CHALLENGES
TO THE COMMERCIALIZATION OF
ADVANCED AIR MOBILITY

AUTHORED BY THE
AIAA Certification Task Force

RELEASE DATE
January 2024

AIAA
SHAPING THE FUTURE OF AEROSPACE

CHALLENGES
TO THE COMMERCIALIZATION OF
ADVANCED AIR MOBILITY

Novel technology is creating a global revolution in air travel. Electric, hybrid, and even hydrogen-powered aircraft are emerging as viable alternatives to conventional short-haul aircraft and most means of surface transportation.

Many technological challenges are being successfully confronted but regulatory and legal hurdles remain. Navigation, type, and production certification and urban traffic management are presenting significant barriers to both public and private sectors.

In this report, the AIAA Certification Task Force proposes solutions to many of these problems.

AUTHORED BY THE
AIAA Certification Task Force

RELEASE DATE
January 2024

AIAA
SHAPING THE FUTURE OF AEROSPACE

TABLE OF CONTENTS

Abstract

This report discusses the potential role of AIAA to help in the certification of Advanced Air Mobility (AAM) vehicles and the creation of their operational infrastructure. Topics include the certification of artificial intelligence and software capabilities, vehicle configurations, and battery/motor systems, as well as the impact of the vehicles in the air traffic management airspace system. Recommendations are made for AIAA participation and technical leadership to facilitate successful and cost-effective AAM certification and implementation.

This report has six major recommendations where the Task Force is confident that AIAA can be especially helpful. AIAA has vast technical capabilities in its membership as well as a reputation as a balanced, honest broker of technical issues and judgments that can help government and industry as it moves toward implementation of AAM capabilities.

RECOMMENDATION 1

Air Traffic Management for the AAM World would establish a standing working group of government and stakeholder organizations, facilitated by AIAA to establish **a unified national plan** for employment of advanced airmobile vehicles.

RECOMMENDATION 2

How Can Novel Technology Survive in a Proscriptive Regulatory Environment? includes two proposals:

1. Leverage the experiences from the Performance-Based Regulations adopted in 14 CFR Part 23, Amendment 64 to allow new technology to be introduced while building standards that ensure safety as a means of compliance and allow for innovation.

2. Encourage AIAA to leverage its deep expertise through its Technical Committees to build the foundation for technically robust standards to develop these means of compliance.

RECOMMENDATION 3

Proposed Curriculum for Start-up Certification Tutorial Teams suggests employing AIAA as an information and expertise clearinghouse, where its vast membership can provide consultation and advisement to quicken the application and certification process for new companies as they develop and certify new air vehicles.

RECOMMENDATION 4

New AAM-Related Laws Must Be 'Future-Proofed advises lawmakers to examine the current legal framework that is being challenged due to the emergence of novel aircraft systems. Laws that focus too heavily on the current state of the art may be rendered ineffective by technology developments.

RECOMMENDATION 5

Delegation of Enforcement Authority Should Be Examined proposes the need for delegation of enforcement authority due to the number of new entrants into the NAS, especially with small UAS and Part 107 operations.

RECOMMENDATION 6

Recruit Staff with AAM Experience/Education suggests that state aviation divisions be provided with some form of incentives to add new staff with the appropriate vertical flight and vertiport background and to provide training specific to these tasks and needs. Federal funding for state officials' education may be a necessary option because of the unique challenges presented by the new AAM technology.

Of special note is the need to assure that future AAM assets enter a system where their full operational and business potential can be realized, while maintaining the excellent safety record of today's system. Such issues as universal on-vehicle detect-and-avoid systems versus partitioned airspace and alternative systems are discussed.

The Chairs of the Certification Task Force and all our contributors wish to express our gratitude to AIAA for the opportunity to contribute to the next dynamic and exciting phase in the evolution of aviation. It is our fervent desire that this report and the efforts of our committee members contribute to the continuation of the safest and most efficient system of transportation in history. There is much work yet to be done and we have no doubt that the next several years will present many challenges. We stand ready to face those challenges.

And to all who contributed to this report, thank you.

Nick Lappos
Task Force Co-Chair

Mike Borfitz
Task Force Co-Chair

Herb Schlickenmaier
Subcommittee Chair, Novel Technology

James Grimsley
Subcommittee Chair, Legal and Policy Implications

Rex Alexander
Subcommittee Chair, Infrastructure Gap Analysis

SECTION 1

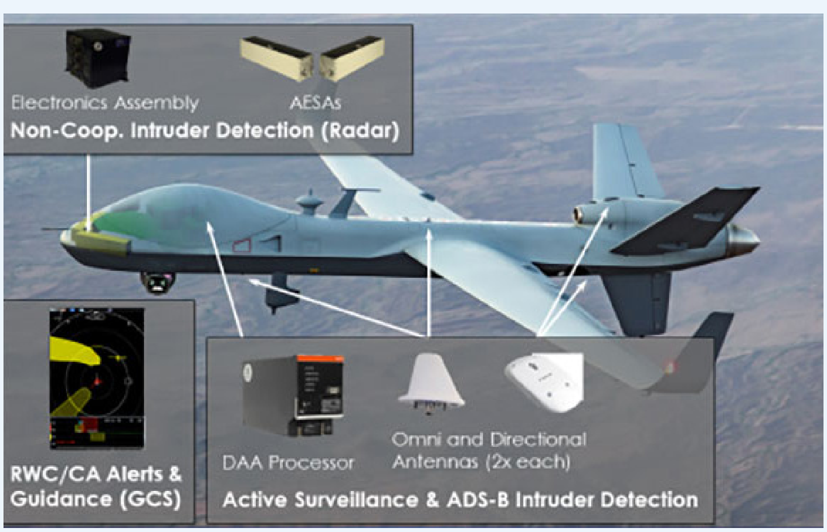
Air Traffic Management for the AAM World

The current FAA policy it to adapt AAM with little interference to current operations.

Wisely, the FAA has established a crawl, walk, run philosophy with regard to the changes in the air traffic management (ATM) system as advanced airmobile aircraft are introduced. Today's system is the safest on the planet, and adapts itself to the business needs and operational requirements of the air vehicles currently in service. For this reason, large changes to the ATM system should take place only as the business requirements grow and the need arises. As advanced airmobile vehicles are put to use, air traffic density will rise in urban areas, and with that rising density the need for major changes to the air traffic management system will occur.

The current FAA proposed policy of detect-and-avoid tasks being pushed down to each of the air vehicles in the system creates an economic burden on each of the vehicles because of the sensor and processing needs to comply with the detection task adequately. If detect and avoid were imposed as a policy for all future vehicles, there would be an economic threshold below which many vehicles could not be sustained. It is difficult to imagine a future advanced airmobile vehicle that carries small packages and letters that could afford a multi-thousand dollar detect-and-avoid system. The Task Force believes that future air traffic management could become a networked task, in which the position, identification, and intentions of each vehicle are sent into a network that partitions the traffic flow and controls the safety and efficiency of the operations. A small device that reports position, identification, and intentions may be far less expensive than a fully capable detect-and-avoid system. The economic burden on the entire air traffic management system would therefore be far less than having a multi-thousand dollar detect-and-avoid system on every air vehicle.

One of the essential ingredients for the development of the future system is to have each of the stakeholders express their requirements before designing the system to meet those requirements.

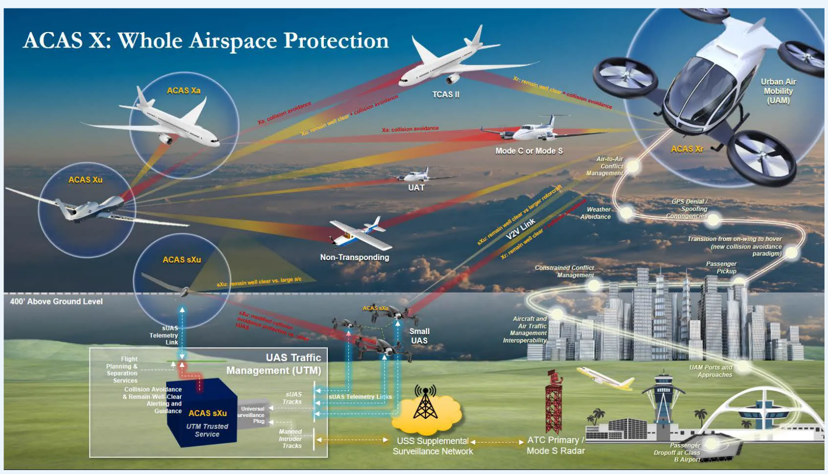


Typical DAA Installation

source: https://www.ga-asi.com/detect-and-avoid-system

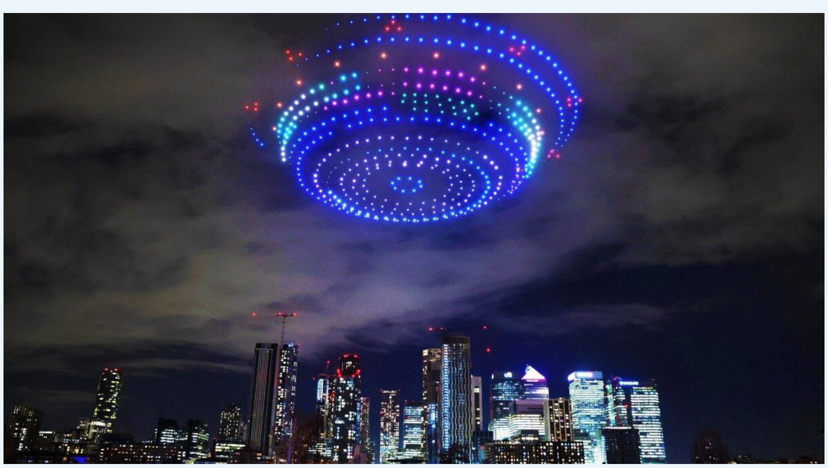
The Task Force urges AIAA to facilitate a working group of the FAA, NASA, OEMs, and commercial companies to discuss and create the requirements for the true future ATM system.

