KPMG

Integrating air mobility into wider infrastructure

Readying physical infrastructure for advanced air mobility

Aviation 2030 series

"AAM has the potential to change how people and goods move around and between cities. Many cities around the world are already building AAM into their roadmaps, strategy and policy as they face challenges of congestion and pollution. Real estate developers and planning authorities should consider how they want to shape connectivity in their cities. Clear long term plans and associated political leadership is essential to reaping the benefits that AAM will bring."

Duncan Walker, CEO, Skyports

"AAM has the potential to positively influence those living with a disability on a global scale. In order to deliver this promise it is vital that alongside the solutions found for the technical and infrastructure requirements of future flight, that the practicalities of access for all are baked into the DNA from the beginning. Otherwise AAM becomes a tool which negatively impacts society, segregating and facilitating parts of society, not all."

Mike Miller-Smith MBE, CEO, Aerobility

As the world's transport infrastructure groans under the twin pressures of chronic underinvestment and rising demand, cautious (and sometimes less cautious) optimism around advanced air mobility (AAM) continues to build. Governments, investors, and OEMs are racing to turn futuristic visions into reality, promising a new era of revolutionized inter and intra-city travel and the creation of a multi billion dollar market in the process. AAM covers a variety of technologies and use cases, including electric vertical take-off and landing (eVTOL), electric short take-off and landing (eSTOL), and unmanned aerial vehicles (UAVs), and promises to improve medical and emergency relief, B2B logistics, B2C delivery, and eventually tourist and commuter journeys. But whilst much is written on the many types of aircraft and the propulsion systems that will drive them, AAM will lag as a niche element of global transport systems until it can be incorporated into existing mainstream transport infrastructure.

"It is time for planning authorities and real estate developers to step up and develop the vertiport landing infrastructure that this industry needs. Those that do will reap the benefits of being an early mover with the attraction of investment.

Without vertiports in new locations that people want to go to there can be no transport revolution. There is not much point developing these clean, quiet aircraft that can take off and land vertically if we don't maximize their potential by breaking the nexus between aviation and existing aviation infrastructure"

Clem Newton-Brown, CEO, Skyportz

Multi-modal hubs: building blocks of the AAM ecosystem?

Today's public transport flows revolve around multi-modal hubs, or stations. These vary, but the most complex already integrate the whole range of existing ground transport options, including long-distance rail, bus, metro, tram, and taxi, connecting different modes to facilitate seamless journeys into, around, and out of the city. But with most of the world's transport grids under strain and accelerating urbanization promising greater pressures to come, most governments are in urgent need of innovative solutions to enhance existing capacity – presenting a natural opportunity for AAM.

Whilst many AAM cheerleaders are understandably excited by the prospect of easy door–to-door connectivity, we believe that – for passenger transport – suburban park'n'ride and multimodal hubs are more natural entry points for such technologies into the transport mix. Last-mile connectivity is already relatively well-served, whilst integrating AAM into already familiar systems in complementary rather than antagonistic ways should lessen their disruptive potential and soften accusations that they are merely another incarnation of travel elitism. Done right, AAM can integrate with multi-modal hubs to provide high speed, user-oriented, and environment-friendly transport, facilitating urban and rural economic growth.

Though the infrastructure would be mostly common for either door-to-door or hub-oriented models, the safety analysis, business case, and risk assessment would diverge markedly between the two, with the main hurdles likely to come from building safety standards and air traffic management rules suitable to handle AAM services at hubs, which tend to lie in congested urban areas servicing high volumes of people.

"Don't buy the hype around imminent high volumes of downtown AAM – aside from vehicle certifications and regulation, tangible and intangible infrastructure are real bottlenecks. Early use cases for commercial drones and then larger passenger or piloted vehicles are more likely to involve coastal cities and suburban and rural settings, with an initial focus on cargo delivery and air ambulances where there are significant economic, social and environmental benefits. That is a positive for urban planning, as it gives the requisite time to start integrating the required thinking now."

Chris Brown, Partner, KPMG in Ireland

What is required? AAM-specific infrastructure needs

Widespread integration of the various AAM types into existing public transport infrastructure will demand a range of specific infrastructural needs. The exact infrastructure to be implemented depends on a multitude of considerations including use case (moving people, moving goods, emergency services, etc.), anticipated volumes, availability of existing infrastructure for retrofit (e.g. helipads, low utilization airfields) and the return on investment hurdles of its backers. Generally, public and private players expect 3-5x on every dollar invested to make infra economically viable, but this would be driven by risk appetite, existing readiness and local political support.

