Catapult
Connected Places

ASSESSING THE IMPACTS OF THE FUTURE OF FLYING

Impact Assessment
Work Package: 2.8

UKRI Innovate UK

Department for Transport

CONTENTS

1 IMPACT ASSESSMENT: OBJECTIVE AND METHODOLOGY

IMPACT ASSESSMENT: OBJECTIVES AND METHODOLOGY

- To identify a comprehensive list of potentially significant impacts of an advanced air mobility ecosystem on various stakeholders and other surrounding ecosystems.
- To provide insights for steering the ecosystem development towards a preferred futuristic scenario which could incorporate larger societal benefits (economic, environmental and social).

METHODOLOGY

- **1.1 Definition and assumptions** – About the Air Mobility Ecosystem
- **1.2 Timelines and Use Case Development** – What is being developed and when will the impacts occur?
- **1.3 Stakeholder and Ecosystem Classification** – Who is impacted?
- **1.4 Identification of Impact Categories** – Long list of impacts based on significance
- **1.5 Final selected list of impact categories** – Based on review of the long list of impacts
- **2 to 7 Comprehensive Impact Assessment** – Further analysis of selected impacts
- **8 Recommendations and Next Steps** – Impact insights

1.1 DEFINITION AND ASSUMPTIONS

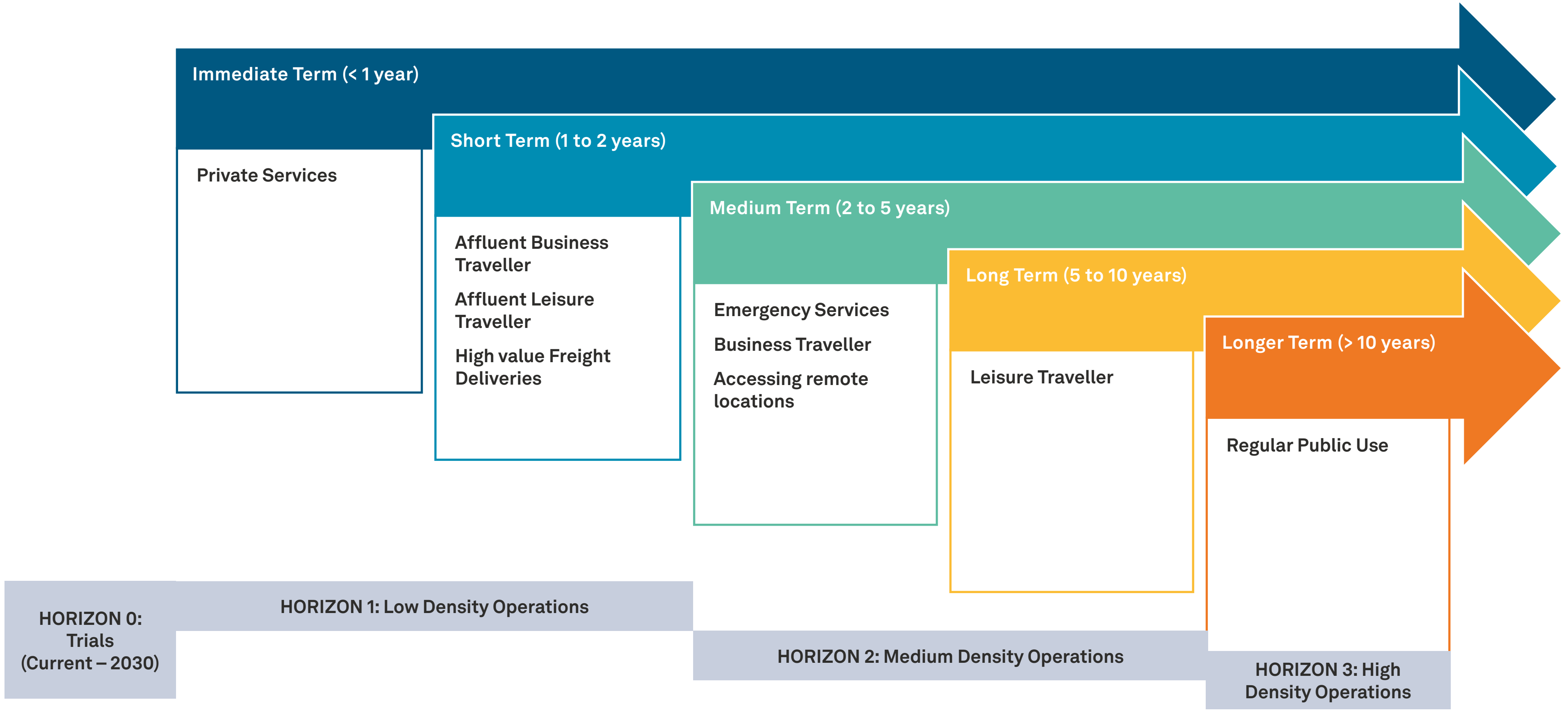
Definition

An ecosystem where electric vertical take-off and landing vehicles are operating in real-world environment.

Assumptions

Safe and reliable ecosystem of eVTOLs which has been adequately trialled (Vertical Aerospace)	Regulatory ecosystem in place for the vehicle operations (NATS)
Infrastructure elements within the ecosystem are in place for the operations to start (Skyports)	Ecosystem consists of both passenger and freight vehicular movements
Ecosystem consists of 4-seater vehicles with varied features (Vertical Aerospace)	Assumed range of the eVTOL vehicle: 15 to 160 kms (Vertica Aerospace)
No labour supply issues related to availability of trained pilots	No supply chain issues for batteries or other elements of the vehicle (WMG)

1.2 TIMELINES AND USE CASE DEVELOPMENT



Use Case Development is based on report by Trajectory
Horizon definitions are based on Urban Air Mobility Conops for London Environment

1.3 STAKEHOLDER AND ECOSYSTEM CLASSIFICATION

System Developers

1. eVTOL vehicle manufactures and their ecosystem
2. Vertiport developers and their operational ecosystem
3. System integrators and the eVTOL ecosystem
4. Air Traffic Management Providers and their operational ecosystem
5. Telecommunication Providers and their operational ecosystem
6. Regulatory Authorities and the ecosystem
7. Financiers and the investment ecosystem

System Enablers

1. Insurance Providers and the ecosystem
2. Academic Institutions and the skill development ecosystem
3. Research Institutions and the innovation ecosystem
4. Current airport and airline stakeholders and their ecosystem
5. Stakeholder of the associated transport modes and the ecosystem around it
6. Vertiport land and the associated planning ecosystem
7. UK Government and the strategic ecosystem

System Users

1. Business Passengers and the ecosystem of domestic and international businesses
2. Leisure service providers and the tourism ecosystem
3. High Value freight companies and their logistics ecosystem
4. Emergency Services and the associated healthcare ecosystem

All Other Concerned Parties

1. General Public
2. Home/ Landowners
3. Local Authorities
4. U.K Government

List of Stakeholders have been sourced from Stakeholder Engagement Report

1.4 IDENTIFICATION OF IMPACT CATEGORIES

Methodology

Step 1. To prepare a draft list of impacts on various stakeholders

Step 2. Score (from 'High' to 'None') the significance of impacts for each stakeholder to identify any gaps in impact identification

Step 3. Validate the impacts and scoring by getting it internally verified by colleagues with expertise in each area

Step 4. Classify the impacts based on insights from scoring and validation exercise

Step 5. Finalise the list of impacts

STEP 1: DRAFT LIST OF IMPACTS

Impact Category	Type of Impact
1. Strategic Impacts (Economic Narrative)	1a. Development planning Impact on land development policies
	1b. Design Impacts on eVTOL ecosystem Impact of design of the vehicle and the flexibility of use on uptake on development of eVTOL ecosystem
	1c. Investment Policy Impacts Investment Policy Impacts: Impact of government policies and subsidies for the new mode
2. Economic Impacts (Non-Welfare Measures)	2a. Capital Costs Impact of manufacturing cost on investment cost and business models
	2b. Operational Costs Impact of an operational cost on fare structure and business models
	2c. Economic Contribution Impact of an eVTOL ecosystem on local, regional and national economy

STEP 1: DRAFT LIST OF IMPACTS

Impact Category	Type of Impact
3. Economic Impacts (Welfare Measures)	3a User Journey Time
	3b. User Journey Cost
	3c. Journey Reliability
	3d. Journey Quality
	3e. Environmental Impacts
	3f. Social Impacts/ Distributional Impacts
	3g. Future Option Value
4. Wider Economic Impacts	4a. Land Use and Land Value Impacts Impact on land use and land value changes due to population redistribution around the eVTOL ecosystem
	4b. Job Opportunities Impact of an eVTOL ecosystem on employment generation
	4c. Agglomeration Impacts

STEP 2: IMPACT SCORING

- After producing the initial list, 28 user/stakeholders and 16 impacts were identified.

Type of Impact	Strategic			Non-Welfare			Welfare							Wider		
Stakeholder	Planning Impacts	Design Impacts	Investment Policy Impacts	Capital Cost Impact	Operational Cost Impacts	GVA	Journey Time	Journey Cost	Journey Reliability	Journey Quality	Emissions	Option Value	Other Social Impacts	Local Spatial and Economic Impacts	Job Opportunity	Agglomeration Impact
Wealthy Individuals	Medium	High	Low	None	None	None	High	Low	High	High	Low	None	None	Low	None	None
Domestic Business Travellers	Medium	Medium	Low	None	Low	None	High	Low	High	High	None	None	Low	Low	High	Medium
Domestic Leisure Travellers	Medium	Medium	Medium	None	Medium	None	Medium	High	Medium	Medium	None	None	Low	None	None	None
International Students	Low	Low	Medium	None	Medium	None	Medium	Medium	Medium	Low	None	None	Low	None	None	None
International Leisure Traveller	Low	Medium	Medium	None	Medium	None	Medium	Medium	High	High	None	None	Low	None	None	None
International Business Traveller	Medium	Medium	Low	Low	Low	None	High	Low	High	High	Low	None	Low	Low	Medium	Medium
Rural Commuters	High	None	High	Low	Medium	None	Medium	Medium	High	Medium	None	None	High	Low	High	Medium
Disabled Travellers	High	High	High	Low	Medium	None	Medium	Medium	High	High	None	None	High	Low	High	Medium
Island Population	High	Low	High	Low	Medium	None	High	Medium	High	Low	None	None	High	Low	High	Medium
Business Owners (Group booking)	High	None	Medium	Medium	Medium	Medium	High	Low	High	High	Low	None	Low	High	High	High
Freight/Logistics Businesses	Medium	Medium	Medium	High	High	Medium	High	Low	High	Low	None	None	Low	Medium	Medium	High
Emergency/ Health Care Services	High	High	High	Medium	High	None	High	Low	High	High	None	None	High	Low	None	None
Military	High	High	High	Medium	Low	None	High	Low	High	Low	None	None	None	Low	None	Low
Potential long term users	Medium	Low	High	Low	Medium	None	Medium	Medium	Medium	Medium	None	High	Low	Low	High	Medium
Insurance Providers	Low	Medium	Medium	Medium	Medium	Medium	None	None	Low	None	Low	None	None	Low	Medium	Low
Financiers/Investors	High	Medium	High	High	High	High	None	Low	Low	Low	Medium	Medium	Low	Medium	Low	Medium
Vertiport Developer and Operator	High	High	High	High	High	High	None	None	None	Low	Medium	Low	None	High	High	Medium
Airline Operator	Medium	Low	High	Low	Medium	Medium	None	None	None	None	None	None	None	Low	Low	Medium
eVTOL Manufacturer and Developers	Medium	Medium	High	High	Medium	High	None	None	None	Medium	Medium	Low	None	Medium	High	Medium
eVTOL Operators	Medium	Medium	High	High	High	High	None	Medium	High	Medium	Medium	Low	None	Low	High	High
Air Traffic Control	High	Low	Low	None	Low	Low	None	None	High	None	None	None	None	Medium	Low	None
Regulatory Authority	Medium	Medium	Medium	None	Low	Low	None	None	Low	None	High	None	None	Medium	Low	None
Local Authorities	Medium	Low	Medium	Low	Medium	Medium	Low	Low	None	Low	High	Low	Medium	Medium	High	High
Central Government	Low	Low	Medium	Low	Low	Medium	Low	Low	Medium	Low	High	Low	Low	Medium	Medium	Low
Public Transport Authorities	Medium	Low	Medium	None	Medium	Low	Low	Low	Medium	None	Medium	Low	None	Medium	Low	Medium
Telecommunications	Medium	Low	Low	None	None	Low	None	None	None	None	None	None	None	None	Low	Low
Home/Land Owners	High	None	Low	None	None	Medium	None	None	None	None	High	None	None	High	Medium	High
General Public (Non-users)	Medium	None	Low	None	None	Low	None	None	Low	None	High	Medium	Medium	Medium	Low	Medium

- To ensure that the impact assessment prioritised the most pertinent impacts, the importance of each impact on each stakeholder group was scored from 'High' to 'None', with additional weighting being given to impacts that are expected to happen sooner. This was done by the CPC impact assessment team.
- Additional written summary was also provided to justify scorings before beginning the validation process.

STEP 3: IMPACT VALIDATION

- Impact validation was conducted by members of the AMEC project team, selected based on their expertise and relevancy to the impact.
- Initial scoring was compared with validators scoring, with a high correlation (correlations of >0.8) being achieved
- Impacts on the eVTOL ecosystem are different from impacts of the eVTOL ecosystem: Difference between elements influencing the uptake of an eVTOL ecosystem and the elements on which the system would have an impact.
- For e.g., Availability of land, land development policy or cost of the eVTOL system will influence its demand and development. Changes in land use, economic changes are impacts due to the ecosystem.
- Timings of impacts can influence the scoring but were mostly found to be aligned with the impact scoring

STEP 4: CLASSIFICATION OF IMPACTS

Type of Impact (Impact ON development of an eVTOL ecosystem)	Type of Impact W(Impact OF an eVTOL ecosystem)
Land Development Policies: Impact of policies and strategies around development of land and land availability on eVTOL ecosystem development	1. Place based impacts: Impacts due to development of land and improved accessibility due to an eVTOL ecosystem
	2. Land Use and Land Value Impacts: Wider impact of economic development due to an eVTOL ecosystem on land use and land value changes
Investment Policy Impacts: Impact of government policies and subsidies for eVTOLs	3. Impact on Economic Contribution: Impact of an eVTOL ecosystem on local, regional and national economy
	4. Impact on Employment: Wider impact of an eVTOL ecosystem on employment generation
	5. Agglomeration Impacts: Wider impact of agglomeration economies emerging due to an eVTOL ecosystem on the local and regional and development
	6. Government Policies and Regulations Impacts: Wider social impact defines user centric policies and regulations
Service Operation Planning: Planning of operational times, route network, overlap with other modes etc.	7. Impact on New Business Models: Wider impact of eVTOL ecosystem on business models in the aviation and transport Sector
Capital and Operational Costs: Impact of development cost on business models	

STEP 4: CLASSIFICATION OF IMPACTS

Type of Impact (Impact ON development of an eVTOL ecosystem)	Type of Impact W(Impact OF an eVTOL ecosystem)
Technical Capabilities of the Vehicle: Impact of speed, weather resilience, energy consumption on the development of the ecosystem	8. Impact on User Savings: Savings for the users due to time and cost savings & Impact on Stakeholder Savings: Savings for other transport mode providers by filling the connectivity gaps
Capital and Operational Costs: Impact of development cost on fare structure	
Service Operation Planning: Planning of frequency, operational times, route network etc.	
User Benefits resulting in Shift: Journey Time, Cost, Quality, Reliability	
Type of Electricity Used: Impact of sustainable sourcing of electricity on development of the ecosystem	9. Environmental Impacts: Impact of the eVTOL ecosystem on various environmental ecosystems
Design Impacts on eVTOL ecosystem: Impact of design of the vehicle and the flexibility of use	10. Social and Distributional Impacts: Social impacts not accounted as part of economic and environmental impact appraisal and the variation across different social groups
Public Perception: Impact of public perception and willingness on development of the ecosystem	
Current Option Value: Impact of current option value of the ecosystem on its future development	11. Future Option Value

1.5 FINAL SELECTED LIST OF IMPACT CATEGORIES

Impact Category	Type of Impact
I. Strategic Impacts	1. Place Based Impacts
II. Economic Impacts (Non-Welfare Measures)	2. Economic Contribution
III. Economic Impacts (Welfare Measures)	3. Impact on Individual and Group Users
	4. Environmental Impacts
	5. Social and Distributional Impacts
IV. Wider Economic Impacts	6. Wider Impacts
	6a. Land Use and Land Value Impacts
	6b. Labour Market Impacts
	6c. Agglomeration Impacts
	6d. Impact on New Business Models
	6e. User Centric Policies and Strategies

2 PLACE BASED IMPACTS

2.1 OBJECTIVE AND METHODOLOGY

Objective:

- To assess place-based impacts (place-based impact analysis concerns appraisal applied to different geographically defined areas to analyse the variation in impact) of development of land and improved accessibility due to an eVTOL ecosystem

Methodology:

- **Step 1:** To identify features of the advanced air mobility ecosystem which would have place-based impacts

  Features of Air mobility ecosystem

  Impact of increased air accessibility to an area

  Impact of vertiport development on an area

2.1 METHODOLOGY

- **Step 2:** To select the impact analysis unit (geographical unit) to understand the variation in impact.

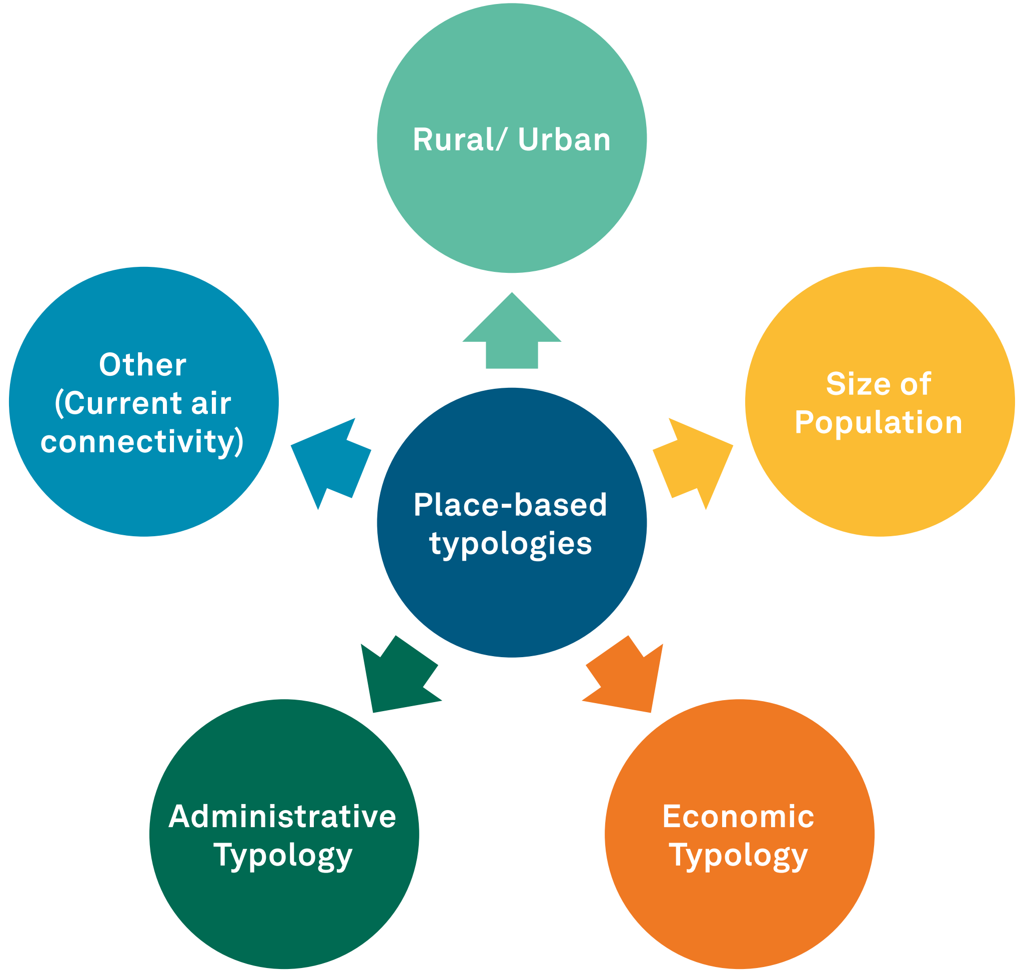
  Selection: Since the ecosystem is at a very initial level of development, it was decided to understand the impact variation on areas with air connectivity and without air connectivity.

