Advanced Air Mobility: Transcending the Frontiers of Aviation Law

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Abstract: This article examines the revolutionary concept of Advanced Air Mobility (AAM) and its potential to transform urban and regional transportation. It begins by contextualizing AAM within the broader trajectory of aviation advancements, showcasing its emergence as a cutting-edge solution for modern transportation challenges. The discussion highlights the defining characteristics of AAM, such as its reliance on autonomous aircraft, electric propulsion technologies, and seamless integration with existing transit systems.

The United States' leadership in this sector is explored, with an emphasis on federal initiatives, partnerships between public and private entities, and the regulatory role of the Federal Aviation Administration. The article identifies key challenges that must be addressed to realize AAM's potential, including technological hurdles, public trust, and the intricacies of managing congested urban airspaces.

Further analysis underscores the significant benefits AAM offers, such as reducing traffic congestion, enhancing accessibility, and promoting environmentally sustainable solutions. The article also delves into the legal and regulatory frameworks governing AAM, identifying critical areas that demand reform, such as liability, certification processes, and safety standards. By addressing these issues, the aviation sector can ensure that AAM evolves responsibly, meeting societal needs while adhering to essential legal principles.

Keywords: Advanced Air Mobility (AAM), Urban Air Transportation, Aviation Law, Regulatory Framework, Technological Innovation, Sustainability.

1. INTRODUCTION

The 14th ICAO Air Navigation Conference (AN-Conf/14) was held at ICAO headquarters in Montreal from 26 August to 6 September 2024. The conference, themed "Performance Improvement Driving Sustainability," aimed to establish a global consensus on performance enhancement measures that will enable ICAO, member States, and the aviation industry to address aviation's global environmental challenges, while considering the rapid advancements in aviation operations and technologies, and the constraints on available resources.

The Conference focused on several Priority Focus area (PFAs) one of which centers on advanced air mobility (AAM) and new entrants to aviation. The goal is to ensure the harmonized development of these areas across different regions, fostering interoperability where necessary. This PFA is designed to support collaboration between various aviation sectors and ensure that AAM and new entrants adhere to ICAO's safety provisions. It also addresses a wide array of topics, including economic regulation and international legal considerations, guiding states in adopting and regulating these emerging aviation operations.

The Conference also discussed electric vertical take-off and landing (eVTOL) aircraft and hybrid operations, reviewing papers presented by the Republic of Korea and the United Arab Emirates regarding AA. The Conference emphasized the importance of developing Standards and guidance to ensure the safe incorporation of technologies like electric and hybrid propulsion aircraft. It acknowledged the experiences of different States in implementing such technologies as critical for advancing this work. While the ICAO work programme already included some elements related to electric and hybrid aircraft, the Conference agreed that an assessment was needed to identify additional requirements. The Conference also proposed sharing relevant materials with expert groups working on early guidance for these operations, including considerations for air traffic management (ATM).

The Conference underscored the importance of States utilizing regulatory sandboxes to collect real-world data and support the creation of effective regulatory frameworks. It also backed the development of public awareness programs to address social acceptance of advanced air mobility technologies.

2. WHAT IS AAM?

AAM is a cutting-edge concept that involves integrating advanced aviation technologies into existing airspace systems to establish more efficient, safe, and scalable air transportation networks. It envisions the use of electric vertical takeoff and landing (eVTOL)

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aircraft, autonomous drones, and other modern aviation platforms to transport people and goods both within urban areas and across rural regions. This article delves into AAM's origins, the technological advances driving it, its present state, and its potential to reshape global transportation systems.

The foundations of AAM can be traced to concepts like urban air mobility (UAM) and personal air vehicles (PAVs), as well as the broader development of unmanned aerial vehicles (UAVs). Though early ideas of flying cars and personal air travel gained attention in the 20th century, technological limitations kept these visions in the realm of science fiction. It wasn't until the 21st century, with the advancement of autonomous flight systems, electric propulsion, and air traffic management, that these concepts began to seem feasible.

In the 1950s and 1960s, with the increasing availability of jet engines and helicopters, there was growing excitement about personal air travel. Yet, essential technologies such as autonomous navigation, efficient electric power systems, and integrated traffic management were not yet developed. The potential for these ideas remained theoretical for many years. However, significant technological progress—particularly in areas like battery technology and artificial intelligence (AI)—in the late 20th and early 21st centuries paved the way for modern AAM.

The rise of UAVs for military use in the 1990s and advances in electrification and AI have been critical to the development of AAM. Drones, initially developed for tasks like surveillance and delivery, became relevant for urban air transport as cities faced increasing issues with congestion and pollution. The environmental concerns surrounding conventional aviation also accelerated research into electric-powered aircraft, leading to the development of eVTOL vehicles. These aircraft, quieter and more efficient than traditional helicopters, are key to the realization of AAM.

The technologies enabling AAM are varied and critical. Electric propulsion is a primary driver of AAM, offering quieter, more efficient, and environmentally friendly alternatives to traditional aircraft engines. Improved battery technologies, such as lithium-ion and solid-state batteries, have enabled the design of lightweight, powerful motors suitable for eVTOL vehicles. As these technologies continue to evolve, the operational range of electric aircraft will expand, enhancing their role in future transportation systems.

