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3

COMMITTEE UPDATES

8

COVID-19 AND EMERGING TECHNOLOGIES THAT WILL AFFECT FUTURE WORKFORCE REQUIREMENTS

AVIATION TECHNICIAN ATEC EDUCATION COUNCIL

ABOUT **THE COUNCIL**

ATEC was founded in 1961. Its mission is to promote and support aviation maintenance technical education.

The council actively engages with regulatory and legislative bodies to advocate on behalf of the community, and provides resources, continuing education, and networking opportunities for our members.

Our membership is made up of employers, vendors, and educational institutions with aviation technical programs. The vast majority of member schools are certificated by the FAA to provide aviation mechanic programs.

Membership supports the following activities and initiatives—

- Advocating for sound regulatory policy, the development of clear and concise guidance, and consistent enforcement and application
- Participating on industry and agency committees to further aviation technical education and workforce development
- Fostering and supporting career pipeline partnerships between industry and educational institutions
- Facilitating networking opportunities through the annual conference, Washington fly-in, regional outreach meetings, and virtual webinars
- Enhancing aviation technical career awareness through support of ATEC's sister organization, Choose Aerospace

ABOUT **THE JOURNAL**

The *ATEC Journal* (ISSN 1068-5901) is a peer-reviewed, biannual electronic publication. The publication provides an opportunity for educators, administrators, students and industry personnel to share teaching techniques and research. Authors are encouraged to submit their articles for publication consideration, whether scholarly, research, application, or opinion, by using the submission form below. Papers supporting the council's regulatory and legislative agenda may be considered for presentation via online webinar and at the annual conference. Suggested topics include:

- Technical and soft-skills curriculum integration
- A history of legislative actions affecting aviation maintenance workforce development
- A study on implementing employer-education partnerships
- Funding implications stemming from Bureau of Labor Statistics occupational outlooks
- Highlighted innovations in the aviation maintenance industry
- A look at successful online teaching methods and subject matter in other technical fields
- Surveying currently used computer-based teaching across aviation maintenance training schools

SUBMISSION DEADLINES

Fall Issue Closing Date: October 1 • Spring Issue Closing Date: May 1

SUBMIT AN ARTICLE FOR REVIEW AT ATEC-AMT.ORG/THE-JOURNAL.HTML

from the EDITOR

I think we can all agree that this has been one of the most challenging years in recent memory, affecting all corners of our lives, including our classrooms. Dealing with combined restrictions levied by federal, state, and institutional entities has forced many of us into the uncomfortable realm of nontraditional instruction. Hybrid delivery of our highly technical curriculum has gone from being an exploratory discussion about the future of programs to the viable path to continuing to teach through this time.

As expected, this adaptation has increased workload on instructors as they transition to online delivery. I've heard many people say that regardless of the restrictions, they're working more now than before. This has also undoubtedly decreased the time available to write scholarly articles, which is why no spring issue of the Journal was published. Likewise, this issue contains only one article but a most timely one at that.

Stephen Ley and Aaron Organ have pulled together an interesting perspective on how the current pandemic will have an impact on emerging technologies and their subsequent workforce training requirements.

I hope that you find their work to be informative and inspiring as we all look ahead to how our niche of academia will surely change in response to the needs of aviation.

As always, I send my deepest gratitude to the Editorial Board for their continued work and dedication to the Journal. Please feel free to reach out to any of us with questions or discussions regarding the Journal's mission.

Sincerely,

Karen Jo Johnson, Ph.D.
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EDITORIAL BOARD

COMMITTEE UPDATES

LEGISLATIVE COMMITTEE

Last December, our champions in the U.S. Congress introduced the Promoting Aviation Regulations for Technical Training (PARTT) 147 Act (S.3043/H.R.5427), legislation that would mandate FAA promulgation of a community-drafted, performance-based part 147. Since that time, the committee has been hard at work educating congressional leaders on the bill and soliciting co-sponsors.

As of Nov. 30, we've garnered formal support from seven senators and 16 representatives, from both sides of the aisle. The bill was recently considered by the Senate Commerce Committee and included as part of the committee-passed Aircraft Safety and Certification Reform Act of 2020 (S. 3969). The important step provides a pathway for the ATEC-drafted language to become law.

Despite our inability to hold in-person meetings this year, ATEC achieved unprecedented milestones in 2020. But we still need your help. Call your congressional leader and ask them to support the PARTT 147 Act. For more information and to access our legislative action kit, visit atec-amt.org/part-147.

JARED BRITT
LEGISLATIVE COMMITTEE CHAIR
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COMMUNICATIONS COMMITTEE

The committee focused on two primary initiatives this year—publication the ATEC Pipeline Report, and implementing its social media and marketing campaign.

I encourage you to review the *2019-2020 Pipeline Report* if you have not already. While the data was compiled and analyzed before the novel coronavirus pandemic triggered a significant decline in commercial air transport, the findings will serve as a valuable benchmark going forward as we assess the pandemic's impacts on the aviation maintenance pipeline. If you are a school representative, please be on the lookout for the annual survey—coming to inboxes in January—which serves as the primary source of information for the pipeline report. We know the questions necessitate research on the respondent's part, so we thank you in advance for taking the time to respond.

If you haven't already, sign up to receive ATEC alerts and updates via text message. We also encourage you to follow ATEC's LinkedIn page and feel free to reach out if your school or company would like to be featured in our "Member Spotlight."

JEFFREY DUNAGAN
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REGULATORY COMMITTEE

Committee members spent more time this summer revising and improving the community's proposed regulatory language in the PARTT 147 Act (see legislative committee update, above). As part of the congressional drafting process, committee members reviewed and responded to FAA technical feedback, and made adjustments to address some of the agency's concerns.

While the committee retained the performance-based rulemaking approach, several improvements were made that will ultimately make for a better rule, if the act becomes law. We invite the community to hear more about our efforts surrounding part 147 reform, and how schools can start preparing now for a potential shift in regulatory oversight, by viewing the recent webinar, Part 147: Where Are We Now?

This spring, the committee will focus on implementing the FAA's safety assurance system (SAS) for part 147 holders, and work with ATEC's sister organization to propose a pathway to certification for high school students that complete curriculum currently being developed by Choose Aerospace. (See Choose Aerospace update, below.)

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MEETING PLANNING COMMITTEE

Despite the committee's incredible work preparing for this year's annual conference, we made the difficult decision to forego the 2020 in-person event amidst COVID-19 concerns. The good news—our efforts were not in vain. We look forward to hosting the community here in Texas as soon as it is safe to do so, and cannot thank our Fort Worth-based hosts enough for their flexibility as we navigate these unprecedented times.

Thanks to an incredible team of volunteers, much of the content we had planned for the spring was transitioned to the fall online event. For those who were not able to attend, recorded versions of all the sessions are available in the members-only portal at atec-amt.org/webinars.

