/1rnBpGE9CJCh7P5YA

Method



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Current in-service & emerging aircraft technologies and required competencies to maintain them

In-service/Emerging Technology	Required Competencies
Electric and Hybrid Propulsion	High-voltage safety protocols, battery maintenance, troubleshooting hybrid-electric propulsion systems, and power management systems
Software & Integrated Aircraft Systems	Proficiency in integrated on-board computer systems and interconnectivity of aircraft systems, advanced troubleshooting of integrated software/hardware systems faults
Composite Materials and Advanced Manufacturing	Inspecting and repairing composites, understanding advanced repair techniques, and familiarity with advanced manufacturing techniques involving aircraft composite material structures
Advanced Avionics and Digital Systems	Troubleshooting digital avionics, use of analog, digital, and PC based diagnostic equipment, interpreting diagnostic outputs, understanding digital system data and communication protocols
Advanced Diagnostics and Self-Monitoring Systems	Interpreting automated fault detection and performance data flight deck displays and reports, understanding fault detection logic, and use of predictive maintenance tools and diagnostic equipment
Data Systems Management	Understanding of digital systems, proficiency in cybersecurity and troubleshooting real-time data links, upload and validation of aircraft system software revisions as well as operational testing post software upload to ensure whole system compatibility and functionality

Impact of advanced aircraft technologies on aviation maintenance roles and skills

Adaptability and Problem-Solving
Technicians must be competent, flexible and possess strong problem-solving skills to effectively troubleshoot and repair ATA

Communication Skills
Effective communication in understanding and conveying complex technical information related to new systems to ensure compliance and system continued airworthiness

Use of Digital Tools
Familiarity with digital tools and data management systems is increasingly important for safety, maintenance tracking and operational efficiency

Safety and Compliance Knowledge
Understanding safety regulations and compliance requirements related to ATA technologies is both necessary and mandatory for technicians

Collaboration with Engineers
Increased collaboration with engineers and designers is important, as technicians will need to understand the intentions behind new technology implementations

Regulatory Adaptations
The current certification for aviation maintenance may not cover newer aircraft systems, prompting discussions about additional certifications or ratings to address these advancements

Source: https://images.app.goo.gl/BAkDNfA3TkhLv6Qy7

Adapting training programs to equip technicians

Updates in curriculum & instructional delivery

- FAA to remove outdated topics and replace with relevant technologies in-service or near entry
- FAA to have an increased focus on purpose of maintenance practices, safety and regulatory compliance
- Integrate technologies such as on-line instruction, VR and AR to allow students to engage with complex aircraft systems

Addressing Technician Shortages

- Expand training programs and introduce aviation education in earlier stages, such as high schools
- Implement apprenticeship models for affordable, hands-on training aligned with industry needs
- Establish periodic training programs to update technicians on evolving technologies and maintenance practices/standards
- FAA to lead & incentivize career pathway programs, lower barriers to entry and enable new program development, create an FAA Academy for core/baseline A&P curriculum

Industry Collaboration

- Foster partnerships with OEMs to enhance training quality through shared expertise
- Collaborate with aviation operators and businesses to access updated equipment and resources
- Address legal and intellectual property barriers to streamline data sharing and industry collaboration & partnerships
- FAA to incentivize industry partnerships & collaboration with 147 schools

Practical Application and Evaluation

- Prioritize application of hands-on skills and critical thinking over traditional rote learning to better address real-world maintenance challenges
- Combine digital learning tools and practical training to build essential technical competencies
- Integrate human factors training to enhance risk assessment and adherence to established practices
- FAA to improve DME certification and make A&P testing assessment standards more transparent

Strategies and technologies to adopt emerging aviation trends into A&P programs

Technology Integration
- Introduce advanced concepts to prepare technicians for interacting with advanced diagnostic systems using interactive learning and virtual maintenance exercises

Training Modernization
- Integrate AI-driven simulations to enhance practical troubleshooting skills and enable real-time digital diagnostics