Automation is another essential element for scaling AAM. While many current eVTOL prototypes require pilots, the ultimate goal is for fully autonomous aircraft to navigate complex urban skies without human intervention. AI, sensor technologies, and digital air traffic management will all play crucial roles in making autonomous flight safe and reliable.

AAM's integration into the existing airspace will require new traffic management solutions, as traditional systems are not designed to handle the large number of autonomous aircraft anticipated. Systems like Unmanned Aircraft Systems Traffic Management (UTM) are being developed to manage this influx of air traffic. These rely on real-time communication and data sharing to ensure safe coordination between vehicles, preventing collisions and allowing seamless integration with current air traffic systems.

The design of eVTOL aircraft represents a significant departure from conventional aircraft. These vehicles combine the vertical takeoff capability of helicopters with the speed and efficiency of airplanes, using advanced rotor systems or fans. Companies like Joby Aviation, Lilium, Volocopter, and EHang are at the forefront of eVTOL development, each pursuing different approaches to propulsion, design, and deployment.

Currently, AAM is transitioning from theoretical development to practical application, as commercial deployment looms on the horizon. The industry has seen significant investment from both established aerospace firms and startups. Governments and regulatory bodies are also working to create the necessary frameworks for safely integrating these new aircraft into national airspaces. In the United States, the Federal Aviation Administration (FAA) is collaborating with industry players to define safety and certification standards, while European and Chinese authorities are taking similar steps.

3. SOME SALIENT FEATURES OF AAM

AAM encompasses a comprehensive framework designed to provide consumers with access to diverse aviation services. These include on-demand air transportation, cargo and package delivery, healthcare logistics, and emergency response, all facilitated through a seamlessly integrated multimodal transportation network. Despite its promise, AAM's growth trajectory faces several critical challenges. Key issues include the technological and regulatory hurdles of autonomous flight, the availability and development of infrastructure such as vertiports, the integration of AAM into existing airspace and other transportation systems, and competitive pressures from alternative transportation modes like shared automated vehicles.

AAM could effectively replace non-discretionary trips exceeding 45 minutes in duration. However, discretionary travel demand remains constrained by consumer price sensitivity and willingness to pay. Under a conservative scenario, daily demand for AAM passenger services is projected to reach 82,000 passengers, requiring a fleet of approximately 4,000 aircraft capable of accommodating four to five passengers each. This represents an estimated annual market valuation of 2.5 billion USD in the United States. The study underscores the transformative potential of AAM in reshaping urban mobility, contingent on overcoming existing barriers to its widespread adoption.

The field of AAM represents a transformative approach to modern transportation, combining technological innovation with integrated network design to deliver on-demand air services. By leveraging advancements in electrification, automation, vertical takeoff and landing (VTOL) technology, and air traffic management, AAM introduces novel aircraft designs and operational models tailored to urban, suburban, and rural environments. This paradigm includes applications ranging from goods delivery and emergency services to passenger transport within localized radii and interregional distances spanning several hundred miles. The broader ecosystem of AAM aligns with related concepts such as on-demand air mobility, urban air mobility (UAM), and rural air mobility, demonstrating its versatility across diverse geographies and use cases.

The proliferation of on-demand aviation services mirrors the success of transportation network companies like Uber and Lyft, with app-based AAM platforms utilizing helicopters and fixed-wing aircraft now entering global markets. For instance, as of 2020, several companies launched or announced AAM services, including Volocopter in Singapore and EHang in Austria, with others like Joby Aviation and Lilium planning expansions in major cities worldwide by 2024. Meanwhile, automakers such as Toyota, Audi, and General Motors have made significant investments in AAM, signaling confidence in its market potential.

However, the widespread adoption of AAM is tempered by challenges such as ensuring public safety, achieving social equity, and addressing community concerns related to planning, airspace integration, and environmental impact. While AAM holds significant promise for emergency medical services and efficient goods transportation, societal acceptance remains a barrier due to perceived risks, privacy concerns, and cost considerations. Positive perceptions of AAM technologies correlate strongly with user adoption, particularly in sectors like aeromedical transport, where benefits are more readily apparent.

Economic projections highlight the substantial growth potential of AAM. By 2030, market valuations for passenger mobility alone are estimated between $2.8 billion and $4 billion, with global AAM market potential ranging from $74 billion to $641 billion by 2035. Analytical studies, such as those utilizing metanalysis and gravity models, suggest that AAM could capture a significant share of urban mobility, with estimates of $318 billion in market potential across key global cities by 2040. Yet, these forecasts vary widely due to differing methodologies, assumptions, and geographic scopes.

Crucial to the success of AAM is the establishment of robust infrastructure, including vertiports, energy systems, and maintenance facilities, alongside advancements in vehicle design and regulatory frameworks. The integration of AAM into urban airspace systems further complicates operations, requiring innovative approaches to manage congestion, noise, and safety. Stakeholders must address these challenges while fostering public trust and ensuring competitive advantages over existing transportation options.

This evolving field offers a promising avenue for research, particularly in VTOL aircraft development, which serves as a cornerstone of AAM's vision. By overcoming technological and infrastructural hurdles, VTOL technology could redefine urban mobility, creating a sustainable and efficient transportation model that integrates seamlessly into multimodal networks. In addressing these multifaceted challenges, AAM holds the potential to reshape transportation and contribute significantly to the future of smart, interconnected cities.