While we are not able to confirm the dates for our next in-person meeting quite yet, mark your calendars for our next virtual event, taking place the week of March 29. Stay tuned for details.

KELLY FILGO

MEETING PLANNING COMMITTEE CHAIR

Executive Director of Special Projects, Texas State Technical College

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COMMITTEE UPDATES

MEMBERSHIP COMMITTEE

Despite this year's unprecedented challenges, the trade association again enjoyed record high membership—for the fifth year running. The continued support by the community is evidence of ATEC's value and the importance of all the initiatives facilitated by my fellow committee leaders.

ATEC is currently processing 2021 membership renewals; we thank you in advance for your continued support in the new year. If you are not a member, we would encourage you to come on board. Members enjoy a wide array of benefits, including access to industry experts, curriculum resources, and discounts on events and ATEC-developed materials. (To see our full suite of benefits, visit atec-amt.org/members-only.)

Most importantly, member dues support our advocacy efforts and fund initiatives that promote aviation technical careers. We are stronger together and as of today, ATEC is stronger than ever.

KIM PRITCHARD
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CHOOSE AEROSPACE, INC.

This year, ATEC officially incorporated a 501(c)(3) to facilitate education-based initiatives and promote careers in aviation maintenance. The entity was made possible only through the support of ATEC members, whose member dues financed the organization's creation. Special thanks to the inaugural board of directors, representing various industry sectors, including industry, education, labor, and government.

The nonprofit's initial objective is a big one—to create curriculum that will track emerging mechanic certification standards, and create a clear pathway to mechanic certification for high school students.

The initiative has garnered a lot of attention—we are currently working with several potential partners to sketch out what we think will be a game changer for technical education. The final product will create new pipelines into aviation maintenance technical schools and aviation technical careers. We look forward to collaborating with the community as we pursue the very ambitious initiative.

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Introducing Safeguard Viewer

A Better and modernized ebook system

ATB introduces SafeGuard Viewer, and says goodbye to Adobe Digital Editions. Safeguard Viewer is the next generation of personal ebook reader programs. While preserving the familiar .pdf format with all its on and off-line functions, Safeguard ebooks are easier to download, easier to add to multiple devices, and offers greater stability than older formats.

Standard distribution of Safeguard ebooks begins on December 21. As of the 21st, students needing technical support for older ADE format ebooks will be served with the Safeguard Viewer update. Instructors using ATB books on Adobe Digital Editions or Bluefire Reader are offered a free upgrade beginning now. Instructors wishing to evaluate the Safeguard Viewer system for use in their programs may also request a free demonstration at any time.

For schools wishing direct integration of textbooks with LMS systems such as Moodle, Blackboard, and Canvas; ATB works directly with Redshelf, Vital Source, and CTS International to provide this integration of all titles.

canvas moodle Bb Blackboard

ATB named global distributor for ICAO

ATB is proud to be named as a global distributor for ICAO annexes, manuals, and courses with availability of products beginning January 4.

ICAO, the International Civil Aviation Organization, a division of the United Nations, sets the global standards for all aspects of civil aviation to which all authorities and training organizations rely. Some of these publications of specific interest to the Part 147 community are:

- Training of Flight and Maintenance Personnel Doc 9868
- Aircraft Maintenance Training Standards Doc 7192
- Human Factors for AC Maintenance Doc 9824
- Approval of Training Organizations Doc 9841
- Competency Based Training Methodology Doc 9941
- On Site Testing of Radio Navigation Aids Doc 8071

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COVID-19 and Emerging Technologies that Will Affect Future Workforce Requirements

BY **STEPHEN LEY & AARON ORGAN**

ABOUT THE AUTHORS

Stephen Ley, Associate Professor, School of Aviation Science – Utah Valley University, Orem, UT

Masters of Aeronautical Science, Embry-Riddle Aeronautical University

Bachelor of Science, Aviation Maintenance Technology, Purdue University

Faculty member, School of Aviation Sciences, Utah Valley University teaching subjects in support of the newly developed BS degree in Aerospace Technology Management. Concentrating in the study of Aerospace Aftermarket Support Services, Aerospace Vehicle Certification, Reliability, and Maintainability Systems, Corporate Aviation Management, and Advanced Air Mobility.

Recently developed and delivered one of the first university-level courses involving the development, integration, and operation of Urban Air Mobility (UAM) and Autonomous Unmanned Aircraft Systems (aUAS). Authored articles for Flight Tip, within the Utah Fire & Rescue Academy (UFRA) Straight Tip Magazine focused on integration of UAS within Fire & Rescue Departments.

Planned lines of research include Airport Rescue Fire Fighting (ARFF) and Fire & Rescue training standards and requirements associated with air crashes involving UAM/eVTOL, Hybrid, and Electric Aircraft. Additional research will include aftermarket support services and MRO planning involving the aforementioned air vehicle types.

Industry experience includes leadership as Head of Customer & Services Training for Rolls-Royce Corporation based in Indianapolis, IN. Generated global operational strategies in training services development, deployment, and sales for US and international based teams. Constructed the Rolls-Royce Regional Customer Training Center in Indianapolis, IN in support of US and international customers operating gas turbine products within Regional Airline, Corporate Aircraft, Defense Aerospace, Helicopter, and Energy business segments. Direct field service support experience includes Rolls-Royce Spey, Tay, BR710, and AE 3007 series propulsion systems for Gulfstream II, III, IV, V, Bombardier Global Express, Citation X, Embraer 135/145 and Legacy aircraft. Served in the US Air Force as an F-16 Aircraft Maintenance Specialist and Crew Chief during Operations Desert Shield & Desert Storm and has provided direct operational and maintenance support for General Aviation light single and twin-engine aircraft. Holds an A&P maintenance technician certificate, and former Inspection Authorization and Designated Maintenance Examiner.

Aaron Organ, Adjunct Instructor, School of Aviation Science – Utah Valley University, Orem, UT

Ph.D. Student – Cranfield University, UK

Aaron Organ, C.M., ACE has a diverse aviation background with experience in general aviation, aerospace manufacturing and airport management professional development. Organ is currently an Adjunct Instructor at Utah Valley University and lead instructor at Jordan Academy of Technology and Careers where he enjoys helping students reach their academic goals and mentoring them into career placement. He takes a special interest in leading undergraduate research teams in conducting applied research to solve relevant industry issues.

Organ is currently in the process of completing his Ph.D. in Transport Systems from Cranfield University in the United Kingdom. His research is focused on Urban Air Mobility (UAM) with an emphasis on community integration. He is conducting research that will result in the framework for the community integration of UAM into local transportation systems and networks.

He has had the opportunity to present various research throughout the United States, South Korea, United Kingdom, and the Netherlands. Recent industry contributions include research on the effectiveness of the Salt Lake City International Airport centralized deicing facilities and an inventory of ground infrastructure for UAM in the state of Utah.