Landing infrastructure

eVTOL craft will need vertiports throughout their intended areas of operations, which might involve a whole range of urban and suburban sites including business rooftops, water facilities, car parks, transport hubs, and purpose-built independent facilities. eSTOL craft will need appropriate runways in and around urban environments and proposed new routes, while delivery drones will need designated landing sites throughout cities if they are to service business and domestic customers. Cities should aim to work smarter, not harder. In an environment with ample space or an existing underutilized airfield, a vertiport (and therefore larger vehicle types that can only take off and land vertically) is likely the wrong solution.

Communication infrastructure

Smaller drones will likely remain unable to plug into existing ATC channels due to the weight of conventional aviation transponders and are therefore likely to require their own ATC systems, built around bespoke regulatory frameworks. However, for larger cargo and passenger carrying aircraft, a conventional transponder (e.g. ADS-B) will likely integrate them into conventional airspace. This is not an issue in the early days of AAM, but as volumes scale past 2040, today's manual ATC processes would become a bottleneck.

> **"Land infrastructure will be a realistic bottleneck in AAM's development. For REGENT's water take-off and landing model, we anticipate lower infra costs and greater flexibility for coastal cities. Seaglider operations will leverage existing ports, requiring only minor modifications to charging and maintenance facilities that will also serve electric ferries. We envision seagliders to be a vital part of a multi-modal transportation system, and encourage developers and relevant authorities to consider co-location of vertiports and STOLports with sea glider terminals at hub airports and harbors. Planning for a seamless passenger experience is critical to the future of a sustainable and effective transit system."**
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> Billy Thalheimer, CEO, Regent

> **"As builders of aerodrome and terminal facilities today, we see the potential of AAM and its infrastructure implications. This may involve pragmatic tweaks to today's quieter airports or purpose-built stations in suburban locations. While grid upgrades for electrical charging, or on-site hydrogen production are bottlenecks to overcome, smaller vertiports can realistically be developed for a relatively modest level of capital investment allowing for flexible network growth at a fraction of the price of road or rail investments."**
>
> Freddie Patterson, Chairman, Lagan Construction

Navigation infrastructure

With greater traffic at lower altitudes in and around the urban environment, new navigational systems will be critical, which will necessitate the deployment of both hardware (VRPs, emergency landing sites, sensors, lighting) and software.

Security infrastructure

Cyber security, data privacy, and geofencing will all be essential for larger social acceptance. With safety paramount and AAM presenting bad actors with a range of new targeting possibilities, robust protection against cyber threats and vulnerabilities will be indispensable.

> "As the AAM market develops the need for advanced cybersecurity becomes imperative. Data and connectivity need to be completely trusted and made secure. This includes securing 5G and Satellite connectivity to and from Drones and Infrastructure, and from Drone to Drone, which in turn needs the physical infrastructure to support that connectivity. To ensure the safety of operations it is paramount that the infrastructure is made secure along all steps of the air journey: all the way from vertiports to drone corridors. Additionally, to scale, there is a need to operate cross-border and across long stretches of water, as is managing the interface between civil and military traffic air spaces.
>
> Steve Berry, Executive Chairman, Angoka

Charging stations

To support envisaged levels of traffic, a dense network of reliable and rapid hydrogen and electric charging facilities will be necessary. For quicker turnaround times of electric vehicles at vertiports, some OEMs (e.g. Volocopter) prefer battery swapping. Though this technique could potentially reduce the down time, specific infrastructure and skilled manpower would be needed.

Parking facilities

The thousands of projected aircraft will all require safe and convenient parking during off-peak hours, within range of their area of operations. Based on the geographical location, facilities may need to be covered and equipped with de-icing infra to protect vehicles and improve turnaround time.