We recognize that today's concepts of partitioned airspace, with permanent allocations and restrictions, may not be applicable in the future. It is quite probable that the airspace above populated neighborhoods and businesses needs to be addressable by the advanced airmobile vehicles, even though that airspace is typically restricted to fixed airline traffic. It is quite possible that the future ATM system would operate as a networked, time-shared system so that access to the neighborhoods is authorized several times during the working day and does not interfere with commercial air transport. We can also recognize that such a networked system, where each vehicle (no matter its size) provides position, identification and intentions could serve as a see-and-avoid system, without burdening each vehicle with a electro-optical detection system.



Example of Drone Networked Control

Courtesy of CAL Analytic: https://www.calanalytics.com/ohio-company-demonstrates-detect-and-avoid-capability-for-drones



Credit: Joe Pepler/PinPep
Copyright: PinPep

The Task Force recognizes that these network concepts will require newly developed ATM systems. Considering the typical development times, there is an immediate need for draft operational standards and development of the prototype hardware to begin on these future systems. We believe the proposed working group also should include standards organizations such as the Radio Technical Commission for Aeronautics (RTCA) to help achieve accurate avionic and operational definitions. The Task Force thinks that the technologies for this future network system already exist so there will not be a technology development task, but rather a task of defining the requirements and having avionics companies develop the products to fulfill them. As an index of how doable this network ATM system could be, we recognize that package delivery systems like FedEx handle 20 million packages a day during the weeks before Christmas and can find the position of each of the packages in their system within a few meters at any time during the day. Similarly, we can see drone shows that employ thousands of drones flying in concert to create three-dimensional shapes, using networked positional reference for each drone.

It would not be hard to imagine that such a drone show could be today's surrogate for tomorrow's ATM system around a major urban area.

The current ATM system works well and has an exemplary record of safety and efficiency for today's aircraft. The future incorporation of advanced airmobile vehicles might increase the air traffic congestion in most urban areas by a factor of 5 to 10, which implies that today's system could not handle the vast load and separation problems of such congestion. The FAA has declared that all future air vehicles shall be individually capable of detect and avoid so that they provide their own air traffic separation. A study of the detect-and-avoid systems that might be available shows that they would have complex visual and radar sensors as well as onboard processing and artificial intelligent software to allow the vehicle to avoid all other vehicles. In a future world, advanced airmobile aircraft might be the type that carry small packages and letters, cost perhaps several thousand dollars, and weigh between 10 to 20 kg. As previously mentioned, these vehicles might find the economic burden of detect and avoid systems onerous. It is very likely that requiring detect-and-avoid tasking for each air vehicle would eliminate many of the advanced airmobile aircraft that are envisioned for a future business system.

The Task Force has studied the issue and believes that a future adoption of a networked air traffic system would be more efficient than detect and avoid, significantly reduce the economic burden for the air vehicles, provide automatic oversight, and ultimately prove to be a far more efficient system of cooperation.

The promise of future advanced traffic management concepts is enormous, but we have a complex and mature air traffic system that services millions of customers each day that must not be disrupted on the possible promise of future growth. For this reason, the FAA has created a niche for advanced airmobile aircraft that will foster the growth of their commercial uses while creating little disruption on today's air transport and air taxi world.

Long-term studies project an enormous increase in the number of air vehicles in the United States. Today we have perhaps 10,000 airline transport aircraft, and it is possible that the future will have that approximate number of AAM aircraft in each major metropolitan city.

The Task Force recommends formation of a joint operating Task Force of stakeholders to help lay out and possibly implement the longer-term future with minimum disruption on today's activities.

A Government Accounting Office report[1] (GAO 23-105189, Recommendations section) recommends that the FAA "…develop a comprehensive strategy to integrate drones into the national airspace."

It describes how future drone activities will require careful FAA planning, and that commercial needs will not be met by today's compromise system. For example, if we simply took the area at the bottom of each ILS (instrument landing systems) corridor in the urban areas of the United States and restricted drone operations in those corridors, we would inhibit major sources of commercial activity. A very good Wendover Productions video[2] of drone activity presents the illustration below, which shows the potentially denied regions in Phoenix, Arizona, as an example of the need to rethink air traffic management in the future.

One extremely important challenge that must be resolved is the FAA's requirement to have detect-and-avoid responsibility pushed down to each air vehicle in the air traffic system. This requirement would mean that each air vehicle must carry the necessary avionics systems to compute and calculate routes around conflicting traffic. Even the FAA estimates project that these systems will probably cost tens of thousands of dollars, meaning even the smallest and cheapest AAM machine would cost tens of thousands of dollars. To be cost-effective, the missions it flies would have to return significant value and small packages, emergency medical equipment, prescription drugs, meal delivery, and many other AAM uses might be frozen out of the market if they don't generate enough income.

City of Phoenix with Airport Airspace Restrictions Superimposed to Illustrate Potentially Denied Urban Neighborhoods

Source: https://www.youtube.com/watch?v=J-M98KLgaUU

The Task Force believes that future ATM tasks might be handled by a networked solution for all air vehicles – a system where each vehicle reports into a network with position, identification, and intentions and receives flight guidance instructions from the network. This automated system could look like the systems used in many businesses in the United States to handle production assets, airline luggage, and so on. There is no doubt that a network solution is technically viable, the real issue is whether it could be produced in time to be of use for this future ATM system. The development of this networked system could become a business opportunity with a worldwide market potential for U.S. avionics manufacturers.

It is important to have a joint meeting of the stakeholders for the system, chaired perhaps by an independent technical authority like AIAA with direct participation by the FAA, NASA, drone OEMs, avionics OEMs, and the commercial companies that will put the drones to use. The proposed future air traffic system also could satisfy the GAO recommendation that the commercial and technical requirements

[1] https://www.gao.gov/products/gao-23-105189
[2] https://www.youtube.com/watch?v=J-M98KLgaUU

for the use of the system be addressed in the development of that future system. We must also note that this joint Task Force was recommended by the National Academy of Engineering's report on future airmobile operations (Advancing Air Mobility a National Blueprint, National Academies Press, ISBN 978-0-309-67026-5)

ATM RECOMMENDATION 1

AIAA facilitates a joint working group of national stakeholders to help lay out the longer-term future ATM integration plan with minimum disruption on today's activities. Participants should include the FAA, NASA, drone and avionics OEMs, package delivery commercial companies, and the RTCA.

ATM RECOMMENDATION 2

AIAA helps facilitate a joint working group to define the technical requirements for a networked ATM system to include the airborne packages that all participants will carry, as well as the ground reception and processing requirements to facilitate this operational system. Members of this working group might include Silicon Valley programming powerhouses like Microsoft and Cisco Systems, and existing network providers like cell phone and microwave system operators.

Prepared by
Nick Lappos, Task Force Co-Chair

SECTION 2
How Can Novel Technology Survive in a Proscriptive Regulatory Environment?

Novel technologies are the antithesis of a proscriptive certification environment. After all, rules are meant to be met, not changed. While regulatory authorities have methods for accommodating novel technologies (the FAA's Title 14 Code of Federal Regulations, Part 21, in particular, and EASA's alternative means of compliance [AltMoC]) come to mind.

However, the approach to certifying novel technologies is typically used to address a novel technology subsystem within a well-established aircraft or engine system. Consider the case of fully automatic, digital engine controls, also known as FADEC. This novel piece of technology allows an aircraft engine to maintain very tight inner-loop control of an aircraft turbine engine and ensures much-improved engine performance and higher efficiency of the engine during all phases of flight. Certifying the FADEC was accomplished through rigorous technical reviews of the engine control system, all under the auspices of the FAA's Part 33, Aircraft Engines, with a detailed assessment of the control system performance and safety.

The overall engine certification was unchanged by and large, with associated certification under the FAA's Parts 23, 25, 27, and 29 associated with powerplants, displays, and warning systems, depending on the associated airplane or rotorcraft intended for the engine.

Now consider the case of electric engines. There are no certification criteria for electric engines. Questions of electric engines' design, performance, durability, endurance, and maintenance are nowhere in the FAA's or EASA's regulatory repository. One can suggest that the airworthiness regulations for electric engines should be expected to be found in the FAA's Part 33 and EASA's CS-E, but they do not yet exist there. The FAA has documented Special Conditions for magniX in 2022, and Beta in 2024 for electric engine type certifications. EASA published its Final Special Condition SC E-19 - Electric / Hybrid Propulsion System. And for Joby, Archer, and others, the FAA has issued Special Conditions with the electric engine criteria set as "Subpart H" of each of their airplane type certificate special conditions. In essence, the onus is on each novel technologist to write their own certification process for their novel technology, in this case electric engines, for their regulatory authority. While this protects the novel technologists' intellectual property, it also challenges the regulator to identify areas of common, foundational certification criteria.

In 2011, the FAA established a Part 23 Reorganization Aviation Rulemaking Committee (ARC). Its purpose was for "...increasing the safety of small general aviation airplanes certificated to 14 CFR part 23,"9 Document sub-title) and its final report was published in 2013.[3] The report recommended to "...reorganize part 23 to maintain performance based safety requirements in part 23 complemented by acceptable consensus standards which provide more detailed means of compliance. ... [and recommended] changes to production, alterations and continued airworthiness regulations, orders, and policies to support [the ARC] goal of twice the safety at half the cost." (page iii) This update to 14 CFR Part 23 falls under Amendment 64, which adopts all the recommendations from the ARC. A key element of the ARC was the adoption of ASTM International to create and maintain consensus standards as Airworthiness Design Standards (ADS) for Part 23.

FROM THE ARC REPORT:

"The ARC accepted that one set of consensus standards would be created and maintained by ASTM International and would follow their processes for standards development that would satisfy the FAA. Their consensus standards process ensures the standards are agreed to by a balanced group of representatives from the regulators, industry, operators, and others."