- **Step 3:** To identify features of area on which the impacts should be assessed

  Area Characteristics:

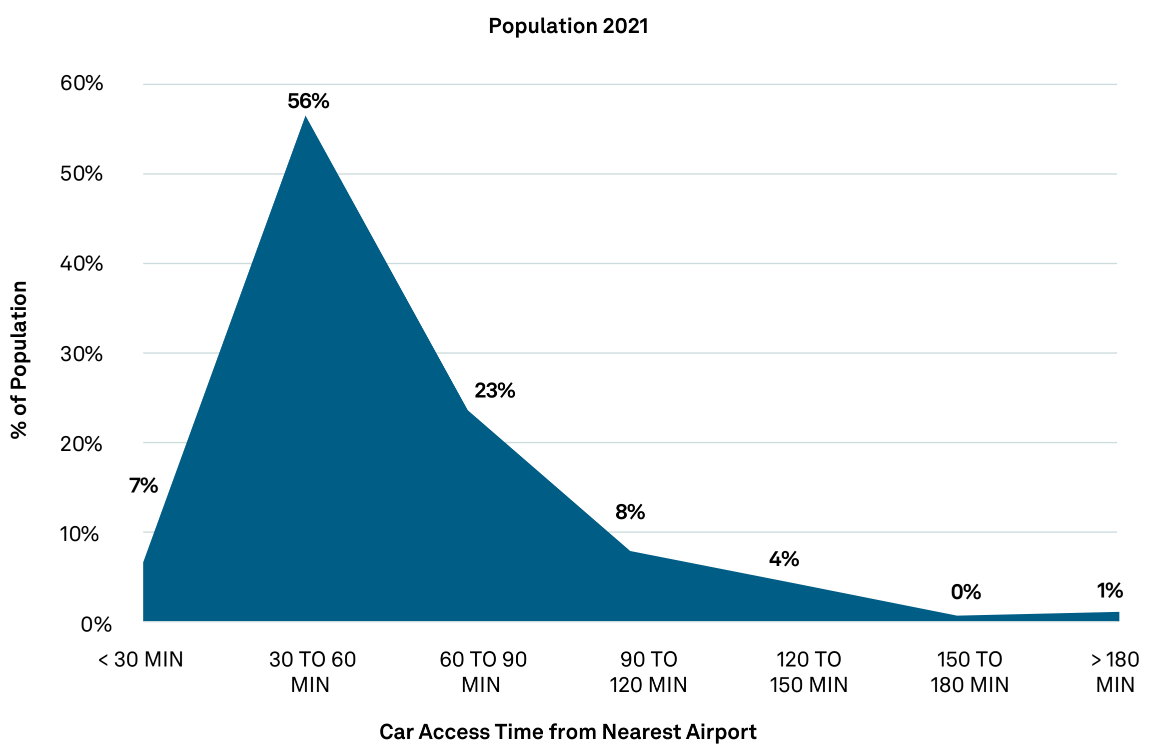
  – Population distribution and growth

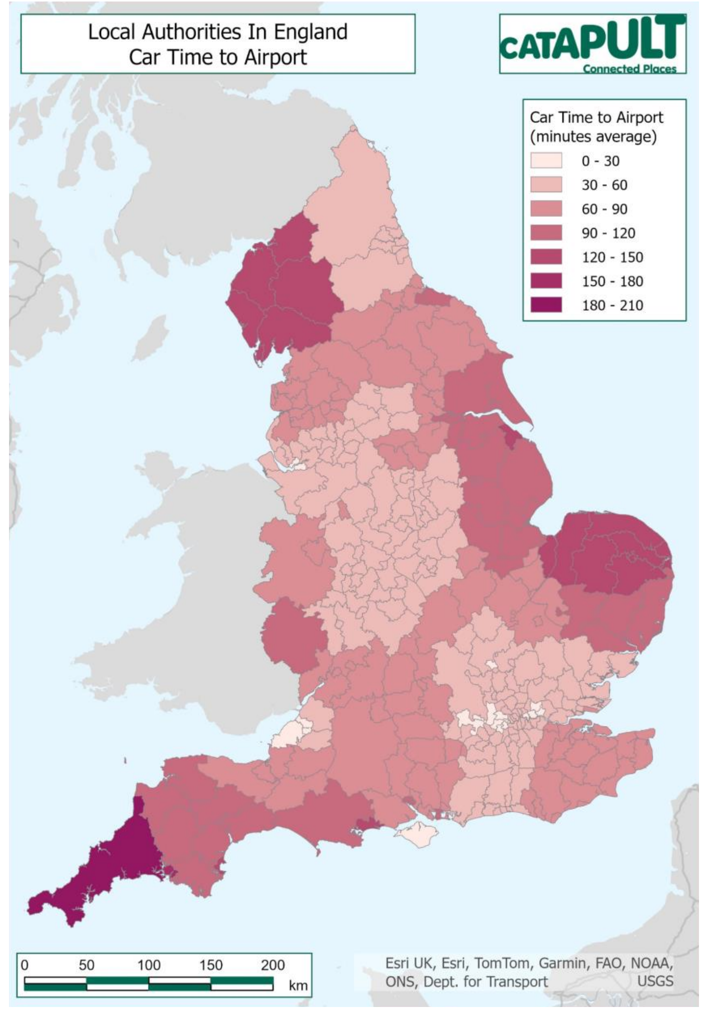
  – Local Impacts



2.2 CURRENT ACCESS TO AIRPORTS BY CAR

Population Distribution based on car access time to airports

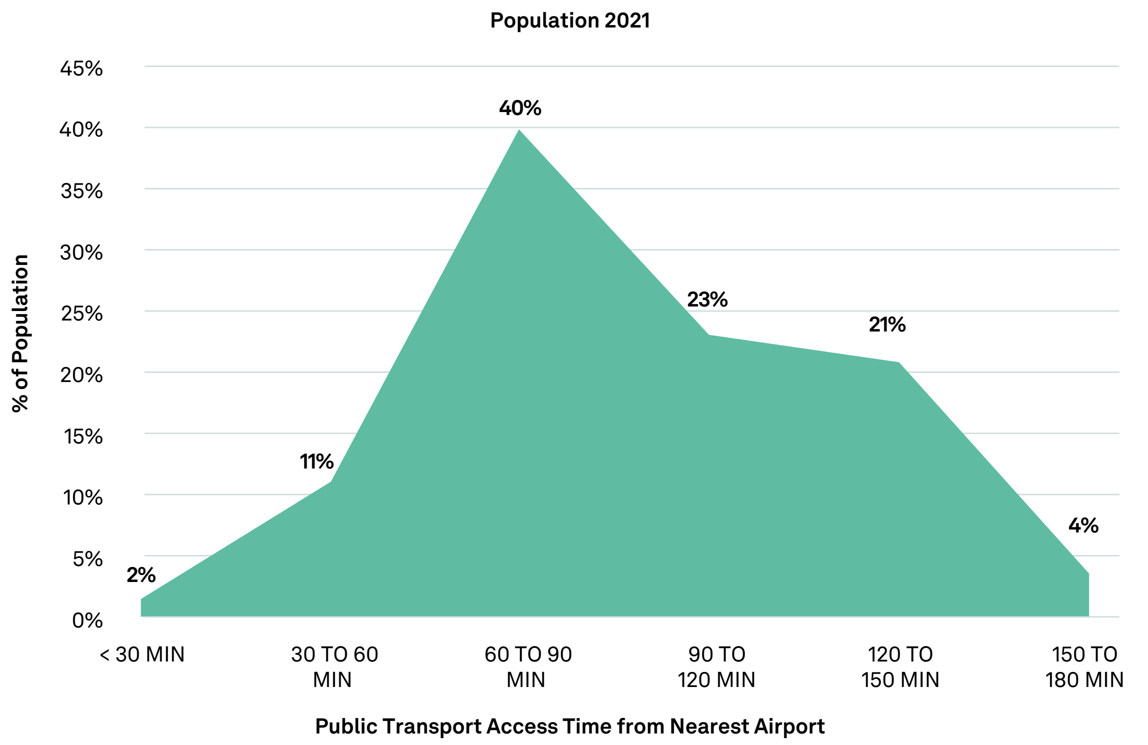


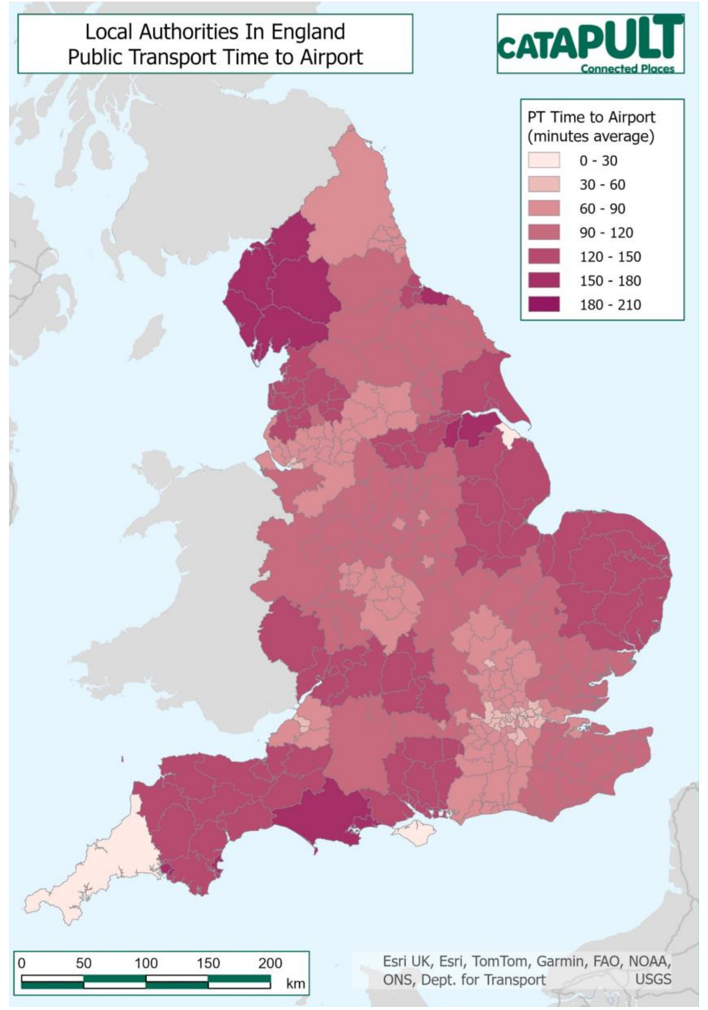


- 63% of the population lives 60-min or less (by car) away from an airport
- People residing in many local authorities in England still take more than 90-minutes by car to access an airport

2.3 CURRENT ACCESS TO AIRPORTS BY PUBLIC TRANSPORT

Population Distribution across public transport access time to airports

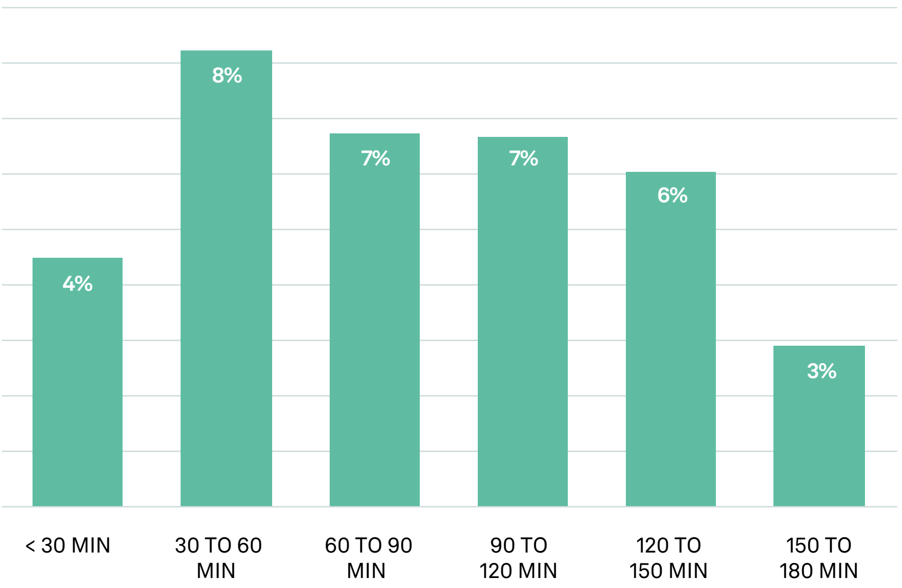




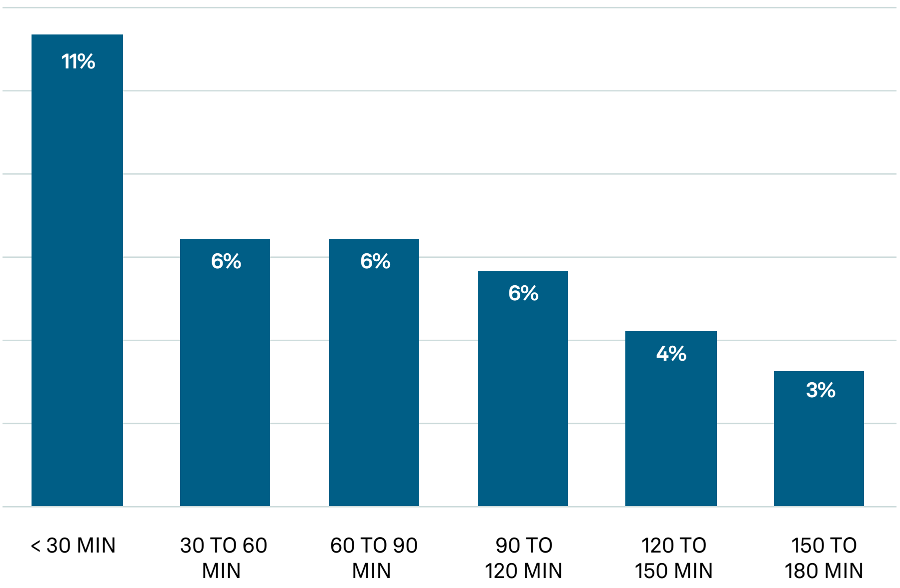
- Around 53% of the population lives within 90-min (by public transport) from an airport
- People residing in many local authorities in England still take more than 90-minutes by car to access an airport

2.4 ACCESS TO AIRPORTS VS POPULATION CHANGE

Population Change vs Public Transport Time to Airportto airports



Population Change vs Car Time to Airport to airports



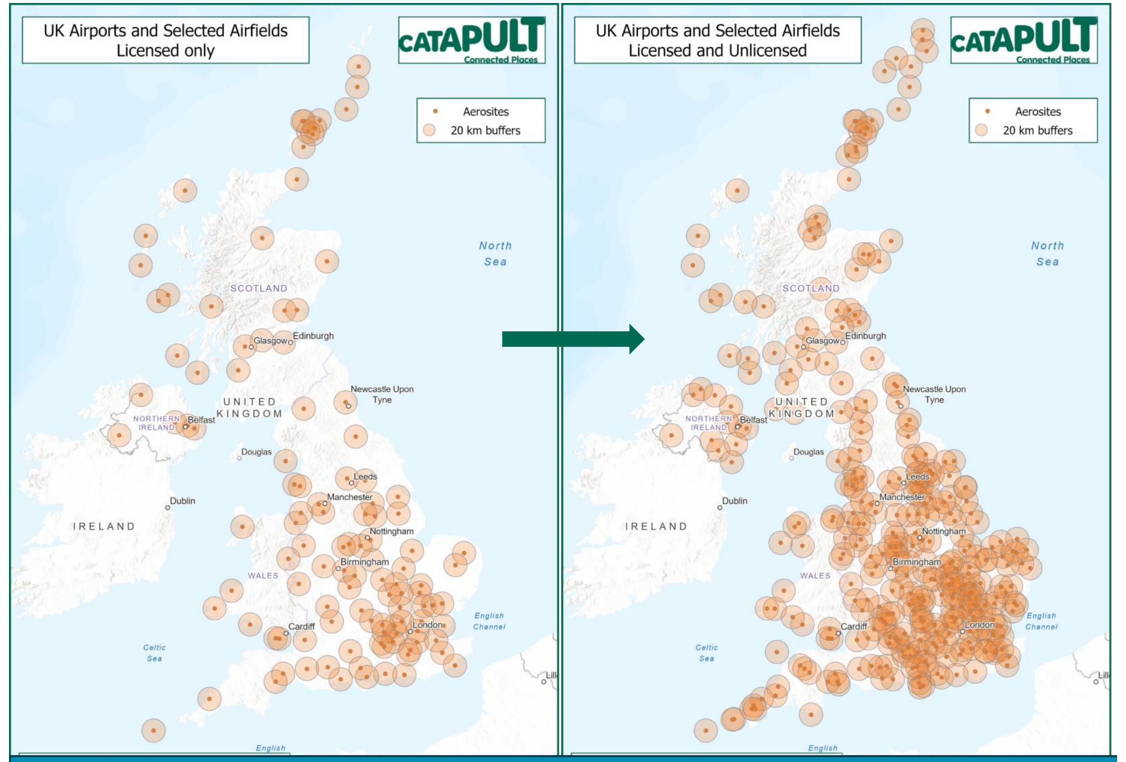
- Correlation observed between population change and access to airports (by both car and public transport) was observed.
- The correlation suggests an interdependence of factors – air connectivity is being provided in areas of higher population growth or vice versa.