> "As architects in the aerodrome and terminal planning space, we believe the physical infrastructure implications for AAM are substantial, though relatively compact. While requiring minimal land compared to traditional airports, the infrastructure needs to be designed and developed to support the unique features of AAM vehicles, including their smaller size, electric propulsion systems, and autonomous capabilities."
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> Gary McConville, Director, Todd Architects

> "Despite the airside environment being more complicated than landside from an overall operations point of view, existing regulations and the proposed design guidelines for Vertiports from both EASA and the FAA leverage the existing rules and regulations of current airport design infrastructure. Therefore, we feel that designing out from an airport as the first point in the AAM network makes the most sense. We anticipate unique planning challenges, that will be more difficult to solve on a per Vertiport basis, as we move landside into urban environments."
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> Russell Vickers,
> Future Mobility Campus Ireland

Fit-for-purpose travel infrastructure will anticipate AAM at every level

Since AAM's most exciting characteristic is its versatility in being able to operate at all levels of the transport system, every level of the existing infrastructure will need to plan to accommodate it. We see a need for ecosystem designers to plan infra across three different levels: at a national and regional level to equip authorities with the appropriate infra for inter-city / inter-region journeys, at a city level to gear up urban areas for both inter-city and intra-city, and at a building level to ensure independent structures are adequately designed to handle relevant AAM formats.

State or regional level

- Top-down incentives on underserved points in the economy for which the cost-benefit of conventional infrastructure spend (e.g. rail, road, tunnel and bridge) does not stack up.
- Establish reference points to assist navigation for low-level flight during equipment failure.
- Upgrade communication infrastructure; existing air traffic control (ATC) services may be inadequate, warranting new frequencies / channels for proposed routes.
- Mandate landing sites with basic service capabilities along proposed higher frequency routes to facilitate landing during sudden adverse weather and to address minor aircraft issues.

City level

- Incorporate AAM take-off and landing sites during city/ township planning phases. For first generation, this may be disproportionately near water and in suburban sites for regulatory pragmatism.
- Redefine multi-modal connectivity hubs to include AAM options as force multipliers to existing services.
- Consider associated support facilities near hubs (e.g. emergency services).
- Identify grid bottlenecks and plan for charging / refuelling site and access requirements.
- Demarcate landing sites to comply with emergency landing rules in congested areas, e.g. certain aviation authorities mandate vehicles fly high enough to land clear of congested area in case of power failure. However, low level flying of AAM vehicles may warrant additional sites to be earmarked for emergencies. Consider associated road widths for emergency use and contingency plans for road traffic rerouting.

Real estate level

- External facades of buildings need to be designed to ensure internal noise levels remain within acceptable limits if AAM services were to operate nearby or land on roof tops.
- Structures need to be designed to cope with the additional load and vibration during eVTOL landings. Similar to Japan's approach to skyscrapers and emergency helipads, new build high rises (or a % thereof within given districts) should be designed to handle such additional loads as default.
- Structures need to consider provisions for onsite battery banks, rapid recharge facilities and / or hydrogen piping.
- Additional firefighting services need to be planned if AAM vehicles are to land on roof tops.

> **"Vertiports will initially be based at existing airfields and heliports, as lower emission and quieter eVTOL aircraft replace helicopters, and given the ease of starting operations at an existing aerodrome. In an urban environment, we anticipate contradictions in terms of where vertiports can be built and where they are most wanted. For example, historic areas of affluence (e.g. older districts in Paris or London) have limited space for large greenfield infrastructure, not to mention considerations around aesthetics, noise and privacy."**
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> John Arbuckle, Partner & Head of Aviation, Gerald Eve LLP

Who's involved? Key stakeholders and roles

Inevitably, upscaling today's highly complex and multidimensional transport infrastructure systems will involve many stakeholders across the private and public sectors. Modern transport systems are highly evolved ecosystems depending on multiple providers of both hardware and software, locked into co-dependence. Governments are the natural instigators for systemic change efforts, since only they have the power to create and promote relevant legal frameworks and standards, and they are the ultimate guarantors of safety and stability at the systemic level, through policy and regulation. They can lead change not only through legislation but by creating sandboxes and other fora for operators to pilot regulations and systems appropriate to their jurisdictions. Below we break down specific stakeholder responsibilities as we see them.

Central government: should establish national policy guidelines, statutory bodies (e.g. special planning authorities) and committees charged with approving, monitoring, and certifying AAM infrastructure development to appropriate standards. Relevant departments of government should be conscious that municipal/local authorities often wait for the right top-down signs rather than risk looking outlandish – central departments of infrastructure and transport should therefore be actively encouraging and name-dropping AAM.