The report recommended initializing the ADS with Amendment 62 to Part 23 as the basis for detailed design specifications and means of compliance. Other methods were offered, such as the Issue Paper process, noting its longer time to develop and approve but offering a means to retain intellectual propriety. The primary goal of using the ASTM was to make all consensus standards internationally accepted so that any civil aviation authority could accept them as a means of compliance. Accordingly, standards development organizations (SDO) have come forward to act as a common ground to develop standards that can be used as certification criteria based on the experience of a performance-based regulatory (PBR) approach in Part 23 and attempting to apply it to other more proscriptive regulatory structures, such as Part 33, Aircraft Engines, and someday, to Parts 25, Transport Category Airplanes, and 27 and 29 for rotorcraft.

The challenge is wrestling with the traditional role of SDOs, where the standards were based on data collected from existing industry and some government projects and products to allow harmonization to improve safety or economics. Under this new PBR framework, standards are being developed prior to initial product introductions to support innovation, not harmonization. The difference is illustrated in Figure 1, which was presented at the SAE-INCOSE-NASA-sponsored Energy & Mobility: Technology, Systems, and Value Chain Conference and Expo, during the HV Aerospace Systems Workshop on Friday, 15 September, by Andrew Telesca of magniX. His point was to underscore the need for data from flight demonstrations to underpin the standards being developed.

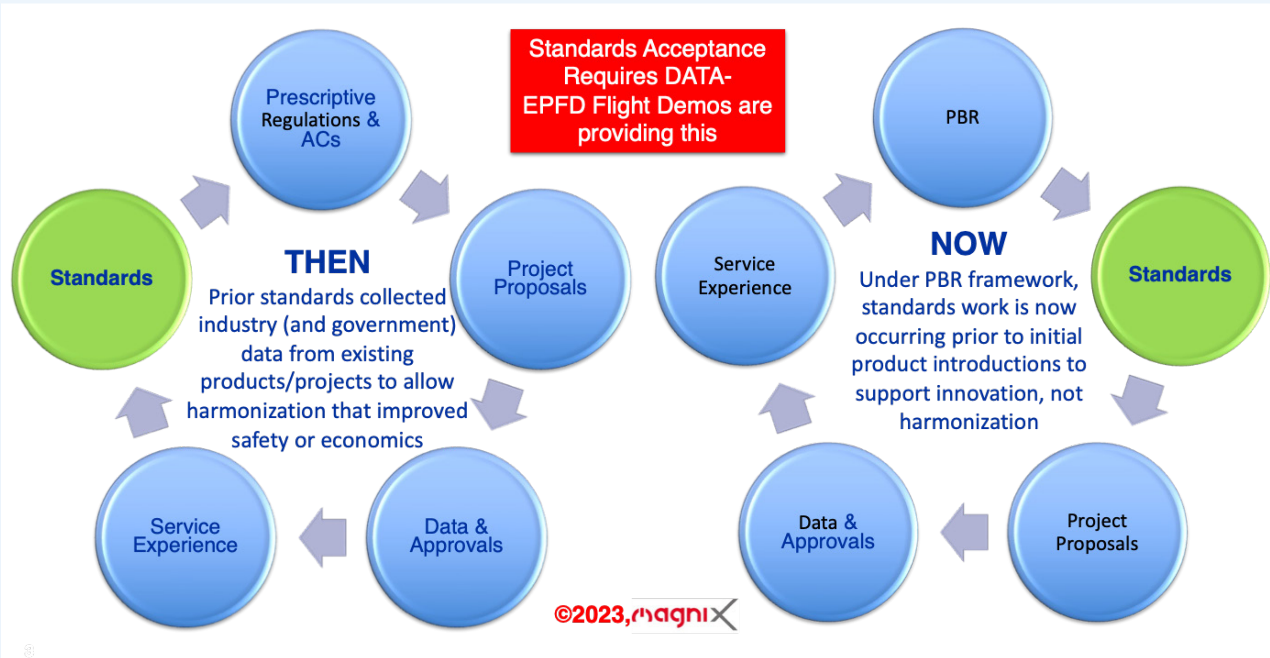
The PBR environment is the answer to the question posed in this section. Until that time when Title 14 regulations are rewritten, there seems to be a sensible approach that the PBR has established, and that is the use of SDOs to build

[3] "Advisory and Rulemaking Committees Part 23 Reorganization ARC Complete File," Task with Related Documents, August 15, 2011 (https://www.faa.gov/regulations_policies/rulemaking/committees/documents/index.cfm/document/information/documentID/668)

ADS and MOCs that regulatory bodies can rely on for these novel technologies.

The challenge is generating the data that can be confidently proposed by the SDOs that shows that the standards can be relied upon for the intended function of the novel technology. That data and expertise must be sought with as much confidence and rigor.

FIGURE 1
The Importance of Data for Today's Standards



Courtesy of Andrew Telesca of MagniX

OTHER CONSIDERATIONS

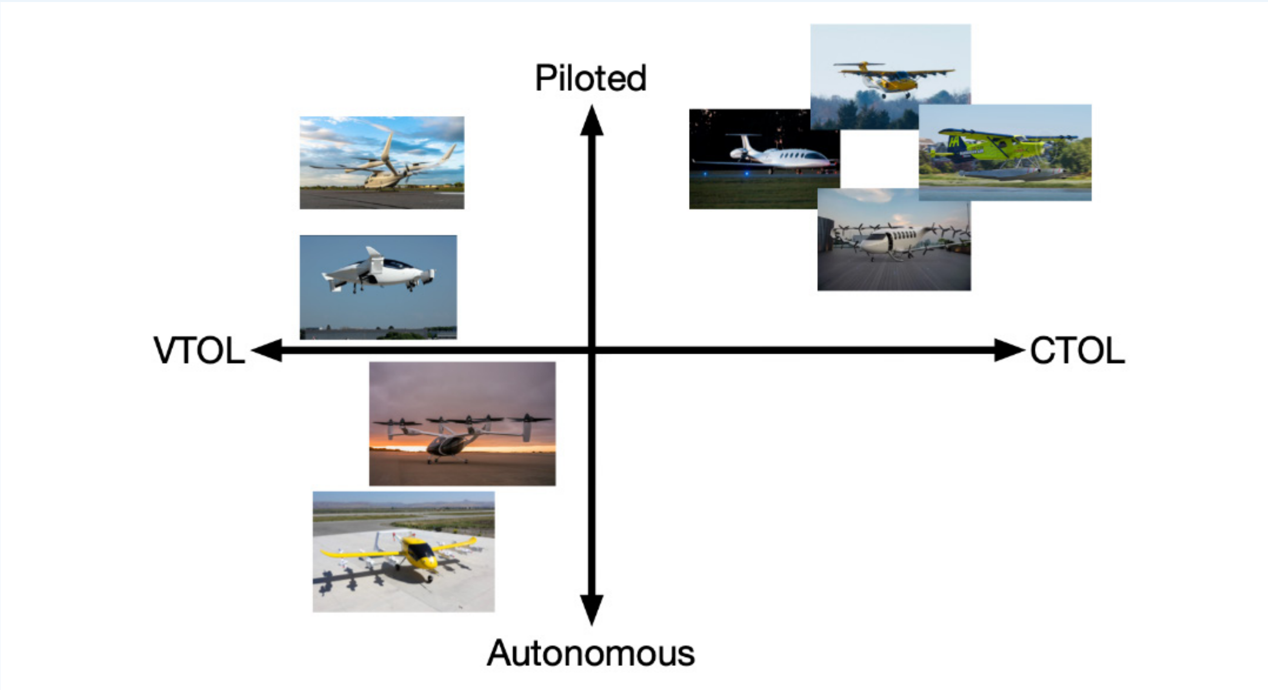
Beyond the aircraft and engine type certification process, novel technologies will need to address new operational modes of the novel technologies, the integration of the novel vehicles into the air traffic system to operate with other vehicles, and the need for infrastructure to support the continued operation of the novel vehicles.

The operational modes of some novel vehicles are very different from traditional single- and multi-engine airplanes and rotorcraft. Figure 2 shows the kinds of novel vehicles currently in flight demonstration with their regulatory authorities to receive type certification. The operations range from piloted to autonomous and from conventional to vertical takeoff and landing. Each of these operations requires expert certification for which there is limited expertise outside of piloted conventional takeoff and landing. While some of the vehicles have vertical takeoff and landing operations, they are distinctly different from rotorcraft in their design and intended operation.

The flight characteristics of these novel vehicles are different from traditional aircraft, and this will require consideration for the entry into the airspace system, where current air traffic operations are based on legacy aircraft designs and thus operating characteristics.

Finally, the infrastructure to support these novel aircraft will need to be supported similarly to how fueled aircraft and rotorcraft are supported today. However, the infrastructure to support legacy aircraft and their operations have existed for decades. The approach to design, develop, and maintain the infrastructure has been established. The novel aircraft will need to build new designs and maintenance for their infrastructure.

FIGURE 1
The Variety of Operations for Novel Vehicles



NOVEL VEHICLE CERTIFICATION NEEDS OF AIAA

AIAA has a unique opportunity to support the development of standards for these novel aircraft. Currently, the AIAA Technical Committees (TCs) have committed volunteers supporting the development of new vehicle concepts. Sharing technical insights that benefit the SDOs would be invaluable. In the Electrified Aircraft Technology Technical Committee, for example, the Liaison Subcommittee has taken on the challenge of hosting panels that bring leaders from the SDOs together to share their needs and opportunities with the technical community at the AIAA AVIATION Forum and during the Electric Aircraft Technologies Symposium. Other technical committees, such as Flight Test, General Aviation, and Transformational Flight, have also sponsored panels and technical sessions that highlight these novel vehicles. Building a concerted effort from the TC community would provide an invaluable resource to SDOs in desperate need of taking on their new role of standards development prior to initial product introductions to support innovation.

Prepared by
Herb Schlickenmaier,
HS Advanced Concepts LLC

SECTION 3

Proposed Curriculum for Start-up Certification Tutorial Teams

This is a proposed tool for the initiation and management of AAM Certification Tutorial Teams (CTT) that is presented as a starting point for a robust conversation among the members of the AIAA community with the hope that we will develop a process that the AAM industry will find useful as they enter the complex world of FAA type and production certification.