ABSTRACT

The effects of COVID-19, the corresponding recovery, and the emergence of Advanced Air Mobility (AAM) will contribute to a growing shortage of qualified aviation maintenance technicians. The integration of emerging technologies involving Urban Air Mobility (UAM), Unmanned Aircraft Systems (UAS), and Hybrid/Electric propulsion will create workforce development and employment opportunities across the globe. A high-level overview of the anticipated UAM air vehicle designs demonstrates the need to address changes to aircraft technician competency requirements and associated training curriculum and standards. A gap analysis is recommended to compare existing aviation maintenance technician curriculum standards to competencies that must be developed for technicians to effectively maintain the safe operation of AAM Aircraft. Unprecedented collaboration among aviation maintenance technician schools, the industry, and the Federal Aviation Administration is needed to develop the highly skilled aviation technician workforce needed not only to support traditional air transportation as it is today, but to enable the success of AAM as it enters our future.

Keywords: Advanced Air Mobility, Urban Air Mobility, Workforce Development, Emerging Technologies

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COVID-19 AND EMERGING TECHNOLOGIES THAT WILL AFFECT FUTURE WORKFORCE REQUIREMENTS

The words coronavirus and COVID-19 have become household names around the world. The effects of this novel virus are being felt differently across the various segments of the aviation industry. As the pandemic struck, the world airlines experienced a 90 percent reduction in passenger demand (Heffintrayer et al., 2020). Because of these record levels of low passenger demand, the airlines have taken the brunt of this health crisis. An analysis of historical shocks to the U.S. airline industry and a study of the current situation suggests that up to 13 percent of the total U.S. airline employee pool will be displaced as a result of the pandemic (Sobieralski, 2020). Airports also rely on passenger demand for both aeronautical and non-aeronautical streams of revenue such as concessions, parking fees, aircraft landing fees, fuel flowage fees, and passenger facility charges. As airports across the nation sit virtually empty, they too feel the financial burden of the coronavirus. Many sectors of the industry continue to suffer, but on the other hand the progression of Advanced Air Mobility (AAM), which is inclusive of small and large Unmanned Aircraft Systems, Electric/Hybrid aviation, and Urban Air Mobility, continues to push forward largely uninterrupted (Dietrich et al., 2020). The continued progression of AAM, the current effect of COVID-19, and the forecasted recovery timeline could contribute to a larger shortage of qualified aviation maintenance technicians.

EMERGING TECHNOLOGIES ON THE HORIZON

Advanced Air Mobility

AAM is an umbrella term for emerging technologies that enable aviation to serve markets historically not served or greatly underserved (Tsairides, 2020). Small Unmanned Aircraft Systems (sUAS) are presently integrating into transportation systems through early adopter cases such as medical supply, blood donation, and organ transplant deliveries. Other proven general use cases across multiple industries for small drones include emergency response, disaster relief, conservation, surveying, weather forecasting, inspections, planning, communications, security, education and many more. Package delivery via drones continue to be a goal of the future with major players such as UPS, FedEx and Amazon all racing to be the first to demonstrate large scale use of the technology. Large Unmanned Cargo Aircraft (LUCA) are also quickly advancing through stages of design, research, development and operational testing. LUCA uses range from drones carrying a couple hundred-pound payload to fully autonomous 100-ton freighters. Elroy Air has built the Chaparral which is successfully working its way through operational testing. The Chaparral is an autonomous drone capable of VTOL operations using an electric hybrid powertrain. This aircraft can carry up to 500 pounds across for nearly 300 miles ("Elroy Air," 2020). Another LUCA company, Sabrewing, has built scaled prototypes of the Rhaegal. The Rhaegal at full scale will be capable of a payload of 5,400 pounds, a cruising speed of over 200 knots, and a range of up to 1,000 miles (The Rhaegal, 2020). The Chaparral and the Rhaegal are on track to earn certification and be operational by 2022 (Choi, 2020). Natilus is another company focused on these unmanned cargo aircraft; Natilus built a small-scale prototype seaplane drone capable of carrying 700 pounds over 2,500 miles (Woods, 2018). The full-scale seaplane cargo drone will be capable of a larger payload of two tons when it comes to market. Nautilus has stated these aircraft are "technology demonstrators," they have a place in the market, but the company is focused on building an autonomous cargo freighter capable of a 130-ton payload and covering great distances (Woods, 2018). The depiction of such a freighter is seen in Figure 1.

Figure 1: Natilus Next Generation Freighter (NATILUS, 2020)

The quest for clean and sustainable energy to power aircraft is not a new quest but is now becoming more of a reality because of the advancements in technology. The year 2020 has been hard for countless companies across various industries, but again, several companies are pressing forward and have accomplished great things this year. In May 2020, the all-electric Cessna Caravan took to the skies powered by the Magnix's Magni500, a 750-hp electric propulsion system (Garrett-Glaser, 2020). In June 2020, Zero Avia Incorporated modified a 6-seater Piper aircraft that successfully earned the title of the largest aircraft to fly powered by 100 percent hydrogen fuel (2020). Zero Avia has noted that although it started relatively small, the technology used to successfully fly hydrogen powered aircraft is scalable and the goal of producing hydrogen fueled airliners by 2030 is a realistic goal (2020). Another player that is more well-known with the same goal of creating CO_2 emissions free aircraft by the 2030s is Airbus. In September 2020, Airbus revealed three different design approaches using similar hydrogen fuel technology. Each of the three designs will continue through phases of research and development until it is clear which will be the best for market by 2035 (Airbus, 2020).

Urban Air Mobility

Urban Air Mobility (UAM) is defined as on-demand or scheduled air service to transport passengers or cargo using aircraft capable of vertical take-off and landing (VTOL) in an urban setting. Many of the aircraft being designed and tested for UAM-use are fully electric and virtually all are being designed with the goal to be completely autonomous. The Vertical Flight Society, which maintains a database of UAM aircraft, has reported more than 360 aircraft that are in various stages of concept, design, research and development, operational testing and even in the certification stage (eVTOL Aircraft Directory, 2020). There are about 80 manufacturers across this list of aircraft ranging from well-known and well-established industry leaders like Boeing, Bell, and Airbus to new entrants like Volocopter, Lilium, and Joby. Many of these aircraft are capable of not only vertical take-off and landing, but the technology also allows for the traditional horizontal flight path of a fixed-wing aircraft. Within this new wave of aircraft development one can see aircraft designed to serve as air taxis in an intracity transportation system, while others are designed for city-to-city travel bringing the short haul market back to life. One design can be seen in Figure 2, depicted is the S-4 by Joby Aviation.