AAM constitutes a progressive initiative in sustainable aviation, aiming to facilitate the transportation of goods and passengers in urban and regional environments through electrified drone technology. The anticipated global integration of AAM is projected to yield significant advantages, including reduced environmental pollution, diminished transportation expenses, enhanced accessibility, and strengthened supply chain resilience. Nonetheless, the absence of comprehensive regulatory frameworks in most jurisdictions impedes its development. The fragmented regulatory landscape undermines the efforts of commercial innovators and international organizations committed to advancing human welfare. Consequently, identifying indicators that predict a jurisdiction's readiness to adopt AAM is essential for informed decision-making and strategic planning regarding drone application.

AAM aligns with international frameworks like the Paris Climate Accords by emphasizing decarbonization in transportation, particularly in aviation, where progress has been limited compared to road vehicles. The initiative leverages innovations in distributed electric propulsion, artificial intelligence, and network-enabled transportation services to deliver practical solutions for congestion reduction and pollution mitigation. Beyond urban mobility, AAM supports humanitarian objectives, enabling cost-efficient delivery of critical supplies and facilitating efficient monitoring of environmental and infrastructural conditions.

While a select group of nations, such as the United States and China, are actively developing regulatory frameworks and technologies to integrate drones into general airspace, the lack of uniformity in international policies creates economic disparities and hampers global supply chain efficiency. The ability to identify effective indicators for AAM adoption thus holds substantial value for policymakers, technology developers, and international organizations, enabling targeted interventions, policy evaluations, and strategic planning to ensure equitable progress.

The concept of integrating aerial vehicles into urban transportation systems has been explored since the early 20th century, with early iterations including "flying car" designs. Technological advancements in electrification, automation, and related fields have recently reignited opportunities to develop innovative air mobility solutions. Urban Air Mobility (UAM) represents a modern vision for an accessible, sustainable, and safe aerial transportation network, facilitating passenger travel, goods delivery, and emergency services across metropolitan regions.

The potential mainstream adoption of UAM, however, is contingent upon overcoming several significant challenges. The existing regulatory framework, public acceptance, and apprehensions regarding safety, noise pollution, environmental sustainability, and social equity may hinder its growth. Additional obstacles include infrastructure demands, such as vertiports and maintenance facilities, and the need for advanced airspace management systems to ensure seamless integration into existing aviation operations. Furthermore, economic feasibility and the development of robust business models will play a critical role in determining the viability of UAM services.

A century of advancements in aircraft design has positioned air transportation as a viable competitor to road transit, particularly for urban services that include both hub-to-door and door-to-door operations.

For passenger transport, air travel consistently outperforms road travel in terms of speed across all distances. Regarding fuel costs and emissions, air travel demonstrates superior performance over longer distances, with specific transition thresholds detailed in the primary text. When analyzing consolidated goods transport, air achieves parity with or outperforms road transit depending on the aircraft type. For unconsolidated goods, air transportation exhibits a clear advantage across all three metrics.

To operationalize these air-based services, urban airspace must be capable of managing traffic volumes significantly higher than those currently seen in manned aviation, while maintaining low congestion levels to realize these benefits.

4. THE UNITED STATES PERSPECTIVE

AAM represents a groundbreaking transportation paradigm aimed at transforming the movement of people and goods within the United States through the use of innovative aviation technologies. Defined under the Advanced Air Mobility Coordination and Leadership Act (P.L. 117-203), enacted in October 2022, AAM encompasses a system employing advanced aircraft, such as electric-powered and vertical takeoff and landing (eVTOL) vehicles, to operate in both regulated and open airspace. However, within the context of its current implementation, AAM is specifically limited to operations involving onboard pilots, whether for passenger or cargo services. This distinction underscores the developmental phase of AAM as it gradually integrates into the broader National Airspace System (NAS).

The Federal Aviation Administration (FAA) has assumed a pivotal role in facilitating the integration of AAM into NAS, leveraging decades of experience in adopting emerging technologies into the aviation sector. Central to the FAA's mission is maintaining the rigorous safety standards that underpin modern aviation. This commitment to public safety informs every aspect of the FAA's approach, which encompasses evaluating aircraft design, operational procedures, and training programs. The agency is equally focused on ensuring equitable airspace access, developing suitable infrastructure, mitigating environmental impacts, and engaging with communities to address public concerns and garner support for AAM initiatives.

As these advanced technologies evolve, the FAA is actively revising operational and pilot certification requirements to reflect the unique demands of AAM. Over time, the agency plans to implement comprehensive regulatory frameworks tailored to these aircraft, ensuring their safe and efficient operation. To achieve this, the FAA has adopted a measured, phased approach, metaphorically described as "crawl-walk-run." This strategy enables initial Entry Into Service (EIS) operations with minimal infrastructural modifications while laying the groundwork for more complex, large-scale, and automated operations in the future.

To further bolster the development of AAM, the FAA has launched Innovate28 (I28), a collaborative initiative involving both government and industry stakeholders. This project aims to showcase integrated AAM operations at select locations by 2028, serving as a practical demonstration of the technology's potential. In parallel, the FAA is working to advance AAM concepts, operational procedures, and regulatory measures, ensuring that the industry can scale effectively while maintaining high safety standards.