Many AAM start-up companies don't have depth of experience in FAA aircraft certification processes and procedures. The addition of new technology such as powered lift, energy density, and autonomous or remotely piloted flight contribute to the complexity of the type certification process, even for seasoned practitioners. Certification requirements are found in 14 CFR Part 21 Subpart B type certificates[4] (TC). The type certification process is iterative and frequently nonlinear; it can be painfully slow even when the applicant is deeply experienced and enjoys a healthy relationship with the FAA[5].

The AAM Appendix, "Proposed Elements for CTT Handbook" at the end of Section 3 outlines the core elements of the TC process for start-up companies. Please note, although this proposed handbook refers only to the FAA, nearly all international aviation regulatory structures are harmonized, that is, most authorities adopt the FAA or European Union Aviation Safety Agency (EASA) regulations and processes, which are very similar.

There are "sharks" who will drain uninformed start-ups of their resources, raising the risk that great designs may never reach the market. The certification process has many subtleties, twists, turns, and blind alleys that can make it relatively easy for a person to appear knowledgeable. A start-up must be very, very careful, and AIAA should be cautious if asked to recommend persons or organizations who might help. The FAA cannot help because they must not participate in private business efforts. The best and safest approach is to use FAA designees and examine the track record of any candidate person or organization.

Here, FAA is primarily intended to mean aircraft certification engineers and inspectors, who are engaged respectively in type certification and production. The FAA Flight Standards Aircraft Evaluation Division (AFS-AED) participates in certification projects to determine operational suitability from the perspective of fleet operations, training, and maintenance, which helps to assure rapid entry into service. Production certification (PC) is not addressed in depth in this proposed handbook, although it is no less critical than type certification. Continued operational safety is the first priority of all FAA organizations.

Operational considerations such as §135 *"Commuter and on Demand Operations and Rules Governing Persons on Board Such Aircraft,"* §137 *"Agricultural Aircraft Operations,"* passenger vs non-passenger (cargo, deliveries, etc.) must be dealt with strategically in the early design phases. Flight standards (AFS) and their international counterparts "…promotes safe air transportation by setting the standards for certification and oversight of airmen, air operators, air agencies, and designees. We also promote safety of flight of civil aircraft and air commerce…"

[4] https://www.ecfr.gov/current/title-14/chapter-I/subchapter-C/part-21/subpart-B?toc=1
[5] https://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afx

The definition of intended operations may vary, but for this purpose may be considered OpSpecs, which is basically a contract between AFS and the carrier. It grants permission for the carrier to operate and imparts the authorizations for several elements of the operation. "A 14 CFR 135 certificate holder has further options depending on the scope of the operations that they wish to conduct. The scope of operations is authorized by the FAA thru the issuance of Operations Specifications (OpSpecs)."[6]

Ultimately, most AAM aircraft will be autonomous and operating beyond visual line of sight (BVLOS). Flight standards will have oversight of the operations, maintenance, training, etc., but air traffic[7] is accountable for ensuring safe flight in the National Airspace System (NAS[8]). Flight standards will oversee individual operators within their accountable regions, but air traffic issues must certainly be addressed at the national level, industry and FAA working together.

ACTIONS, TOOLS, & ADVICE

- **Build a certification handbook that focuses on the notion that many start-ups lack certification experience.** The handbook will address not just the type certification process but production certification and at a minimum introduce the start-ups to the broader regulatory world in areas such as production, international validation, fleet management, and continued operational safety (COS) requirements. We must help them understand and embrace the fact that positive relationships with the FAA are based on performance and knowledge that few possess, and AIAA can offer support, insight, and assistance.
- **From that handbook, develop a standardized presentation** for CTT members to deliver to potential start-ups, perhaps a 1-hour briefing that can be presented online, and longer versions for 1–3-day presentations.
- **The AIAA tool might be a document that walks the start-up through the certification process**, especially with regard to developing a functional and trusting relationship with the FAA. Perform, never make a promise you can't uphold, demonstrate integrity, meaning do not be afraid to tell on yourself, but always identify and correct problems.
- **Conduct a CTT briefing, then introduce an individual as their CTT guide**, a principal contact to walk the applicant through the process. Some sort of time limits on the guide's engagement will be helpful, guides can be very busy. AIAA may consider setting a time limit on unpaid guide assistance. Maybe weekly 1–2-hour calls for a short time, until the start-up finds a certification professional.
- **Encourage reaching out to a management DER, ODA**, or an experienced specialist who has a proven certification process background.
- **The CTT must emphasize that start-ups should not be discouraged** if they need to go back to the FAA a few times, even if they have certification experts, which is strongly recommended. What's critical is to demonstrate forward progress based on understanding and acting on FAA inputs in those go-backs.
- **Create a means of getting the AIAA word out**, reaching those who have the need, and maybe partner with the Association for Uncrewed Vehicle Systems International (AUVSI). A webpage or some online manner of promoting services and providing related information could be used.
- **Subtly woven into the CTT mentoring process, airworthiness is critical**, and has two parts. 14 CFR Part 3.5(a) "Definitions" declares "Airworthy means (1) the aircraft conforms to its type design and (2) is in a condition for safe operation." *[parentheses added]*

[6] https://www.faa.gov/licenses_certificates/airline_certification/135_certification/general_info
[7] https://www.faa.gov/air_traffic
[8] https://www.faa.gov/air_traffic/nas

- Conformity is black and white, "it is or it ain't", meaning the design data and the manufactured product are a perfect match.
- Then, "...condition for safe operation." is a judgement call, the word "and" in the definition is taken very seriously by the FAA. Airworthiness applies to everything we do and everything we touch in the TC, PC, operational and maintenance worlds, and throughout the operational life of any product, part or appliance that functions in our regulatory system.

The heart of the certification process resides principally in these three documents. They provide clear instructions that facilitate compliance with 14 CFR Part 21:

14 CFR Part 21 *"Certification Procedures for Products and Articles"*

This is the regulation that is the map to type and production as well as various other types of certification such as technical orders (TSO), parts manufacturer approvals (PMA), issuance of airworthiness certificates, and perhaps most critically, TC holders requirement to report potential unsafe conditions, typically referred to as continued operational safety (COS).

FAA Order 8110.4C *"Type Certification"*

An FAA order within aircraft certification sets policy and directs the activities of aviation safety inspectors and engineers. It is the principal document used throughout industry for project management.

***"The FAA and Industry Guide to Product Certification,"* 3rd edition**

This document has been negotiated between the aviation industry and the FAA and "...encourages the broader and more consistent use of the principles and expected operating norms for efficient design approval processes consisting of TC, STC, TSOA, and Parts Manufacturer Approval (PMA)."

And yes, these documents are referenced elsewhere in this proposed handbook because they are important.

These two statements are critical to start-ups who are about to engage with the FAA to begin their type and production certification programs.

The type certification process is unchanged throughout all projects and types of aircraft products and parts, including modifications. There is no avoiding it.

The certification process has a history of flexibility that enables and accommodates revolutionary change. The FAA will not stifle innovation.

Those may seem to be conflicting statements, but another way of looking at it might be to examine the flexible nature of the process first. This begins with §21.17(b), which allows the FAA to use whatever regulations are necessary to achieve a level of safety that is acceptable, or equivalent to aircraft that operate in a similar way. The typical AAM is unique and must be dealt with appropriately. The FAA has the discretion to determine an acceptable level of safety based on the aircraft design, reliability, intended operations, and many other factors. A small UAV may not present a threat to the general public and may be used in the city environment for delivery of small parcels. A large two-seat piloted eVTOL may be certificated as just another aircraft with special considerations for powered lift and all electric propulsion. Take the pilot out of the equation, however, and the system safety analysis for the unpiloted model will become more critical by an order of magnitude or more. Software, emergency procedures, navigating through traffic, and many other critical considerations instantly arise.

It is possible, even likely, that AAM system safety analyses (SSA) will be required to include the effect of major failure modes on intended concept of operations (ConOps), as opposed to being limited only to a single machine and its systems. We must be mindful of the fact that the regulatory system has spent the last century working on the assumption that an onboard pilot is baked in to the system. It's not just a mechanical or software issue, we're dealing with deep cultural realities in both regulatory and private sectors.

The future vision of the AAM industry foresees hundreds, even thousands of these new machines in the air over densely populated areas at any given moment, a situation the FAA regulatory and air traffic systems have never envisioned. At the time of this writing, efficient and cost-effective airspace management is yet to be determined. That is an immediate challenge as more designs are reaching maturity and are beginning to reach the final stages of type certification.

Similarly, cybersecurity poses an industry-wide challenge not just to individual aircraft, but to large numbers of aircraft that may be in the air in a given space.

The FAA TC process is inherently flexible and may be tailored to any specific project by selecting regulations that apply to a design and eliminating those regulations that have no bearing on safe operation or simply don't apply. For example, an all-electric UAS delivering food will not be required to address cabin safety or fuel system requirements.

The FAA and its predecessors span nearly a century,[9] and the regulations that have been built over that time are intended to address the safety requirements of classic aircraft – airplanes, helicopters, balloons, and so on. The regulatory structure has evolved as necessary to accommodate technological shifts, and this is no different.

These new AAM aircraft are novel in every way, and even though the current regulations fail to address the specific technology and modes of operation, there will be a way to certificate every UAV that is presented to the FAA if the applicant has the time, resources, and regulatory knowledge to navigate through the process. §21.17(b) is the single regulation that the FAA has determined to be the entry through which all unique AAM efforts will pass.

§21.17 Designation of applicable regulations.[10]

"(b) For special classes of aircraft, including the engines and propellers installed thereon (e.g., gliders, airships, and other nonconventional aircraft), for which airworthiness standards have not been issued under this subchapter, the applicable requirements will be the portions of those other airworthiness requirements contained in Parts 23, 25, 27, 29, 31, 33, and 35 **found by the FAA to be appropriate for the aircraft and applicable to a specific type design, or such airworthiness criteria as the FAA may find provide an equivalent level of safety to those parts."** *[emphasis added]*

THE TASK FORCE PROPOSES:

- Publication of a "Type Certification Handbook for AAM Designs."
- Forming Certification Tutorial Teams (CTT) to help start-ups understand the type and production certification processes.
- Volunteer to act as a CCT guide, or mentor, to provide assistance as needed.