The National Aeronautics and Space Administration (NASA) predicts scaled demonstrations of automated and complex operations at high-volume vertiports by 2025 (Tsairides, 2020). A vertiport is the term used for the physical landing and takeoff infrastructure for these new UAM aircraft. Vertiports can be as simple as one landing pad for the aircraft or be viewed like an airport hub of sorts with roadway access, passenger terminals, and multiple landing pads. In November 2020, Germany-based Lilium GmbH, announced it would build by 2025 an Orlando based vertiport with a 56,000 square foot terminal and multiple landing pads; the project will cost $25 million (2020). A depiction of this vertiport design can be seen in Figure 3. This investment into the physical infrastructure of UAM is the first of many. A NEXA Advisors study predicts that $318 billion will be spent over the next 20 years across the top 75 cities in physical infrastructure alone (2020). As for total industry market growth predictions, according to a Morgan Stanley Research study, the UAM industry "in its base case, points to a total addressable market of $1.5 trillion by 2040. A more bullish forecast places the market at $2.9 trillion" (2019).

Figure 2: Joby Aviation S-4 (Joby Aviation, 2020)

Figure 3: Orlando-Based Lilium Vertiport (Lilium GmbH, 2020)

Workforce Development Opportunities

As these emerging technologies enter the market, surely the workforce gap of qualified technicians will grow. This gap will grow because AAM will revolutionize the transportation system and bring several new markets to life within the aviation ecosystem. The graphic below in Figure 4 is from NASA and provides a visual representation of these new markets. The 2019-2020 Aviation Technician Education Council Pipeline Report showed that new A&P technicians account for only 2 percent of the overall population while 33 percent are at or nearing the age of retirement. The report further shows that the industry will need to produce another 2,700 mechanics each year over the 2019 output to meet U.S. market demand over the next two decades (2019-20 Pipeline Report, 2020). This is a daunting workforce shortage and the *ATEC Pipeline Report* only accounts for traditional sectors of the industry such as air carriers, general aviation, and repair stations.

Considering the pandemic, the Boeing Company recently updated their *Pilot and Technician Outlook 2020-2039 Report*. Under the assumption that passenger demand will recover within the next few years the report states that 739,000 new technicians will be needed to maintain the global fleet (2020). Although there is a current downturn as a result of the pandemic it is important to remember that the fundamental factors that drive air travel remain strong, which is why the industry has historically always recovered. The Boeing report is inclusive of the commercial aviation, business aviation and civil helicopter industries. According to Thomas E. Wagner, Senior Manager of Maintenance Training at Boeing, the outlook numbers are not inclusive of emerging technologies (T. Wagner, personal communication, November 13, 2020). It will take unprecedented industry collaboration in the immediate and long-term future to meet the continual demand for qualified aviation technicians, not only for traditional aviation, but to enable and support these emerging technologies.

EFFECT OF COVID-19 AND RECOVERY TIMELINE

The aviation industry has been through economic recessions, terrorist attacks, and past pandemics before but none affected the industry as negatively as the coronavirus. Travel bans and local shutdowns resulted in travel demand disappearing seemingly overnight. Between January and April of 2020, 70 percent of the global aircraft fleet were grounded, more than 18,000 aircraft went into storage, and more than 4,500 airplanes were parked in North America (Cooper et al., 2020). One major U.S. carrier that reported operating at a loss of $40 million each day warned almost 50 percent of its workforce of imminent furloughs, over 5,000 of whom are A&P mechanics (Schaper, 2020). The original forecasted

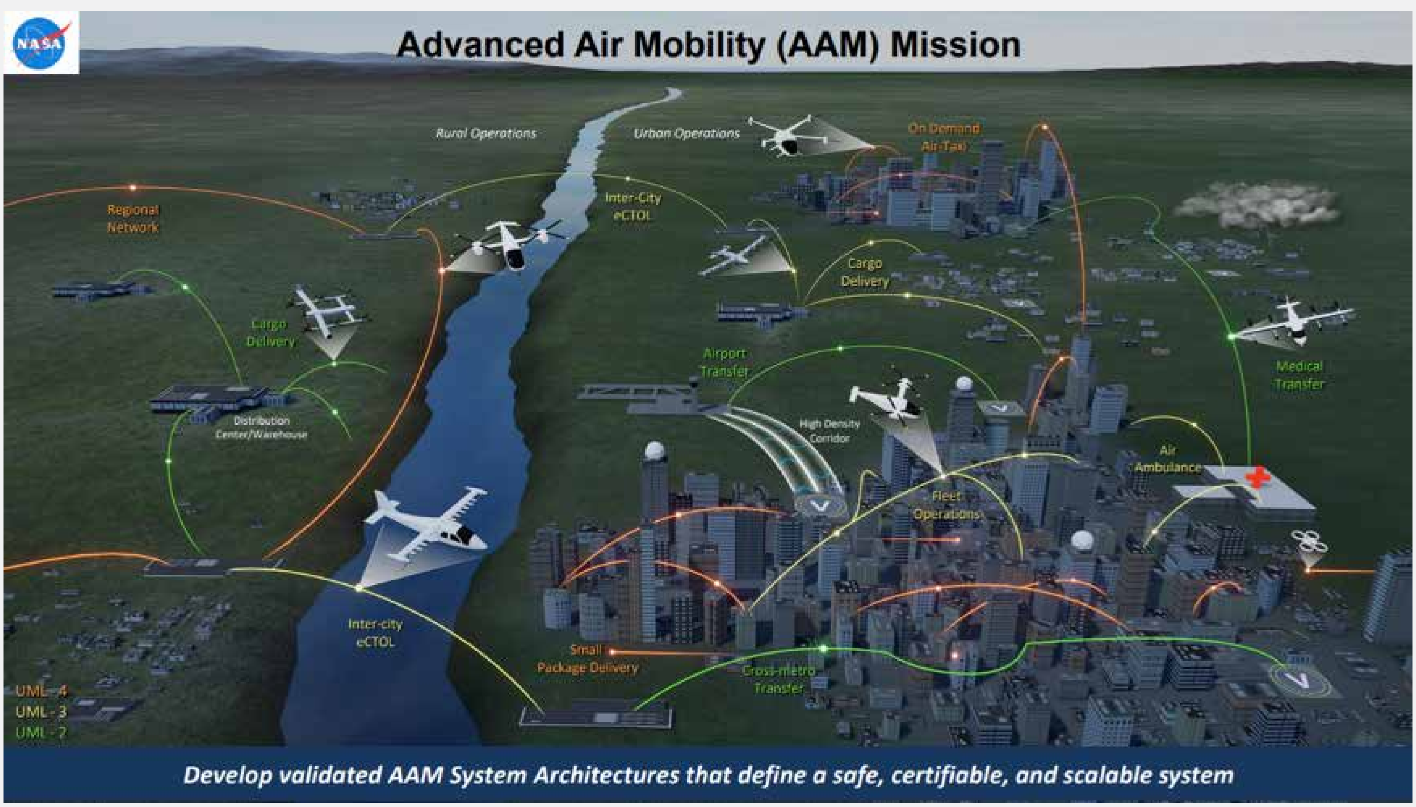

Figure 4: NASA AAM Mission Graphic (Hackenberg, 2020)

2020 cumulative spending budget for Maintenance, Repair, and Overhaul (MRO) services has been cut by $45 billion, which has resulted in companies like GE Aviation furloughing 50 percent of its technicians involved with MRO services (Tirpak, 2020). These are sobering statistics, but the *Boeing Pilot and Technician Outlook 2020-2039 Report* sheds a positive light: "Despite a large number of aircraft in storage, technicians continue to play a vital role in ensuring the aircraft remain airworthy. Improper or incomplete maintenance could lead to corrosion, damaged wires and other issues that lead to more extensive and expensive repairs. The need for continued maintenance of the parked fleet has mitigated the impact on technician employment worldwide" (p. 5).

