UK Urban and Regional Air Mobility

Key Considerations

www.eamaven.com

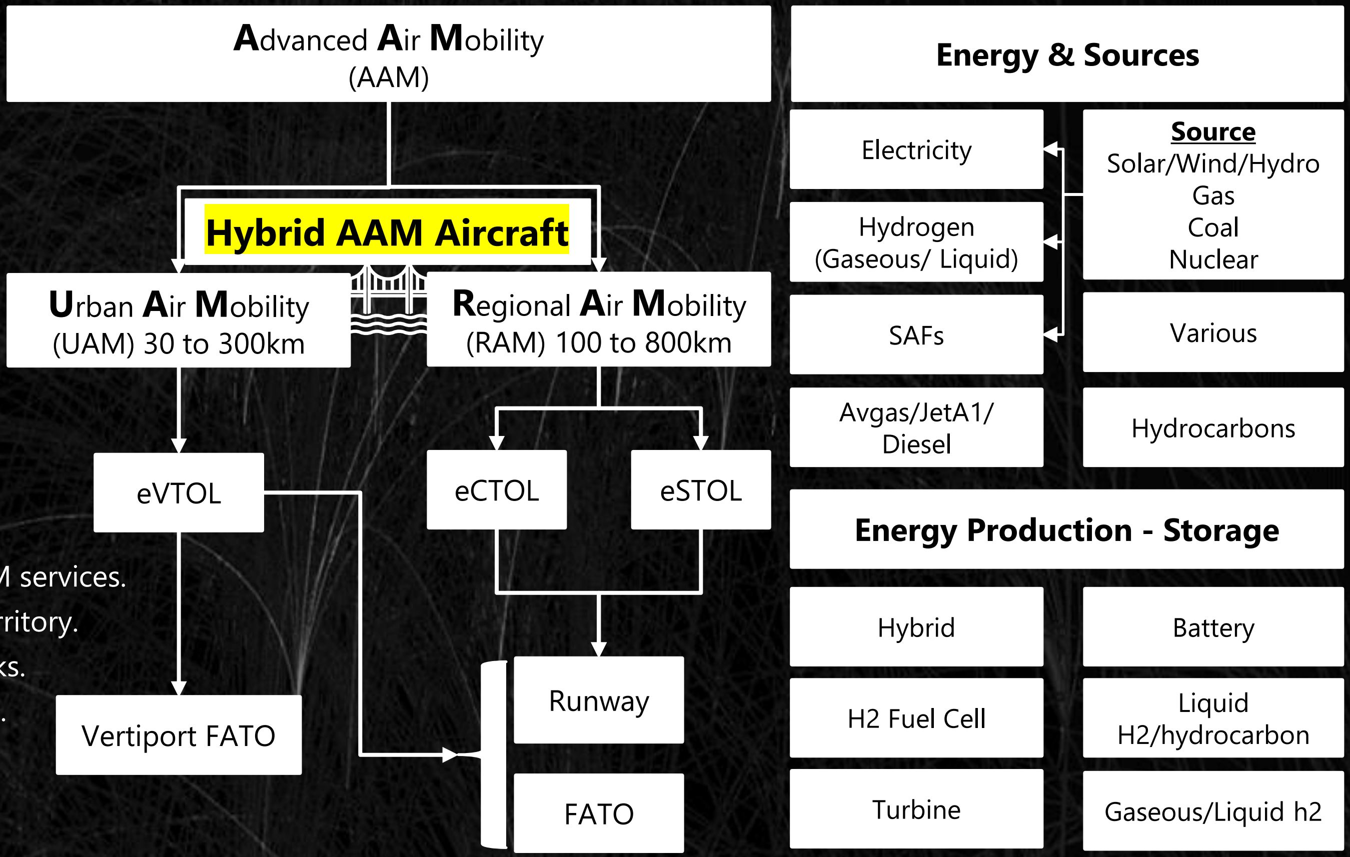
Electric Aviation Background

Key Considerations

Advance Air Mobility

EA Maven's Approach

- Urban Air Mobility describes a market which is typified by routes with a range between 30 and 300 km served by eVTOL aircraft at specialised vertiports or existing airports with suitable infrastructure to support operations.
- Regional Air Mobility is a sub section of Regional Aviation which is distinct from the Commuter Aviation market
- Regional Air Mobility is defined by trips that are of high value to the passenger who would otherwise spend significant time on other surface modes of transport.
- This is driven by airline operating economics in that the volume of demand for Sub Regional Aviation is below the threshold for commercially viable services



AAM HORIZON

H: Hybrid - A nod to hybrid propulsion systems expanding operational range.

O: Opportunity - Capturing the emerging market potential for extended AAM services.

R: Range - Overcoming traditional UAM limitations and extending into RAM territory.

I: Integration - Seamlessly merging urban and regional air mobility frameworks.

Z: Zoom - Focusing on speed within aerodynamic and passenger comfort limits.

O: Optimisation - Balancing technology, efficiency, and user needs.

N: Next - Representing the next phase in AAM evolution.

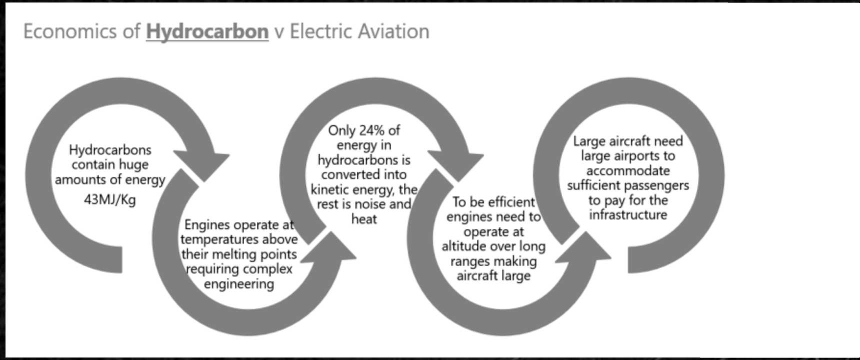
HORIZON represents forward-looking innovation and the expanding boundaries of what is possible in air mobility, symbolizing the industry's continuous growth and redefinition.