Municipal/Local authorities: can facilitate AAM deployment at the local level by: making AAM infrastructure a routine consideration in town planning and major development processes; allocating budgets to AAM infrastructure; developing private partnerships to expedite development of AAM infrastructure where possible; developing regulated income streams from AAM infrastructure operations.

AAM OEMs & infrastructure suppliers: will be responsible not only for initial development of the infrastructure itself but also routine maintenance. In addition, they can catalyze the sector's evolution through government lobbying on development policy and sandboxes. To be credible, operators will need to remain abreast of the latest concepts and technologies, in possession of all relevant licences and certifications, and know which solutions are appropriate for their proposed built environments and geographies.

Questions to answer

Inevitably, such a highly dynamic and early-stage industry has yet to establish its core practices. In particular, we see emerging conflicts over these four critical questions:

1 Business model for ground infra development

- Operator / OEM specific: in which the eVTOL manufactures strive to build specific infra to suit only their vehicles. This would lead manufactures to form a franchised network, partnerships, or sub-contracts. e.g., Volocopter intends to build their own infra for their vehicles.

Vs.

- Multi-vehicle: in which infrastructure would be developed per local constraints but aiming to accommodate as many AAM vehicle types as possible, giving greater flexibility and reducing ground infra spending.

2 Infrastructure designs

- Standardized: in which regulatory bodies would approve and mandate key infrastructure designs, e.g. in Dubai, Skyports has an approved vertiport design, allowing for quicker implementation and less complex site-specific approvals.

Vs.

- Variable: in which vertiport design would be customizable to suit local factors, which should better accommodate external constraints and promote flexibility.

> "Belgium is a classic example of how difficult build out of an AAM ecosystem can be, needing coordination between cross-border, national, regional and local policy makers. Local councils, planning approvers and real estate developers take a risk if not clearly aligned with aviation regulators. Clarity boosts enterpreneurship especially in an ecosystem setting."
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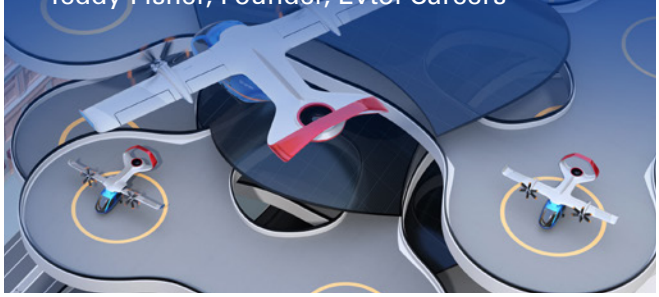
> Ozturk Taspinar, Partner, KPMG in Belgium

> "Israel's small size, its mild climate, and openness to adopting new technologies makes the country a prime candidate for introducing eVTOL solutions to solve its lingering congestion problems. Israel has been at the forefront of unmanned defense systems for decades, and has succeeded in developing an innovative eVTOL technological ecosystem. The country's challenge now to support next generation urban mobility will be to adopt a whole-of-government approach needed to lower regulatory hurdles and create conditions for establishing the right national and local infrastructure."
>
> Erez Henig, Special Advisor, KPMG in Israel

> "While commercial eVTOL flights are still in development, drone delivery services are experiencing rapid growth. A particularly promising area is medical logistics, with companies such as Zipline and Skyports making significant strides. As for passenger use cases, we expect the Middle East to pioneer much of the real-world physical infrastructure build out and integration into car-centric networks."
>
> Teddy Fisher, Founder, Evtol Careers



3 Funding initial infrastructure costs

- Government-owned and operated: in which governments would fund construction and generate revenue from operations on an ongoing basis.

Vs.

- Private: in which private players would build and operate infrastructure, and charge users to recover the cost, before either transferring the assets to or sharing the revenue with government.

Vs.

- Hybrid: in which governments can consider leasing their real estate and/or providing trunk infrastructure to private operators to build specific AAM infrastructure, in return for revenue sharing arrangements.

4 Maintenance and servicing

- Brand-led: in which each brand of operator, vertiport, vehicle, and technology equipment leads maintenance of their own infrastructure in a vertically integrated supply chain. At larger stations, this might result in multiple maintenance providers side by side, and lead to increased service times due to dependencies. However, this would be more reliable in a swiftly evolving industry.