Collaborative Resource Sharing
- Create regional networks of aviation schools to share high-cost resources like training simulators, mockups, and equipment, reducing financial strain on individual institutions

Flexible Learning Pathways
- Chunked and modular training programs will allow students to progress incrementally and on-demand
- Support non-traditional students whose life commitments and schedules preclude traditional educational pathways

Addressing Workforce Challenges
- Align training with career pathways while fostering industry engagement through peer mentoring to bridge skill gaps and enhance competency development
- FAA led, foster, enhance workforce development for technicians as they are for pilots. Create resources for career advisors and school councilors

Practical Competency Development
- Develop interdisciplinary, hands-on training aids that combine electrical, software, and troubleshooting skills for real-world diagnostics that are applicable to aviation
- Integrate existing training technologies developed by operators into 147 schools through equitable distribution

Challenges in adopting technologies / Ways to overcome barriers

Challenges	Ways to Overcome Barriers
High cost of online, VR/AR tools, specialized equipment, inadequate facilities and funding constraints	• Collaborate with OEMs, vendors, secure grants, and engage employers to co-fund training technologies and resources • Create economies of scale to acquire equipment at discounts from larger pool of buyers
Technician shortages and limited capacity to train challenges workforce preparation for specialized skills	• Create career pathways that include exploration and partial 147 program completion while in high school, FAA incentivize & enable • Provide career pathway solutions for veterans and military personnel near separation from service • Implement apprenticeship programs that blend classroom learning with real-world experience through industry partnerships using on-the-job training (OJT)
Intellectual property restrictions, and issues in accessing manuals hinder curriculum updates	• Leverage industry relationships to access technical data and sponsors for training programs • Create a user pool of authorized users sponsored by industry OEMs, operators, businesses, or vendors
Uneven distribution of schools with some areas lacking access to A&P programs, others oversaturated	• Expand A&P training access in underserved areas by adapting infrastructure and fostering aviation industry partnerships w/ schools • Create career pathways integrated with STEM programs/FAA incentives • Leverage and integrate with existing CTE programs to create new career pathways linked to local aerospace employers

Educational technologies to develop technician competencies

Enhancements

- Digital learning tools ensures regular updates aligned with industry practices and technology advancements
- VR/AR tools offer safe, time-efficient, cost-effective practice for complex maintenance tasks without requiring physical hardware and special tools
- Digital learning tools enhance engagement and help students visualize and understand advanced systems w/o need for expensive or unattainable 'physical' training aids

Drawbacks

- Over-reliance on digital tools may reduce opportunities for students to practice & develop hands-on skills
- Some skills, like use of torque wrenches or diagnostics equipment, require physical interaction that digital tools can't fully replicate
- High cost of educational technologies and willingness to integrate them create differences in training access and quality between schools

Recommendations

- Enable the adoption of a hybrid approach that combines online/digital tools with in-person, hands-on training to ensure comprehensive skills development
- Focus on short, intensive training modules that integrate practical application with theoretical knowledge
- Create and leverage economies of scale that enable a larger pool of schools to participate in equipment discount programs

Stories from the Field

"When you get your certificate, it's really just your license to learn"