According to a study conducted by the University of Bergamo, the worldwide recovery of passenger demand to pre-coronavirus levels will not happen, on the optimistic side, until late 2022, and on the pessimistic side, until 2026 (Gudmundsson et al., 2020). In a study and analysis done by Joseph B. Sobieralski the results show that a recovery to 2019 levels of travel would take between four and six years (2020). Research from the aviation infrastructure investment firm Moody's predicts that it will be 2024 before the airlines see pre-COVID-19 load factors (Heffintrayer et al., 2020). Although the ranges of a recovery timeline differ slightly one thing all these researchers agreed on is that the air transportation industry will indeed recover as it has always done in the past.

EMERGING TECHNOLOGIES - EFFECT ON TECHNICIAN QUALIFICATIONS

The recovery of COVID-19, which coincides with integrating these emerging technologies, will create workforce development and employment opportunities. MRO requirements, as the industry knows them today, will change forever. As a result of the pandemic, the industry will lose many qualified maintenance technicians to either early retirement or to other industries (marine, industrial, petroleum and gas energy, alternative energy, agriculture, automotive, manufacturing, and the like). Now is the time to prepare current and future aircraft maintenance and avionics technicians. Now is the time to evolve training curriculum standards, technical data delivery methods, and MRO service delivery models to align with the emerging technologies of UAM and LUCA vehicles. These technologies are already on the industry's doorstep. The following sections focus on just two of these elements: emerging technologies effect on technician qualifications and developing technician competency requirements for AAM.

AAM Technologies – A Sample

With more than 360 AAM aircraft designs listed in the eVTOL Aircraft Directory and each associated with "known electric and hybrid-electric vertical takeoff and landing (eVTOL) concepts" (eVTOL, 2020), there are a significant number of new and innovative technologies that have been awarded patents for their designs or are in the process of patent application. Many of these technologies involve flight controls, airframe systems, propulsion systems, avionics, electrical systems, motors, sensors, and structural material applications. These technologies are beyond the scope of existing Federal Aviation Regulation (FAR) Part 147 Appendix B, C, and D curriculum and the proposed FAA-S-ACS-1 Aviation Mechanic General, Airframe, Powerplant Airman Certification Standards.

The following technologies and systems can be found on many of the current UAM designs:

- Complex composite structure and forms
- High-capacity battery storage systems and associated charging, electricity regulation, and safety subsystems
- High-torque electric motors and a fully integrated thrust management and flight control system with complex pivoting motor mounts
- Stowable propeller configurations
- Tilt-wing configurations
- Advanced vibration analysis and dampening system
- Ground/object proximity and dynamic object of interest tracking sensors and video imaging
- Autonomous airborne vehicle instrumentation, navigation and communications systems that will interlink with ground-based unmanned air traffic management systems or low-altitude air traffic management systems
- Active stabilization control and associated sensors and system
- Flight, airframe and propulsion monitoring systems to perform fault isolation, system health monitoring, and post-maintenance functional checks

Joby Aviation Designs

According to the article "Inside Joby's Unicorn: Recent Flood of Patents Reveal New Details," a total of 40 patents have been awarded to Joby Aero, Inc. and JoeBen Bevirt (inventor) between the dates of Feb. 15, 2000 through Sept. 29, 2020 that are associated with their various aircraft designs and unique components and systems. There are also a total of 18 patent applications outstanding from October 31, 2019 through October 29, 2020 as of time of this writing (Swartz,

2020). Table 1 outlines the 10 patents awarded to Joby Aero, Inc. for its innovative aircraft designs and systems. Many of the patents reference to different aircraft configurations with various electric propulsion solutions that include tilt rotor mechanisms (Figure 5) and stowable propellers (Figure 6).

Table 1: New Technology Patents Awarded – Joby Aero, Inc. Assignee (Swartz, 2020)

Patent Date granted	Patent Title
10,710,741 July 14, 2020	System and method for airspeed determination
10,625,852 April 21, 2020	Aerodynamically efficient lightweight vertical take-off and landing aircraft with pivoting rotors and stowing rotor blades
10,556,700 Feb 11, 2020	Aerodynamically efficient lightweight vertical take-off and landing aircraft with pivoting rotors and stowing rotor blades
10,479,490 Nov 19, 2019	Multi-configuration autonomous platform with mounted camera
10,315,760 June 11, 2019	Articulated electric propulsion system with fully stowing blades and lightweight vertical take-off and landing aircraft using same
10,046,855 Aug 14, 2018	Impact resistant propeller system, fast response electric propulsion system and lightweight vertical take-off and landing aircraft using same
10,035,587 July 31, 2018	Aerodynamically efficient lightweight vertical take-off and landing aircraft with multi-configuration wing tip mounted rotors
9,694,911 July 4, 2017	Aerodynamically efficient lightweight vertical take-off and landing aircraft with pivoting rotors and stowing rotor blades
9,527,581 Dec 26, 2016	Aerodynamically efficient lightweight vertical take-off and landing aircraft with multi-configuration wing tip mounted rotors
8,733,690 May 27, 2014	Lightweight vertical take-off and landing aircraft and flight control paradigm using thrust differentials