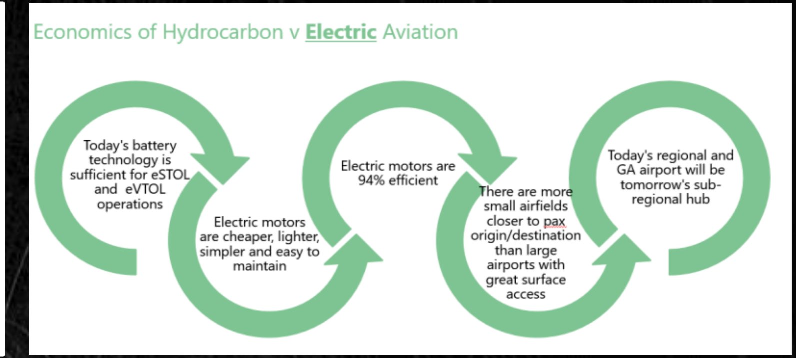
AAM as enabled by electric propulsion system architectures which is agnostic with regards to energy source and storage system (Battery, Hydrogen (gas/liquid), Hybrid, SAFs, Hydrocarbons

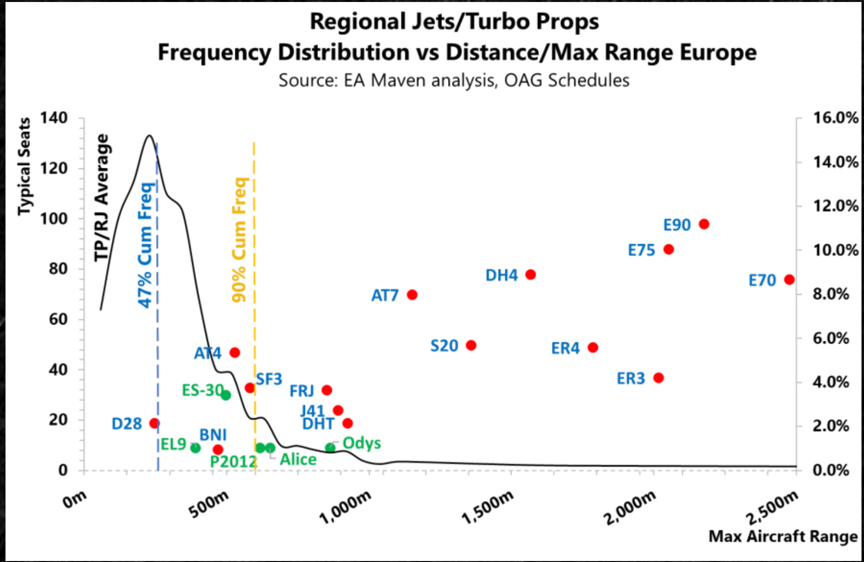
Electric and Hybrid Aviation Background

Hydrocarbon vs Electric

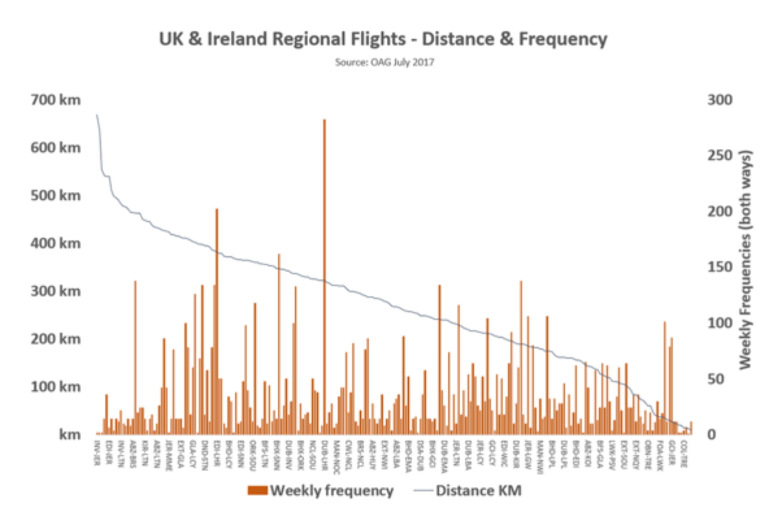
- Electric Aviation presents us with an unprecedented opportunity in the aviation sector not seen since the very early days of aviation. This innovation has come about through the incremental development of electric propulsion systems which has its roots in electric car manufacturing.
- **The Economics of Hydrocarbon Aviation v Electric Aviation**
    - In this new world the economics of aviation are upside down. In this case traditional hydrocarbon powered aviation favoured large aircraft and large airports to pay for effectively the energy density of Jet A1. As engine technology evolved the complexity increased requiring aircraft to be larger, carrying more passengers over longer distances. This in turn required larger airports to be able to pay for the whole system.
    - Conversely electric aircraft due to their lower capital, operating and maintenance cost will be able to operate out of smaller airfields at lower costs which may be closer to the passenger's true origins and destinations.
    - With reference to regional aviation, we identified a trend whereby regional aircraft manufacturers are developing aircraft with more and more range and seat capacity whereas airlines peak average sector length is only 200nm. In this case we have aircraft with a range of up to 2,500nm being operated on sectors of 200nm or only 8% of their range capability. In this case electric aviation has the potential to operate in this 'sweet spot' thus addressing almost 50% of aviation carbon emissions which have been identified by sectors flying less than 500km.







The significance of this chart is that it demonstrates that 90% of flights in Europe using Turbo Prop and Regional Jets are less than 575 miles , yet these aircraft have ranges up to 3000 miles



eS/CTOL could access +90% of the 249 airport pairs

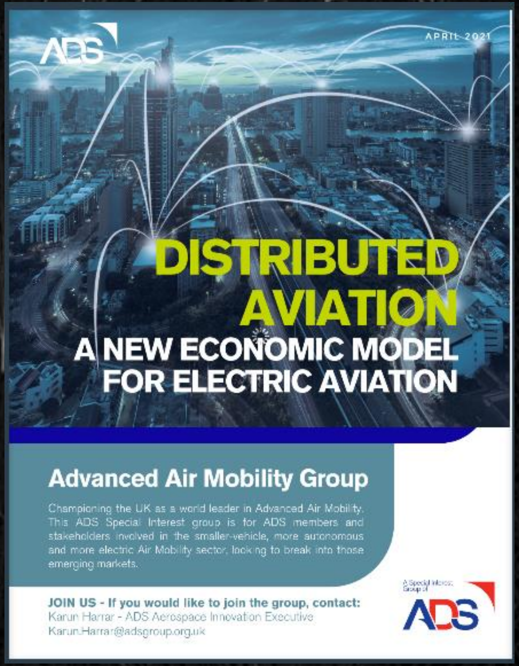
Electric and Hybrid Aviation Background

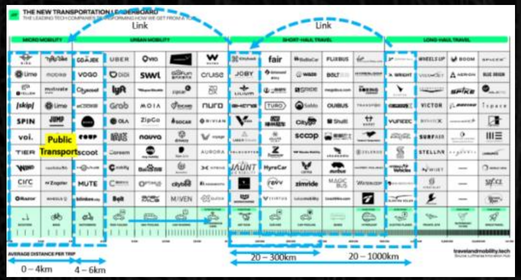
The Rise of Distributed Aviation

- The opportunity presented via electric propulsion is that we can develop a distributed aviation system that allows us to make the best use of existing aviation infrastructure while still increasing regional connectivity leading to increased economic benefit. The evolution of a distributed aviation system is set out below:
  - Electric propulsion will disrupt the current sub regional aviation system that will lead to a future of distributed aviation.
  - Electric low-cost sub regional airlines (eLCCs) will operate on thinner routes enabled by lower capital, operating and maintenance cost of electric propulsion systems.
  - A quantity of sub-regional traffic will distribute away from the current hub and spoke system of airports (international & regional airports) to secondary and smaller airports.
  - eLCCs will operate out of secondary and general aviation airports due to their lower charges, available capacity, and closer proximity to markets which are viable even though they are uneconomic for hydrocarbon powered airlines.
  - Fixed wing electric aircraft will take passengers over longer distances where passengers will transfer onto either local transportation services or an eVTOL for access into large urban environments. As technology permits direct city center to city center eVTOL operations will be established.
  - A distributed electric aviation system offers lower cost sub-regional flights closer to passengers' origins and destinations while helping reduce the carbon impact of travel.