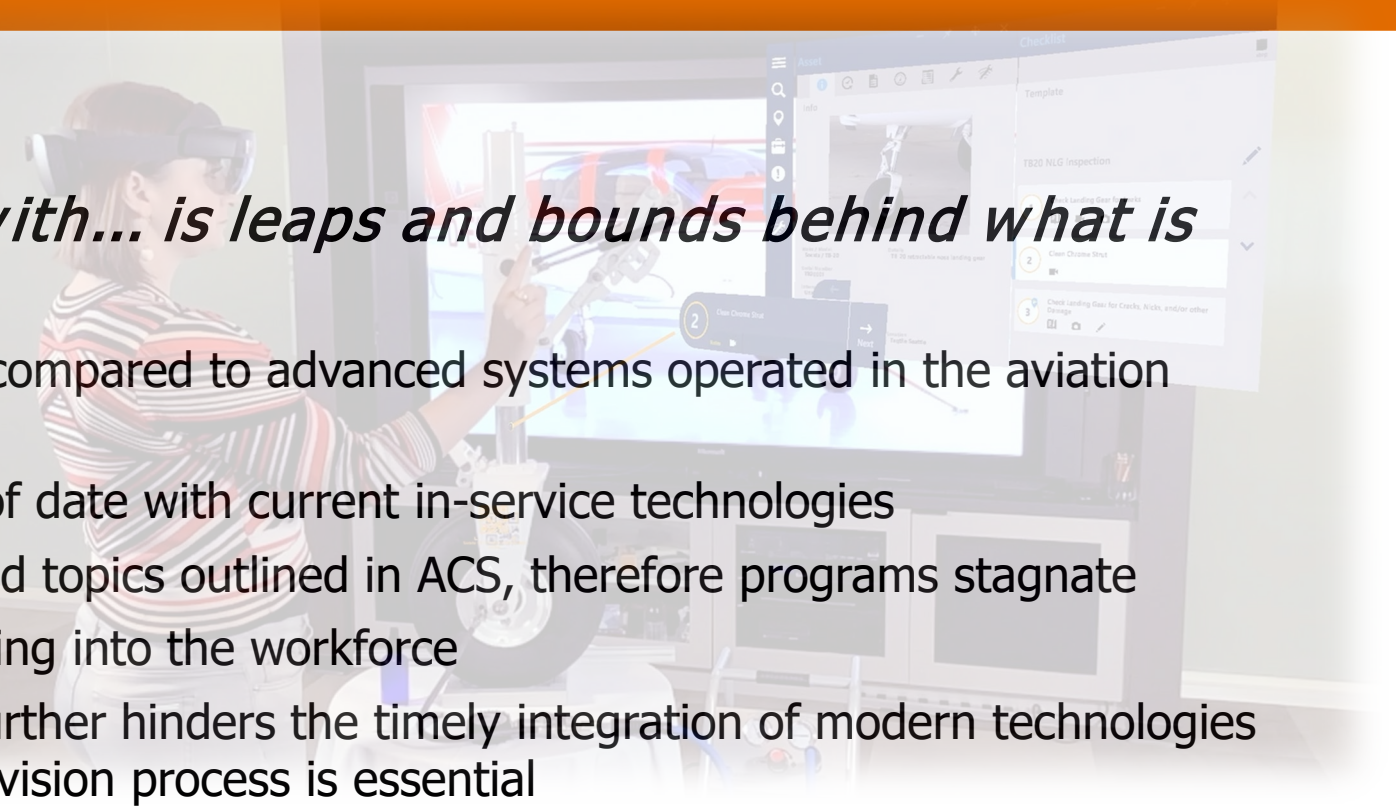
- Earning a certification is just the beginning of a lifelong learning process in a highly dynamic and evolving field like aviation maintenance
- The A&P certificate provides foundational, core, or baseline knowledge but does not encompass all the skills or competencies needed for newer technologies or specialized aircraft and their systems
- Illustrates the importance of ongoing education, professional development, and adapting to new and emerging technologies and associated maintenance practices to remain effective in the industry
- FAA messaging can assist using Part 147 requirements and ACS language that identifies the required curriculum to be an established 'core' curriculum for the development of baseline technician competencies and it is expected that employers will provide additional training as necessary to ensure new technicians are qualified on equipment they will be maintaining

Participant Comments

"When you get your certificate, it's really just your license to learn. If a person views this as a career and is motivated to keep growing, they'll be fine. But if someone gets the certificate just to have a job and isn't interested in ongoing learning, we might have issues."[sic] *- Participant 16*

Source: https://images.app.goo.gl/67N4jGoL95pvzrm89

Stories from the Field



"Our technology that we're training with… is leaps and bounds behind what is actually being used out in the field."