2.5 CURRENT AVIATION ECOSYSTEM VS. POTENTIAL EVTOL ECOSYSTEM

- Current Annual Passenger Air Traffic (UK): ~150 million (one-direction)
- Annual Passenger Air Traffic (International): ~125 million
- Annual Passenger Air Traffic (Domestic): ~25 million
- Potential eVTOL Market Size for high probable routes UK: ~10.5 million
- This is based on -
- AMEC Demand Model Prediction: eVTOL demand on high probable routes (10) for 3 regions by 2035
- Estimated shift from all regions on high probable routes by 2035
- UK Advanced Air Mobility (Annual Passengers): ~316 million (Source: EA Maven)

eVTOL ecosystem can serve almost 50% of domestic avaiation passengers by 2035. While an eVTOL ecosystem on its own might have limited influence on population distribution and growth, it has the potential to influence the overall accessibility of an area due to:

- Ease of setting a vertiport
- Use of wider air network: both licensed and unlicensed airfields (see diagram)
- Ability to target specific use cases like access to airports



Airfields that have commercial flights with fare paying passengers, or where there is flying training using large aircraft, need to have a safety licence from CAA.

2.6 VERTIPORT DEVELOPMENT

Factors influencing vertiport development

Type of Service
- Passenger
- Freight
- Passenger & Freight

Service Category
- Domestic
- International
- Domestic and International

Ownership
- Public
- Private
- Mixed

Demand
- High
- Medium
- Low

Demand-Supply Gap
- Demand ~ Supply
- Demand > Supply
- Supply > Demand

Space Constraints
- Limited space
- Average space
- Abundant space

Access Constraints
- Restricted/ Difficult access
- Access to be well planned
- Ease of access

Type of Vertiport (Total Area/ Built Up Area; FATO/ Stands; Business Model; Extra Services)

ESTIMATED IMPACTS

Land Use and Land Value impact	Need for Multimodal Integration	Economic Opportunity	Energy Demand/ Environmental	Traffic Congestion

Estimate potential variation in these impacts due to different types of vertiport

2.7 PLACE BASED IMPACTS OF VERTIPORT

Type of Impact	RAG for impacts due to type of vertiport	Potential Place based variation
Changes in Land Use and Land Value	**High**	Location of vertiport in rural/ urban environment and across different city typologies can result in different level of land use/ land value impact. (Please refer to section 6A for further analysis)
Need for Multimodal Integration	**Medium**	Current availability and integration of modes in an area and the role eVTOLs would play in the current multimodal environment would determine the future need for integration. (Please refer Annexure 3 for further information)
Economic Opportunity	**Medium**	While economic opportunity can be assumed to have a steady impact in all types of city typologies, the impact might be more based on the specific use cases eVTOL ecosystem is targeting
Energy Demand/ Environmental	**Low**	Energy/ environment impacts should be similar across cities. It might help local areas build a case for reinforcement of local energy grid. In case of areas with no potential to reinforce local energy grid, presence of a vertiport might put additional pressure on the energy grid.
Traffic Congestion	**Medium**	Current congestion levels and traffic capacity in an area will be the factors determine the level of variation in impact

Place based impacts due to vertiport development would be dependent on the type of vertiport being planned and the current setting in the area. Given this, some areas (where vertiports can be aligned with the development policy, energy grid capacity is present, eVTOLs can be integrated with other modes of transport, demand is both internal and external) might be more acceptable for vertiport development.

PLACE BASED IMPACTS

Summary

1.1 Positioning of the eVTOL ecosystem

- eVTOL ecosystem can serve almost 50% of domestic aviation passengers by 2035. While an eVTOL ecosystem on its own might have limited influence on population distribution and growth, it has the potential to influence the overall accessibility of an area due to:
- Ease of setting a vertiport
- Use of wider air network: both licensed and unlicensed airfields
- Ability to target specific use cases which fills in gaps in the current multimodal network. For e.g., Access to airports

1.2 Location and size of Vertiports

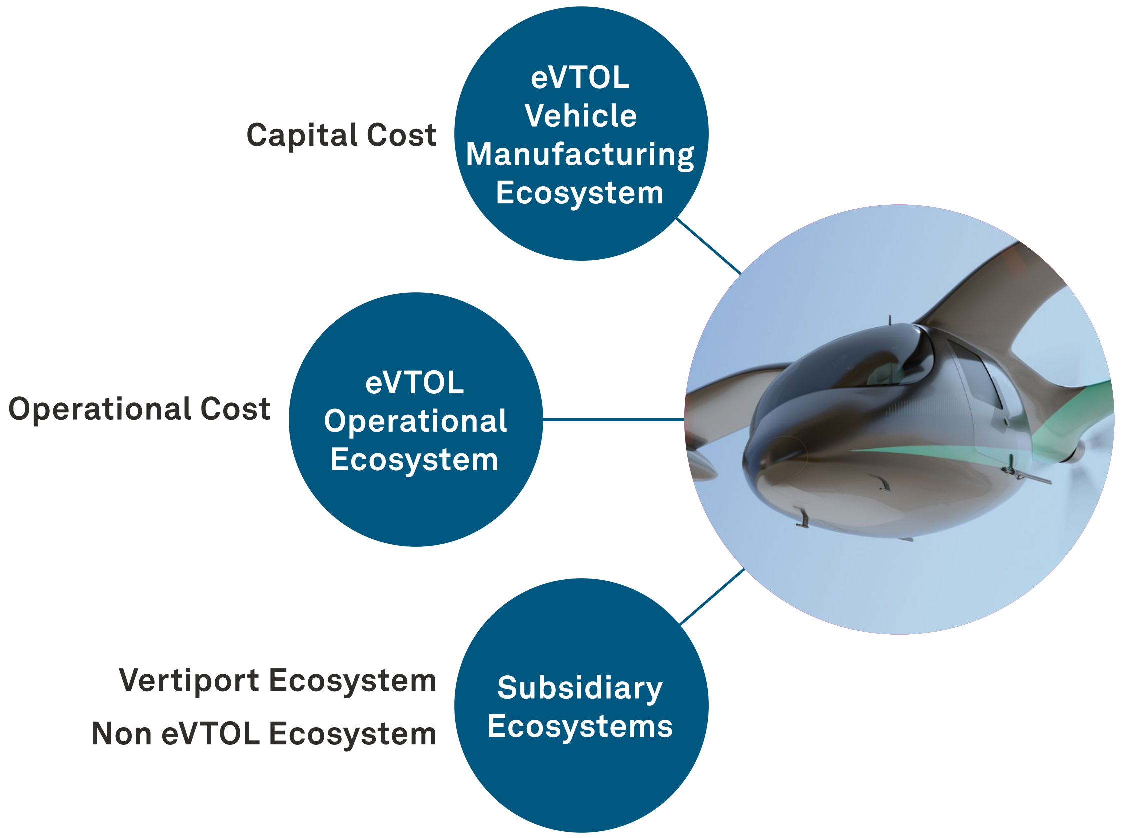
Place based impacts due to vertiport development would be dependent on the type of vertiport being planned and the current setting in the area. Given this, some areas (where vertiports can be aligned with the development policy, energy grid capacity is present, eVTOLs can be integrated with other modes of transport, demand is both internal and external) might be more acceptable for vertiport development.

3 ECONOMIC CONTRIBUTION

OBJECTIVE AND METHODOLOGY

Objective:

- To assess the potential economic contribution of an eVTOL ecosystem



Economic Contribution Methodology 1:

- Align with economic contribution of current aviation ecosystem

Economic Contribution Methodology 2:

- Estimating potential revenue

Economic Contribution Methodology 3:

- Using Input/ Output (I/ O) Tables

ECONOMIC CONTRIBUTION OF CURRENT AVIATION SECTOR

Contribution of UK Aviation Sector to GDP (in £million)					
Benefit Streams	**What they contain?**	**Direct (Airlines/ Airports/ Ground Services/ Aerospace)**	**Indirect (Supply-Chain)**	**Induced (Wage financed through Employees)**	**Total**
Aerospace (Manufacturing)	High-tech manufacturing, Basic metals, Finance, Business services, Technical consultancy, Computing	9,000	6,682	4,124	19,806
Airlines (Operations)	Aviation fuel, Catering, Repair and Maintenance, Ticketing and Distribution, Freight forwarding, Aircraft financing, Other finance and Business services	5,210	2,553	3,122	10,885
Airports and Ground Services	Finance, Construction, Facilities management, Electricity, Water supply, Food and Drink, Business and Marketing services, Computing	8,137	7,478	5,660	21,275
Total		**22,347**	**16,713**	**12,906**	**51,966**
Catalytic (Tourism)		7,232	8,513	3,886	19,631
Total including Catalytic		**29,579**	**25,226**	**16,792**	**71,597**

Source: Economic Benefits from Air Transport in the UK, Oxford Economics, 2014

ESTIMATING EVTOL MANUFACTURING CONTRIBUTION

Review of External Literature:

Some of the selected sources:

- https://www.marketsandmarkets.com/Market-Reports/evtol-aircraft-market-28054110.html
- https://investingstrategy.co.uk/financial-news/30-evtol-and-electric-aircraft-statistics-including-market-size-trends-and-predictions/
- https://www.globalmarketestimates.com/market-report/evtol-aircraft-market-3772
- https://uk.finance.yahoo.com/news/evtol-aircraft-market-analysis-2028-..
- https://www.novaoneadvisor.com/report/evtol-aircraft-market?trk=article-ssr-frontend-pulse_little-text-block

- Average Global Market Size: £22.5 billion
- Average UK Market Size: £7.8 billion (7,821 million) (assuming double the share of current UK aviation sector)

Market Size based on Demand:

Road/ Rail Shift to eVTOLs:

- Total Daily eVTOL Passenger Trips (by 2035): (based on the Shift observed along the 8 routes) — **32,616 passenger trips**
- Total Vehicular Trips (by 2035): (assuming 3.5 occupancy) — **9,319 vehicular trips**
- Number of eVTOLs required: (assuming 1 vehicle to support every 4 trips) — **2,330 eVTOLs**

Helicopter Shift to eVTOLs:

- Small rotorcraft (<9 passengers): — **805 Vehicles (100% Shift)**
- Non-part 21: — **190 Vehicles (80% Shift)**
- Part 21: — **4 (80% Shift)**
- Total eVTOL Demand: — **917 eVTOLs**
- Assumed cost per eVTOL: — **£2 million**

Demand Category	Market Size (£ bn)
Road/ rail shift to eVTOLs	4.66
Helicopters to eVTOLs	1.83
Induced Demand (@5%)	0.32
Freight	0.03

- Average UK Market Size: £6.84 billion (6,844 million)

ECONOMIC CONTRIBUTION OF EVTOLS: METHODOLOGY 1

- Assumed 50% reduction (in proportion) in contribution from operations and ground services
- Sectors where eVTOLs would cost lower than a conventional aircraft: Aviation fuel, Catering, Security and baggage handling
- Sectors where eVTOLs would be higher cost: Vertiport construction (since new infrastructure), Cost of Electricity

Contribution of eVTOLs to GDP (in £million)				
Benefit Streams	**What they contain?**	**Direct (Airlines/ Airports/ Ground Services/ Aerospace) and Indirect (Supply-Chain)**	**Induced (Wage financed through Employees)**	**Total**
Aerospace (Manufacturing)	High-tech manufacturing, Basic metals, Finance, Business services, Technical consultancy, Computing	7,332	964	8,297
Airlines (Operations)	Aviation fuel, Catering, Repair and Maintenance, Ticketing and Distribution, Freight forwarding, Aircraft financing, Other finance and Business services	726	292	1,018
Airports and Ground Services	Finance, Construction, Facilities management, Electricity, Water supply, Food and Drink, Business and Marketing services, Computing	1,460	529	1,990
Total		**9,519**	**1,785**	**11,304**
Catalytic (Tourism)		1,840	454	2,295
Total including Catalytic		**11,359**	**2,240**	**13,599**

Source: Economic Benefits from Air Transport in the UK, Oxford Economics, 2014

Economic Contribution Methodology 1: ~ £13.6 billion

REVENUE ESTIMATE: METHODOLOGY 2

Average distance	100 kms
Average revenue	£3/ km
Annualisation Factor	300*
Annual Passenger Trips (two-way)	21 million
Total Revenue in 2035	**£ 5,821 million**

- Assumed to account for non-flying days due to VFR. (This number will vary from one vertiport to another – weather data was not analysed to arrive at this assumption)

Total Revenue 2035	6,045 million
Total Revenue up to 2035	**10,957 million**

- Revenue from Vertiport Businesses: Assuming 10% of the total revenue

Total Mail by Aircrafts	6599 Tonnes
Assumed % Shift to eVTOLs	70%
Average revenue from 1st class signed mail	£2.85 for 100 grams
Total Revenue in 2035	**£ 224 million**

Economic Contribution Methodology 2: ~ £12.1 billion

GVA ESTIMATE USING I/O TABLES: METHODOLOGY 3

- The 2019 versions of both the UK input-output and UK supply and use tables were used to develop the Type 2 GVA multipliers. The type 2 multipliers include:
- Direct impacts - The immediate economic contributions resulting from investment in eVTOLs and vertiports.
- Indirect impacts - Secondary economic effects arising from supply chain interactions and business-to-business transactions.
- Induced impacts - Broader economic benefits from increased household incomes due to employment generated by the investment.
- The total investment for the eVTOL's and vertiports was estimated, as shown in the table below:

Investment categories	Cost (£ million)
eVTOL vehicles	4,659
Vertiports (including hubs, standard and basic)	95
Total investment	**4,754**

- Relevant industries for both investment categories were identified, and proportions of the investment were assigned to each industry
- The Type 2 GVA multipliers were applied to estimate the total economic contribution of the investments, as shown below:

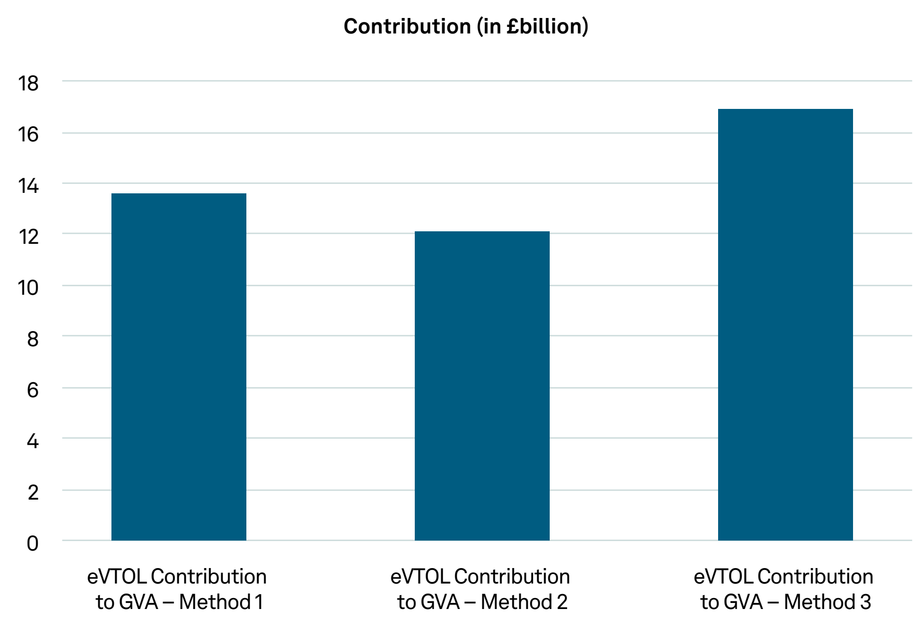
Industry	Multiplier	Proportion	Economic impact (£ million)
Manufacture of air and spacecraft and related machinery	3.92	90%	£16,441
Manufacture of other transport equipment	4.04	5%	£7
Air transport	4.72	5%	£9
Total			**£16,457**

Industry	Multiplier	Proportion	Economic impact (£ million)
Warehousing and support activities for transportation	3.65	60%	207
Construction	3.72	35%	123
Air transport	4.72	5%	22
Total			**£352**

Economic Contribution Methodology 3: ~ £16.9 billion

ECONOMIC CONTRIBUTION

Summary



2.1 Further assessment of economic contribution

While the estimated contribution of an established aviation sector to UK GDP is around 70 billion, the eVTOL ecosystem has the potential to contribute between 12 to 17 billion by 2035. A further detailed analysis can help build the business case for the ecosystem.

4 IMPACT ON INDIVIDUAL AND GROUP USERS

OBJECTIVE AND METHODOLOGY

Objective:

The purpose of this work is to assess the impact of the ecosystem on individual and group users. This is primarily done through the monetization of journey time/cost impacts.

Impacts that cannot be quantified or monetized, such as journey quality, are assessed qualitatively.

Methodology:

The user (individual) benefits model uses the following approach:

Assumptions:

- Opening year: 2030
- Appraisal period: 2030-2060
- Discount rate: 3.5%
- Base year: 2023
- Occupancy factor (car): 1.55

Inputs:

- Passenger demand mode shift (One-way trips)
- Travel time, distance, cost
- Value of Time (VoT) parameters, Marginal External Cost (MEC) parameters

Annualisation/Profiling:

- Timeline
- Demand profile
- MECs profile
- VoT profile

Calculations:

- MECs calculations
- VoT calculations
- Revenue abstraction (from rail) calculations

Outputs:

- MECs benefits
- VoT benefits
- Revenue abstraction

All outputs are broken down by route and journey purpose. VoT benefits are also given by mode.

METHODOLOGY (QUANTITATIVE BENEFITS)

The route specific benefits assessment uses an excel model to calculate and monetize Value of Time (VoT) savings, Marginal External Costs (MECs) savings, and Revenue Abstraction from rail operators. The model uses the demand modelling outputs (see: Demand Modelling Technical Note) and various other journey details and parameters as inputs to calculate the three impacts. The model's process of calculation is given below.

VoT calculations:

Value of travel time savings refers to the time saved by passengers switching to eVTOL, and how much monetary value they place on this time saving. The extra cost of an eVTOL ticket is subtracted from this benefit.

Number of passengers shifting to eVTOL * (time savings * VoT parameter) * (cost difference between eVTOL and previous mode)

MECs calculations:

Marginal external costs savings refers to the reduction of the costs associated with car travel (e.g. congestion, accidents, infrastructure costs).