https://www.adsgroup.org.uk/knowledge/distributed-aviation-a-new-economic-model-for-electric-aviation/

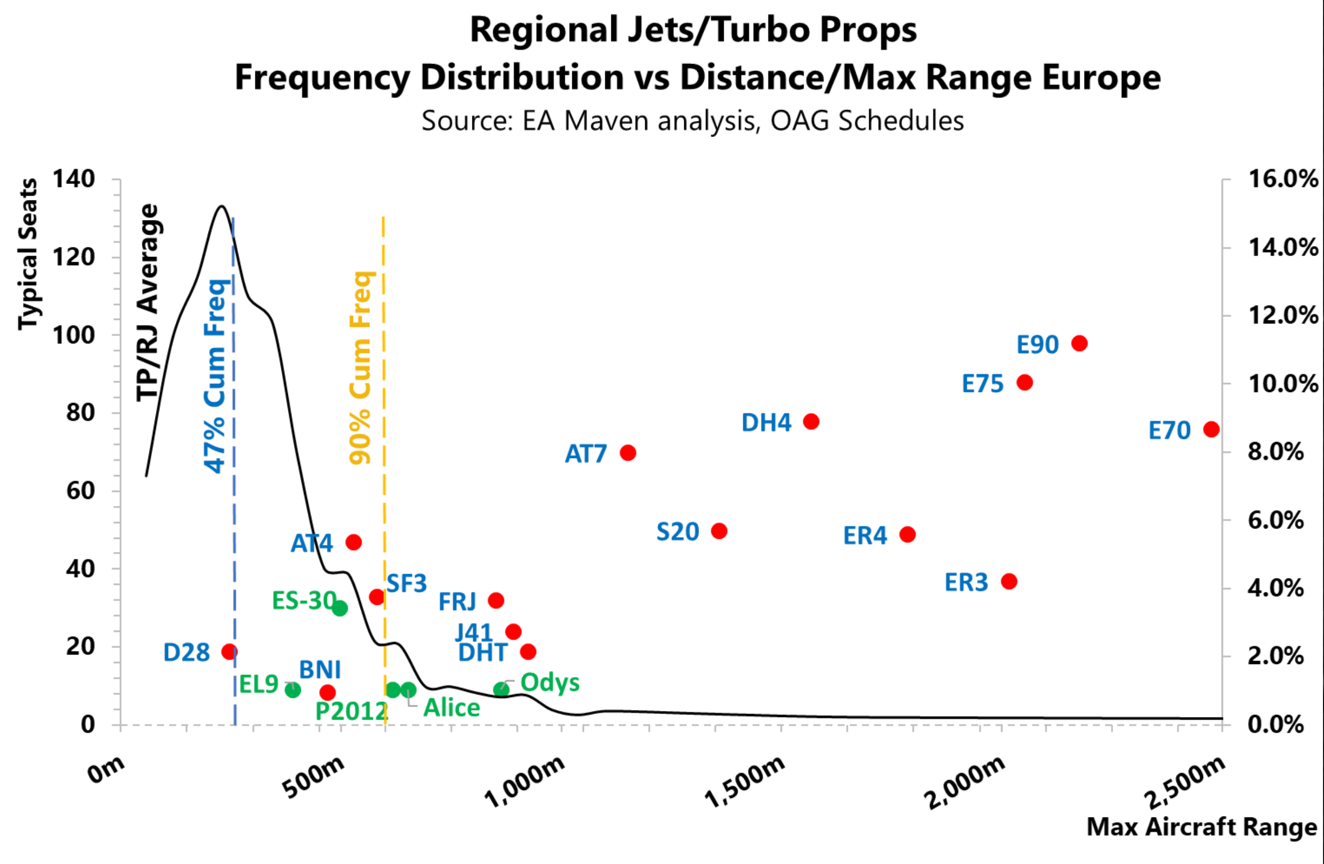
- Larger international airports may lose some domestic traffic but gain in terms of a reduction in the number of smaller less profitable routes which can be replaced with long haul international flights whilst still maintaining regional connectivity. This has the potential to make the best use of our existing hub airports and their precious runway slots whilst still accommodating growth.
- As electric aviation technologies develop, they will enable larger aircraft, they will be incorporated into our well-established aviation system helping the UK to meet its carbon commitments.





Electric and Hybrid Aviation Background

The Rise of Distributed Aviation



- 47% of frequencies in Europe are offered within 400km, and 90% of frequencies are within 900km.
- There is a clear demand for sub-regional services up to 1000km.

- Regional Jet/Turbo Prop Frequency Distribution & Cumulative Frequency in Europe outlining key aspect of Sub Regional Aviation aka Regional Air Mobility
- This sets out range consideration for RAM aircraft against a backdrop of Regional Aviation.
- With reference to the US and the commuter market, this should be considered separately and with great care as the market dynamics are very different from RAM.
- **Transitioning to regional point-to-point travel using economically viable eSTOL and eVTOL air vehicles will benefit the UK, Europe, and globally by fostering high-skilled job creation in infrastructure development and supporting services. This shift will also spur economic activity around new and existing vertiports and airports, enhancing regional connectivity.**
- **The anticipated increase in international travel allows smaller airports to handle more regional traffic, thus enabling major airports to expand long-haul operations without sacrificing regional links. Integrating sub-regional fixed-wing and vertical aviation with existing and new mass transit systems will improve regional connectivity and social inclusion.**
- **Furthermore, the adoption of electric and hybrid aviation promises a lower environmental footprint compared to traditional air and ground travel, supporting increased travel volumes without proportionate environmental impacts. While eVTOL and eSTOL journeys supplement sustainable surface travel, they also shorten the distance from origin to destination, making more locations accessible within the sustainable public and private transportation network.**

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The UK Drone Market: Opportunities for Local Authorities

Market Overview

- Projected market size: £84.5 million by 2029
- Over 45% of operators are Drone Service Providers (DSPs)

Key Use Cases Land Surveys & Inspections: Efficient data collection and monitoring

- Emergency Services: Search & rescue, disaster response
- Transport Management: Traffic monitoring, infrastructure inspection
- Environmental Monitoring: Coastal management, pollution tracking

Benefits

- Cost-effective solutions
- Reduced health and safety risks
- Improved service efficiency

Challenges

- Regulatory compliance
- Privacy concerns
- Need for skilled operators

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The UK Advanced Air Mobility Opportunity

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Our Approach – not top-down econometric guessing

Scheduling

- **Network Scheduling** – The demand for the system of operations is then put through a scheduling tool to develop linked schedules on an OD or network basis. Outputs include but are not limited to:
  - Aircraft required, Aircraft utilisation
  - Revenue generation, Energy requirements
  - Economic impact through time savings and many others.