The integration of AAM into the national transportation network represents a significant leap toward innovative, sustainable, and efficient mobility solutions. By fostering collaboration among stakeholders and carefully balancing innovation with regulation, the FAA is not only addressing the immediate needs of the AAM ecosystem but also paving the way for its long-term success. This coordinated effort illustrates a forward-thinking approach to aviation, one that seeks to harmonize technological advancement with societal benefits and safety imperatives.

5. CHALLENGES FACING AAM

Several leading companies are shaping AAM's future. Joby Aviation, for instance, is developing an all-electric aircraft for urban air taxi services, while Lilium is focusing on a ducted fan jet system for regional air mobility. Volocopter is creating vehicles for short-range, urban trips, and EHang is exploring autonomous passenger drones, particularly in the tourism sector.

Despite the promising potential, several challenges remain before AAM can be widely implemented. Regulatory frameworks are critical to ensuring the safe operation of these new technologies. Certifying new types of aircraft, particularly autonomous ones, requires extensive testing. Moreover, global collaboration is necessary to standardize regulations, allowing for seamless cross-border operations.

Infrastructure development will also be crucial. Vertiports for eVTOL takeoffs and landings, charging stations, and advanced communication networks will need to be integrated into urban and regional landscapes. Building a system that manages both traditional and autonomous air traffic will be a significant technical hurdle. Public acceptance is another key consideration. Concerns about safety, noise, and privacy must be addressed through transparent communication and demonstrable safety records. Additionally, reducing the cost of these technologies to make AAM widely accessible remains a long-term goal.

Despite rapid technological advancements, the regulatory landscape for AAM still lags behind. The WEF report emphasizes the urgent need for harmonized and consistent regulations at both national and international levels. Without uniformity in standards, AAM deployment could face significant hurdles in terms of operational delays and inconsistent enforcement.

Safety remains the top priority for regulators. The WEF advocates for a global regulatory framework that imposes strict safety standards for both autonomous and human-piloted AAM vehicles. Regulatory agencies, such as the Federal Aviation Administration (FAA) in the United States and the European Union Aviation Safety Agency (EASA), are currently focused on regulating traditional aircraft. However, eVTOLs and autonomous drones present unique challenges—especially with their operation in urban environments and their heavy reliance on automation.

The WEF suggests that regulatory bodies should adopt a phased approach to AAM certification, initially focusing on piloted eVTOLs before gradually shifting towards fully autonomous systems as both technology and public trust evolve. Additionally, interoperability between airspace regulations in different countries will be essential to AAM's success as a global industry.

In addition to aircraft certification, the WEF report underscores the need to develop standards related to cybersecurity and data privacy. Given that autonomous aircraft and air traffic management systems will heavily rely on real-time data exchanges, these systems could be susceptible to cyberattacks. Governments must put in place robust cybersecurity frameworks to protect sensitive data and ensure AAM operations remain safe and secure.

AAM will also necessitate considerable investment in new infrastructure. Current airports and air traffic control systems are not designed to accommodate eVTOLs or autonomous aircraft. According to the WEF, substantial investment in both physical and digital infrastructure will be needed to facilitate the expansion of AAM.

One of the key infrastructure components for AAM will be vertiports, which are specialized hubs for the vertical takeoff and landing of eVTOLs. The WEF report stresses that these vertiports should be strategically located in urban environments, optimizing connectivity while mitigating noise and environmental impacts. These facilities will need to be seamlessly integrated with existing transportation networks, providing easy connections between air, road, and rail systems. To support their development, public-private partnerships will likely play an essential role, with governments offering financial incentives.

Charging infrastructure is another critical element. Electric-powered eVTOLs will require widespread charging networks to maintain continuous operations. The WEF report suggests that governments should consider offering subsidies or other incentives to promote the development of these charging stations. Moreover, research into alternative energy sources, such as hydrogen fuel cells, should be accelerated to further enhance the range and operational efficiency of eVTOLs.

Digital infrastructure is equally vital for the success of AAM. The WEF advocates for the rapid deployment of next-generation communication networks, such as 5G, to enable real-time data transmission between aircraft and air traffic management systems. This digital backbone will be crucial to ensuring the safe and efficient operation of autonomous AAM vehicles. The report also calls for the development of cloud-based UTM systems to manage the expected surge in air traffic.

6. ADVANTAGES OF AAM

Looking ahead, AAM has the potential to revolutionize transportation in numerous ways. Urban centers could benefit from faster, more efficient travel solutions, reducing congestion and pollution. eVTOL air taxis may offer commuters a quicker, eco-friendly way to bypass traffic, while AAM systems could enhance regional connectivity, improving access to jobs, healthcare, and education in rural areas. In disaster response scenarios, these new vehicles could deliver aid where traditional infrastructure is damaged.

The future of AAM holds great promise, but it will require continued innovation, regulatory evolution, and public engagement to realize its full potential. As technologies mature and infrastructure is developed, AAM could usher in a new era of mobility, creating more sustainable and efficient transportation networks around the world.

AAM signifies a transformative leap in transportation, introducing novel methods of incorporating air travel into daily routines. The World Economic Forum's report on AAM explores the intricate technological, regulatory, and societal aspects that come with the growth of this sector. Emphasizing the swift advancements in electric vertical takeoff and landing (eVTOL) vehicles, the report also addresses the complexities surrounding infrastructure development and the necessity of comprehensive regulatory frameworks. In this essay, the origins, technological progression, current applications, and future possibilities of AAM as presented by the World Economic Forum will be thoroughly examined.