Number of passengers shifting from road to eVTOL * MEC parameter

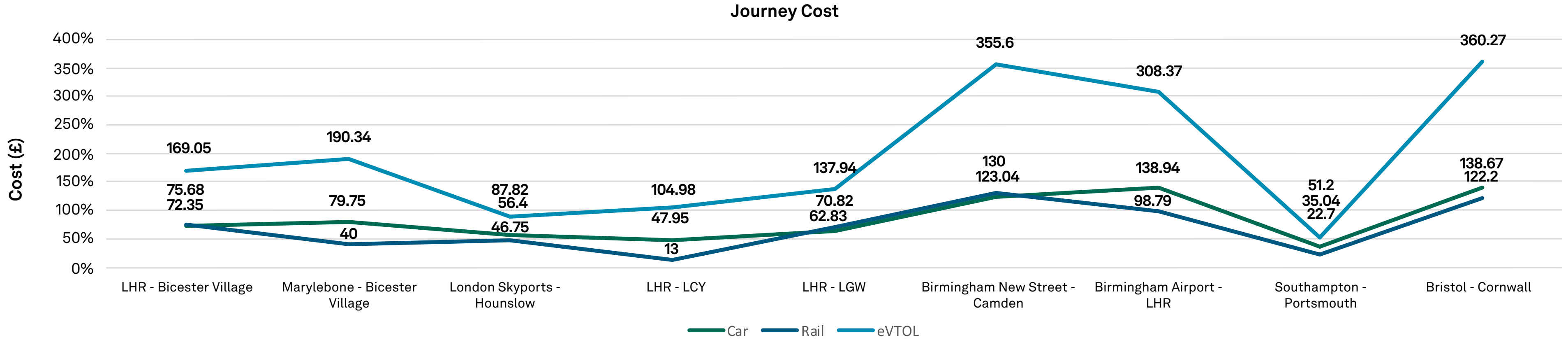
Revenue abstraction:

This is the loss in revenue for rail operators due to reduced passenger demand.

Number of passengers shifting from rail to eVTOL * rail ticket cost

INDIVIDUAL USER: JOURNEY COST

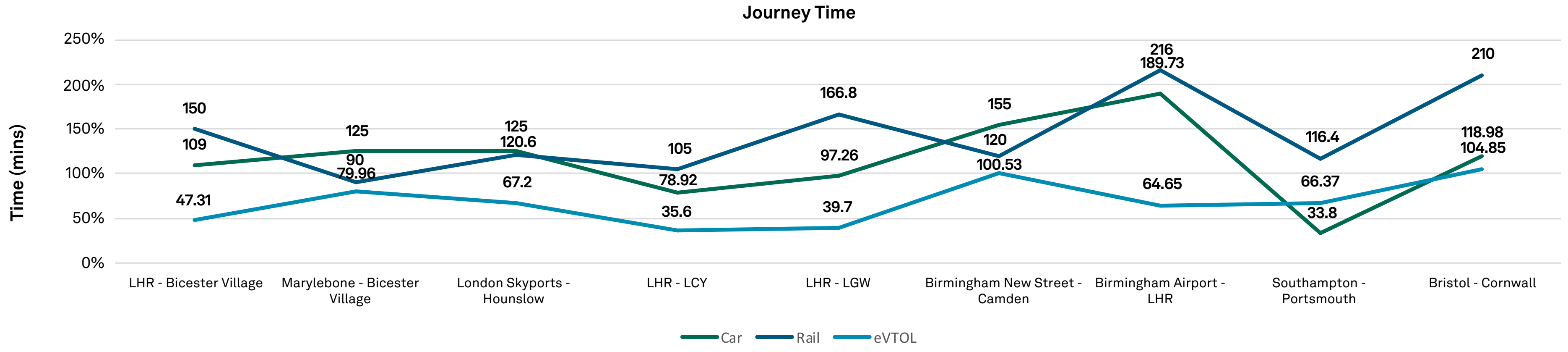
	Car (£)	Rail (£)	eVTOL (£)
LHR - Bicester Village	72.35	75.68	169.05
Marylebone - Bicester Village	79.75	40.00	190.34
London Skyports - Hounslow	56.40	46.75	87.82
LHR - LCY	47.95	13.00	104.98
LHR - LGW	62.83	70.82	137.94
Birmingham New Street - Euston	123.04	130.00	355.60
Birmingham Airport - LHR	138.94	98.79	308.37
Southampton - Portsmouth	35.04	22.70	51.20
Bristol - Cornwall	138.67	122.20	360.27



For all of the selected routes, eVTOL is the most expensive mode.

INDIVIDUAL USER: JOURNEY TIME

	Car (mins)	Rail (mins)	eVTOL (mins)
LHR - Bicester Village	109.00	150.00	47.31
Marylebone - Bicester Village	125.00	90.00	79.96
London Skyports - Hounslow	125.00	120.60	67.20
LHR - LCY	78.92	105.00	35.60
LHR - LGW	97.26	166.80	39.70
Birmingham New Street - Euston	155.00	120.00	100.53
Birmingham Airport - LHR	189.73	216.00	64.65
Southampton - Portsmouth	33.80	116.40	66.37
Bristol - Cornwall	118.98	210.00	104.85



For all nine of the selected routes eVTOL is faster than rail, and it is also faster than road on eight out of nine.

ROUTE SPECIFIC USER BENEFITS

	MECs Benefits (£)	VoT Benefits (£)	Revenue Abstraction (£)
LHR - Bicester Village	13.1m	89.4m	13.5m
Marylebone - Bicester Village	4.4m	-143.8m	41.9m
London Skyports - Hounslow	40.8m	2,277.9m	1,208.8m
LHR - LCY	22.1m	1,735.7m	348.8m
LHR - LGW	11.1m	190m	16m
Birmingham New Street - Euston	0.7m	-90.5m	59.6m
Birmingham Airport - LHR	2.4m	23.7m	1.9m
Southampton - Portsmouth	0.1m	11m	4.4m
Bristol - Cornwall	0.1m	-1.5m	0.5m
Total	94.7m	4,091.9m	1,695.4m

Despite the higher cost of travel, the time saving more than outweighs the cost, giving a considerable (£4bn) VoT benefit for users over 30 years.

- There is a total annual mode shift of 2.9m one-way passenger trips per year from road/ rail to eVTOL.
- Over the 30 year appraisal period across all routes there is:
- £95m MEC benefits;
- £4bn VoT benefits;
- £1.7bn revenue abstraction.
- The main beneficiaries of eVTOL services are the London Skyports – Hounslow and London Heathrow – London City Airport routes. However, these routes also abstract significant revenue from rail operators.
- Some routes are with negative VoT benefits because the monetized time saving is less than the ticket price difference. However, people are still expected to travel on these routes due to their personal preferences (like privacy, reliability, novelty etc.).
- Full detail for each route can be found in the annex, including mode shift shares.

NATIONAL USER BENEFITS

	MECs Benefits (£)	VoT Benefits (£)	Revenue Abstraction (£)
North East – All	112m	681m	514m
North West - All	291m	2,137m	1,614m
Yorkshire & The Humber - All	260m	1,821m	1,376m
East Midlands – All	249m	1,591m	1,202m
West Midlands – All	371m	2,583m	1,951m
East of England – All	405m	2,617m	1,976m
London - All	923m	-102m	2,618m
South East - All	736m	4,837m	3,611m
South West - All	719m	4,544m	3,414m
Total	4,067m	20,708m	18,277m

The national results are in line with the route specific results, there is a large VoT benefit of nearly £21bn, despite the higher cost.

- These figures used the same assumptions as the route specific analysis, with demand numbers scaled up to reflect the whole of England (nearly 12m one-way passenger trips per year).
- Given that AMEC is prioritising the highest demand routes, this scaling may over-estimate the actual national demand.
- Over the 30 year appraisal period, the ecosystem is forecast to generate:
- £4bn is marginal external costs benefits;
- £21bn in value of time benefits;
- £18bn of revenue abstraction from rail.
- The South East and South West are the main beneficiaries of the ecosystem.
- London has negative VoT benefits due to the cost of eVTOL outweighing the monetized travel time saving.
- To contextualise these numbers via comparison, in the 2020 Full Business Case, HS2 estimated its user benefits for the full network to be £77bn, with an additional £800m in MECs benefits.

METHODOLOGY (QUALITATIVE BENEFITS)

Journey quality

There will be an expectation of a high-quality service versus other modes of transport due to the premium price of eVTOL services, and the expected first users (wealthy individuals and businesses). TAG advises on several factors to be considered when examining journey quality. These factors are considered qualitatively based on available information about the expected passenger experience.

The mode shift assumptions in the demand modelling assume the only people who are likely to shift are currently travelling by chauffer/private taxi if travelling by road, and first class if they are travelling by rail. It is against these that the eVTOL service quality is compared.

For each of the factors, TAG also advises to score the scale of the impact:

- Slight if less than 500 passengers per day are impacted
- Moderate if between 500 and 10,000 passengers per day are impacted
- Large if more than 10,000 passengers per day are impacted.

The demand modelling forecasts a daily mode shift of roughly 7,000 passengers per day across all routes, so all impacts are assumed to be moderate.

JOURNEY QUALITY: FACTORS

Cleanliness: Internal and external cleanliness and graffiti; the condition of the seats; tables; brightness of internal lighting.

Facilities: Types of seats, handles, luggage racks and storage, toilets, buffet/restaurant facilities and level of staff customer service, presence of service stations and facilities for motorists.

Information: Audibility, frequency and usefulness of on-board PA announcements; the provision of general travel information and customer magazines; and the condition of advertising posters.

Environment: Extent of overcrowding, ventilation; temperature; noise; overall condition and smoothness of ride, motor vehicle condition and driver capability.

Travellers' Views: Depth of cuttings or natural/artificial barriers, the presence of which may block views of the surrounding countryside or townscape.

Frustration: Road layout and geometry; condition of the road network; ability to make good progress along a route.

Fear of potential accidents: Presence of other vehicles, inadequate sight distances, possibility of pedestrians stepping into the road, presence of central reservation or safety barriers (or not); inadequate lighting; the width of the road/ carriageway/lane; presence of roadworks; the absence of lane markings, cats eyes, and hard shoulders.

Route Uncertainty: Timetables and network maps (e.g. available in public places, or on the Internet), provision of in-vehicle route signs.

JOURNEY QUALITY: SCORING

Beneficial: As a premium service, and with new vehicles, eVTOL services should be clean and free of graffiti. Unlike (even 1st class) trains, which can be messy due to other passengers on the service, eVTOLs will carry a small number of passengers meaning litter and other dirt should be minimal or non-existent. It is important that, despite needing quick turnaround times to maximise passenger numbers, time is taken to ensure the cleanliness is maintained.

Adverse: Due to weight and space restrictions, eVTOLs will not have as much luggage space as trains and private taxis. This could have more serious implications for wheelchair/pushchair users.

Neutral: eVTOL services should have sufficient information available to passengers through the app booking system. Alternative sources of information should be available to people with poor sight or those who are not normally users of technology.

Beneficial: As the service will have only 4 passengers, overcrowding and noise disturbances should not be an issue. However, noise from the vehicle itself may be a slight disbenefit to some passenger.

Beneficial: A key user benefit of eVTOL (aside from the time savings) is the enjoyment of travelling by air versus on the road/railway/underground. Some tourist eVTOL journeys are expected to be made purely for the views they offer (similarly to current helicopter tourist flights).

Beneficial: eVTOLs will be able to avoid the congestion, particularly in urban areas, that road users face. Similarly, unlike the railways, which have dated infrastructure causing delays and cancellations, modern eVTOL infrastructure should have good reliability.

Neutral: eVTOLs are expected to be safe, with rigorous testing before beginning passenger services. Those who have reservations about the safety of eVTOLs are unlikely to use the service.

Beneficial: Services are limited and direct, with origin and destinations pre-booked on an app, meaning that there should not be confusion.

5/8 factors beneficial
2/8 factors neutral
1/8 factors adverse

5/8 factors beneficial 2/8 factors neutral 1/8 factors adverse

JOURNEY DISPATCH RELIABILITY

Reliability is among the most important benefits of an eVTOL ecosystem, particularly for high wealth travellers making time critical journeys, a group which is expected to drive the initial uptake of eVTOL. Whilst we can assume that due their avoidance of traffic and the new infrastructure eVTOL services should be substantially more reliable than existing modes of transport, we do not know what the realised reliability will be upon operation. Therefore, we cannot forecast a specific reliability benefit. This analysis therefore outlines the current dispatch reliability issues with existing modes, and the potential time savings for passengers if eVTOLs are fully reliable.

Rail:

- For the 2023/24 FY, there were 1.61bn rail passenger journeys made, of these 70% were on time (or have delays of less than 1 minute and are considered on time by the ORR), 17% were 3 minutes (or less) late, and 12% were 15 minutes (or less) late. More specific data is not available, so delay values of 3 and 15 minutes are applied.
- This means that 273.7m journeys were 3 minutes late, and 193.2m journeys were 15 minutes late, giving a total of 2,898m delay minutes, or 869.4m delay hours.
- This averages to 0.54 hours of delay per passenger journey
- The demand modelling forecasts a mode shift of 1,908,220 passenger journeys per year from rail to eVTOL.
- Meaning that there is 1 million hours of delays for rail to eVTOL shifters that could be mitigated.

Car:

- Drivers spend an average of 38 hours in traffic each year.
- There is a forecasted mode shift of nearly 700,000 passengers from car to eVTOL.
- This means that there are 26.5 million hours of congestion for road to eVTOL shifters that could be mitigated.
- There is a secondary benefit for the remaining road users, who are now able to drive in roads with slightly less congestion (accounted for in the MEC).

This highlights the importance of eVTOL and vertiport operators building robust networks that are resilient against technical faults. If a grounded eVTOL held up other services from a taking-off/landing, one of the driving factors of eVTOL up-take would not be realised.

Ecosystem developers must ensure a robust and reliable network to attract passengers.

GROUP USERS: IMPACTS

Objective:

To assess the strategic impacts on selected groups (airports and NHS) based on potential use cases (eVTOLs to help access airports, emergency services).

Methodology:

1. To assess the impact on Heathrow airport

Current Access Modes

Public Transport: 39.3%

- Underground: 51%
- Bus and Coach: 29%
- Rail: 20%

Private Transport: 60.7%

- Car: 84.8%
- LGV: 4.4%
- Taxi: 3.6%
- HGV: 2.6%
- Plant HGVs:1.5%
- Bus/ Coach: 1.4%
- Other: 1.1%
- Unknown: 0.7%
- Motorcycle: 0.1%

The Airports National Policy Statement required Heathrow to:

"increase the proportion of journeys made to the airport by public transport, cycling and walking to achieve a public transport mode share of at least 50% by 2030, and at least 55% by 2040 for passengers."

"from a 2013 baseline level... achieve a 25% reduction of all staff car trips by 2030, and a reduction of 50% by 2040".

Domestic routes, if well planned can reduce road traffic (car and taxi) to key destinations like large airports. If not well planned it can increase the surface access traffic issues at these locations.

Source: Heathrow: 2019 Travel Report

GROUP USERS: IMPACTS

2. To assess the impact on NHS: Ambulance and Air Ambulance Service

On-road Ambulance Service Performance

Ambulance Response Category		Average (hr:min:sec)	90th Percentile (hr:min:sec)
C1 Response: An immediate response to a life threatening condition, such as cardiac or respiratory arrest	Standard1	<= 7:00	<= 15:00
	Response Time	8:25	14:56
A serious condition, such as stroke or chest pain, which may require rapid assessment and/or urgent transport	(Feb 24)2	<= 18:00	<= 40:00
	Standard	36:20	1:17:39
An urgent problem, such as an uncomplicated diabetic issue, which requires treatment and transport to an acute setting	Response Time		<= 2:00:00
	(Feb 24)		4:51:59
A non-urgent problem, such as stable clinical cases, which requires transportation to a hospital ward or clinic	Standard		<= 3:00:00
	Response Time (Feb 24)		5:56:23

- eVTOLs can substantially reduce the response time of on-road ambulance services and a 60 min saving would equate to £133 saving for NHS3
- Refer to Annexure 1 for a Scotland Case Study

Source:
1. https://www.england.nhs.uk/statistics/wp-content/uploads/sites/2/2021/05/20230825-AmbSYS-specification.pdf
2. https://www.england.nhs.uk/statistics/wp-content/uploads/sites/2/2024/03/20240314-Statistical-Note-AQI-1.pdf
3. Ambulance handover delays cost the NHS an estimated £225m in 2022 as health system... - LBC
4. Air Ambulance Funding - Hansard - UK Parliament

Air Ambulance Services

- 2450: Average rescue helicopter taskings in last 5 years
- 24% taskings in 2022-23 were to beaches and cliffs
- 16% taskings in 2022-23 were to mountains
- 12% taskings in 2022-23 were to vessels
- Cost per mission : £25004; Cost of operating one air ambulance: £12000 per day4

By reducing access times and due to ease of landing/ take-off, eVTOLs can act as game changers for the emergency services. This analysis does not consider if the evtol vehicle's technical features are capable of addressing this use case.

IMPACT ON INDIVIDUAL AND GROUP USERS

Summary

3.1 Route Refinement

- For all nine of the selected routes eVTOL is faster than rail, and it is also faster than road on eight out of nine.
- For all nine routes, eVTOL is the most expensive mode.
- Over the next 30 years, the ecosystem is forecast to generate nearly £4bn in travel time savings for users.
- There is a loss for rail operators, who will lose an estimated £1.6bn in ticket revenue over the same period due to eVTOL.
- There is a monetized benefit of £95m due to the removal of cars (and their associated disbenefits such as congestion and accidents) from the roads.
- Reliable and high-quality services are important for the ecosystem's success by obtaining high value travellers as first switchers to eVTOL
- For routes that have negative benefits, there should be a refinement of the ticket price or service frequency assumptions. This improvement may in turn further increase demand on these routes
- Consideration should also be given to the source of mode shift. eVTOLs should aim to compete with road more than rail travel.

3.2 Route Selection

Domestic routes, if well planned can reduce road traffic (car and taxi) to key destinations like large airports. If not well planned, it can increase the surface access traffic issues at these locations.

3.3 Route Prioritisation

If technically and financially viable, eVTOLs have the potential to significantly reduce journey times and hence function as game changers for the emergency services.

5 ENVIRONMENTAL IMPACTS

OBJECTIVE AND METHODOLOGY

Objective:

- To assess the potential environmental impacts of an eVTOL ecosystem

Methodology:

1. Identify all potential environmental impacts of an evtol ecosystem

This analysis does not cover lifecycle assessment of eVTOLs

METHODOLOGY

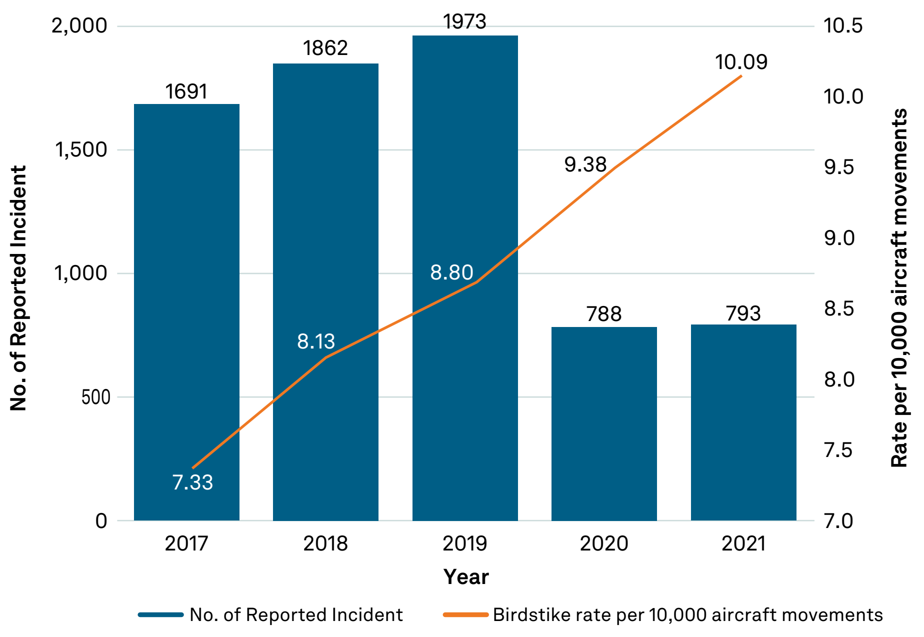
2. RAG analysis to screen the significant impacts

In case of no supply issues related to green electricity, eVTOL energy demand could help build a case for local energy grid and opportunities which would come with it.
In case of unavailability of green electricity, eVTOLs can increase the carbon footprint of the area. It would also be important how efficiently the locations for vertiport development are selected (current sites might require less construction activity compared to completely new sites) and they are constructed.