Demand Modelling

- **Demand Modelling** – Using a modified airline forecasting methodology we then calculate the proportion of travelling public that would switch modes given a certain density of flight operations in the system. This gives us hourly profiles for passenger demand with an understanding of mode of transport they switched from, purpose of travel and time of day.

Indexing

- **Indexing** – Identifying all possible routes between airport catchments and or cities and applying filtering to identify the routes that are potentially viable. The results are then indexed.

Data

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did I say data?

- Mobility data, economic, income, airline schedules, fares, travel options, socioeconomic etc, etc, etc

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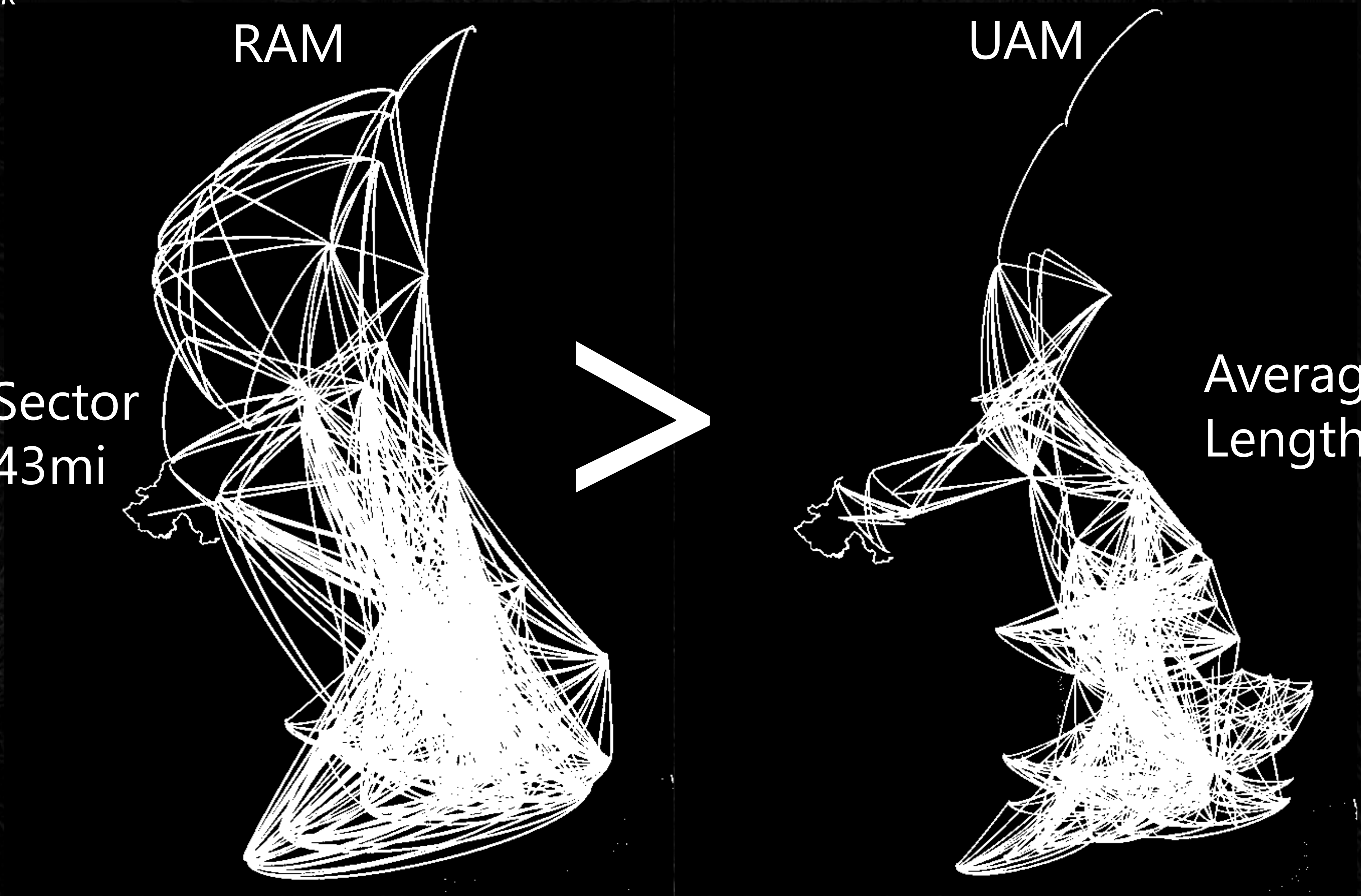
Total UK AAM Potential Summary

Routes Network



Average Sector Length 143mi

Average Sector Length 71mi

Total UK AAM Potential Summary

RAM		UAM
63/684 airports/routes	>	264/994 cities/routes identified with at least 96k travellers per year with 49 routes having over 1m travellers per year
TM – 430.7m travellers annually	>	TM – 316.8m travellers annually
82.5% of journeys by car producing significant carbon emissions	>	75% of journeys by car producing significant carbon emissions
21.9% business, 78.1% leisure/VFR travellers	<	33.3% business vs 66.4% leisure/VFR travellers
47.2m hours saved weekly/annually if switched to RAM 5.4k years annually!	>	27.8m hours saved weekly/annually if switched to UAM 3.2k years annually!

Based on LAU1 UK spatial division of 400 shapes. Each airport and its respective catchment based on the shape where each airport is located plus the adjacent shapes.
Total possible routings between all airports and their respective catchment areas with a minimum distance of 70 statute miles. Excluding routes touching London.
Sum of all travellers on 1,706 routes analysed. Demand numbers based on airports' catchment areas.

Cities selected based certain sifting criteria.
Total possible routings between all cities based on 3 main selection criteria: distance (50-120 statute miles), population (min 20k inhabitants per city), min travellers
Sum of all travellers on 994 routes analysed. Demand scaled down based on population distribution (city-city demand adjustment).
Based on mixed capture rates of top 994 routes. Time savings based on flight vs car/rail travel time ratios for biz and leisure. Economic stimulation based on the DfT WebTag data.