AAM stems from a fusion of various technological and societal evolutions. Its conceptual framework can be traced back to the mid-20th century when the idea of flying cars and personal aircraft was popularized through science fiction. Despite this vision, progress was initially hindered by technical limitations like insufficient electric propulsion systems, inadequate battery performance, and underdeveloped air traffic management systems.

The concept of AAM gained significant momentum during the 2010s as breakthroughs in electric propulsion, automation, and artificial intelligence began to align. These advancements made the development of eVTOL aircraft possible. These aircraft resemble helicopters but produce much less noise, emit fewer carbon emissions, and come with lower operating costs. This technological milestone unlocked new opportunities for air mobility in both urban and regional contexts.

The World Economic Forum played a pivotal role in shaping AAM's vision. Through its AVIATE (Advancing Vertical Aviation in a Transitioning Environment) initiative, the Forum brought together key players from the aviation, technology, and regulatory sectors to create a collaborative framework for AAM. The WEF report emphasizes that AAM's future involves more than just a technological revolution; it is also a social and environmental solution to today's transportation challenges.

At the heart of AAM's potential lies electric propulsion technology. Unlike conventional aircraft that rely on jet fuel, eVTOL vehicles operate with electric motors, offering quieter, more environmentally friendly, and sustainable alternatives. These aircraft are specifically designed for short- and medium-distance flights, making them particularly suitable for urban air mobility in crowded cities as well as for accessing rural or remote areas.

The design and functionality of propulsion systems used in AAM mark a significant departure from traditional aircraft models. Electric motors, unlike combustion engines, provide the vertical lift necessary for eVTOLs. A key factor driving this innovation is the advancement in battery technology. The WEF's report highlights that continued investment in energy storage systems is crucial, as improvements in battery density and efficiency will directly impact AAM's range, payload capacity, and economic viability.

Additionally, integrating autonomous technology and artificial intelligence is another critical facet of AAM. Autonomous flight systems reduce the need for human intervention, increasing operational efficiency. The WEF report emphasizes that automation can greatly reduce the costs of pilot training, while also allowing the system to scale. However, full automation will depend on the creation of comprehensive regulatory standards to ensure safety and reliability, as well as public acceptance.

Another fundamental requirement for AAM's success, according to the WEF report, is an air traffic management system specifically designed for its needs. With more low-altitude flights expected in urban settings, traditional air traffic management systems will be inadequate. The report advocates for the development of an Unmanned Aircraft Systems Traffic Management (UTM) framework to manage both autonomous and piloted eVTOLs as they integrate into shared airspace.

AAM's most immediate application is Urban Air Mobility (UAM), which promises to alleviate urban congestion. eVTOLs could be employed as air taxis, allowing passengers to navigate across densely populated areas and avoid traffic jams on the ground. Companies like Volocopter, Joby Aviation, and Lilium are pioneering efforts to bring this vision to life by the late 2020s. The WEF report suggests that in major cities like New York, São Paulo, and Los Angeles, these air taxis could substantially reduce commuting times.

However, AAM's potential extends beyond just passenger transport. The logistics and healthcare sectors are also poised to reap benefits from this technology. Autonomous drones and eVTOLs could be used for delivering goods and medical supplies, especially in areas where ground transport is less efficient or feasible. For instance, medical drones have already been successfully deployed in countries like Rwanda to transport blood and essential medications to remote locations. The WEF report identifies this use case as one of the most immediate and impactful applications of AAM, with the potential to transform supply chains and enhance access to critical services in rural regions.

Regional air mobility (RAM) presents another promising use case. While UAM primarily targets short-distance, urban travel, RAM envisions using eVTOLs to connect different regions over moderate distances. This could provide a more sustainable alternative to traditional aviation, especially for regional travel. RAM could also play a significant role in connecting suburban and rural areas to metropolitan hubs, reducing road traffic and improving accessibility.

One of AAM's greatest strengths is its potential contribution to global sustainability efforts. By shifting some urban and regional transportation to the air, AAM could reduce dependency on fossil fuels and help decrease traffic congestion. The WEF highlights the fact that eVTOLs, which produce zero emissions, can play a critical role in lowering the transportation sector's carbon footprint.

In terms of its societal impacts, AAM could democratize air travel by making it more accessible to broader populations. The WEF suggests that AAM could drastically cut travel times for people living in underserved or remote areas, improving their access to healthcare, education, and employment opportunities. Additionally, AAM could revolutionize urban mobility by easing traffic congestion, leading to a better overall quality of life for city dwellers.

Looking to the future, the WEF anticipates significant economic opportunities in the AAM sector. As the demand for sustainable transportation solutions increases, the global AAM market is projected to grow substantially. Key areas of growth identified by the WEF include aircraft manufacturing, air traffic management, infrastructure development, and on-demand air taxi services.