BIRD STRIKES

Reported Birdstrikes

Rate per 10,000 aircraft movements.
Includes only aerodrome operators reporting the number of aircraft movements

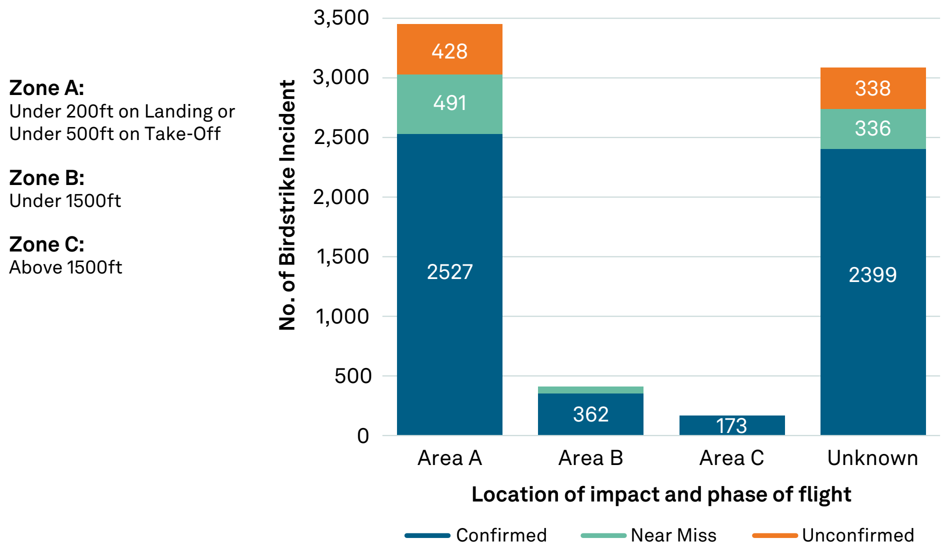


Bird strike rate (number of reported incidents per aircraft movement) has been increasing in the past 5 years

Source: UK Reported Bird strike 2017-21 (caa.co.uk)

Reported Birdstrikes

By Location of Occurrence and Phase of Flight 2017-21



- eVTOLs will be mainly operating in zone 'B' during cruise

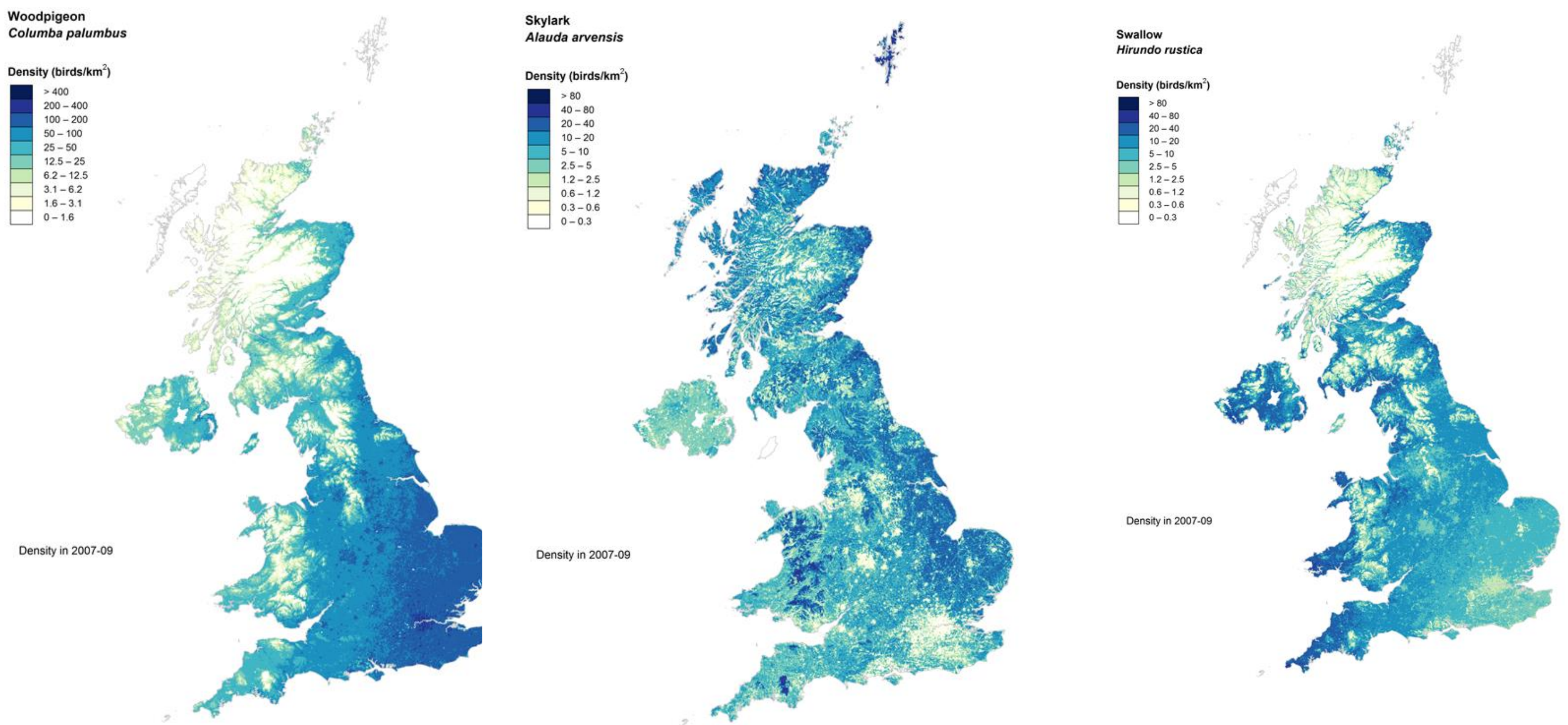
  A Bell 407 helicopter flying at 116 kt at 1,200 ft crashed near Stuttgart, Arkansas on November 19, 2017. Remains of snow geese were identified in the cockpit area to the first bulkhead. The pilot and two medical crew members did not survive. Source: eVTOL, The Case for a Bigger Bird, Alex Scerri, 2019

- eVTOLs will be in zone 'A' during take-off and landing

  Zone 'A' is a high-risk area in terms of bird strikes

BIRD STRIKES

CAA-UK data suggests that the five bird types contributing to the maximum bird strikes are gulls, wood-pigeon, pigeon, skylarks and swallows. The maps below gives an idea on density of these birds. (Source: https://www.caa.co.uk/media/xoqp1c4z/uk-reported-birdstrike-2022.pdf)



BIRD STRIKES

Points to consider (based on literature review) while planning and designing an eVTOL network a

- **Threat is inevitable:** Cities normally have several attractants for birds which include bodies of water, parks and green areas as well as a constant food supply. Many studies show that bird populations, especially some of the larger species are showing an upward trend, so it appears that eVTOL exposure to this threat is all but inevitable.
- **Vehicle design is important:** Large aircrafts have an advantage as their critical systems can be segregated around different parts of the aircraft and thus a strike would unlikely disable multiple critical systems. However, eVTOL, although presenting a smaller target size, would probably have quite a few systems concentrated in small areas due to space limitations and these locations housing flight critical systems would need to be protected.
- **Wildlife management should not be an option:** Major airports tend to have wildlife management policies in place to control bird and other wildlife concentrations. Implementing the same in cities would somewhat dent the green credentials of eVTOL.
- **Detailed regulations needed:** It is important to have detailed vehicle regulations for eVTOL in order to sustain a bird strike.
- **Designing Sensors:** Another solution is to design and local sensors on the eVTOL aircraft which could identify a bird threat and help change the course of the flight.
- **Planning for eVTOL network:** It is important to plan the network and locate the vertiport to avoid areas of major concentration of bird population

Source: Alex Scerri, eVTOL, The Case for a Bigger Bird, https://www.linkedin.com/pulse/evtol-case-bigger-bird-alex-scerri/

Bird strikes are inevitable and given the risks involved with eVTOLs, this should not only be incorporated at the design of vehicle and regulation stages but also at route planning and design stages through use of bird risk registers containing information on bird population, type of birds, past bird strikes and migratory bird fly paths.

NOISE LEVELS

UK Standards:

Noise is regulated to varying extents at all UK airports. This can include noise limits and restrictions on operations. The specific restrictions will differ from airport to airport, reflecting the types of aircraft that operate there, how busy the airport is and what flight paths are.

Although maximum noise limits are set for occupational noise exposure, **there is no limit defined for environmental noise, including aviation noise**. However, to assess the adverse impact of aircraft noise in the UK, government policy has established that the Lowest Observed Adverse Effect Level (LOAEL) is 51 dB LAeq,16h for an average summer's day and 45 dB LAeq,8hr for an average summer's night.

This doesn't mean that noise above these levels will not be allowed. But it does mean that **noise will be an important factor in planning decisions within that area** (for example, about airport expansion), and that there may be support available for noise mitigation (such as double-glazing).

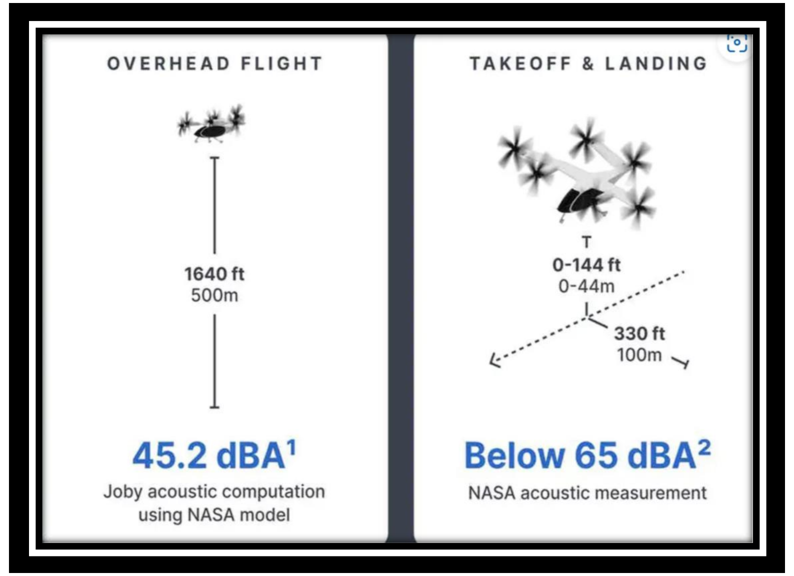
Noise Metrics:

- dB: Unweighted sound pressure levels
- dBA: frequency-weighted sound levels, measured over the 'A' frequency range
- LAeq: A-weighted, equivalent continuous sound level, in decibels
- EPNdB: Effective perceived noise in decibels
- EPNL: Effective Perceived Noise Level

Source: https://www.caa.co.uk/passengers-and-public/environment/noise/noise/

NOISE STANDARDS FOR EVTOLS – CURRENT STATUS

- CAA: Reviewing research, studies into the effects of noise and its relationship with sleep disturbance and response. It is expected that further findings would be reviewed to develop noise policy and legislation for eVTOLs, and for the protection of the people exposed to noise from them.
- The European Union Aviation Safety Agency (EASA) has published noise standards for electric vertical-take-off-and-landing (eVTOL) aircraft. The noise limits are 86-106 EPNdB for take-off, 84-104 EPNdB for overflight and 89-109 EPNdB for approach. There is no maximum noise level for hover.
    - In NASA tests, the flyover noise generated by Joby Aviation's 2,200-kg-class S4 tilt prop was measured as 45.2dBA at 500 m (1,640 ft.) altitude. A direct comparison is not possible, as dBA measures loudness while ENPdB measures annoyance by adjusting the sound level to account for human response, but the results indicate eVTOLs are significantly quieter. (Source: https://aviationweek.com/aerospace/advanced-air-mobility/easa-expands-evtol-noise-standards-limits).
- The Federal Aviation Administration (FAA), is proposing making light sport aircraft meet noise standards required of type certified aircraft under part 36. A prescriptive process is where the FAA directs, in incredible detail, exactly how a developer must test to earn certification. There has been opposition on this and it is still under review.



Source: NASA acoustic testing puts real numbers on Joby's eVTOL noise signature (newatlas.com)

The noise generated by eVTOLs can vary based on factors such as aircraft type, propulsion system, altitude, and flight patterns. It will hence form an important criterion in planning applications for vertiports.

URBAN DESIGN/TOWNSCAPE

All infrastructure associated with the eVTOL ecosystem will need to obtain planning permission to be built, which includes considering the impact on the local townscape.

The impact of an ecosystem on urban design/townscape will vary depending on factors including the size and location of vertiports, the frequency of flights, and the town/city's existing infrastructure. However, one unavoidable feature is that for eVTOL to be competitive against other modes of transport, vertiports must be in close enough proximity to population/business/leisure centres.

For some towns and cities, vertiports may be able to slot into the townscape with minimal impact to the surrounding areas. London, for example, already has vastly varied architecture and a range of bus, tube, and train stations located throughout the city, and building a vertiport is unlikely to be detrimental to the city's character.

However, other smaller towns and cities (for example Bath or Bristol) have a distinct local building style, and vertiports could have a negative impact on the town's architectural cohesion and local identity. Historical old towns or cultural centres could also be impacted by the presence of a vertiport.

Aside from the vertiport, eVTOL services themselves also pose a risk to townscape. Many towns and cities receive visitors due to historic buildings or city centres, and eVTOLs flying at low altitudes could negate the charm that tourists visit, or residents move there for.

As the ecosystem develops, it is essential that vertiports and eVTOL services are designed and located in the most optimal way not only for the operators and users, but for residents as well (by integrating with the local identity and not adversely disturbing the visual skyscape).

ENVIRONMENTAL IMPACTS

Summary

4.1 Bird strikes

Bird strikes are inevitable and given the risks involved with eVTOLs, this should not only be incorporated at the design of vehicle and regulation stages but also at route planning and design stages through use of bird risk registers containing information on bird population, bird strikes and bird fly paths.

4.2 Noise limits

The noise generated by eVTOLs can vary based on factors such as aircraft type, propulsion system, altitude, and flight patterns. It will hence form an important criterion in planning applications for vertiports.

4.3 Urban design and skyscape

As the ecosystem develops, it will be essential that vertiports and eVTOL services are designed and located in the most optimal way not only for the operators and users, but for non-users as well by integrating the infrastructure with the local identity and not adversely disturbing the visual skyscape.

4.4 Electricity Source

Carbon emissions are not expected in case of eVTOLs due to use of green electricity. However, lack of green electricity can increase the carbon footprint of the eVTOL ecosystem.

6 SOCIAL AND DISTRIBUTIONAL IMPACTS

SOCIAL AND DISTRIBUTIONAL IMPACTS

Objective

To assess the social impacts (which cover the human experience of the transport system and its impact on social factors, not considered as part of economic or environmental impacts) and distributional impacts (which consider the variance of transport intervention impacts across different social groups) of an eVTOL ecosystem.

Methodology

1. High level assessment of various social impacts
2. Further detailed analysis of selected social impacts
3. High level assessment of distributional impacts

1. High level assessment of various social impacts

Social Impact as per TAG A4.1	Definition	High Level Assessment
Accidents	Alters the risk of individuals being killed or injured because of accidents	• Assuming the eVTOL intervention to be safe; • Reduction in road traffic might reduce accidents but that is estimated to be a less significant impact. It has been captured through Marginal External Costs in user savings
Physical Activity	Affects level of physical activity	• Less significant impact as most of the transfer is expected from cars or taxis and the pedestrian movement inside vertiports is expected to be much less than at railway stations.
Security	Affects the level of security for transport users and non-users	• Users: On flight security is assumed to be taken care of before the service is operational • Non-users: Impact on non-users privacy along the flight path should be explored further

SOCIAL IMPACTS

Social Impact as per TAG A4.1	Definition	High Level Assessment
Severance	Separation of residents from facilities and services caused by substantial changes in transport infrastructure	No significant impact as the planned infrastructure on ground is very limited in size.
Journey Quality	Measure of the real and perceived physical and social environment experienced while travelling	Being covered as part of user savings
Option and Non-use values	Measures impact of schemes that will substantially change the availability of transport services within the area	Though usually measured for public transport modes, potential of public use cases in the longer term warrants further analysis
Accessibility	Measures impact of the new mode by minimising social exclusion	To assess benefits for physically inaccessible areas
Person Affordability	Assesses if monetary costs of eVTOL travel can be a major barrier to mobility for certain groups of people, with particularly acute effects on their ability to access key destinations	While eVTOL fare is expected present a short-term barrier to travel for some potential groups (future eVTOL users), right policies and strategies can ensure that it does not stop them from accessing key destinations.