- Part 147 schools often use outdated technology compared to advanced systems operated in the aviation industry
- Even the new standards within ACS are still out of date with current in-service technologies
- There is no requirement for a school to go beyond topics outlined in ACS, therefore programs stagnate
- This gap impacts student readiness for transitioning into the workforce
- The FAA's slow process for updating standards further hinders the timely integration of modern technologies into training programs – Deliberate and timely revision process is essential
- Modernizing training equipment is necessary to bridge this gap to ensures students competencies are better aligned with industry needs and can contribute effectively from day one on the job

Participant Comments

"We're operating in a very technology deficient setting. Our technology that we're training with, while it addresses some of the basics of being an aircraft maintenance technician is leaps and bounds behind what is being used out in the field. And we're not training up to the standard while we're training to the FAA standards. We're not training to industry standards that are required for a future technician to get up to speed[sic] *- Participant 6*

Source: https://images.app.goo.gl/8SQ2tuC1uLiYoHti6

Next Steps

- Analyze and share findings from stakeholder interviews and importance survey
- Use results to map these competencies against the ACS and identify areas for improvement
- Work with the FAA, educational institutions, aerospace companies, and organizations like Aviation Technician Education Council (ATEC), ASTM International, SAE International, and the Aircraft Electronics Association to close identified gaps
- Work with above entities to establish:
  - Deliberate, timely, effective, and transparent process by which emerging technologies can be forecasted
  - New or revised standards can be developed and published
  - Assessment and certification standards are developed and published in parallel with published ACS standards

Source: https://images.app.goo.gl/1oSijjNv4V3TPbrX7; https://images.app.goo.gl/m4dymgUZK7J5aU1J7

Acknowledgement

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Questions & Discussion

Source: https://images.app.goo.gl/6YTBrqduAv1j3cdc6

NASA University Leadership Initiative (ULI)

Adoption of Transformative Technologies and Workforce Development for Maintenance and Repair of Advanced Air Mobility Airframe Structures

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https://www.wichita.edu/industry_and_defense/NIAR/Laboratories/atlas/atlas.php

AS9100D CERTIFIED ISO 9001

ATLAS

ADVANCED TECHNOLOGIES LAB FOR AEROSPACE SYSTEMS

Future Aviation Maintenance Technical Challenges

- **Key Goal**: Investigate key maintenance and training challenges facing the next-generation of air transportation
  - Advanced Air Mobility (AAM) 200-400 aircraft/yr → +1000
    - Structure (New materials)
    - Powerplant (Hybrid, Electric, Hydrogen)
    - Infrastructure (Runways vs. Vertiports)
    - Energy Supplies (Refueling, Charging)
    - Avionics (Piloted, Remote-Controlled, Autonomous)
    - Integration with Ground Transport

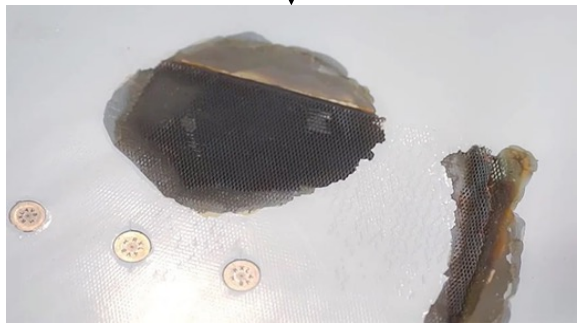
Top-level technical challenges facing the adoption of AAM aircraft

Literature review

- Non-destructive methods
- Surface treatment techniques
- Composite welding techniques
- Composite repair levels
- Types of composite repair

Aircraft repair scenarios

- Technical Gaps
- Training Gaps
- Aircraft on Ground (AoG)
- Cosmetic/Subcritical Damage
- Clearly Visible Airframe Damage



Prioritized List

AAM Fleet Challenges

- AMTS curriculum additions for the sustainment of eVTOLs
- Inspection Challenges for eVTOL
- Maintenance Challenges for eVTOL
- Repair Challenges for eVTOL

Gaps in Technologies

- NDI/NDT/NDE
- Surface treatment for repair bonding
- Welding
- Composite repair
- AR/VR/MR
- AI & ML
- Structural Health Monitoring (SHM)
- Prognostics Health Monitoring (PHM)