7. LEGAL AND REGULATORY ISSUES

A major challenge in the field of AAM is the certification of new aircraft models. The FAA is currently applying its existing certification processes to new types of AAM aircraft, such as electric vertical takeoff and landing (eVTOL) vehicles. However, the increasing complexity and diversity of these aircraft designs raises concerns that the FAA may face delays in the certification process. The number of manufacturers and their various designs is growing quickly, and this expansion may exceed the FAA's capacity to review and approve them using current procedures. As a result, there is a strong need for the certification process to evolve rapidly to keep pace with innovation while ensuring that safety standards and operational requirements are met.

Another significant issue is the management of airspace. U.S. airspace regulations were primarily designed with piloted aircraft in mind, raising questions about whether these rules can adequately accommodate the needs of uncrewed, autonomous AAM vehicles. In the short term, the FAA is relying on existing air traffic control systems to manage AAM operations. However, as autonomous flight systems become more common in AAM aircraft, there will likely be a need for substantial regulatory changes. New frameworks will be essential to ensure the safe and efficient operation of AAM vehicles within national airspace. This could involve developing specialized air traffic management tools or integrating unmanned aircraft systems traffic management (UTM) systems to help coordinate AAM operations.

Land use and infrastructure development also present potential legal challenges. Vertiports, the landing and takeoff facilities required for AAM aircraft, typically require changes to local zoning laws. Since vertiport construction falls under the jurisdiction of state and local governments, these facilities can face a range of legal obstacles, including issues related to location, design, and environmental impacts. Local governments generally have authority over land use, and the noise and environmental concerns associated with AAM aircraft, particularly in urban areas, are expected to generate legal disputes. Addressing these challenges may require revising zoning laws and fostering cooperation between local, state, and federal authorities to ensure that development aligns with community interests and environmental protections.

Although no specific court cases have yet comprehensively addressed AAM issues, the legal landscape is evolving. Federal and state agencies are collaborating to create a coordinated approach to managing the introduction of AAM. This cooperation is essential for establishing legal precedents that will govern the integration of AAM into both public and private spaces. As the sector continues to evolve, it is likely that courts will become more involved, and legal disputes will arise that deal with aircraft operations, airspace management, infrastructure, and environmental regulations. These future legal cases will help set the standards for how AAM systems will function.

The transformative potential of AAM, with the promise of reducing congestion, enabling faster travel, and offering new opportunities for connectivity, makes these legal considerations even more crucial. Balancing the rapid pace of technological innovation with the need to address safety, environmental, and infrastructure concerns will be key. As the industry continues to grow, judicial involvement will likely be necessary as stakeholders—including manufacturers, governments, and communities—work together to ensure that AAM technologies are integrated into existing legal frameworks governing aviation and urban infrastructure.

While AAM has the potential to revolutionize transportation, it also faces a host of legal challenges.

From aircraft certification and airspace management to land use and infrastructure development, each issue requires careful consideration. The decisions made by regulators and courts in the coming years will be vital to ensuring the safe and effective integration of AAM into the aviation ecosystem.

A. The Montreal Convention

Liability for AAM aircraft under Article 17 of the Montreal Convention of 1999 raises crucial legal questions, particularly in relation to the concept of "embarking" and "accidents" within the air transportation system. This becomes especially pertinent when considering air taxis that transport passengers to airport terminals, as these vehicles could be seen as integral to the process of "embarking" for a flight.

Article 17 of the Montreal Convention outlines that carriers are liable for damage sustained by passengers in cases of death or injury, but only if the accident occurred "on board the aircraft or in the course of any of the operations of embarking or disembarking." This means that liability is tied to two factors: the accident must either happen during the flight or occur as part of activities related to boarding or disembarking. Crucially, these operations are not confined to the aircraft itself but include activities such as check-in, boarding, or transferring from ground transportation to the aircraft.

In the context of AAM, particularly air taxis used to transport passengers from urban areas to the airport, the critical issue becomes whether these operations are considered part of "embarking" under the Convention. Typically, embarking in commercial aviation refers to the movement from the terminal gate to the aircraft. However, for AAM air taxis, the question is whether the transport to the airport or vertiport could be considered part of the boarding process.

There are several factors that may influence how liability is determined in this context:

a. *Operational Continuity:* An air taxi, although not a part of the scheduled airline, might be viewed as an extension of the passenger's journey. If the air taxi transports the passenger to a location where they then board an aircraft, this could be interpreted as part of the embarking process. This concept is explored in cases such as Moore v. British Airways PLC, where courts examined what constitutes an "accident" under the Montreal Convention, particularly in relation to events that are external and unexpected from the passenger's perspective. In these cases, if an injury happens during the air taxi's operation and the taxi is deemed part of the boarding process, liability could apply.

b. *Precedents from Air Travel Cases*: In *Arthern v. Ryanair DAC*[1], courts applied an objective standard to determine whether an event was "unusual or unexpected," based on the knowledge and expectations of an ordinary passenger. This approach could also be applied to AAM. If a passenger were injured during the ride to the vertiport or while boarding the air taxi, and the injury was unexpected by the reasonable passenger, this might fall within the scope of the Montreal Convention.

c. *Challenges in Determining Liability*: The complexity of AAM vehicles, such as eVTOLs, and their operations, introduces potential legal challenges. Since these vehicles often operate in urban settings and on a different scale compared to conventional aircraft, their involvement in "embarking" might be questioned. If a passenger is injured while traveling in an air taxi to the airport or vertiport, there might be debate as to whether this constitutes part of the embarking process as traditionally understood in airline operations.