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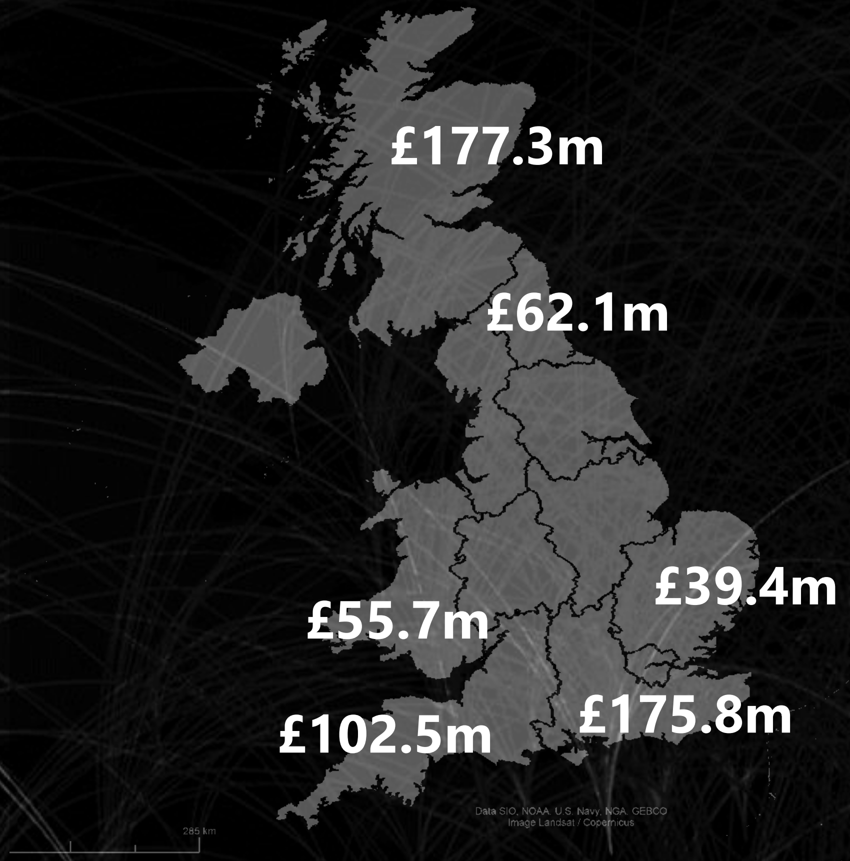
Total UK AAM Potential Summary

Economic Boost by Top Regions (annually)

RAM



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UAM

£1.1bn per year
Economic stimulation through increased productivity

615.9m per year
Economic stimulation through increased productivity

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Total UK AAM Potential Summary

Aircraft, Stands, Energy, Hydrogen & Carbon Emissions

RAM

Up to 1,5k aircraft required

448.3k/214.7k tonnes
Carbon emission savings (on people switching from cars and rail) annually assuming using 100% of SAF/JET A fuel

120.9k tonnes – H2 Aircraft
Carbon emission savings (on people switching from cars and rail) **annual** assuming using Hydrogen (22% of blue and 78% grey hydrogen)

2,730 GWh to create the 52m kg of hydrogen for an all-hydrogen system

UAM

Up to 2.2k aircraft required

905/314 stands/vertiports required

178k tonnes
Carbon emission savings annually

849.1 GWh
cumulative energy required annually

Assuming all routes are operated. Calculations based on a 9-seater aircraft; performance based on various OEMs. Annual aircraft utilisation at max 2000hrs.
Across all routes
CO2 emission of 9kg per 1kg of grey hydrogen and 2kg of CO2 per 1kg of blue hydrogen.

Assuming all routes are operated. Calculations based on a 4-seater aircraft; performance based on various OEMs. Annual aircraft utilisation at max 2800hrs
Across all routes

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Total UK AAM Potential Summary

Airline/Operator Revenues

RAM

£2.8bn Annual operator ticket revenue

£621m
Annual airport operator revenue from landing and ground handling charges

£203m
Annual airport operator revenue from passenger charges

>

UAM

£2.27bn Annual operator ticket revenue

£495.3m
Annual vertiport operator revenues from landing and ground handling charges

£100.9m
Annual revenues for vertiport operators from energy

£953m
Capital cost of infrastructure excluding planning application and design costs

[illegible] Cost structure based on EA Maven analysis derived from various

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UAM or RAM

Which is potentially more economically significant?

Measure	**RAM**	**< >**	**UAM**	**Total/Note**
Cities/Airports	63	<	264	327
Average Sector Length (mi)	143	>	76	
Potential Routes	684	<	994	1,678
Target market	430	>	316	
Hours Saved (m hours)	47.2	>	27	74.2
Economic Impact (£bn) increased productivity	1.1	>	0.61	£1.71bn
Operator revenues (£bn) tickets sales	2.8	>	2.27	£5.07bn
Routes/City or Airport	10.9	>	3.8	RAM is **3**x bigger than UAM
Economic Impact/City or Airport £m	15.9	>	3.8	RAM is **8**x bigger than UAM

- In terms of potential economic impact, RAM is 8.16x bigger than UAM
- This is because RAM offers more utility to travellers in terms of potential time savings and hence the ability for them to be more economically productive.
- An additional contributory factor is that the catchment area for airports in this study are larger than cities given the longer range of fixed wing aircraft attributing to increased utility of RAM flights. This approach is consistent with airport catchment area analysis.

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Total UK AAM Potential Summary

Carbon Emissions Savings – Regional Air Mobility

- The provided slide effectively outlines the environmental advantages of Regional Air Mobility (RAM) solutions, emphasizing their role in significantly reducing carbon emissions by transitioning passengers from traditional surface transport to RAM aircraft.
- <u>If RAM were implemented across all planned routes</u>, it could lead to the removal of over 11.4 million cars from roads annually. This shift translates into a reduction of more than 456,200 tonnes of carbon emissions per year. Additionally, including reductions from rail travel, estimated at 41,400 tonnes annually, total carbon savings would surpass half a million tonnes each year.
- Even if RAM operates using conventional fossil-fuel-based propulsion systems (Jet A/Av Gas), the initiative would still cut emissions by approximately 215,000 tonnes per year over 684 routes. For hydrogen-powered RAM operations, assuming a mix of 78% grey hydrogen and 22% blue hydrogen, annual carbon savings would still amount to 120,000 tonnes. However, grey hydrogen—produced through the steam methane reforming (SMR) process—poses environmental challenges, emitting between 9 and 12 kilograms of CO_2 per kilogram of hydrogen produced, primarily due to its reliance on fossil fuels.
- To achieve greater sustainability, transitioning from grey hydrogen to green hydrogen is essential. Green hydrogen, produced using renewable energy and water electrolysis, offers a cleaner alternative, supporting the reduction of greenhouse gas emissions and aligning RAM operations with long-term sustainability objectives.
- In summary, Regional Air Mobility presents significant environmental benefits, with the potential to reduce emissions substantially across various operational models. However, advancing green hydrogen adoption is crucial for maximizing these benefits and addressing the environmental drawbacks of grey hydrogen.

RAM operations on hydrogen (78% Grey, 22% Blue)
RAM operations on traditional JET A fuel
calculated based on the number of potential passengers that could switch from cars/rail to RAM

Cars off the Roads

239k
weekly

11.4m
Annually

Carbon Emission from Cars

CO_2

9.7k
Tonnes of carbon weekly

465.2k
Tonnes of carbon annually

Carbon Emission from Rail

CO_2

864
Tonnes of carbon weekly

41.4k
Tonnes of carbon annually

Passengers switch to AAM Service resulting in net savings

Total Carbon Emission Savings H2

CO_2 CO_2

2.5k
Tonnes of carbon weekly

121k
Tons of carbon annually

Total Carbon Emission Savings JetA1

CO_2 CO_2

4.4k
Tonnes of carbon weekly

214.7k
Tons of carbon annually

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Total UK AAM Potential Summary

Carbon Emissions Savings – Urban Air Mobility

- The provided slide effectively outlines the environmental advantages of Urban Air Mobility (UAM) solutions, emphasizing their role in significantly reducing carbon emissions by transitioning passengers from traditional surface transport to RAM aircraft.
- If UAM were implemented across all planned routes, it could lead to the removal of over 12.5 million cars from roads annually. This shift translates into a reduction of more than 247.5k tonnes of carbon emissions per year. Additionally, including reductions from rail travel, estimated at 22.4k tonnes annually, total carbon savings would surpass half a 178k tonnes each year.
- In summary, Urban Air Mobility presents significant environmental benefits, with the potential to reduce emissions substantially across various operational models. However, advancing green hydrogen adoption is crucial for maximizing these benefits and addressing the environmental drawbacks of grey hydrogen.