- Hardware Limitations
- Data Management and Processing
- Control during Automation
- Workforce Adoption
- Hybrid Material
- Integration with existing system
- Data Security and Privacy
- Cost and return on investment
- 3-D Inspection / Evaluation
- Regulatory Compliance
- Standardization

Technical challenges associated with maintenance and repair of AAM Aerostructures

Literature review

- AAM timeline division
- Establishing possible AAM repair scenario as a function of AAM timeline

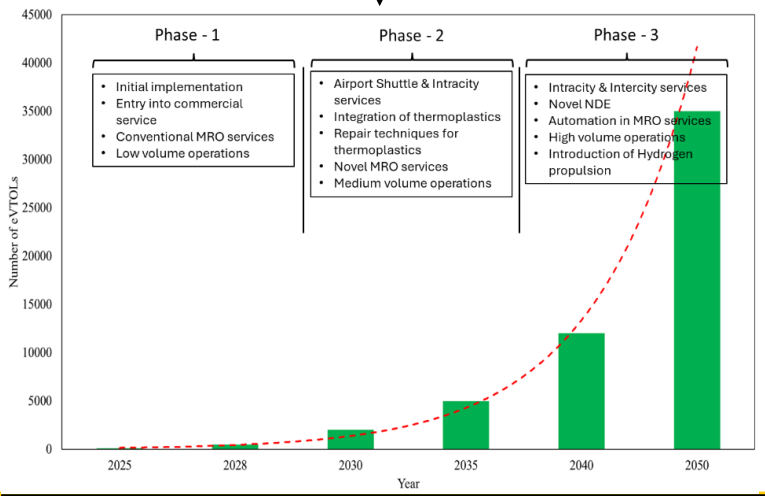
Prioritized List

- Technical challenges as a function of AAM timeline

Challenge
Non-destructive Inspection
Repairs
Integrated / Modular Structures
Certification

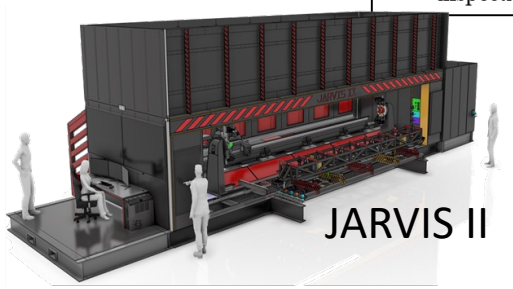
- Technical challenges associated with repair scenarios as a function of AAM timeline

Phase	Repair scenarios
Phase 1	eVTOL AOG
	Cosmetic/Subcritical Damage
	Standard/Major Structural damage
Phase 2	eVTOL AOG on Rooftop
	Cosmetic/Subcritical Damage
	Standard/Major Structural damage
Phase 3	eVTOL AOG on Rooftop
	Cosmetic/Subcritical Damage
	Standard/Major Structural damage



Potential solutions

- Automated Technologies developed by NIAR ATLAS
  - Joint Autonomous Repair Verification And Inspection System (JARVIS)
    - Rail-mounted multi-axis robotic arm
    - Paint removal - Laser ablation
    - NDI - Laser shearography and thermography
    - Scarfing – Grinding by automated robotic arm
    - Surface treatment - APT
    - Post-repair inspection
  - Augmented Reality Visualization Of Detected Defects
    - Scan the damage using a locator
    - Investigate the damaged location on AR visualization device
- Technologies currently being automated
  - Multi-Method Multi-Robotic NDI
    - Eddy Current
    - Thermography
    - Local Immersion Phased Array
    - TTU Yoke
    - Laser Teaching End Effector
  - Automated ultrasonic continuous welding using multi-axis robotic system for thermoplastic composite repairs



Workforce Education

- Further identify gaps in AMTS curriculum and potential training solutions
- Interfacing with students, faculty, and staff to develop better learning strategies
- Provide insight for introducing new technologies to students in the future