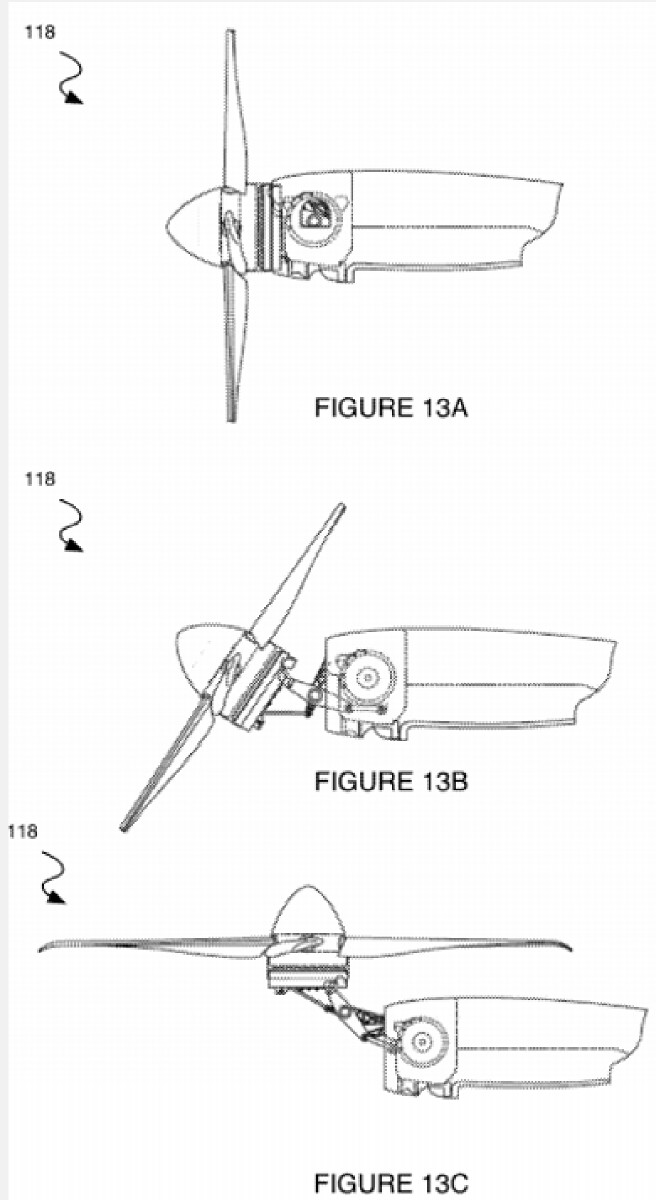

Figure 5: Joby Aviation Tilt Rotor Mechanism in Various Flight Regimes (Bevirt & English, 2020, Sheet 10)

In both Figures 5 and 6, Joby Aviation illustrates in its patents a system of propulsion that is quite remarkable and will likely require a great deal of integration among a variety of systems and components. It is important to note that these configurations are from different patents and thus different aircraft configurations and models. The authors are suggesting the following systems and primary components may be involved: 1) electrical, 2) high-torque drive motors, 3) servo motors to drive the tilt mechanism, 4) tiltrotor position feedback sensors, 5) hinged propellers to allow for deployment, operation and stowage (Figure 6), 6) airspeed, rpm and airflow sensors (or derived/calculated based on key performance parameter inputs) to balance thrust in all phases of flight, 7) active stabilization control,


The functionality of an aircraft scaled to fit a classroom

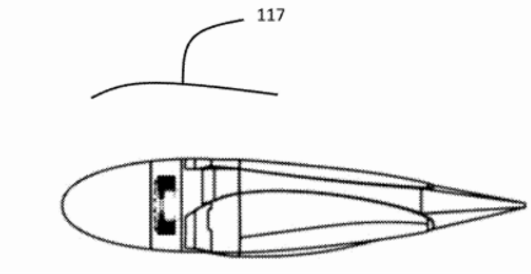

FIG. 20

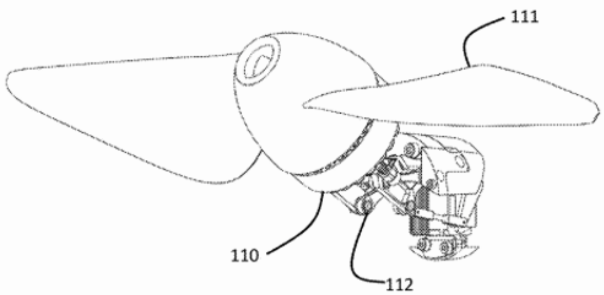

FIG. 21

Figure 6: Joby Aviation Stowable Propeller with Tilt Rotor (Bevirt & Stoll, 2020, Sheet 12)

8) vibration sensing, control, and annunciation, and 9) tilt rotor and airframe mount structures. This is a complex package in a relatively small space. Effective and high-quality maintenance performed on this aircraft will be essential, so will be the technician training.

XTI Aircraft Designs

XTI Aircraft has an aggressive certification schedule that will introduce the XTI TriFan 600 into the market by 2023 (Moorman, 2020, March 6). By definition, this aircraft is envisioned to be a part of NASA's AAM ecosystem. The aircraft is capable of VTOL and conventional takeoff and landing (CTOL) lifted by three 6-foot diameter ducted fans. Two fans are installed on pivot mounts on each wing with one fan embedded in the aft fuselage that is covered during transition to horizontal flight. The propulsion system uses a hybrid electric drive. This drive system includes a GE Catalyst gas turbine engine driving three electric generators that provide electrical current to the dual electric motors powering each fan. Batteries will be used to provide additional power during VTOL operations. This is only an intermediate step as the aircraft is planned to transition to all-electric or hydrogen fuel cells to offer zero-emissions in the future. This is a very flexible aircraft that is considered a technology disruptor, XTI Aircraft calls it "Technology Reimagined" (Swartz, 2020). eVTOL News included in its summary of the TriFan 600 aircraft an illustration provided by XTI Aircraft that identifies some of its key technology features, Fig. 7 (2020).

Figure 7: XTI TriFan 600 Technology (eVTOL News, 2020)

The range of the XTI TriFan 600 is 670 nautical miles and 1,200 nautical miles during VTOL and CTOL operations, respectively. Because of this longer range, the TriFan 600 has access to and use of existing airports and service center facilities within its flight path. This is an advantage over the all-electric UAM aircraft currently under development. However, its configuration and technologies will challenge that network and the qualifications of the technicians that can support it.