Cars off the Roads

260k
weekly

12.5m
Annually

Carbon Emission from Cars

CO_2

5.2k
Tonnes of carbon weekly

247.5k
Tonnes of carbon annually

Carbon Emission from Rail

CO_2

466
Tonnes of carbon weekly

22.4k
Tonnes of carbon annually

Passengers switch to AAM Service resulting in net savings

Total Carbon Emission Savings

CO_2 CO_2

3.7k
Tonnes of carbon weekly

178k
Tons of carbon annually

calculated based on the number of potential passengers that could switch from cars/rail to UAM

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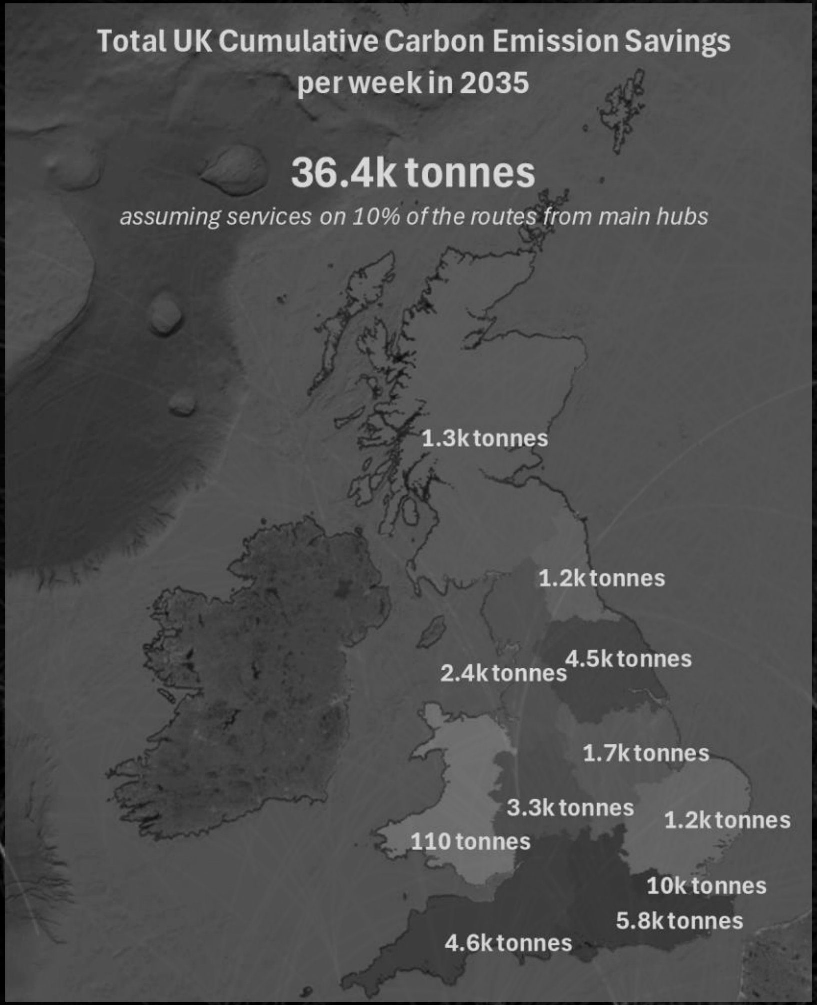
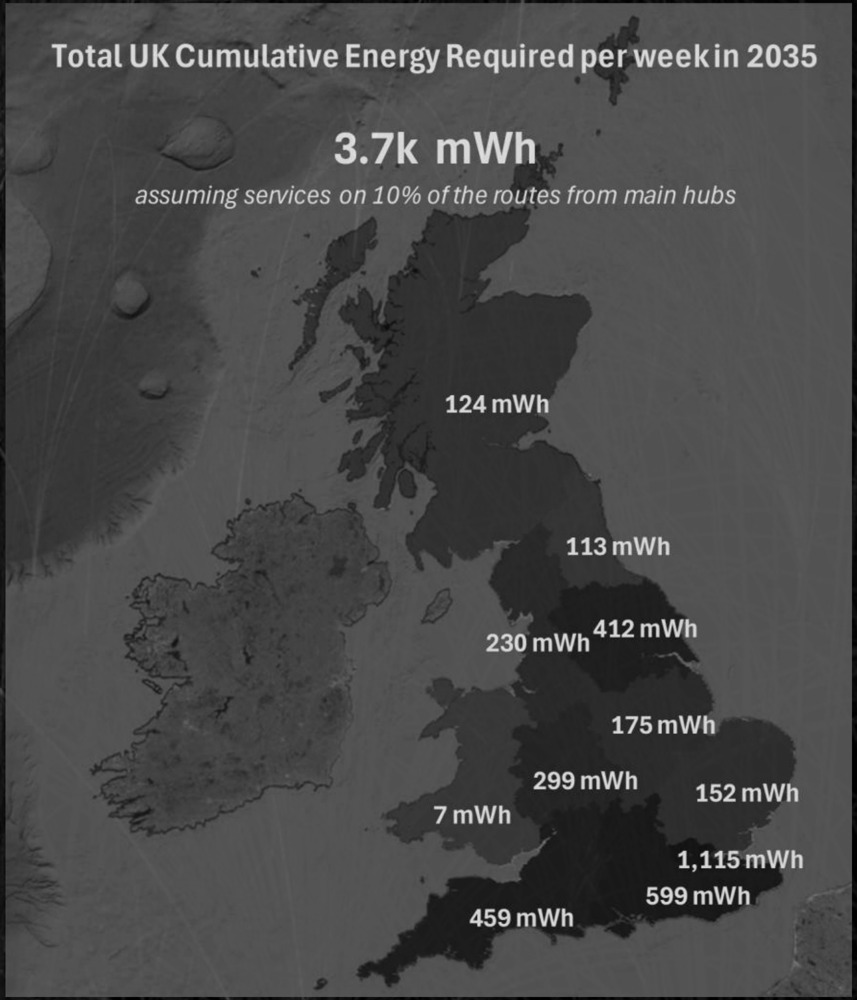
Total UK AAM Potential Summary

10% routes operated in 2035 – Carbon Emission Savings and Energy Required by Region