Prepared by
Mike Borfitz, Task Force Co-Chair;
CEO, Kilroy Aviation LLC

[9] https://www.faa.gov/about/history/brief_history
[10] https://www.ecfr.gov/current/title-14/chapter-I/subchapter-C/part-21/subpart-B/section-21.17

Proposed Elements for CTT Handbook

1. Introduction

- ☐ Introduce AIAA Certification Tutorial Teams (CTT), who, what, why, etc.
- ☐ How AIAA can help a start-up. Coordinating review and mentoring panels who will help a start-up understand the FAA and their expectations
- ☐ Explain why help is needed
- ☐ Describe CTT role and what the start-up (applicant) will walk away with
- ☐ NOTE: These CTT's must avoid setting the expectation that the first approach to the FAA will satisfy all FAA needs. It is normal and expected that the first run will generate feedback, even rejection of the applicant's proposal. Start-ups should be encouraged to employ a Management DER and/or an ODA. **See Section 3.**

2. Tutorial: What to Expect from the FAA

- ☐ Who has accountability and why, TC vs PC differences
- ☐ The FAA will not help with designs, the applicant is ultimately accountable, not the FAA
- ☐ Process and options, every step leads to more options
- ☐ Very few FAA resources, type certification is a low priority behind COS vs rules and policy. Delegation is the norm, and start-ups should prepare to pay designees for assistance.
- ☐ The certification process is iterative and can be painfully slow.

3. Assistance: Find a Person or Organization Who Is Familiar with the FAA

- ☐ AIAA is neutral but will have a list of potential candidates
- ☐ A person with a proven history of success in certification
- ☐ Designated engineering representative (DER)
- ☐ Management DER: an individual who is trusted by the FAA to act as project manager. There are only ~80 in the DER directory
- ☐ Organization designation authorization (ODA) a delegated organization with designees in multiple disciplines in engineering and inspection
- ☐ Beware: Ensure whoever is selected has a proven track record. All too many people will be happy to take the money and run.

4. Get Started with the FAA

- ☐ See 14 CFR Part 21, Subpart B - Type Certificates
- ☐ Certification basis. Part §21.17(b) is likely because it's the "MacGyver" of regulations.
- ☐ G-1 Issue Paper documents the certification basis, OK to propose G-1, offer something the FAA can sink their teeth into
- ☐ Issue papers for unique design and operational aspects
- ☐ Special conditions, exemptions, equivalent level of safety (ELOS) per §21.21(b)(1)
- ☐ Develop test plans: #1 applicant tests required per 21.33(b), #2 FAA Cert tests "for score"

5. Tutorial: What the FAA Expects from You (Bring us another rock?)

- ☐ Concept of Operation (ConOps)
- ☐ At pre-application familiarization meeting OR presentation of TC application per §21.15: A certification plan and schedule, relatively complete aircraft description (3 view minimum), high-level compliance checklist
- ☐ Maybe two iterations of submittal for FAA feedback maximum before they put applicant on the back shelf, expertise matters
- ☐ Consider finding experienced help, technical or management DERs and DARs
- ☐ FAA Priority #1 Continued Operational Safety (COS): A prime responsibility of a TC holder is to manage their fleet and, when required, report safety-related service issues §21.3 *"Reporting of failures, malfunctions, and defects."*

6. The AAM Certification Process as It Applies to Different AAMs

- ☐ Rubber meets the road, two very different sets of FAA requirements
- ☐ <55 lbs Durability & reliability (D&R) fly it off per FAA CPP-DR-1.1 and CPP-DR-2.1
- ☐ >55 lbs 14 CFR 21.17(b) special class, develop/negotiate cert basis with FAA, much more rigorous

7. Type Certification; Moving Forward

- ☐ Aircraft certification (AIR) owns TC, PC and COS
- ☐ 14 CFR Part 21.17(b) for "…special classes of aircraft…"
- ☐ Issue papers
- ☐ System description
- ☐ System safety assessment (SSA)
- ☐ Client/mission requirements or types of use (Drives the ConOps)
- ☐ Consider BVLOS from Day 1
- ☐ One operator, multiple aircraft
- ☐ Very different roles for flight standards (AFS) and air traffic (ATO) especially BVLOS operations
- ☐ The importance of §21.3 *"Reporting of failures, malfunctions, and defects."* And why it must be a core element of a TC holder's culture

8. Production Certification (PC)

- ☐ Consider AS9100 accreditation as a good start
- ☐ Use Advisory Circular 21-43A
- ☐ A PC is primarily a process document that is FAA approved in Part 21 Subpart G "Production Certificates"
- ☐ The difference between a TC and a PC must be emphasized: In its simplest form, a TC is a "noun," it's a thing that can be put on a shelf or put into production, the FAA doesn't care until it's put into production. A PC, however, is a "verb," it's action-based because it's process oriented and the FAA must oversee those processes with surveillance and enforcement.

9. International TC Validation Is a Strategic Effort

- ☐ After starting with the FAA, start planning for EASA validation
- ☐ A TC from either the FAA or EASA will generally be accepted internationally, with some process requirements. There may or may not be a required visit to the validation authority, or the authority may wish to visit the TC holder

10.References & Links

A. Boilerplate documents:

- ConOps
- UFM (FAA has a boilerplate)
- UMM
- Training manual
- ICA
- MMEL
- Others as determined necessary

B. Type & Production Certification Documents

- FAA ACs, orders, position papers, etc.
- FAA Order 8100.4C type certification (An FAA order = You must)
- The FAA and Industry Guide to Product Certification, 3rd Edition, aka CPI III
- AC 21.43A Production Under 14 CFR Part 21 Subparts F, G, K, and O

C. Who can help

- AIAA should remain neutral, not manage a list of preferred providers, and point to public sources like the FAA DER Registry
- Caveat: Encourage AAM start-ups to double- and triple-check "specialists" backgrounds

SECTION 4

Legal and Policy Implications of Novel Aircraft Technology

INTRODUCTION

This working group was established to focus on the legal and policy implications for certification of novel aircraft technologies. Rapidly evolving technology opportunities (both unique to aviation and not unique to aviation) create potential challenges within our long-standing legal and policy environments.

In recent years there is a convergence of different technologies that have directly impacted the development and progress of novel aircraft technologies. The transition from an analog world to a digital world in aviation has accelerated in recent decades, especially in the last decade. In addition, direct drive electric propulsion continues to improve viability and feasibility and has the potential to significantly impact aircraft performance, safety, and reliability. A common factor evident in this convergence of different technologies is the steady move toward automation.

Technology based on artificial intelligence (AI) and machine learning (ML) have advanced rapidly in the past 40 years and continues to progress toward ubiquity in many domains. Developments in AI/ML have accelerated in the past decade due to significant increases in computational capability and capacity. New concepts such as generative AI have emerged that challenge our previous perceptions of AI/ML. Given the transition in aviation to automation, it is logical to believe that AI/ML will have an increasingly more significant impact on aviation in the future.

It is often stated that technology development tends to outpace the evolution of safety regulations. The rapid developments across the technology spectrum in aviation is creating significant pressure on the safety regulatory system to modernize and adjust to new operational situations that are increasingly complex in nature. In the context of AI/ML, there is an emerging area of potentially conflicting constraints for the aviation safety regulatory community. As has been demonstrated, AI/ML systems can surpass human performance when the AI/ML systems are properly designed and trained. AI/ML systems have the potential to self-train in working environments that can lead to systems that can improve in safety at a much faster pace than human-in-the-loop systems. Therefore, it can seem very enticing for technologists to promote the expansion of AI/ML in terms of the potential for safety improvements in systems. From the technologist's perspective, how can we argue against systems with the potential for rapid safety improvements, perhaps not possible without AI/ML?

However, these rapidly evolving technology opportunities create potential challenges within our long-standing legal and policy environments.

LEGAL IMPLICATIONS AND CONSIDERATIONS

The pursuit of aviation safety requires a multidisciplinary approach that touches on the technical, economic, managerial, and legal domains. The legal aspects of aviation safety are complex. From an international perspective, aviation safety often relies on harmonization of legal systems. Within the United States, the complexities of federalism and federal versus state jurisdictional authorities has evolved over the past century of powered flight. Generally, there are two categories of legal implications and considerations for aviation safety: 1) those legal implications and considerations that are not aviation specific; and 2) those legal implications and considerations that are unique to the aviation safety environment.

GENERAL LEGAL IMPLICATIONS AND CONSIDERATIONS (NOT UNIQUE TO AVIATION)

An overarching issue regarding legal concerns for novel aircraft technologies involves the different paths of evolution of tort law versus prescriptive laws that are enacted. In the absence of prescriptive laws, it can take considerable time before stability is reached in consistent tort law cases. There is always the risk of "patchwork quilt" situations between jurisdictions that can challenge the development of consistent safety frameworks. Likewise, the development and evolution of new technologies can be very complicated and there is too often an urge to enact early legislation to establish laws in response to the technology. All too often, these early laws are wrought with issues resulting from unintended consequences. If the early laws weigh heavily toward promotion of the technology, then important civil liberties concerns can be overlooked. Likewise, early laws intended to put safeguards on the technology can unnecessarily impede innovation and ultimately trade.

Intellectual property protection concerns and challenges can significantly impact aviation safety. An obvious legal concern involves design liability, in particular the chain of liability for complex systems that incorporate AI/ML. As can be imagined, a system that in theory has an ability to change itself can pose profound legal questions regarding chain of liability, since the success of an AI/ML-based system depends not only on the initial architecture, but also on the continued training/retraining of the system based on new data that becomes available. Improperly constructed/faulty training data sets (such as training corpora) could have profound implications of the AI/ML-based system performance and thus impact the liability chain.

There also can be civil liberties concerns involved in the acquisition of data for training. Issues such as the evolving "right to record" could have an impact on data availability for AI/ML systems based on the trajectory of the courts as the topic and associated legal questions are furthered examined.