d. *Potential Liability Framework*: Courts will need to decide whether the air taxi's operation is sufficiently connected to the boarding process. If the taxi directly transports a passenger to the aircraft or vertiport, which is part of airport infrastructure, it could be considered a part of embarking, thus falling under Article 17. However, if the taxi operates independently from the airline's processes, its connection to embarking might be tenuous, potentially excluding it from the scope of Article 17's liability.

e. *Future Considerations*: As AAM technologies develop, courts will likely address these issues with increasing frequency. Current legal frameworks primarily concern traditional air travel, and integrating AAM into this system may present novel challenges. Future decisions will

[1] [2023] EWHC 46 (KB).

likely explore how innovations like eVTOL aircraft fit within the liability frameworks of international aviation law, potentially expanding or modifying the scope of liability for AAM operations.

The Montreal Convention does not provide a detailed definition of "embarkation," leaving courts to interpret its meaning in various contexts. A central issue in cases concerning taxi rides to the airport is whether "embarkation" can be interpreted to include events that occur away from the aircraft, such as the ride to the airport.

Although there is limited case law on whether a taxi ride to the airport constitutes embarkation, several key decisions offer valuable perspectives on how courts have handled the issue.

B. Case Law

In *Air France v. Saks*[2] - a case decided in 1985 - , the U.S. Supreme Court addressed whether an injury caused by a passenger's medical condition on the plane could be considered an "accident" under the Montreal Convention. While this case did not involve a taxi ride to the airport, it played a critical role in interpreting the term "accident." The court ruled that an accident under the convention must be unexpected or unusual in the context of air travel. This suggests that courts are likely to limit the concept of embarkation to incidents directly related to boarding the aircraft, rather than pre-boarding activities such as a taxi ride to the airport.

In *Day v. Trans World Airlines*[3], the Second Circuit considered whether injuries sustained on a shuttle bus operated by the airline were covered by the term “in the process of embarkation.” The plaintiff had been injured while boarding an airline shuttle bus that transported passengers from the terminal to the aircraft. The court determined that this incident fell within the scope of embarkation, emphasizing that the shuttle, as an airline-operated vehicle, was integral to the boarding process. This interpretation reinforced the notion that “embarkation” can include activities closely related to boarding when those services are provided directly by the carrier as part of the flight journey.[1]

In *Chutter v. KLM Royal Dutch Airlines*[4], the Southern District of New York analyzed whether an injury in an airport terminal could be considered as occurring during embarkation. The plaintiff had been injured within the terminal, at a distance from the boarding area. The court concluded that this incident did not fall within embarkation since the passenger was not yet in close proximity to the aircraft, nor was he under the direct control of the airline. This case suggested that simply being in the terminal is insufficient to constitute embarkation; instead, a closer connection to both the carrier and the boarding process is necessary.[3]

In *Evangelinos v. Trans World Airlines*[5], the Third Circuit addressed whether passengers injured in a terrorist attack within the airport terminal could be considered as “in the process of embarkation.” The passengers were in a secure, designated area of the terminal close to the boarding gate. The court found that these passengers were indeed in the process of embarkation, given that they were in a controlled space managed by the airline and intended for boarding purposes. This ruling highlighted that pre-flight activities occurring in a carrier-controlled area may fall under the definition of embarkation.[4]

In *McCarthy v. Northwest Airlines*[6], the First Circuit reviewed a case where a passenger slipped in the terminal while waiting to board. The court ruled that this fall did not meet the criteria for embarkation, as the passenger had not yet reached the boarding gate or entered a zone under airline control. The court distinguished between embarkation and general terminal activities, underscoring that embarkation requires the passenger to be actively involved in the boarding process within a controlled area linked closely to the aircraft.[5]

In *Singh v. North American Airlines*[7], the Eastern District of New York determined that an injury sustained in the airport terminal did not constitute embarkation under the Montreal Convention. Here, the court held that embarkation had not begun because the passenger was outside the secure gate area and was not directly interacting with any airline-controlled equipment or personnel related to the flight. This case reaffirmed that, to fall under embarkation, there must

[2]470 U.S. 392 (1985).
[3]528 F.2d 31 (2d Cir. 1975).

[4]132 F. Supp. 611 (S.D.N.Y. 1955.
[5]550 F.2d 152 (3d Cir. 1977).
[6]56 F.3d 313 (1st Cir. 1995).
[7]No. 05-CV-4629, 2006 WL 1384306 (E.D.N.Y. May 17, 2006).

be spatial proximity to the aircraft and a clear element of control by the carrier.[6]

In general, the courts have consistently interpreted embarkation in a limited way, focusing on the act of boarding the aircraft and events in the immediate vicinity of the airport. This suggests that activities like taxi rides to the airport are not considered part of embarkation since they are not directly tied to the physical boarding of the aircraft.

Most decisions emphasize that embarkation is closely linked to the timing and proximity of getting on the plane. A taxi ride to the airport, being a broader journey, is seen as too removed from the actual boarding process to fall within the scope of embarkation.

Furthermore, the courts typically highlight that the airline's responsibility for passenger safety begins at the airport and extends through disembarkation. This distinction implies that the airline's responsibilities do not extend to the general journey to the airport, but rather begin once the passenger arrives at the airport and is preparing to board the flight.