UAM





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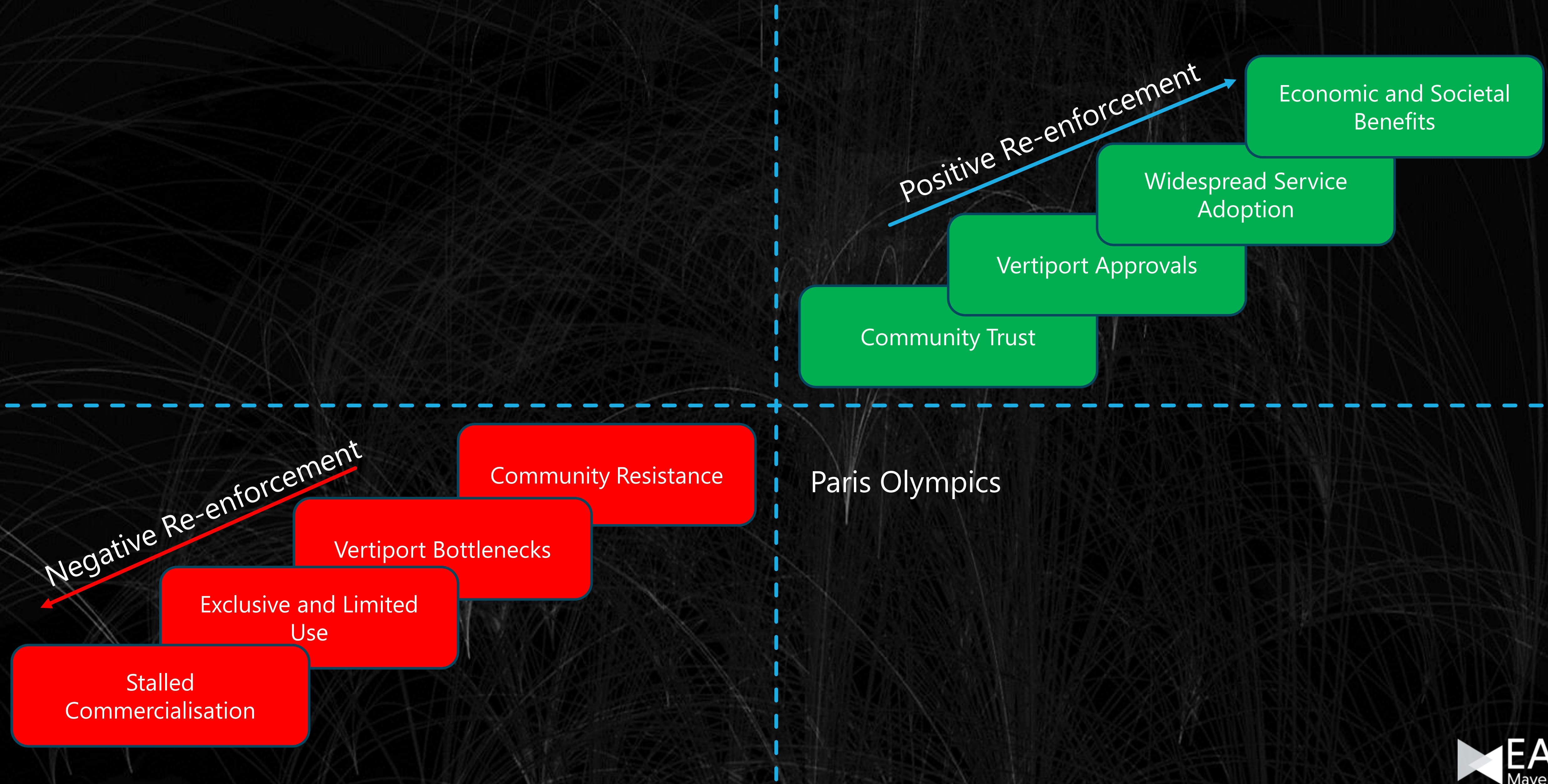
The Impact of Social License on Advance Air Mobility



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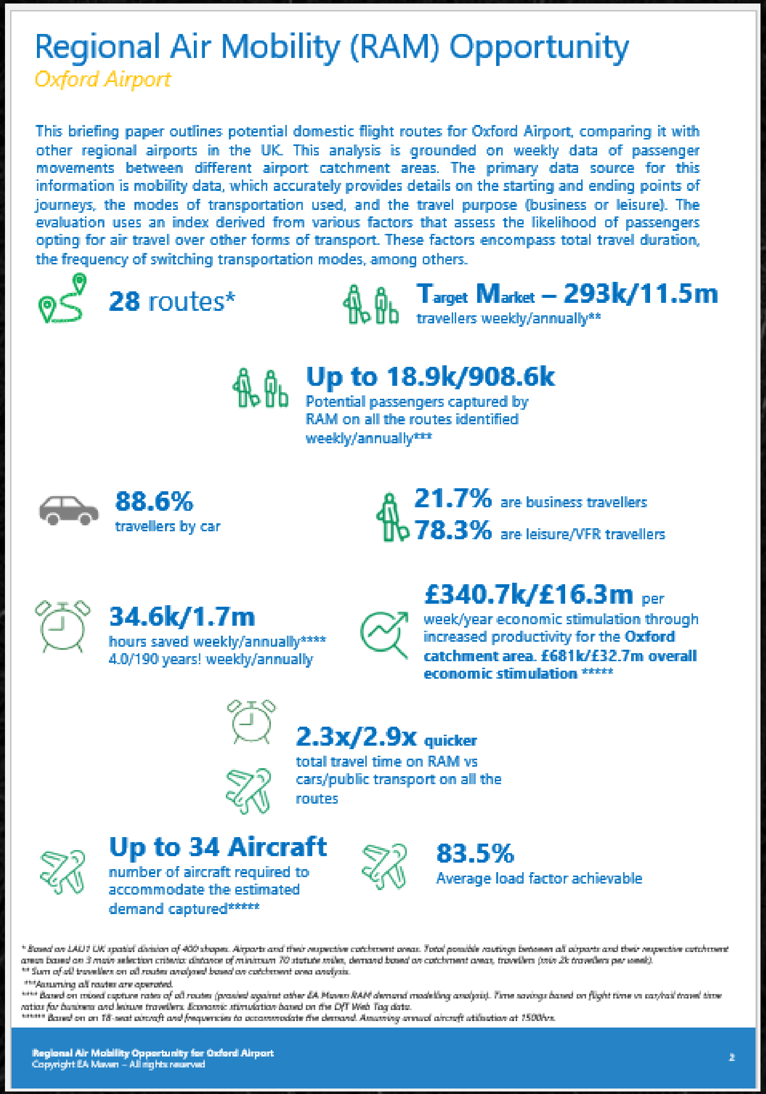
UAM & RAM Potential Summary Reports – Free – Just Ask

- 264 UAM and 63 RAM potential reports available for local authorities and airports
- Outputs include:
  - Economic contribution
  - Time savings
  - Carbon emissions savings
  - Number of routes
  - Number of aircraft needed
  - Mode of transport for mode shift calculations
  - Purpose of travel
  - Number of travellers switching to AAM services



Regional Air Mobility (RAM) Opportunity

Oxford Airport

This briefing paper outlines potential domestic flight routes for Oxford Airport, comparing it with other regional airports in the UK. This analysis is grounded on weekly data of passenger movements between different airport catchment areas. The primary data source for this information is mobility data, which accurately provides details on the starting and ending points of journeys, the modes of transportation used, and the travel purpose (business or leisure). The evaluation uses an index derived from various factors that assess the likelihood of passengers opting for air travel over other forms of transport. These factors encompass total travel duration, the frequency of switching transportation modes, among others.