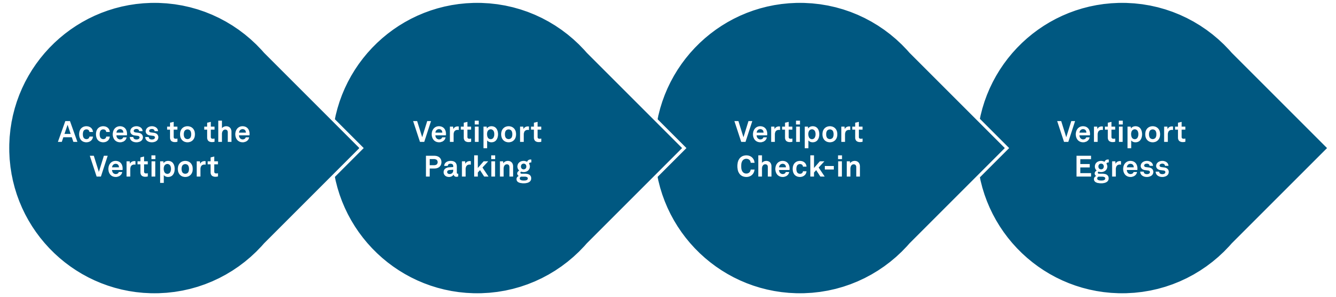
SECURITY

Objective

To assess the impact of eVTOL ecosystem on security of users (safety perspective) and non-users (privacy perspective)

Safety of Use

Vulnerable Points during the Journey



Factors to be considered:

- Safety and security of eVTOL users travelling to the vertiport
- Site perimeters entrances and exits
- Formal and informal surveillance
- Landscaping in and around the vertiport site
- Lighting and Visibility
- Access to emergency services

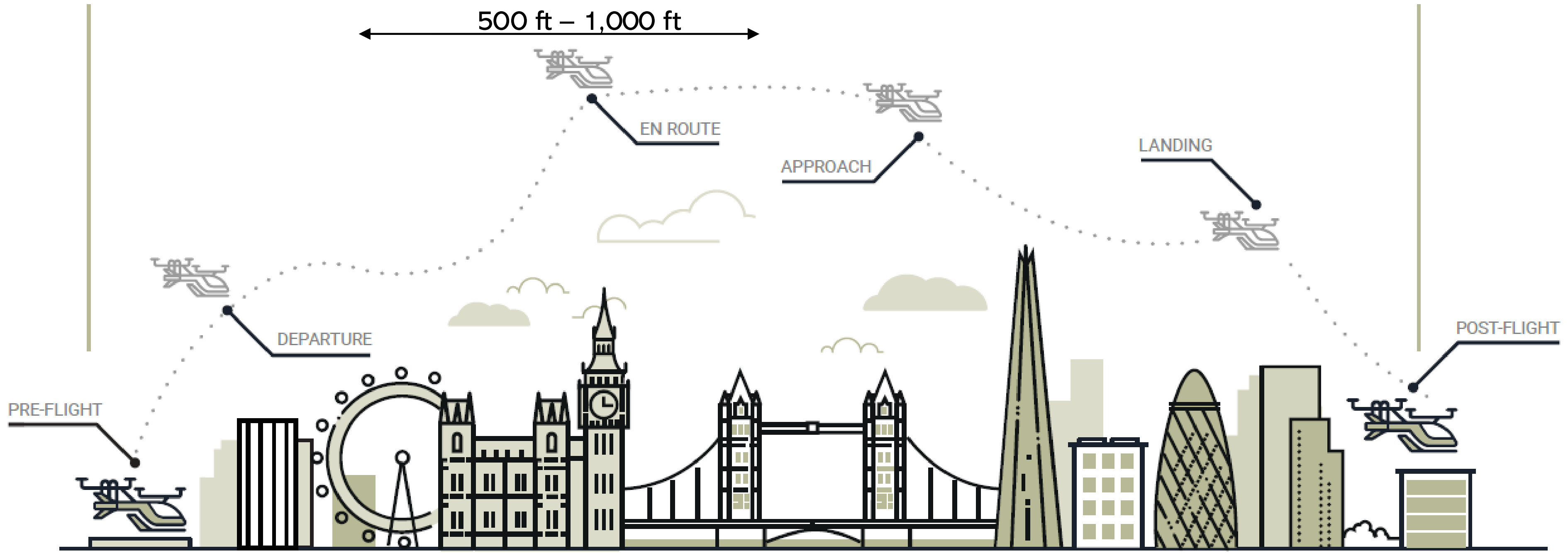
There are some vulnerable points along the eVTOL user journey which needs further investigation during detailed design to ensure greater confidence and higher offtake.

SECURITY

Privacy of Non-users

Factors to be considered from a privacy perspective:

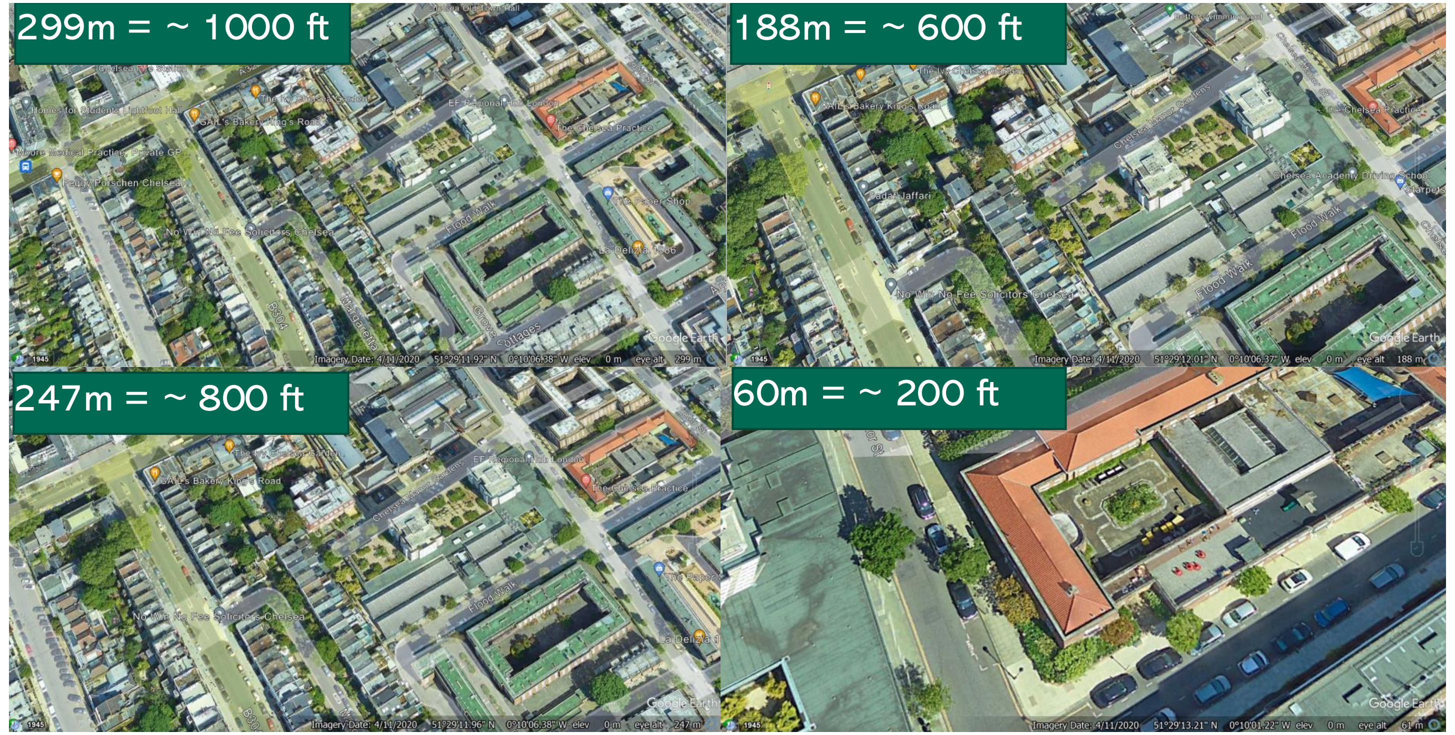
1. UAM vehicles are expected to operate primarily between 500 ft – 1,000 ft AGL, but they will also operate above this level.
2. Wikipedia lists around 45 buildings (present in 3 cities: London, Manchester and Birmingham) which are taller than 500 ft. In addition, 9 are under construction. Shard: 1016 ft; Elizabeth Tower (Big ben): 310 ft. There are more than 100 buildings whose height is between 300 and 500 ft.



SECURITY

Privacy of Non-users

3. Privacy along the flight path does not seem to be an issue as the eVTOL is flying between 500 ft and 1000 ft. However, as the altitude goes down (either due to the building height restrictions or during approach and take-off), there might be some privacy issues especially in sensitive areas like military areas, airports, hospitals etc.



At lower eVTOL vehicle altitudes (either closer to tall buildings or during approach and take-off), there will be some privacy issues especially in sensitive areas like military cantonments, airports, hospitals etc.

OPTION AND NON-USE VALUE

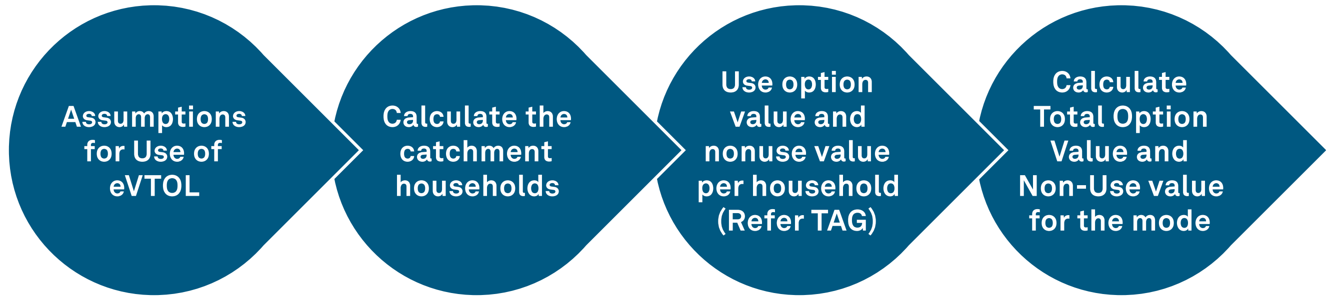
Objective

To assess the option value and non use value (see definition below) of a new eVTOL ecosystem.

An option value is the willingness-to-pay (not actually paying) to **preserve the option of using a transport service** for trips not yet anticipated or currently undertaken by other modes, over and above the expected value of any such future use.(TAG)

Non-use values are the values that are placed on the **continued existence of a service** (i.e. transport facility), regardless of any possibility of future use by the individual in question

Methodology:



QUANTIFYING OPTION VALUE

1. Data for April 2023 to March 2024 https://www.gov.uk/government/statistical-data-sets/average-speed-delay-and-reliability-of-travel-times-cgn#average-speed-delay-and-reliability-of-travel-times-on-srn-cgn04https://www.ethnicity-facts-figures.service.gov.uk/work-pay-and-benefits/pay-and-income/household-
2. Number of households in top two weekly income bands income/latest/#:~:text=Summary%20of%20Household%20income%20By,of%20%C2%A32%2C000%20or%20more
3. Planning The Future Of Flying, A Planning Framework to unlock vertiport implementation across the country by CPC

QUANTIFYING IMPACT: OPTION VALUE

Insights:

- TAG provides the following impact classifications based on the number of households.
  - >1,000 households: Large impact;
  - 250-999 households: Moderate impact;
  - 1-249 households: Slight impact;
  - 0 households: Neutral impact.

Based on the above, eVTOL ecosystem is estimated to have a high option and non-use value for the households.

- Level of option and non-use value would depend on factors like:
  - Presence of certain use cases. E.g., Health, emergency,
  - Income levels in the catchment area

Households can attribute a significant option and non-use value to a well-developed eVTOL ecosystem. This would depend on presence of certain social use cases like health, emergency and would also depend on the income levels in the catchment area.

ACCESSIBILITY

Case study: UK island population

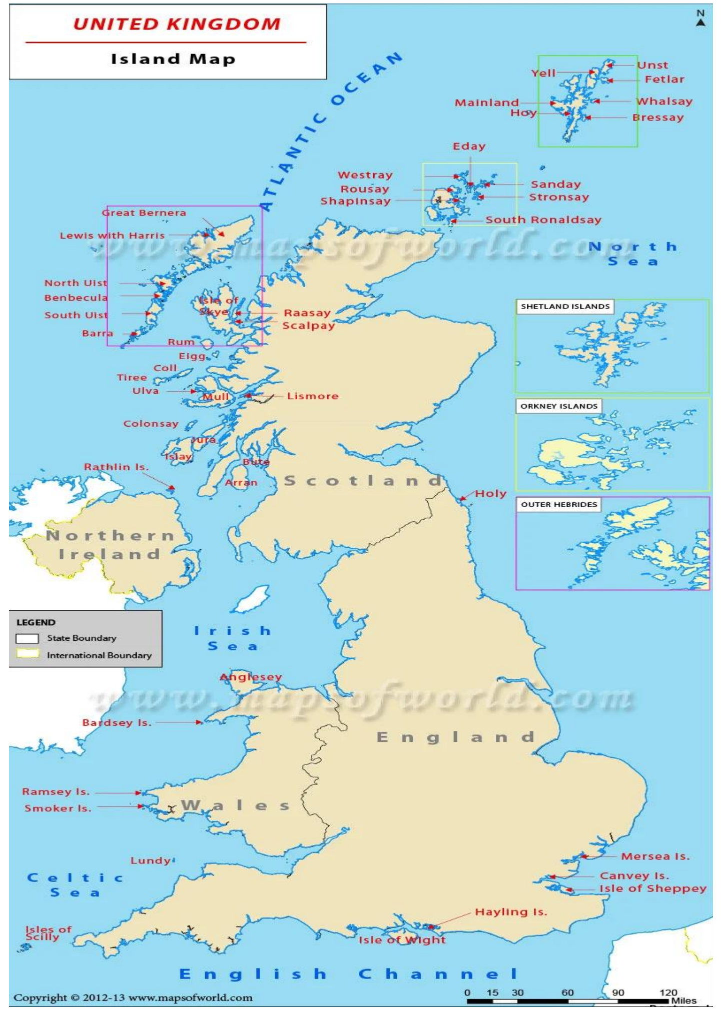
420
Islands in UK

130 (30%)
Inhabited Islands in UK

24	9	94	1
In England	In Wales	In Scotland	In NI

656,000 (approx.)
people in UK Islands

469k	83k	104k	140
In England	In Wales	In Scotland	In NI



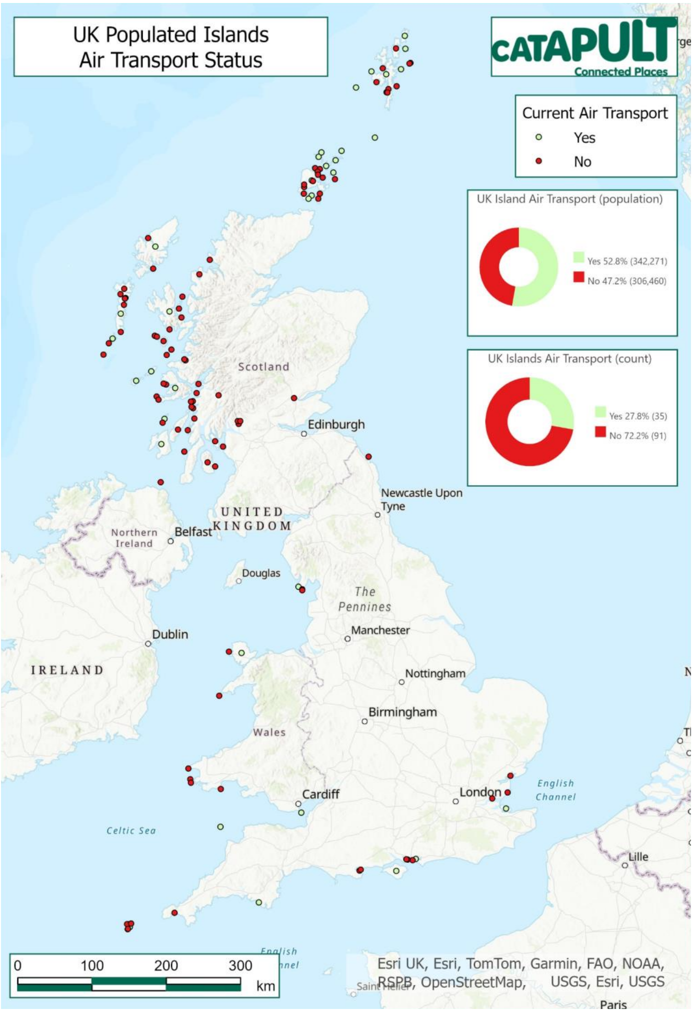
ACCESSIBILITY

Current and potential air Connectivity for island population

Only 53% of island population has access to air connectivity

This air connectivity access varies by country. Wales provides air access to its maximum island population (83%) followed by Scotland (77%), England (42%) and Northern Island (0%)

Enhanced air connectivity through an eVTOL ecosystem can have a high impact on accessibility of people staying in these islands.

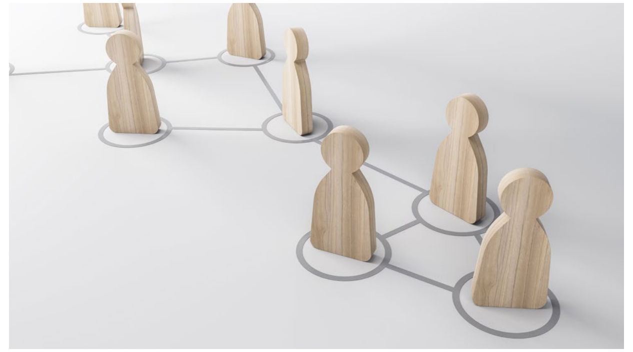


Enhanced air connectivity through an eVTOL ecosystem can have a high impact on accessibility of people residing in areas with currently limited accessibility like the islands around UK mainland.

DISTRIBUTIONAL IMPACT ANALYSIS

Distributional impacts (DIs) consider the variance of transport intervention impacts across different social groups. Some of the factors distinguishing these social groups mentioned in the TAG are:

- Age
- Access to private mode
- Disability
- Ethnicity
- Gender
- Income Groups
- Carers



Social Group	Security	Journey Quality	Option and Non-use values	Accessibility
Age	Security impacts are not expected to be age specific	Journey quality impacts are not expected to be age specific	Younger individuals are expected to attribute higher value to the eVTOL ecosystem as they are more open to new technology	Accessibility impacts are not expected to be age specific
Access to Private mode	Security impacts are not expected change based on individuals' access to a private mode	Individuals with access to a private mode for the same route would prefer similar comfort and privacy with eVTOLs	Individuals with access to a private mode (affluent traveller/ business traveller) for the same route are expected to attribute higher value to the eVTOL ecosystem	Accessibility impacts are expected to be more for individuals with no or limited access to private modes
Disability	Security impacts are not expected to be based on individuals' disability	Journey quality and accessibility impacts are expected to be different for people with disability. They also might have a different option value or non-use value to the ecosystem for certain use cases. Please refer to the report "What Should an Inclusive Advanced Air Mobility Service Look Like?" for further insights into this.		

DISTRIBUTIONAL IMPACT ANALYSIS

Social Group	Security	Journey Quality	Option and Non-use values	Accessibility
Ethnicity	Security impacts are not expected to be based on ethnicity	Journey quality impacts are not expected to be based on ethnicity	Option and non-use values are not expected to be based on ethnicity	Accessibility impacts are not expected to be based on ethnicity
Gender	Safety during access to the site is expected to have greater impact on some genders.	Journey quality impacts are not expected to be based on gender	Option and non-use values are not expected to be based on gender	Accessibility impacts are not expected to be based on gender
Income Groups	Security impacts in terms of privacy are expected to more significant for higher income groups	Individuals in higher income category are expected to attribute higher value to journey quality	Individuals in high income category are expected to have higher option and non-use value for the ecosystem even if they are not the first movers as they are expected to be more open to new technology[1]	Accessibility impacts are expected to be more for individuals in lower income categories as they are expected to have fewer alternative options.
Carers	Security impacts are not expected to be based on individuals' carer status	Journey quality impacts are not expected to be based on individuals' carer status	Option and non-use values are not expected to be based on individuals' carer status	Accessibility impacts are not expected to be based on individuals' carer status

Some social groups classified based on income, access to private mode and disability might experience differential impacts of an eVTOL ecosystem.