Simple Technician Training Gap Analysis

To begin to demonstrate the gap between existing curriculum and these new technologies the TriFan 600 was selected as a sample aircraft to compare to the existing standards. Table 2 below outlines the key systems advertised for the TriFan 600. The table also identifies subjects associated with that system for both the current FAR Part 147 Appendix B General; Appendix C, Airframe; and Appendix D, Powerplant curriculum, and the proposed Aviation Mechanic General, Airframe, and Powerplant Airman Certification Standards, FAA-S-ACS-1. The far-right column suggests the effect on the standards and subjects listed as either neutral or additive to the existing and proposed standards. *Neutral* suggests that the existing and proposed curriculum standards will likely be sufficient to develop the knowledge and skills necessary to perform maintenance on the listed aircraft system compliant to FAR Part 43, Maintenance, Preventive Maintenance, Rebuilding, and Alteration. *Additive* in this

Table 2: New Technology Comparison to FAA Curriculum - XTI TriFan 600 Aircraft (Air Mobility, 2020)

System	Part 147 Subject FAA-S-ACS-1 Subject	Effect on standards
Advanced flight controls - fly by wire; stabilization enhancement	Airframe I, F. Assembly & Rigging • Sect. II Airframe, C. Flight Controls • Sect. II Airframe, N. Rotorcraft Fundamentals	Additive – Unique System
Redundant electric generators driving electric motors	• Airframe II, G. Aircraft Electrical Systems • Powerplant II, C. Engine Electrical System • Sect. II Airframe, K Aircraft Electrical System • S. III Powerplant, C. Electrical Systems	Neutral
Pivoting ducted fan (6 ft) x 2 Fuselage embedded fan (6 ft) x 1	Powerplant II, K. Propellers • Sect. II Airframe, N. Rotorcraft Fundamentals • Sect. III Powerplant, N. Propellers	Additive – Unique System
Closing body fan door	Airframe II, A. Aircraft Landing Gear Systems Sect. II Airframe, E. Landing Gear Systems	Additive – Unique System (Similar – Gear Doors)
Hybrid-Electric Drive System 1,100 SHP turbine engine	Powerplant I, B. Turbine Engines Sect. III Powerplant, B. Turbine Engines	Hybrid Propulsion – New System Turbine - Neutral
Dual 250 kw electric motors driving each fan	• Airframe II, G. Aircraft Electrical Systems • Powerplant II, C. Engine Electrical Systems • Sect. II Airframe, K Aircraft Electrical System • S. III Powerplant, C. Electrical Systems	Additive – Unique System
High-capacity batteries	• General, A. Basic Electricity • Airframe II, G. Aircraft Electrical Systems • Sect. 1 General, A. Fundamentals of Electricity and Electronics • Sect. II Airframe, K Aircraft Electrical System	Additive – Unique System
Carbon fiber composite structure	Airframe I, D. Sheet Metal & Non-Metallic Structures Sect. II Airframe, B. Non-Metallic Structures	Additive (current 147) Neutral (ACS)
Embedded solar film – ground power	Airframe II, G. Aircraft Electrical Systems Sect. II Airframe, K. Aircraft Electrical System	Additive – Unique System
Full airframe parachute	Airframe I, G. Airframe Inspection Sect. II Airframe, D. Airframe Inspection	New System

column suggests that the existing and proposed curriculum standards will likely be sufficient to develop the knowledge and skills necessary to perform maintenance on the listed aircraft system compliant to FAR Part 43, Maintenance, Preventive Maintenance, Rebuilding, and Alteration. *Additive* in this column suggests that the existing and proposed curriculum standards can use the foundation of the *147* and *ACS* subject listed, but it is recommended that additional lessons or projects be added to the subject because of the uniqueness of the technology being deployed. The primary technology takeaways from the XTI TriFan 600 is the hybrid gas turbine/electric propulsion system, and the ducted, pivoting, and embedded fans for VTOL. Note: At the time of this writing, XTI Aircraft has partnered with VerdeGo Aero for the development of the Hybrid-Electric VTOL TriFan 200 Cargo/Logistics Aircraft. This introduces a diesel (Jet A) hybrid powertrain coupled to electric motors similar in configuration as to the TriFan 600. This will be a non-piloted, autonomous aircraft ("XTI Aircraft," 2020). The industry is on the verge of introducing significant technological changes to aircraft as they are known today.

When comparing AAM aircraft and the various designs and applications, similarities begin to stand out. The entire aircraft will be consolidated into highly complex and integrated systems residing within a relatively small platform; however, the technology is scalable. It is envisioned that a maintenance technician will be expected to perform onsite line maintenance for the entire aircraft for UAM operations within an urban environment. UAM vehicle repairs will be expected to be turned quickly to ensure on-demand flight services are not interrupted. The responsibility and skill set required of this individual cannot be overstated. Technician training to a well-defined standard using the most effective delivery methods will be paramount.

DEVELOPING TECHNICIAN COMPETENCY REQUIREMENTS

It has been established that current FAR Part 147 Aviation Maintenance Technician School (AMTS) curriculum standards fall short of the subjects and skill levels required to effectively maintain today's modern aircraft ("Part 147," 2020). The ATEC article *Part 147 Reform* outlines concerns stated in the 2003 Government Accountability report that current FAR Part 147 programs do "not fully prepare A&P mechanics to work on commonly flown, technologically advanced commercial aircraft," and that "today's modern aircraft require A&P mechanics to have a different set of skills than those being taught at aviation maintenance technician schools" (as cited in *Part 147 Reform,* 2020, para. 2). The proposed outcomes-based Airman Certification Standards (ACS) is a step in the right direction and opens doors to enable more timely changes to topics and standards as technologies evolve. However, the system for proposed curriculum changes will not progress as quickly as the new technology will enter service. This gap will only widen with the introduction of UAM and LUCA vehicles previously discussed. This leads to the following set of recommendations that we, as an Aviation Technician Education Council (ATEC) community, can do together:

Recommended Part 147 Gap Analysis

Note: This was partially completed in Table 2 in a very abbreviated format.

1. Perform an assessment of the UAM vehicles design, equipment installed, and maintenance requirements that ensures continued airworthiness and compliance to the type certificate or design standard by which the aircraft achieved its airworthiness certificate.
    i. Review available manufacturer's technical data and type certificate data sheet to identify unique maintenance practices and technologies within the aircraft's systems, components, operations, and limitations, compared to traditional aircraft designs.
    ii. If published technical data cannot be found within the public domain, research and identify patents and patent applications assigned to the manufacturer. Carefully review the patent documentation and available drawings to identify operations and technology points of interest.
    iii. Document findings into common categories such as aircraft operations, and airframe and powerplant systems.
2. Complete a knowledge and task analysis to determine the technician competencies required to safely and effectively maintain these aircraft in an airworthy condition.
    i. From the UAM aircraft assessment previously completed, identify and list the knowledge requirements necessary for a technician to comprehend, examine, recall, judge and apply information related to the aircraft's operation and equipment installed.
    ii. Next, identify the specific skills or behaviors necessary to perform maintenance tasks on the equipment installed.
    iii. Ensure knowledge and skills remain within their associated subject categories.