28 routes*

Target Market – 293k/11.5m travellers weekly/annually**

Up to 18.9k/908.6k Potential passengers captured by RAM on all the routes identified weekly/annually***

88.6% travellers by car

21.7% are business travellers
78.3% are leisure/VFR travellers

34.6k/1.7m hours saved weekly/annually****
4.0/190 years! weekly/annually

£340.7k/£16.3m per week/year economic stimulation through increased productivity for the Oxford catchment area. **£681k/£32.7m overall economic stimulation** *****

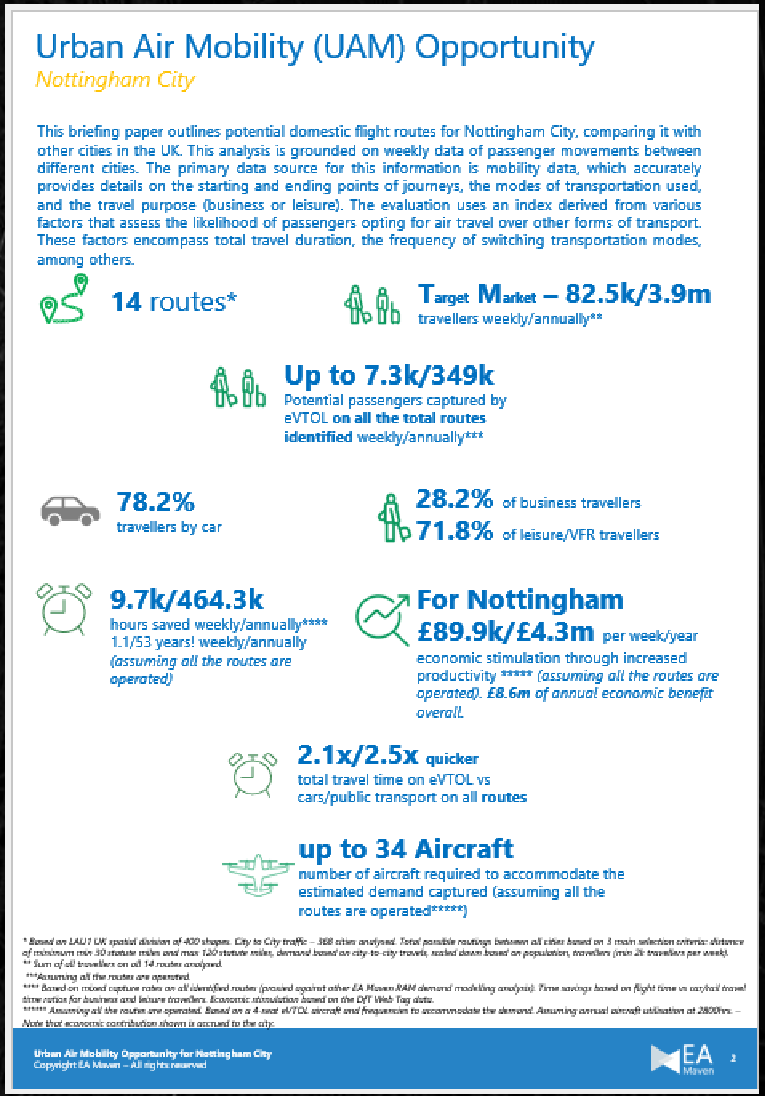
2.3x/2.9x quicker total travel time on RAM vs cars/public transport on all the routes

Up to 34 Aircraft number of aircraft required to accommodate the estimated demand captured*****

83.5% Average load factor achievable

*Based on LAU1 UK spatial division of 400 shapes. Airports and their respective catchment areas. Total possible routings between all airports and their respective catchment areas based on 3 main selection criteria: distance of minimum 70 statute miles, demand based on catchment areas, travellers (min 2k travellers per week).
** Sum of all travellers on all routes analysed based on catchment area analysis.
***Assuming all routes are operated.
**** Based on mixed capture rates of all routes (proxied against other EA Maven RAM demand modelling analysis). Time savings based on flight time vs car/rail travel time ratios for business and leisure travellers. Economic stimulation based on the DfT Web Tag data.
***** Based on an 18-seat aircraft and frequencies to accommodate the demand. Assuming annual aircraft utilisation at 1500hrs.

Regional Air Mobility Opportunity for Oxford Airport



Urban Air Mobility (UAM) Opportunity

Nottingham City

This briefing paper outlines potential domestic flight routes for Nottingham City, comparing it with other cities in the UK. This analysis is grounded on weekly data of passenger movements between different cities. The primary data source for this information is mobility data, which accurately provides details on the starting and ending points of journeys, the modes of transportation used, and the travel purpose (business or leisure). The evaluation uses an index derived from various factors that assess the likelihood of passengers opting for air travel over other forms of transport. These factors encompass total travel duration, the frequency of switching transportation modes, among others.

14 routes*

Target Market – 82.5k/3.9m travellers weekly/annually**

Up to 7.3k/349k Potential passengers captured by eVTOL **on all the total routes identified** weekly/annually***

78.2% travellers by car

28.2% of business travellers
71.8% of leisure/VFR travellers

9.7k/464.3k hours saved weekly/annually****
1.1/53 years! weekly/annually *(assuming all the routes are operated)*

For Nottingham £89.9k/£4.3m per week/year economic stimulation through increased productivity ***** *(assuming all the routes are operated). **£8.6m** of annual economic benefit overall.*

2.1x/2.5x quicker total travel time on eVTOL vs cars/public transport on all routes

up to 34 Aircraft number of aircraft required to accommodate the estimated demand captured (assuming all the routes are operated*****)

* Based on LAU1 UK spatial division of 400 shapes. City to City traffic – 358 cities analysed. Total possible routings between all cities based on 3 main selection criteria: distance of minimum min 30 statute miles and max 120 statute miles, demand based on city-to-city travels, scaled down based on population, travellers (min 2k travellers per week).
** Sum of all travellers on all 14 routes analysed.
***Assuming all the routes are operated.
**** Based on mixed capture rates on all identified routes (proxied against other EA Maven RAM demand modelling analysis). Time savings based on flight time vs car/rail travel time ratios for business and leisure travellers. Economic stimulation based on the DfT Web Tag data.
***** Assuming all the routes are operated. Based on a 4-seat eVTOL aircraft and frequencies to accommodate the demand. Assuming annual aircraft utilisation at 2800hrs. – Note that economic contribution shown is accrued to the city.

Urban Air Mobility Opportunity for Nottingham City

EA Maven

EA Maven

THANK YOU!

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