1. https://commercial.yougov.com/rs/464-VHH-998/images/Global-Technology-2020.pdf

SOCIAL AND DISTRIBUTIONAL IMPACTS

Summary

5.1 Safety along an eVTOL journey

There are some vulnerable points along the eVTOL user journey (like access to vertiport if located outside cities, security checks etc) which need further investigation during detailed design to ensure greater confidence and higher uptake.

5.2 Privacy around sensitive areas

At lower eVTOL vehicle altitudes (either closer to tall buildings or during approach and take-off), there will be some privacy issues especially in sensitive areas like military cantonments, airports, hospitals etc. These should be considered at route planning and design stages.

5.3 Appropriate Combination of Routes

Households can attribute a significant option and non-use value to a well-developed eVTOL ecosystem. This would depend on presence of certain social use cases like health, emergency and would also depend on the income levels in the catchment area.

5.4 Route Prioritisation

While some UK islands have access to air transport, eVTOLs can be a game changer by enhancing the air connectivity and can have a high impact on accessibility for people residing in these areas.

5.5 Minimise negative differential impacts

Some social groups classified based on income, access to private mode and disability might experience differential impacts of an eVTOL ecosystem.

7 WIDER IMPACTS

6A. LAND USE AND LAND VALUE IMPACTS

Objective

To assess the impact of an eVTOL ecosystem on adjacent land use and land values.

Methodology:

1. To identify impact of current aviation system on adjacent land use and land values

Regulated development of real estate	Regulated development of real estate
Regulated development of real estate	Unregulated development of real estate
Regulated development of real estate	**Regulated development of real estate**
Regulated development of real estate	Unregulated development of real estate
Accessibility for certain group of individuals	Due to noise levels
	Due to road traffic
	Due to air pollution
	Due to visual pollution
	Due to safety
	Due to privacy concerns for nearby properties

LAND USE AND LAND VALUE IMPACTS

2. To estimate the land use and land value impacts of an eVTOL ecosystem

<table>
<tr><th rowspan="2">Type of Impact</th><th rowspan="2">Reason for Impact</th><th>Basic Vertiport</th><th>Standard Vertiport</th><th>Hub Vertiport</th></tr>
<tr><th>1 FATO* with 1-2 stands (only if needed and space is available)</th><th>1-2 FATOs (along with multiple stands (usually between three to five, as per demand).</th><th>At least 2 or more FATOs along with multiple stands (usually between three to five, as per demand)</th></tr>
<tr><td>Positive Impact on Land Use</td><td>Regulated development of real estate</td><td rowspan="3">Neutral as the volume of traffic will not lead to any significant changes in land use and land value.</td><td colspan="2">Vertiports can increase opportunities in an area by providing better accessibility. If the real estate is regulated (aligned with the local plans and strategies - types of permitted development around the vertiport, density of development and space regulations), it can have positive impact on the adjacent land use development</td></tr>
<tr><td>Negative Impact on Land Use</td><td>Unregulated development of real estate</td><td colspan="2">Unplanned real estate can have negative impact on adjacent land use development by making it unbalanced towards certain types of land uses.</td></tr>
<tr><td rowspan="2">Positive Impact on Land Value</td><td>Regulated development of real estate</td><td>Neutral as the volume of traffic will not lead to any significant changes in land value.</td><td>Regulated development aligned with local strategies and plans can have positive impact on land values too.</td></tr>
<tr><td>Accessibility for certain group of individuals</td><td colspan="3">Better accessibility can have positive impact on land values too as it might attract high-end land uses (high income housing, retail parks, event locations etc.).</td></tr>
</table>

*FATO: Final Approach and Tak Off Area (Refer Annexure 1)

LAND USE AND LAND VALUE IMPACTS

2. To estimate these impacts of an eVTOL ecosystem

Type of Impact	Reason for Impact	Potential impact of AMEC 1 FATO with 1-2 stands (only if needed and space is available)	Potential impact of AMEC 1-2 FATOs (along with multiple stands (usually between three to five, as per demand).	Potential impact of AMEC At least 2 or more FATOs along with multiple stands (usually between three to five, as per demand)
Negative Impact on Land Value	Unregulated development of real estate	Neutral as the volume of traffic will not lead to any significant changes in land value.		Unplanned real estate can have negative impact on adjacent land use development by pushing up the current rents in the market making it unaffordable for current residents.
	Due to air pollution	NA	NA	NA
	Due to noise levels	Neutral as the volume of traffic will not lead to any significant changes in land value.	Standard vertiports too would need EIAs to ensure minimal negative impact of noise levels.	Hub vertiports need a detailed EIA to ensure minimal negative impact of noise levels, additional traffic and visual air pollution.
	Due to road traffic		Neutral as the volume of traffic will not lead to any significant changes in land value.	
	Due to visual pollution			
	Due to safety		If the location of the vertiport is outside the city, there should be strategies in place to ensure safety during access (assuming that the initial riders will be the wealthy individuals).	
	Due to privacy concerns		eVTOL routes will have to ensure that they are designed to avoid and sensitive areas along it	

Extent of land use and land value impacts would be dependent on the type of vertiports (size and functionality) being developed in an area and the characteristics of the area. If poorly planned, hub vertiports can have more negative impacts than positive.

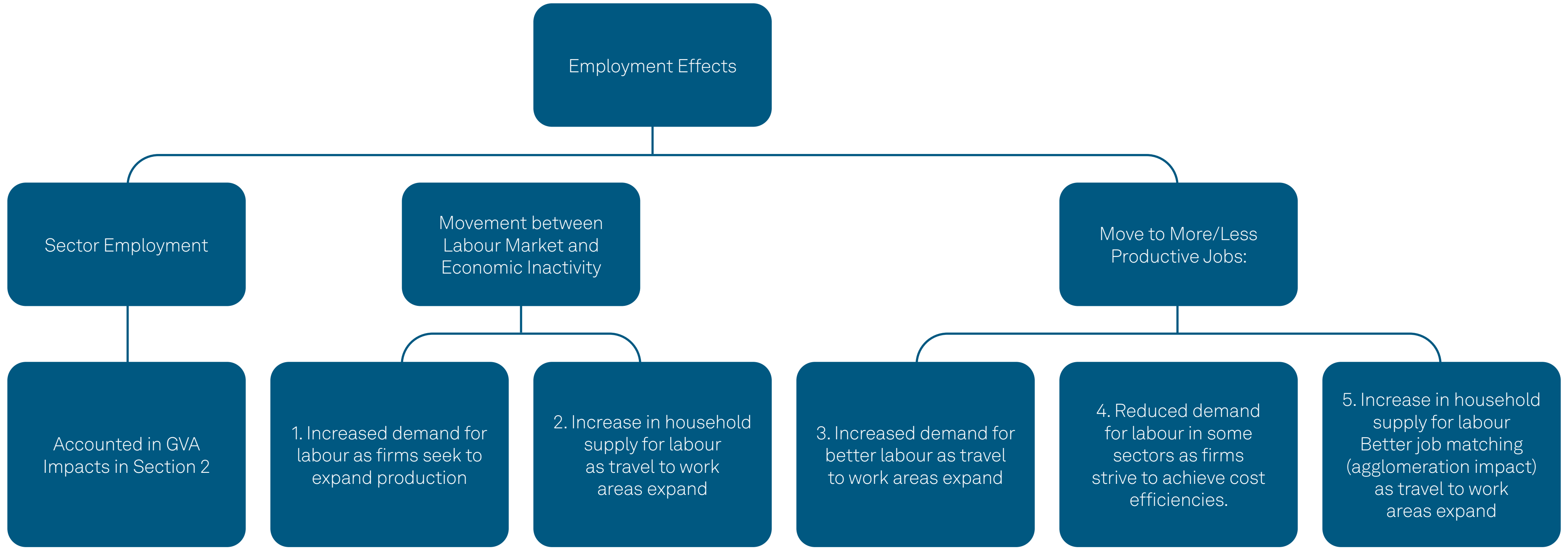
6B. LABOUR MARKET IMPACTS

Objective

To assess the impact of an eVTOL ecosystem on local and national employment. (Employment effects refer to changes in the level and location of employment as a result of a transport investment.).

Methodology:

1. Identify and categorise various employment effects



LABOUR MARKET IMPACTS

2. Assess the potential employment effects based on TAG guidance

Employment Effect of transport investments	Example Use Case	Potential impact of AMEC
1. Increased demand for labour as firms seek to expand production	With increase in the travel to work areas, a research facility expands as it can now recruit increased number of research scientists (some of whom might be willing to work on a part time basis too)	AMEC might have these impacts in a restricted way (for certain individuals) depending upon the frequency of trips to a location.
3. Increased demand for better labour as travel to work areas expand	With increase in the travel to work areas, a research facility expands its work in new areas as it can recruit better researchers	
2. Increase in household Supply for labour as travel to work areas expand	Since the journey time decreases substantially, researchers who stopped working as the most suitable job for them is located far away might come back to the job market	In the immediate/ short time frame, eVTOLs are not expected to be an option for commuter trips. It might also have supply constraints. It might have more potential when the ecosystem is well established.
4. Reduced demand for labour as firms strive to achieve cost efficiencies.	The research facility has redundancies as there are better researchers who can be approached. The present set of researchers are assumed to be accommodated in a different research facility.	
5. Increase in household supply for labour as there is better job matching (agglomeration impact) as travel to work areas expand	With increase in the travel to work areas, a researcher opts to change jobs and select an employment more suitable for his credentials.	

In the immediate/ short time frame, eVTOLs are not expected to be an option for commuter trips due to pricing, supply and other factors. Hence the labour market effects would be limited to certain target markets. It might have more potential to have labour market effects when the ecosystem is well established.

6C. AGGLOMERATION IMPACTS

Objective:

To assess the impact of an eVTOL ecosystem on creating agglomeration economies (in which individuals and firms derive productivity benefits from locating near other individuals and firms).

Methodology:

1. Identify and categorise potential agglomeration economies
2. Assess the impacts in the context of an eVTOL ecosystem.

	Static Clustering	Dynamic Clustering
Localisation Economies (as per TAG)	Transport investment increases the effective size of the cluster for firms in a particular industry. Individuals and firms traverse the cluster more easily, facilitating interactions. Productivity benefits are derived from improved connectivity of single-industry cluster.	Transport induces a change in the location or intensity of an industry's activity; productivity benefits are derived from improved connectivity of single industry cluster (assuming the urban cluster expands/contracts).
AMEC Ecosystem	AMEC impact on single industry clusters will be more visible in certain markets related to leisure and business trips. For e.g., Retail, tourism, entertainment etc.	AMEC is unlikely to induce change in location due to improved connectivity due to its limited scale and focus on specific target markets.
Urbanisation Economies (as per TAG)	Transport investment brings all industries effectively closer together, encouraging labour market interactions, knowledge spill-overs and linkages. Productivity benefits are derived from the scale and diversity of accessible markets.	Transport induces a change in the location and intensity of overall economic activity; productivity benefits are derived from improved connectivity of multi-industry cluster (assuming the urban cluster expands/contracts).
AMEC Ecosystem	Impact of AMEC on the scale and diversity of accessible markets will be more visible in certain regions. For e.g., Industry clusters around an international airport, an event location, etc.	AMEC is unlikely to induce change in location due to improved connectivity due to its limited scale and focus on specific target markets.

AMEC is unlikely to induce change in location due to improved connectivity but is likely to have some impact on single industry clusters related to retail, tourism, entertainment etc and in certain regions like close to international airports or a large event location, etc.

6D. IMPACT ON NEW BUSINESS MODELS

Current Business Models

Aviation Business Models

Private

- **Individually Owned Aircraft** → **Personal Use Only**
- **Group:** Full (One entity owns)/ Co-Ownership (Multiple companies co-own) 100-percent of an aircraft → **Exclusive Use by the group owners**
- **Group:** Joint Ownership (one registered owner employs pilot and others share the cost) Fractional Ownership: Share allows use for specific time of the year → **Lease to Operate (Open for All)** — Dry Lease

Public

- **Full Ownership** → **Lease to Operate (Restricted / Charter):** Specifies use by selected individuals/ groups and for selected airports/ times — Damp Lease
- **Co-ownership:** With Public Partners → **Lease to Operate (Time Share Agreement):** Lease aircraft and crew in lieu of time — Wet Lease

Public-Private Partnership

- **Group:** Co-Ownership with Private Partners → **Lease to Operate (Revenue Share Agreement):** Lease in lieu of share in revenue — Damp Lease

POTENTIAL BUSINESS MODELS

Service Models	Exclusive eVTOL Flight	eVTOL Flight on Demand (Taxi Service)	Scheduled eVTOL Flight
Personal Use Only	Wealthy Individuals	NA	NA
Exclusive Use by the group owners	Businesses/ Government	NA	NA
Lease to Operate (Open for All) (Usually a 'dry lease' where the lessee takes full responsibility of the aircraft's operation, maintenance, crewing, and insurance.)	NA	Any Route (Expensive option for initial operations)	Any Route (Long term option)
Lease to Operate (Restricted /Charter) (Could be a 'damp lease' where the lessor provides the aircraft, while the lessee is responsible for providing the crew and other operational aspects, such as maintenance and insurance.) (CMI)	NA	Lease to Military/ Emergency Services/ High Value Freight (Potential option for initial time periods)	NA
Lease to Operate (Time Share Agreement) (Usually a 'wet lease' where the lessor provides not only the aircraft but also the crew (including pilots and cabin crew), maintenance, and insurance.) (ACMI)	NA	Business Use (Potential option for initial time periods)	NA
Lease to Operate (Revenue Share Agreement) (Could be a 'damp lease' where the lessor provides the aircraft, while the lessee is responsible for providing the crew and other operational aspects, such as maintenance and insurance.) (CMI)	NA	Business Use (Potential option for initial time periods)	Any Route

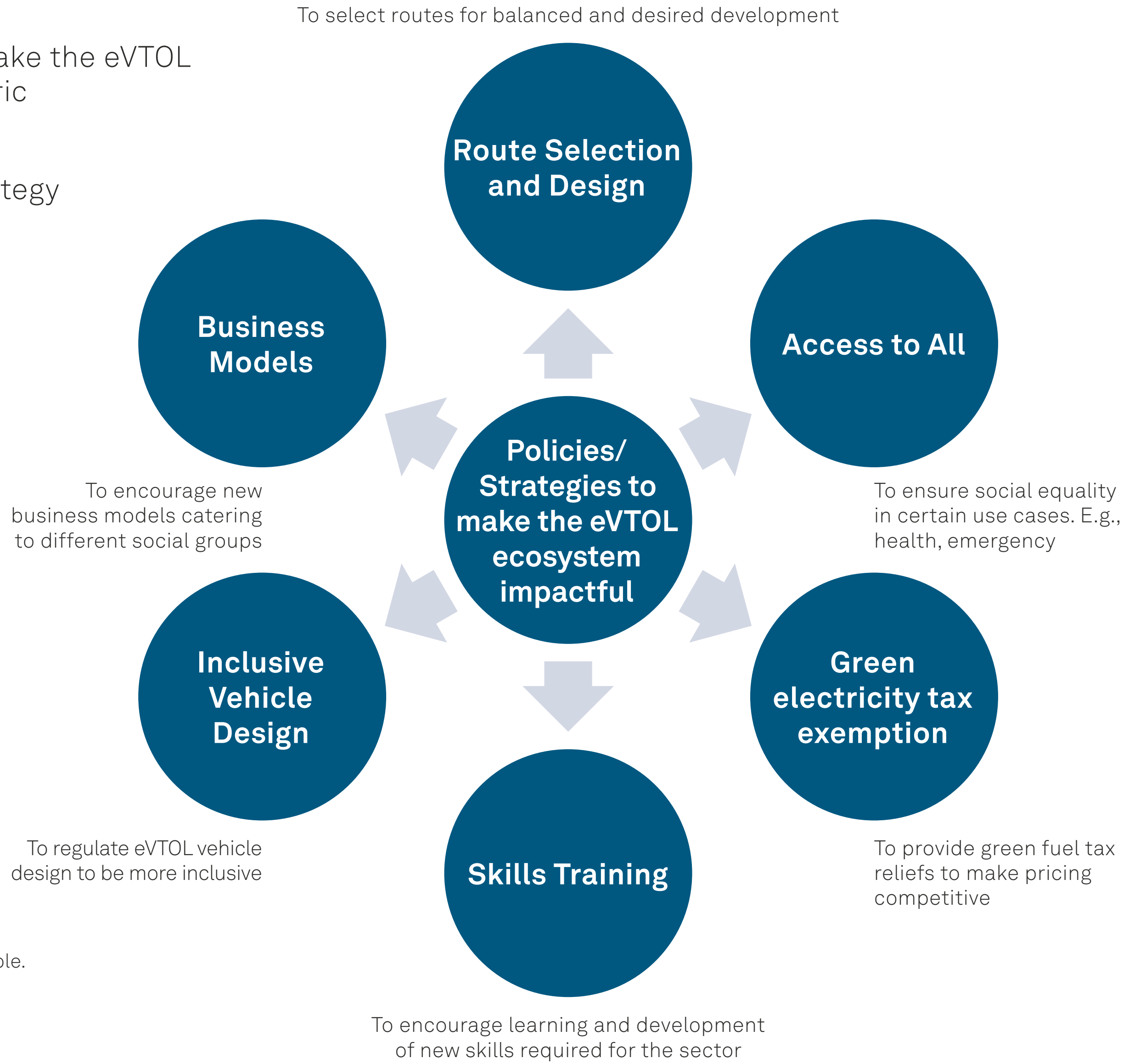
Current aviation business models (like time share agreements) should be explored further (reduction in tax implications for routes with larger societal benefits) to suit the needs of the potential eVTOL operators and users.

6E. USER CENTRIC POLICIES AND STRATEGIES

Objective: To identify additional policies required to make the eVTOL ecosystem not only operational but more people centric

Policies to make the eVTOL ecosystem operational:

1. eVTOL Vehicle/ Vertiport: Investment/ Funding Strategy
2. Electricity Pricing
3. Infrastructure Tax
4. eVTOL Vehicle Taxes (VED)
5. Project Financing Schemes: PPP etc.
6. Vertiport Design Standards
7. eVTOL Vehicle Design Standards
8. Infrastructure Operational Decisions
9. Pilots'/ Other Workers' Working Hours rules
10. Pilots' Licensing Policy
11. eVTOL Operator Licensing Policy
12. Infrastructure Safety Codes/ Regulations
13. Border Rules and Regulations for Freight
14. Border Rules and Regulations for Passenger
15. Domestic Freight Movement Restrictions
16. Rules on transport of Hazardous Materials
17. Local Noise Limits
18. Decarbonisation Strategy/ Projects
19. R & D – Vertiport and eVTOL technology
20. Import and Export Rules and Regulations



Policies and strategies can help define the direction and speed of the eVTOL ecosystem development and at the same time make it more inclusive and equitable.

WIDER IMPACTS

Summary

6.1 Regulate real estate growth

Extent of land use and land value impacts would be dependent on the type of vertiports (size and functionality) being developed in an area and the characteristics of the area. If poorly planned, hub vertiports can have more negative impacts than positive.