Another concern with nascent technologies (and nascent companies) is long-term survivability and viability. There are immediate concerns such as parts replacement concerns, and also more complex issues such as the dissolution/liquidation/bankruptcy of suppliers that own intellectual property. In these situations, intellectual property can transition to owners that may not be equipped to provide ongoing sustained support for components, parts, and/or systems. For safety-critical products, this can have very disruptive impacts, which opens questions on the latitude of the courts to factor sustainment of safety systems into decisions regarding trustees, buyers, and owners of this type of intellectual property.

There are also complexities associated with the domains of physical hardware versus virtual technology. Certifying software systems, especially those incorporated AI/ML, can be particularly challenging.

Civil liberties concerns will always be an important consideration, especially if systems gather, store, and/or use large amounts of data. Public trust of the technologies may depend in large part on assurances that important civil liberties are protected. This is also a difficult area where lawmakers must carefully tread. Striking an optimal balance between fostering an environment for technology to flourish and protecting civil liberties can be especially difficult during the nascent stages of a technology (or industry).

If prescriptive laws are developed and adopted early in the development of the technologies, it is critical that these laws be "future-proofed." Laws that focus too heavily on the current state of the art can be rendered ineffective by technology developments, which poses a significant challenge to lawmakers.

GENERAL LEGAL IMPLICATIONS AND CONSIDERATIONS (UNIQUE TO AVIATION)

The existing complex legal framework for aviation in the United States has evolved over the past century. Some of it is now being challenged due to the emergence of novel aircraft systems that have the potential to operate in ways or areas that are usually not possible with legacy aviation systems.

Throughout the history of aviation, the evolution of the law has many times tracked the physical impacts of aviation as well as human physiological limitations of pilots and passengers. For example, aircraft noise has been a significant issue that has played out in the legal system that impacted the zoning authorities of states and siting of airports. However, some of the novel aircraft systems may have potential for dramatically reducing noise and acoustic emissions. Will the century of evaluation of aviation law be amenable to these new systems if the harms or nuisances disappear or diminish? Likewise, as human pilots move from the primary sensor in a system (i.e., human eyesight) and transition to modes of operation that approach autonomy, will there be increased trust in the systems that will be accommodated in the law? This could conceivably impact approach paths and traffic patterns if public confidence in the systems increases.

There are numerous artifacts in the law that may emerge with novel aircraft systems. An interesting example is the General Aviation Revitalization Act (GARA) of 1994 that became Public Law 103-298. For decades general aviation manufacturers had been plagued with very long-tail liability that ultimately led to closure and failure of domestic aircraft producers. Accidents involving 50-year-old aircraft too often resulted in significant damages being awarded in liability litigation that in effect made aircraft manufacturers perpetually liability for their products, even though many were produced before a lot of engineering best practices were in place. The GARA solved this issue by mandating a 20-year liability tail for any aircraft that carried less than 20 passengers. For most general aviation manufacturers this was a significant victory.

The FAA Modernization and Reform Act of 2012 added a new complication by defining all uncrewed aircraft (UA) to be aircraft. Uncrewed aircraft by definition carry zero passengers. When reconciled with the GARA, this meant that a 3-pound mostly plastic UAS (drone) sold to the public had a 20-year liability tail. In the small UA industry, development has accelerated to the point where small UA can be obsolete within 2 to 3 years of production. Could a 20-year liability tail for these systems be exploited in the courts? The challenged faced by the GA industry prior to 1994 may have been unintentionally transferred to the small UA industry.

Another challenge in aviation law has always been enforcement. Prior to ADS-B, it was difficult to prove altitude infractions, especially if only eyewitnesses were involved due to the inability of humans to accurately assess height and altitude outside of clear reference systems. There is an immediate assumption that systems such as ADS-B are used to discover infractions, which can undermine trust from the aviation industry. It may be necessary to reframe how safety-critical information is gathered, maintained/retained, and used where a return to basic Fourth Amendment principles might be advantageous. After all, if there are significant safety advantages to adopting and equipping an aircraft with new safety technologies, then should society place enforcement restrictions on this technology as a means to gain or retain trust from the public (and aviators)? In reality, these types of data issues are much broader than just aviation, but the implications for aviation can be unique in many ways.

POLICY IMPLICATIONS FOR NOVEL AIRCRAFT SYSTEMS

Just as novel aircraft systems pose unique challenges for our legal system, so do these systems pose unique challenges for policymakers. In the most general sense, public policy for technology can be viewed as a social contract with the public that defines the permissible uses and operations of technology. When powered flight emerged the public perceived aviation as inherently very risky. It took many decades before public trust has improved to a level where travel by aircraft moved to democratization, where the general public could and would utilize aviation in their daily lives. There are several areas where novel aircraft systems will either challenge existing policy or provoke new policies.

Delegation of Authorization

One of the unique possibilities associated with the evolution of novel aircraft systems involves the acceleration of product development cycles. Historically the FAA's processes for type certification and related approvals in many ways mirrored the length the of the manufacturers RDT&E cycles. However, novel aircraft systems – especially those that incorporate electric direct-drive propulsion – may experience rapidly accelerating development cycles that far outpace the ability of the regulatory system to provide efficient oversight. If there are tremendous financial and economic pressures that are brought into the overall balance, then that could have an impact on safety oversight where industry quickly overwhelms the resources/availability of public officials and regulators. This too often creates pressure to transition delegation of authorization to private and non-government/public actors, which carries a significant risk of safety oversight priorities being overtaken by economic pressures for expansion and profitability.

Obsolescence ("Future-Proofing")

Another policy challenge involves obsolescence and the inherent need to "future-proof" some systems to ensure sustained safety of operations. As we have seen with the small UA industry, there can be fewer barriers of entry that enables large pools of manufacturers to emerge. Competition and basic economics mean that many of these manufacturers won't survive and therefore ongoing safety support of systems is greatly diminished. Even rapid technology developments within a single manufacturer can create economic pressures to cease support/production of parts and subsystems. As an analog, in the early days of the automobile industry there were hundreds of automobile manufacturers in the United States. Many automobile owners were left with no ability to sustain or maintain their automobiles due to the lack of production of replacement parts.

Obsolescence can be very disruptive to the aviation safety culture, which in recent decades has stabilized in terms of the availability of replacement parts and ongoing maintenance. If we experience a rapid expansion of novel aircraft industries, this could be a significant issue especially in the formative years when the industry is not yet stabilized and settled.

Security

After the September 11th, 2001 terrorist attacks, there was a heightened focus on physical security for aviation. Securing cockpits became an immediate high priority and airport operations were directly impacted as well. We are now facing a new growing area of threats associated with cybersecurity.

For example, there are tremendous safety advantages and benefits as novel aviation systems become more connected and become part of larger networks. It is easy to envision a future where there may be a self-managing national airspace system. This reliance on communication technologies also introduces the risks of cyber-vulnerabilities. Although these risks and vulnerabilities are not necessarily unique to novel aircraft systems, the potential for serious negative outcomes can be more pronounced. The risks of a malicious actor taking control of a large number of novel aircraft systems to mount a formidable terrorist attack is extremely frightening.

Another consideration involves the increasing reliance on spectrum as the need for access to spectrum continues to grow rapidly. The safety and security of novel aircraft system operations will depend heavily on the ability to protect and efficiently manage spectrum. The need for spectrum access significantly grows each day. As the need for spectrum grows, it becomes a bigger challenge to ensure that adequate portions of spectrum are protected.

Social

As discussed earlier, the success of the aviation industry depends heavily on public trust. Public perceptions of risk can become hardwired very early in a nascent technology industry and can even prevent success and growth. The social factors involved are complex and involve notions such as the social amplification of risk perception. In a globally connected society, immediate impressions and reactions are amplified more intensely than any in history. In the most fundamental level, the issue with social acceptance and perception is one of social trust.

In this globally connected society, data can be taken out of context and opinions established without the discipline of critical thought. Factual data can be misstated or presented in ways where only a partial amount of the data is considered. This means that isolated safety issues can be rapidly overstated and magnified without any factual or realistic statistical underpinning or understanding.

Additionally, novel aircraft systems can become fault lines in public perceptions and debates of equity. If novel aircraft systems are seen early on as a toy for the rich and wealthy, this can impact public perception in negative ways that will be manifested in the political system. However, if there is democratization of the novel aircraft technologies, then significant markets can develop as demand grows, and public opposition can diminish. This places very weighty demands on the early producers and promoters of novel aircraft technology to ensure that public acceptance is not lost early, and that the public is enabled to make accurate judgments on safety, accessibility, and overall impact to society.

Economic

Legacy aviation has depended in large part on public and private economic investments. Municipalities that envision growth have made significant investments in airports in the past with the hope that this type of infrastructure will spur economic growth in their communities and improve overall quality of life as more mobility is available to their citizens.

However, in this era as novel aircraft technologies are emerging, the United States faces very significant global economic threats including competitive threats. As a result, domestic technology companies must compete with foreign companies that may have significant state economic investment and support.

Novel aircraft technologies will rely very heavily on a broader array of infrastructure build-out opportunities and availability. The ability to build and scale infrastructure will have a direct impact on the growth potential of industries involved in novel aircraft technologies. Cost recovery models for public-private-partnerships (P3) involved in infrastructure development may different than traditional aviation infrastructure cost models. The quintessential question of who pays for it will be a critical issue very early in the nascent stages of the novel aircraft technology industries.

There is also the potential for reliance on third-party providers of safety-critical data (where the data might be less objective) versus a reliance on objective government providers of data. This also could directly impact social acceptance and trust, as well as open up questions on civil liberties concerns involving the collection, use, and retention of safety data.

ROLES & RESPONSIBILITIES

It is unlikely that there will be an ability to scale dramatically federal safety enforcement personnel to meet the needs of a rapidly expanding novel aircraft technology industry. This has already been witnessed with the rapid growth of the small UAS industry, where the number of UA pilots (Part 107) has far exceeded the number of legacy (Part 61, etc.) pilots. Traditionally the authority for ensuring and enforcing aviation safety rules and regulations has been with the federal government. Public trust will drive the need for demonstrated enforcement, and limitations on the expansion of federal safety enforcement personnel may necessitate delegation of authority to state, local, tribal, and territorial governments that have historically not had the resources to manage this level of safety oversight. This also involves the societal fault lines associated with federalism and states' rights. For many decades, this issue has been mostly resolved with the acceptance that aviation safety works best when managed at the federal level. However, the potential for a need for delegation of enforcement authority may become a very real issue very quickly in the novel aircraft industries.