3. Conduct a gap analysis to compare the derived UAM maintenance technician knowledge and skill requirements against the current FAR Part 147 curriculum subjects and rigor. This includes a review of the proposed ACS.
    i. Using the proposed ACS found within FAA-S-ACS-1, create a matrix table that outlines each of the Sections, Subjects and individual Knowledge topics and Skill activities.
        - *Note: This creates the baseline for the matrix table since its list of subjects and topics is more comprehensive than the current published FAR Part 147 curriculum subject standards.*
    ii. Using the matrix table created previously, integrate and align each of the curriculum subjects listed within Appendix B, C, and D of FAR Part 147 AMTS to the ACS subjects.
    iii. Next, create a new set of columns that are associated with the aircraft design(s) that was(were) assessed. Place these to the right of the ACS and Part 147 curriculum subjects.
    iv. Align the maintenance technician knowledge and skill gap analysis recommendations completed in Step 3 with subjects most closely associated with the listed Part 147 and ACS curriculum subjects.
4. Generate recommendations for revisions of the subjects and teaching levels within Appendix B, C, and D for the General, Airframe, and Powerplant curricula, respectively, within FAR Part 147 (Electronic Code of Federal Regulations, 2020).
5. Generate recommendations for revision of the ACS appropriate to the Section, Subject, Knowledge topic and/or Skill activity ("Mechanic," 2020).

At this point, it is recommended that any progressive changes to the FAR Part 147 curriculum should be completed through the proposed ACS document. It is the most comprehensive list of competencies desired for A&P Technicians and is best positioned to facilitate curriculum changes as technology advances.

CONCLUSION

Both traditional aircraft manufacturers, such as Bell and Airbus, and nontraditional aircraft developers like XTI Aircraft, Natilus, Lilium, Volocopter, EHang, and Joby Aviation (to name only a few), are entering the AAM market in earnest. Of the more than 360 designs listed in the eVTOL Aircraft Directory, some aircraft designs are being developed, while others are operating and are going through FAA certification. The world could see entry into service as early as 2022-2023 for specific models. Even with the economic setbacks caused by COVID-19, the deployment of these emerging technologies will place a strain on existing talent pools, instructional resources, and curriculum standards necessary to prepare aircraft maintenance technicians for these new technologies.

However, the participation of automobile manufacturers such as Hyundai and Toyota, in partnership with Uber Technologies, Inc., and Joby Aviation, respectively, into the UAM market, could drastically tip the scales in opening available MRO services and increasing the available sources for technician talent. According to Park, the resources and capacity available for aftermarket service and support of UAM vehicles will be profoundly increased (Park, 2020; Intelligent Aerospace, 2020). This fact alone could materially change how the ATEC community will be looked to for providing the necessary curriculum standards, education, and training to support these emerging technologies.

Hybrid propulsion, tiltrotors, ducted pivoting fans, embedded fans, autonomous flight systems, ground and object proximity sensors, active stabilization control, and transitional lift systems, are but a foretaste of the technologies that are emerging that will affect the course designs and curriculum of the existing Part 147 and proposed ACS for Aircraft Maintenance Technician Schools. As an educational community, in collaboration with the Federal Aviation Administration, and with existing and new partners within the aerospace industry, we must work together to help create a modern, highly skilled maintenance technician workforce who can ensure the successful introduction and safe operation of AAM technologies. As the integration of these new technologies continues to progress it will result in sustainable growth within the aviation industry. The industry has been challenged because of COVID-19, but the human capacity to innovate and turn ideas into reality to solve problems, including developing new methods for air transportation, gives hope for greater opportunities tomorrow.

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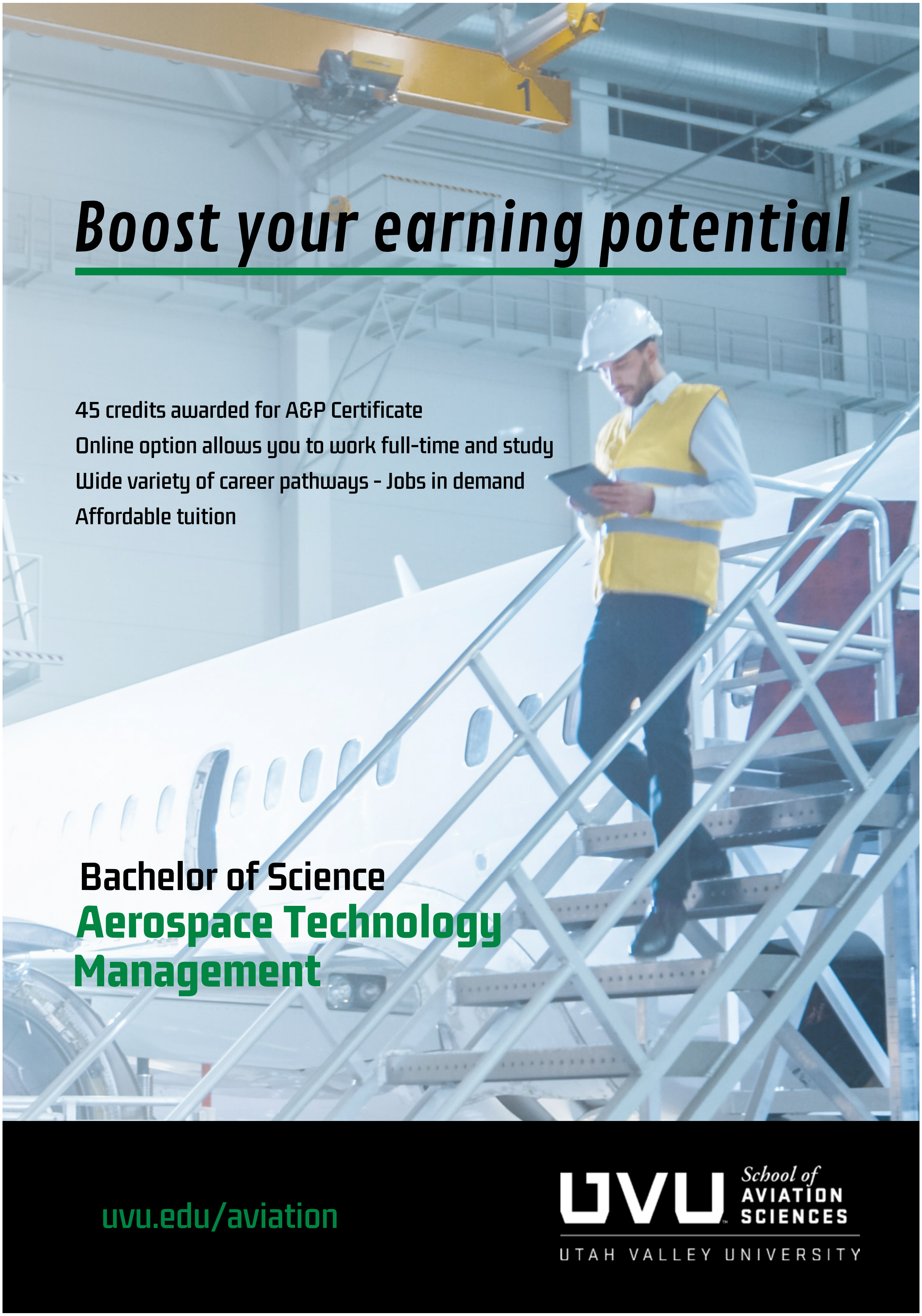
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