In conclusion, the prevailing view in case law is that a taxi ride to the airport does not qualify as embarkation under Article 17 of the Montreal Convention. Courts generally restrict embarkation to the act of physically entering the airport and preparing to board, excluding the journey to the airport itself. This narrow interpretation is in line with the convention's objective of assigning liability for incidents directly connected to the boarding process.

In summary, while traditional aviation law has established clear parameters for liability under Article 17, the rise of AAM introduces uncertainty regarding the interpretation of "embarking." Whether air taxis and other AAM vehicles are considered part of the embarking process will likely be influenced by future legal precedents, technological advancements, and the evolving nature of air travel regulations.

8. CONCLUSION

The rapid rise of AAM introduces substantial legal questions, especially regarding how established air law frameworks, such as the Montreal Convention of 1999, should apply to these novel forms of passenger transport. AAM encompasses air taxis and similar transit options that facilitate short-distance travel, often connecting city centers with airports. This essay explores how AAM could challenge and reshape traditional views of liability under international air law, specifically examining whether the Montreal Convention's provisions on liability apply to passenger injury or death involving an air taxi service. At the core of this analysis is whether an air taxi transporting a passenger to an international flight qualifies as part of the "process of embarkation" under Article 17 of the Montreal Convention.

The Montreal Convention governs the liability of international air carriers for passenger injuries, deaths, and delays when passengers are "in the process of embarkation, disembarkation, or while on board the aircraft." Historically, these regulations have primarily applied to commercial airlines on international routes, creating a system of strict liability and compensation. However, as AAM solutions, such as air taxis, increasingly operate within urban airspace and link to traditional aviation networks, it remains uncertain if such operations fall within the Montreal Convention's framework, especially in cases where incidents cause passenger injury or death.

Article 17 of the Montreal Convention establishes strict liability for air carriers if passengers are injured or killed while on board, embarking, or disembarking from an international flight. The notion of "embarkation" has been interpreted through various case law to encompass activities closely associated with boarding, but its exact definition remains flexible. Generally, embarkation is understood as involving a series of actions leading to boarding, including passing through security, waiting in designated areas, and moving toward the gate. However, the boundaries of embarkation have occasionally extended to include transport services like shuttle buses operated by airlines. Determining if an air taxi ride to the airport constitutes embarkation depends on elements such as the carrier's contractual obligations, the connection to the international itinerary, and the nature of the transport service.

AAM introduces unique complications for legal definitions of embarkation within the Montreal Convention due to its mix of ground and air transport elements. Traditional interpretations of embarkation rely on a specific spatial and temporal proximity to the boarding process. For instance, an airline shuttle bus directly delivering passengers to an international flight might be viewed as part of embarkation, depending on its integration with the travel itinerary. In contrast, AAM vehicles, which often provide access points spread throughout urban areas, may create a greater distance from main embarkation points. Furthermore, AAM operations often feature shorter travel times, and in some cases, such as unpiloted air taxis, may not follow traditional boarding processes. Given these distinctions, courts may face challenges when applying established principles of embarkation to incidents involving AAM, especially if the air taxi service operates independently from the international carrier.

If a passenger in an air taxi is injured or killed while en route to the airport, liability under the Montreal Convention could potentially apply if the air taxi service is considered part of the international journey. For liability to extend, the air taxi service would need to be closely integrated with the international flight itinerary, such as being included in the ticket or marketed as part of the airport transfer. If a carrier partners with an AAM provider for direct terminal transportation, it may be possible to extend liability under the Montreal Convention. However, if the air taxi operates independently from the airline, responsibility would likely fall under national laws governing general aviation, which do not offer the same protections as the Montreal Convention.

This division in legal treatment could create inconsistencies and lead to gaps in passenger protection. While the Montreal Convention provides a well-defined framework for liability in international air travel, it does not cover the unique operational models and technologies that AAM brings. To ensure passenger safety and clarify carrier obligations, an interpretive shift or regulatory change may be necessary. This might entail developing new standards for liability in AAM contexts or expanding the definition of "embarkation" to include a broader scope of pre-boarding activities. Regulatory bodies, including ICAO, could play an essential role in aligning international air law with AAM by either amending the Convention or creating supplementary protocols.

Insights from case law and comparative legal analysis help illustrate how courts have addressed similar issues previously. In cases involving injuries during transport via airline-provided buses or other ground services, courts have sometimes determined that these transports are part of the embarkation process if they are contracted by the carrier. By drawing parallels between these instances and AAM, a case could be made for extending Montreal Convention liability to air taxi incidents directly linked to an international flight. Conversely, cases involving injuries on independently operated transport services may indicate that liability lies outside the Convention when the service's connection to the international flight is too remote.

In conclusion, the expansion of AAM necessitates reconsidering the Montreal Convention's relevance to intermediary air transport modes, such as air taxis. The question of whether liability extends to these services depends heavily on interpretations of "process of embarkation," but existing frameworks may struggle to account for the logistical and operational complexities that AAM introduces. Legal authorities may ultimately need to update air law to incorporate AAM-specific liabilities, especially as these vehicles become part of the larger aviation ecosystem. With AAM likely to become a critical link between urban areas and international flights, updating the Montreal Convention or creating complementary legal frameworks may prove essential to maintaining consistent and effective passenger protection as air mobility continues to evolve.

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