Prepared by
James Grimsley,
Choctaw Nation of Oklahoma

SECTION 5
AAM Infrastructure Gap Analysis

Weather

The legacy policies and standards utilized in evaluating and classifying aviation meteorological equipment, sensors, and processes for the purposes of gathering and disseminating weather information have been identified as lagging far behind the technological advancements that have occurred in the weather sciences field over the past several years. The majority of weather products and services in the aviation community today were designed for traditional airplane operations to and from established airports operating at 3,000 feet above ground level (AGL) and above. The airspace below 3,000 feet AGL has become a weather desert with little to no coverage. To bridge these gaps, those policies that were established in the 1960s and 1970s related to aviation weather standards need to be updated to better reflect and account for advancements in science and technology to fill this low altitude weather gap.[11] The following recommendations are designed to address these shortcomings and bridge the low altitude aviation weather gap.

WEATHER STANDARDS

Develop performance-based weather standards

1. Move from certifying sensors to a data performance standard.
2. FAA supports the transition to performance-based regulations and policy.
3. Private industry is working with NASA and the FAA on methods to quantify weather data accuracy and methods of compliance.
4. All weather data will require quality quantification, validation, and metadata.
5. CAAs and ANSPs consider providing third-party weather providers opportunities to become approved weather sources to drive weather innovation.

DENSITY

Increase density of weather reporting stations

The installation of aviation weather observation sights historically has been predicated on fixed wing operations conducted to and from airports at altitudes above 3,000 feet AGL. Due to this fact, most aviation weather observation systems such as Automated Weather Observing Systems

[11] Campbell, S. E., D. A. Clark, and J. E. Evans, 2017: Preliminary Weather Information Gap Analysis for UAS Operations.

(AWOS) and Automated Surface Observation Systems (ASOS) are co-located at airports. There is a significant lack of aviation weather observation sights in urban, metropolitan, and rural communities. An increase in the density of weather reporting stations within these regions will be necessary for gathering and disseminating weather information for AAM flight operations to take place in the low altitude flight environment.

To foster a safe operational environment for the AAM industry to flourish, an increase in specialized weather reporting equipment installed in urban, metropolitan, and rural areas will be needed. New standards for the placement of these instruments will need to be developed that consider non-airport criteria beyond what is currently stipulated by the FAA.[12]

According to the National Center of Atmospheric Research (NCAR) there are approximately 4,014 surface observation weather reporting sites in the United States.[13] However, according to NOAA only a little over 900 of these sites are identified as ASOS sites and just over 1,100 as AWOS sites. This would indicate that there are close to 2,000 weather reporting sites whose information could potentially be integrated into the aviation weather reporting system but since those sites are not certified AWOS or ASOS sites the information is not being integrated.[14] We recommend that these sites be evaluated in future research studies to ascertain whether or not the data produced by them is equivalent to AWOS and ASOS data through a validation process.

ACCESS

Improve connectivity to all weather reporting systems

The current regulations governing what aviators are allowed to have access to through certified weather platforms, for the purposes of preflight and enroute requirements, restrict the use of weather systems that do not meet the specification criteria of an AWOS-III or ASOS. These 1960s and 1970s regulations do not take into account the advancements in aviation weather observation technologies and improvements in sensor technology. Excellent examples are the U.S. Remote Automatic Weather Stations (RAWS)[15] and the roadway weather observation platforms established by individual states' Department of Transportation.[16] The majority of the weather information generated by these types of weather reporting sites is currently not accessible to pilots through standard preflight means, is not accessible while airborne, and is not being utilized in many of the aviation weather algorithms use for weather forecasting.

AIRCRAFT

Utilize aircraft to gather and report weather data

The equipage of aircraft including traditional fixed wing and helicopters, along with eVTOL, UAS and drone aircraft with meteorological sensors would be:

1. Beneficial for flight safety and the estimation of aircraft performance
2. Beneficial for more detailed information of current weather conditions
3. Beneficial for validation of urban micro-weather prediction capabilities
4. Fill in the gaps where ground-based weather observations are few or nonexistent.

PROVIDERS

Expand third-party weather providers

- Define minimum performance requirements and standards for weather information providers (WIPs) (formerly known as weather

[12] 09/06/2017, FAA Order JO 6560.20C – Siting Criteria for Automated Weather Observing Systems (AWOS)
[13] https://weather.rap.ucar.edu/surface/stations.txt
[14] https://www.weather.gov/lmk/observation_networks#:~:text=AWOS
[15] https://www.nifc.gov/about-us/what-is-nifc/remote-automatic-weather-stations
[16] https://ops.fhwa.dot.gov/weather/resources/links.htm

supplemental data service providers) to provide data and services in support of extensible traffic management (xTM) systems, UAS, and AAM operations up to 5000 ft (1524 m) AGL.

- Strongly encourage CAAs and ANSPs consider providing third-party weather providers with opportunities to become approved weather sources to drive weather innovation.

CAMERAS

Acceptance and validation of weather camera data

Weather cameras have proven their utility and functionality in some of the harshest environments in Alaska and have since been implemented in Hawaii, Colorado, and Mississippi.[17] However, there is a need for acceptance and validation of weather camera data and information as a viable approved weather source and decision-making tool for pilots and flight operators. Funding for these new weather systems needs to be addressed so that they will be capable of accessing similar streams of funding currently reserved for AWOS and ASOS systems.[18] This funding methodology could take the form of a joint venture between infrastructure owners and each state's Department of Transportation.

PHYSICAL INFRASTRUCTURE STANDARDS

Develop performance-based standards

Two attempts, one in 1981 and another in 1991, have been made to develop performance-based standards for heliport design in the past, which were designed to allow for different helicopter performance levels for classification purposes.[19,20] The 1981 report states that "Aircraft consistent with the detailed heliport information proposed is urged." It had previously been determined that "helicopter manufactures do not provide the necessary performance data in their heliport flight manuals to inform the pilot of the aircraft's capability for operations at confided area heliports." (Section D3) For an equivalent level of safety to be achieved between all types of infrastructure, i.e., airports, heliports, and vertiports, equivalent levels of performance for each aircraft by type, make, and model will need to be determined and published. This would allow for an equivalent comparison of infrastructure, i.e., vertiport to heliport to airport, on a performance basis regardless of what type of aircraft was being evaluated.

DATA

Expand data requirements, integrity, accountability, and accuracy

49 USC 329(b) empowers and directs the Secretary of Transportation to collect and disseminate information on civil aeronautics. In addition, Section 47310 of the U.S. Code Title 49, Sub VII, Part B, Chapter 471 mandates the collection of airport safety data. Aeronautical information is required by the FAA to carry out agency missions such as those related to aviation flying safety, flight planning, airport engineering and federal grants analysis, aeronautical and flight information publications, and the promotion of air commerce as required by statute.

However, this level of oversight is not afforded to "private-use" facilities in the United States. This is critical in that out of the current 6,166 heliports in existence (as of 29 December 2023) only 53 are identified as "public-use."[21] Therefore, the FAA has little to no oversight of roughly 99% of all vertical flight infrastructure. Compounding this issue is the question as to what vertiports will be classified as in the future, i.e., "public-use" or "private-use."

Current effort by the FAA to collect data for vertical flight infrastructure falls short of the necessary accuracy and completeness of

[17] https://weathercams.faa.gov
[18] https://www.faa.gov/airports/planning_capacity/non_federal/awos
[19] June 1981, F.D. Smith, A.G. DeLucien, DOT/FAA/RD-81/35, Development of a Heliport Classification method and an Analysis of Heliport Real Estate and Airspace Requirements.
[20] August 1991, Robert K. Anoli, Edwin D. McConkey, Robert J. Hawley, Margaret B. Renton, DOT/FAA/RD-90/4, Heliport VFR Airspace Design Based on Helicopter Performance.
[21] FAA Airport Data and Information Portal: https://adip.faa.gov/agis/public/#/public

information to promote the appropriate level of safety for a public transportation system. Shortcomings include but are not limited to no accountability of vertical flight infrastructure approach/departure paths, infrastructure weight classifications, numerous lighting configurations, the existence of close in hazards, data validation processes, and last inspection dates.[22]

We recommend implementing a data quality management system for all AAM infrastructure with classification criteria that includes accuracy, resolution, integrity, traceability, timeliness, completeness, and format. This would then better align the FAA system with the International Civil Aviation Organization (ICAO) requirements.[23]

AIRSPACE

Capture and protect vertical flight infrastructure airspace

At the present time, the associated airspace that supports a heliport or vertiport, i.e., the approach/departure paths, is not captured by the FAA in the airport master record (AMR). As such it is unknown at the majority of heliports in the United States what the preferred approach departure is, i.e., the one evaluated for obstructions by the FAA. While it is a required data field for submitting for FAA review,[24] which is required by the Code of Federal Regulations, this data does not have a dedicated field in the FAA Form 5010 or the airport master record database. The FAA data system and recordkeeping process for vertical flight infrastructure is based on airports and does not take into account many of the idiosyncrasies that are specific to vertical flight infrastructure.

UAS INFRASTRUCTURE

Define, standardize, oversee, track, and chart

With the proliferation of drone and UAS operations being used to conduct cargo and delivery operations, numerous ground infrastructure sites have since been developed and are conducting aircraft flight operations; in some cases this involves hundreds of flights a day with the expectation that some may conduct thousands.[26] However, there is no defined aviation standard that these sites are required to meet, there is no clear oversight criteria for these commercial sites in place, there is no mechanism in place to capture data on these sites, and none of these sites are being charted in the National Airspace System. To this end, on 2 February 2024, the FAA announced their Request for Information effort to address the subject of what a droneport is and how UAS operations are to be integrated at airports.[27]

COMPATIBILITY

Develop equivalency criteria for other types of infrastructure

There is a need for the FAA to define what each individual type of infrastructure, airport, heliport, and seaplane base is capable of supporting in regard to AAM operations and aircraft. This includes what type of ground equipment and fire safety equipment will be required at a traditional airport or heliport that intends to support electric, hybrid-electric, and/or hydrogen aircraft. We also will need to address the required equivalences for a vertiport that is intended to support other powered lift aircraft such as helicopters that may operate on either 100% liquid fuel or are configured as some sort of hybrid design.