Vs.

- Third parties with a consolidated approach: in which trained contractors would service the multiple infrastructure dimensions (civil, tech, electrical, etc.) on a station by station basis, potentially enabling greater speed and fewer dependencies.

> **"The future is here and we need to catch up when it comes to city planning and developing infrastructure to support the AAM industry. We need to be looking at rooftops, car parking spaces, open spaces and allocating areas for drone and eVTOLs to carry out deliveries or drop off and pick up passengers. Our mission at Avtrain has always been to encourage prolific drone operations and keep the skies safe through the highest standards of training and certification – to achieve the volume of operations envisaged for the future we need to be working with city planners, architects, developers along with the aviation and airspace regulatory authorities and designing the cities of the future...now."**
>
> Julie Garland, CEO of Avtrain

> **"There is a huge concern around the commercial feasibility of drone cargo operations due to the high amount of manual handling that is required in ground processes. The long term solution therefore needs to automate all key processes in drone charging, drone storing, parcel loading/unloading and inventory management to ultimately enable completely remote drone operations."**
>
> David Park, Co-founder of Inteliports

Conclusion

The much-anticipated AAM revolution will have to be underpinned by dramatic upgrades in existing national transport infrastructure, presenting commercial opportunities and operational challenges for the whole transport ecosystem. To conclude, we consider some possible next steps by stakeholder type.

National policy makers

- AAM infrastructure development won't happen in a vacuum; policymakers will need to provide frameworks and standards at the national level.
- Conduct simulation studies to understand traffic flows around multimodal hubs to determine potential AAM routes.
- Mandate for municipal authorities, urban planners, and private organisations to consider AAM infrastructural needs during all major development planning.
- Elaborate responses to the up-front funding challenge, e.g., public-private partnerships.
- Outside of large metropolitan areas already attracting pure private sector interest, consider economic, social and environmental cost-benefit studies that quantify the wider spillover benefits of bringing AAM to smaller urban and rural communities.

Municipal authorities

- Incorporate site allocation for AAM infrastructure (landing, take-off, charging, parking) to the planning phase of major new developments.
- Conduct feasibility studies to understand constraints for AAM in urban areas.
- Evolve building regulations to account for likely AAM requirements, e.g. mandating minimum load-bearing capabilities for top terraces.
- Consult widely to gauge social acceptance levels and anticipate public concerns on safety, privacy, noise and emissions.
- Similar to the national level, conduct economic, social and environmental cost-benefit assessments on proposed routes, considering land use and comparisons to mobility alternatives.

Physical infrastructure and AAM vehicle manufacturers

- Define technical infrastructure requirements for different AAM vehicles considering relevant geographical, environmental and technological factors.
- Bring forward workable retrofitting solutions for existing infrastructure, e.g. heliports for eVTOLs, defunct airfields for STOLs.
- Commission economic, social and environmental cost-benefit assessment on proposed routes, pre-empting pushback on noise and carbon emissions perceptions.
- Liaise with government bodies to explain economic benefits of AAM infrastructure, e.g. increased tourism and employment.

Communication and navigation equipment OEMs

- Conduct surveys on proposed AAM routes to understand the unique infrastructure requirement dependent on terrain, weather, security, and other local factors.
- Partnerships are likely to be needed to ensure robust cyber security and tamper-proof communications between AAM aircraft and communication infrastructure.
- Champion geofencing measures to control infringement of drones in sensitive areas.

Charging solutions providers and battery OEMs

- Explore the likely extent of fast-charge facility requirements and communicate to relevant public and private stakeholders.
- Understand existing grid capacities and anticipate new demand requirements.
- Innovate to minimise aircraft turnaround time, e.g. through battery swaps rather than holding aircraft for charging.
- As charging infrastructure, including grid upgrades, will be a key bottleneck, those infrastructure builders which already have in-house engineering solutions will be at an advantage.

Hydrogen suppliers

- Liaise with municipal planners and emergency services to develop robust risk mitigation measures around hydrogen storage.
- Anticipate hydrogen demand and appropriate supplies. For rural sites close to renewable generation, consider onsite production opportunities.
- Anticipate fuel-specific infrastructural and regulatory blockages such as road widths for supply trucks, planning constraints for pipelines and safety regulations.

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