REGULATIONS

Update and harmonize federal, state, local

A key component to making the AAM business model successful will be the harmonization of regulations, terminology, and definitions at all levels of government.[28] To successfully deploy the AAM business model throughout all the states and municipalities, the regulatory landscape

[22] 14 July, 2023, FAA Airport Data and Information Portal (ADIP) Airport Master Record (AMR) Module Data Dictionary.

[23] November 2018, George P. Sempeles, presentation, ICAO Data Quality Requirements, presented at the SAM Region Seminar on PANS-AIM.

[24] FAA Form 7480, Notice for Construction, Alteration and Deactivation of Airports.

[25] U.S. Code of Federal Regulations, Title 14, Part 157.

[26] January 9, 2024, Article, Sky High Ambitions: Walmart to Make Largest Drone Delivery Expansion of Any U.S. Retailer: https://corporate.walmart.com/news/2024/01/09/sky-high-ambitions-walmart-to-make-largest-drone-delivery-expansion-of-any-us-retailer

[27] Department of Transportation Docket No. FAA-2024-0189 Request for Comments on Unmanned Aircraft System (UAS) Integration at Airports and Necessary Planning, Design, and Physical Infrastructure Need.

[28] Code of Federal Regulations, Title 14.

must have a sufficient level of equivalency and harmonization. If this cannot be achieved, increased costs and delays are to be expected. The federal government must be prepared to offer well-thought-out regulations as well as guidance for states and municipalities. To accomplish this an Aviation Rule Making Committee (ARC) will need to be established.

OVERSIGHT

Increase federal legal oversight authorityand responsibility

Numerous AAM proponents, as well as several U.S. legislators, have indicated that current heliports and airports will be utilized to support AAM. At the present time the FAA has no legal oversight or responsibility for "private-use" aviation infrastructure facilities other than to make recommendations.[29] Currently 99% of the 6,166 heliports and 63% of the 13,148 airport in the U.S. are classified as "private-use."[30] This regulatory gap would allow AAM operations conducted at "private-use" facilities to have the lowest level of federal oversight of any public transportation system. Historically, this gap had been identified and filled in the helicopter industry by Federal Regulations Part-127, Certification and Operations of Scheduled Air Carriers With Helicopters, which required all heliports operating under Part-127 to be certified under Part-139, Certification of Airports. However, this regulation was canceled in the 1990s. Additionally, Part-139 currently exempts all heliports from any requirements of being certified by the FAA.[31] To achieve the level of safety that the public expects and demands of its transportation system changes in current regulations will be required. Given the number of lines of business that a change such as this would impact, for the federal government to assume a position of oversight and enforcement rather than one of recommendations only, an Aviation Rule Making Committee (ARC) will most need to be established.

CATEGORY

Expand FAA use-case to include commercial and personal use

Under current federal regulations two choices are allowed in regard to aviation infrastructure use cases: "public-use" or "private-use." Some states have identified this as an issue as it does not allow for the appropriate level of oversight to be achieved in those situations where commercial operations are being conducted or when only personal operations are being conducted at "private-use" facilities. By adopting and implementing the category of "commercial-use," states have been able to better enforce recognized safety standards for those situations where a higher level of oversight is warranted. Conversely, by adopting the category of "personal-use," states also have been able to allow private individuals conducting general aviation operations on their own property to flourish. The inclusion of a new use case into the Code of Federal Regulations that speaks to this would require an Aviation Rule Making Committee (ARC) be established.

SAFETY MANAGEMENTS SYSTEMS (SMS)

Require for commercial vertical flight infrastructure

Under current regulations all Part-121 flight operations are required to have an operational Safety Management System (SMS) that meets the requirements that are set forth by the FAA in the Code of Federal Regulations.[32] All airports that support Part-121 flight operations that are certified under Part-139 certification requirements are also required to have an SMS in place. With recent rule changes regarding SMS requirements, commuter and on-demand operators conducting Part-135 and some Part-91 operations will be required to have an SMS in place that meets the criteria in the Code of Federal Regulations. Under current regulations, those sites identified

[29] January 5, 2023, U.S. DOT/FAA Heliport Advisory Circular AC 150/5390-2D
[30] FAA Airport Data Information Portal (ADIP)
[31] Code of Federal Regulations, Title 14, part 139, Certification of Airports
[32] Code of Federal Regulations, Title 14, Part 5, Safety Management Systems

as either "public-use" or "private-use" facilities that do not support Part-121 flight operations, regardless of type of commercial operations, tempo, flight volume, or type of operation being conducted, are not required to have an SMS. Certificate holders operating aircraft under Part 135 are only expected to evaluate whether or not an airport is adequate for the proposed operation, considering such items as size, surface, obstructions, and lighting.[33] To the extent feasible, all flight operations being conducted in support of our national public transpiration system should be done so at infrastructure that has a functional SMS in place that meets the requirements as identified in 14 CFR Part 5.

Education and Training

TSI

AAM infrastructure training programs

The Transportation Safety Institute (TSI), a division of the U.S. Department of Transportation, offers accident investigation education and training to aviation professionals and is the only U.S.-recognized training course on vertical lift infrastructure, e.g., the heliport evaluation course.[34] Going forward there is a need to expand this course to include vertiports. Additionally, given the number of eVTOL infrastructure sites expected to be built over the next 10-15 years, it will be necessary to increase the annual offerings provided by the TSI to include more FAA staff members, state aviation officials, and municipality planners. The permanent allocation of federal funding to accomplish this should be expanded and made a priority as soon as possible.

FAA

AAM workforce needs and training requirements

Given the rapid pace with which AAM is manifesting as a transportation model, the FAA needs to be prepared to meet this future demand, including the development, validation, and inspection of both new and existing infrastructure. Historically, "private-use" heliports have been relegated to the lowest priority level within of the FAA's Flight Standards District Office (FSDO) and the Airport District Office (ADO), with little to no incentives provided to inspectors to accomplish these tasks when compared to other assigned duties. Infrastructure development will need to prioritize and incentivize equally with other tasks across all divisions of the FAA. Additionally, there is a significant lack of personnel within the FAA who have vertical flight and powered lift experience, and only a few of those have had any training in vertical lift infrastructure standards and development criteria. To address this gap of qualified subject matter experts, the FAA will need to higher more technicians who have vertical flight and powered lift experience as well as increase training and education for these individuals that includes vertical flight infrastructure regulations, standards, and safety.

NTSB

Accident investigator vertical flight infrastructure education

While the U.S. National Transportation and Safety Board (NTSB) and their investigative team are some of the best trained accident investigators in the world, they lack any formal training and education on vertical lift infrastructure accident investigation. This has been identified in several accident investigations involving heliports reviewed by third party that found that the NTSB routinely blamed pilot error as the primary cause of accidents occurring at infrastructure when in fact the infrastructure where the accident occurred was at fault because it did not meet even the most basic of FAA safety standards.[35,36] It is therefore recommended that all NTSB accident investigators involved in rotorcraft, powered lift, and AAM accident investigations going forward be afforded the opportunity to attend the Transportation Safety Institutes

[33] Code of Federal Regulations, Title 14, Part 135.229 Airport Requirements

[34] U.S. DOT Transportation Safety Institute: https://www.transportation.gov/transportation-safety-institute

[35] May 10-14, 2021, Rex J. Alexander, Raymond A. Syms, Cliff Johnson, John Roberts, A Retrospective & Historical Analysis of Vertical Lift Infrastructure Accidents for the Purpose of Operations Risk Identification an Accident Prevention, Vertical Flight Society Forum 77, Virtual.

[36] May 7-9, 2024, Rex J. Alexander, Cliff Johnson, Vertical Flight Infrastrucure Data Quality Shortcomings, Vertical Flight Society Fourm 80, Montreal, Canada.

Heliport, and soon Vertiport, Evaluation training course as well as their basic and advanced rotorcraft accident investigation courses.

STATES

AAM infrastructure education programs

Each state has its own independent Department of Transportation that is governed by that state's legislative body. Each of these organizations provides for its own independent state aviation division that is responsible for aviation oversight in their state. While most state aviation divisions have individuals on staff that have experience and training in traditional airport design and airplane operations, few have anyone on staff that has had any formal education or training in vertical flight infrastructure development and safety or is an experienced vertical flight aviator. As such, many states lag far behind in the area of standardization and safety as it relates to the vertical flight industry. To address the expected number of infrastructure sites that will be necessary to support AAM, each state will need to ensure that their members who will oversee this effort have the proper training and education.

To accomplish this, the Task Force recommends that states be provided with some form of incentives to both add new staff with the appropriate background and to provide training or educate specific to these tasks and needs. Federal funding for state officials' education may be an option.

MUNICIPALITIES

Standardized land-use criteria and education

While some municipalities have begun the arduous effort of addressing AAM as a new transportation in their districts, many have not. While the FAA has oversight of managing airspace, it is the local municipalities who have the ultimate authority over land use for their districts. As such, it is the local municipality that will dictate AAM infrastructure fire and building code, zoning criteria, permitting processes, noise studies, environmental impact studies, and required standards. There is a significant need to provide AAM educational and materials to municipalities that address AAM and AAM Infrastructure development and safety. This may be accomplished through the U.S. DOT's Transportation Safety Institute or potentially through an educational effort conducted by someone such as NASA.

Prepared by
Rex Alexander,
Five-Alpha LLC

SHAPING THE FUTURE OF AEROSPACE

12700 Sunrise Valley Drive, Suite 200, Reston, VA 20191-5807
703.264.7500 | aiaa.org