6.2 Labour Market strategy

In the immediate/ short time frame, eVTOLs are not expected to be an option for commuter trips due to pricing, supply and other factors. Hence the labour market effects would be limited to certain target markets. It might have more potential to have labour market effects when the ecosystem is well established.

6.3 Induce productivity via agglomeration

AMEC is unlikely to induce change in location due to improved connectivity but is likely to have some impact on single industry clusters related to retail, tourism, entertainment etc and in certain regions like close to international airports or a large event location, etc.

6.4 Future business models

Current aviation business models (like time share agreements) should be explored further (reduction in tax implications for routes with larger societal benefits) to suit the needs of the potential eVTOL operators and users.

6.5 User centric policies

Policies and strategies can help define the direction and speed of the eVTOL ecosystem development and at the same time make it more inclusive and equitable.

8 RECOMMENDATIONS AND NEXT STEPS

8. RECOMMENDATIONS

Advanced air mobility is a growing sector attracting significant investment. To ensure that the sector maximises its positives and minimises its negatives, it is important to steer the developing ecosystem towards a scenario with maximum societal (economic, environmental and social) benefits. A comprehensive assessment of impacts has identified seventeen recommendations which could help towards this.

		eVTOL Operators	Initial trials	Intensive trials	Route Identification	
Government at National, Regional and Local Levels	Policies	User centric national policies and strategies	■	■		Commercial Start of the eVTOL Ecosystem
	Policies	Policy on positioning of eVTOL ecosystem	■	■		
	Policies	Policy on design of eVTOL network		■	■	
	Policies	Inclusive Business Models Policy		■	■	
	Policies	Safety and Privacy Policy		■		
	Planning Considerations	Planning service frequency and fare structure		■		
	Planning Considerations	Route selection for large airports			■	
	Planning Considerations	Prioritisation (Emergency Services)			■	
	Planning Considerations	Prioritisation (Areas with low accessibility)			■	
	Planning Considerations	Route Combinations		■		
	Regulations	Regulations: Location and size of Vertiports	■	■		
	Regulations	Regulations: Real estate development		■		
	Regulations	Bird Strike Regulations	■	■		
	Regulations	Noise Regulations	■	■		
	Regulations	Urban design regulations		■	■	
	Others	Further assessment of economic contribution	■			
	Others	Further assessment of green credentials	■			

8. RECOMMENDATIONS: POLICIES

The first step towards developing an advanced air mobility ecosystem is to steer it using a robust set of policy and strategies. Some of the considerations at the **policy level** identified based on the impact analysis are:

1. Identification of user centric national policies and strategies

What should it include?
Additional policies and strategies ensuring balanced selection of routes, compulsory use cases, inclusive vehicle design, green electricity tax exemptions, skills training and supporting business models. (Refer 5.5, 6.5)

Why is it important?: To add more collective societal value to the proposed ecosystem making it more impactful.

2. Positioning of eVTOL ecosystem

What should it include?
Strategic framework to develop the eVTOL ecosystem as part of wider multimodal ecosystem to achieve the desired effects on local and regional accessibility. (Refer 1.1, 6.2)

Why is it important?: To achieve the desired local, regional and national impacts (population growth, redistribution, employment generation, movement in labour market) by influencing air accessibility.

3. Design of eVTOL network

What should it include?
Design of the eVTOL network to maximise productivity in single industrial clusters like retail, tourism, entertainment and in regions close to international airports and large event locations. (Refer 6.3)

Why is it important?: To induce agglomeration impacts within static clusters.

4. Inclusive Business Models

What should it include?
Development of new business models which can ensure development of low demand or low profit routes. (Refer 6.4)

Why is it important?: To help owners and operators add more community related benefits to the offering.

5. Safety and Privacy

What should it include?
Safety and privacy regulations for smooth operation and higher confidence on the new network. (Refer 5.1, 5.2)

Why is it important?: To ensure safety of users at vulnerable points during the journey and privacy of non-users along the flight path.

8. RECOMMENDATIONS: PLANNING CONSIDERATIONS

The second step towards developing the advanced air mobility ecosystem would be to plan the route network. Some of the considerations at the **planning level** identified based on the impact analysis are:

6. Route Planning: Refine service frequency and fare structure

What should it include?
Careful planning of service frequency and fare structures as the level of benefit varies from one route to another either due to low demand or higher costs. This could result in some routes being not profitable. (Refer 3.1)

Why is it important? To increase offtake and make the routes profitable.

7. Route Planning: Route selection for large airports

What should it include?
Detailed assessment of type of routes from large airports with current surface access issues so that the new eVTOL service acts as a supplementary service. (Refer 3.2)

Why is it important?: To solve the current surface access issues instead of increasing them.

8. Route Planning: Prioritisation (Emergency Services)

What should it include?
Following technical assessments, prioritise eVTOL services for patients in need of emergency treatment which could then reduce response time and associated costs for NHS. (Refer 3.3)

Why is it important?: To realise the extensive social benefits eVTOLs can achieve for emergency services.

9. Route Planning: Prioritisation (Areas with low accessibility)

What should it include?
Prioritising eVTOL services to provide connectivity to less accessible areas (difficult terrain) like islands around the mainland UK. (Refer 5.4)

Why is it important?: To maximise social impacts and strengthen the business case.

10. Route Planning: Route combinations

What should it include?
Appropriate combination of profitable (demand responsive) and non-profitable routes (social value perspective) to an area. (Refer 5.3)

Why is it important?: To increase option value of the system for the households in the catchment area helping to build its business case.

8. RECOMMENDATIONS: REGULATIONS

The third step towards developing an advanced air mobility ecosystem is to support it with pre-defined regulations which could steer it to minimise any negative impacts. Some of the considerations at the **regulatory level** identified based on the impact analysis are:

11. Planning Regulations: Location and size of Vertiports

What should it include? Develop planning regulations (permitted areas) for vertiport development in alignment with the local characteristics (current land use, transport network etc.). (Refer 1.2)

Why is it important?: To minimise any potential negative impacts (especially of larger vertiports) and augment the positive impacts on the local area.

12. Planning Regulations: Real estate development

What should it include? Develop planning regulations (permitted real estate development) for local areas based on size and functionality of the vertiport. (Refer 6.1)

Why is it important?: To regulate real estate development to minimise any potential negative impact on land use and land value of a local area.

13. Environmental Regulations: Bird Strikes

What should it include? Risk register on potential bird strikes as part of environment clearances during planning approvals. (Refer 4.1)

Why is it important? To minimise the risk associated with bird strikes.

14. Environmental Regulations: Noise Limits

What should it include? Define noise limits for eVTOLs based on factors such as aircraft type, propulsion system, altitude, and flight patterns. (Refer 4.2)

Why is it important? To minimise the .noise impacts on users and non-users of the system.

15. Urban design and Skyscape

What should it include? Urban design and skyscape considerations when designing and locating eVTOL services and vertiports. (Refer 4.3)

Why is it important? To ensure integration with the local identity and minimise any adverse visual impacts.

8. RECOMMENDATIONS: OTHERS

Other than the three basic steps, there would be other considerations required to ensure proper development of an advanced air mobility ecosystem. Some of the **other considerations** identified based on the impact analysis are:

16. Further assessment of economic contribution

What should it include? Further assessment of estimates of economic contribution of eVTOLs. According to the current estimates, eVTOL ecosystem has the potential to contribute 20% of the contribution from an established current aviation sector by 2035. (Refer 2.1)

Why is it important? To build the case for investment – both public and private.

16. Further assessment of eVTOLs green credentials

What should it include? Further assessment of the green credentials of eVTOLs based on the type of electricity being used and the life cycle assessment. (Refer 4.4)

Why is it important? To build the environmental case for the new mode.

THANKS

Authors

Shipra Samanta – Shipra.Samanta@cp.catapult.org.uk
Jack Vickers – Jack.Vickers@cp.catapult.org.uk
Dominic Stevens – Dominic.Stevens@cp.catapult.org.uk
and
Philipp Thiessen – Philipp.Thiessen@cp.catapult.org.uk

9 ANNEXURES

ANNEXURE 1: DEFINITIONS AND ABBREVIATIONS

AAM – Advanced Aerial Mobility
A transport method that now makes it possible and cost-effective to carry people and goods to places where air travel was previously not practical.

AMEC – Air Mobility Ecosystem Consortium

ATM – Air traffic management
The coordinated and efficient handling of air traffic and airspace, including services for air traffic, airspace, and traffic flow. This is done safely and cost-effectively, with the help of facilities and continuous services, in cooperation with all involved, and includes both airborne and ground operations.

ATMS – Air traffic management system
A system that supports air traffic management (ATM) by combining the efforts of people, information, technology, facilities, and services. This is aided by communication, navigation, and surveillance systems on the ground, in the air, or in space.

D-Value
The smallest circle that can surround the VTOL aircraft's outline on a flat surface, when the aircraft is ready to take off or land, and the rotor(s) are spinning if it has any.

Elongated FATO/TLOF
A FATO or TLOF where the length of the area is more than twice its width.

eVTOL – electric Vertical Take-Off and Landing

FATO – Final Approach and Take-off Area
The specific area where the final steps of the approach to hover or land are finished, and where the process of taking off begins.

FBO – Fixed-base operator
A fixed base operator is a business that offers a range of flight services at both big and small airports. They provide everything from fuelling to repairs, parking, and more, helping to ensure all flights run smoothly.

MRO – Maintenance, Repair and Overhaul
MRO in aviation, refers to the specific tasks of fixing, servicing, or checking an aircraft. It includes all the maintenance work done to make sure an aircraft is safe and ready to fly.

Protection Area
A defined area surrounding a stand intended to reduce the risk of damage from VTOL aircraft accidently diverging from the stand.

Runway-type FATO
A final-approach and take-off area (FATO) that has characteristics similar in shape to a runway.

Safety Area
It is an area on a VTOL port that surrounds the final approach and take-off area. This space is kept free of obstacles, except those necessary for air navigation, to reduce the chance of damage to VTOL aircraft that might accidentally move away from the take-off area.

STOL – Short Take-Off and Landing
Short Take-Off and Landing (STOL) refers to the ability of an aircraft to take off and land on very short runways.

Taxiways – Vertiport taxiways and taxi-routes
These are set paths on a VTOL port for moving aircraft from one area to another. They're designed for safe operations when multiple aircraft are moving at the same time. The impact of downward and outward airflows also needs to be considered.

TDPM – Touchdown positioning marking
It is a marker for a normal landing. It's placed so that when the pilot's seat is over it, the entire landing gear is within the landing and take-off area. This ensures all parts of the VTOL aircraft are safely away from any obstacles.

ANNEXURE 1: DEFINITIONS AND ABBREVIATIONS

TLOF – Touchdown and lift-off area
An area on which a VTOL aircraft may touch down or lift-off.

Vertiport
A type of aerodrome or operating site that is used or intended to be used for the arrival, departure, and surface movement of VTOL aircraft.

Vertiport Clearway
It is a chosen and prepared flat area where a VTOL aircraft can operate between the final approach and take-off area (FATO) and the inner edge of the approach/climb-out surface.

Vertiport Stand
An aircraft stand which provides parking for a VTOL aircraft and where ground taxi operations are completed or where the helicopter touches down and lifts off for air taxi operations.

VTOL aircraft
It is a chosen and prepared flat area where a VTOL aircraft can operate between the final approach and take-off area (FATO) and the inner edge of the approach/climb-out surface.

UAM – Urban Aerial Mobility
Is about using small, automated aircraft to transport people or goods in urban areas. It's a solution to traffic issues, providing a safe, eco-friendly air transport system. It integrates new technology with other transport systems and typically uses helicopters, VTOL, eVTOL, and UAVs, which are controlled by computer systems.

UAS – Unmanned aircraft system
An aircraft and its associated elements which are operated with no pilot on board.

UAV – Unmanned aerial vehicle
Is as an aircraft designed or modified to carry no human pilot. It operates either under remote control or in some autonomous mode of operation.

UTM – Unmanned (aircraft system) traffic management
This is a part of air traffic management that handles Unmanned Aircraft Systems (UAS) operations. It does this safely, cost-effectively, and efficiently by providing facilities and continuous services. It works with all involved parties and includes both airborne and ground functions. The term UTM is also used by the International Civil Aviation Organisation (ICAO), but it has a different meaning there.

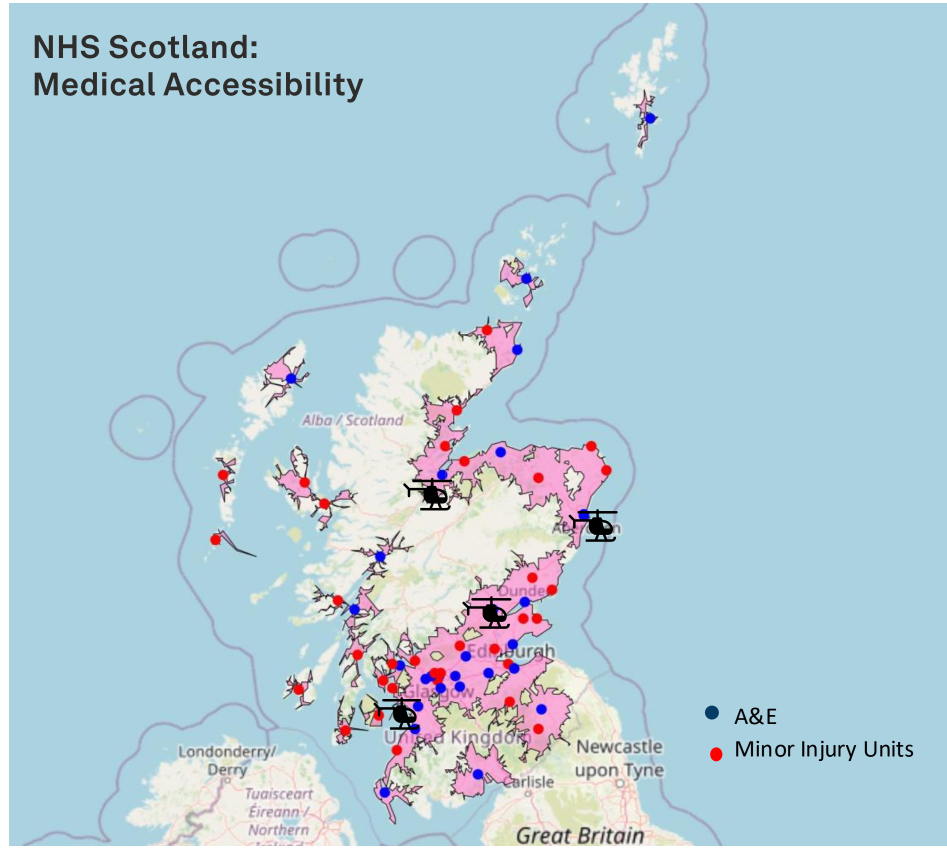
UTMS – Unmanned aircraft system traffic management system
A system that provides UTM through the collaborative integration of humans, information, technology, facilities and services, supported by air, ground or space-based communications, navigation and surveillance. d ground-based functions.

Note: Some definitions are based on the description in CAA's CAP 168: Licensing of Aerodromes (12th edition) and CAP 722 Unmanned Aircraft System Operations in UK Airspace – Policy and Guidance (9th edition Amendment 2), CAP 722DUnmanned Aircraft System Operations in UK Airspace: Abbreviations and Master Glossary (3rd edition).

Source: Planning The Future Of Flying, A Planning Framework to unlock vertiport implementation across the country by CPC

ANNEXURE 2: STAKEHOLDER IMPACTS

Case Study: Emergency Access to Medical Facility in Scotland



Source: NHS-accident-emergency-travel-time-map - Scotland's data on a map (datamap-scotland.co.uk)

Category	Population	Percentage
within 30-minute drive time from A&E	4,787,612	88%
greater than 30-minute drive time from A&E	637,188	12%
within 30-minute drive time from MIU	5,096,900	94%
greater than 30-minute drive time from MIU	327,900	6%

Supported by:

- 4 Scottish Air Ambulance
- 2 Scottish Charity Air Ambulance
- Weekly A&E Visits in Scotland: 25,000
- Annual Visits: 1.3 million
- Visits from more than 30-min away: 156,000
- Potential positive impact of an eVTOL ecosystem on these 156,000 patients

ANNEXURE 3: INTEGRATION OF EVTOL ECOSYSTEM WITH CURRENT MODES

Mode	Integrated Journey	Integrated Infrastructure
Walking	Access to eVTOL ecosystem is unlikely going to be by walk during the initial stages of development	
Cycling	Access to eVTOL ecosystem is unlikely going to be by cycling during the initial stages of development	
Car		Car Parking at vertiports
Taxi		Taxi Parking at vertiports
Public Buses	Access to eVTOL ecosystem is unlikely going to be by buses during the initial stages of development	
Private Coach		Coach parking at vertiports
Rail	Integrating scheduled services	Planning mode transfers
Helicopters		Use of helipads
Domestic airplanes	Integrating scheduled services	Planning mode transfers
International airplanes	Integrating scheduled services	Planning mode transfers

ANNEXURE 4: ROUTE ANALYSIS

INTER-CITY

1. Heathrow to Bicester Village

Annual route demand (2035): 7.77m. Annual mode shift (2035):

64,250 eVTOL passengers shifting from: 5,118 rail passengers, and 59,403 car passengers

	Business		Leisure		Total	Per Passenger
	Rail	Car	Rail	Car		
MECs		£1.3m		£11.8m	£13.1m	£220
VoT	£4.7m	£6.7m	£17.1m	£60.8m	£89.4m	£1,391
RA	£2.9m		£10.6m		£13.5m	£2,638

- For Heathrow to Bicester Village, around 92% of the mode shift to eVTOL comes from car travellers.
- The aggregated benefits of bringing nearly 60,000 cars off the road per year is £13.1m due to reduced congestion, accidents, infrastructure costs etc.
- Nearly 65,000 passengers per year are saving time by switching to eVTOL, resulting in a transport user benefit of £89.4m.
- Despite a lower share of mode shift, the high cost of rail tickets results in £13.5m of revenue being abstracted from rail operators.

*All benefits are appraised over 30 years and discounted.

*Per passenger benefits are the total benefit over 30 years divided by the annual mode shift (under the simplifying assumption that the same passengers shift each year

ANNEXURE 4: ROUTE ANALYSIS

INTER-CITY

2. Marylebone to Bicester Village

Annual route demand (2035): 7.71m. Annual mode shift (2035):

44,730 eVTOL passengers shifting from: 29,966 rail passengers, and 14,765 car passengers

	Business		Leisure		Total	Per Passenger
	Rail	Car	Rail	Car		
MECs		£0.3m		£4.1m	£4.4m	£298
VoT	-£18.5m	-£0.6m	-£117m	-£7.7m	-£143m	-£3,197
RA	£4.2m		£32.5m		£36.7m	£1,225

- For Marylebone to Bicester Village, around two thirds (67%) of the mode shift to eVTOL comes from rail passengers.
- The aggregated benefits of bringing nearly 15,000 cars off the road per year is £4.4m,
- VoT benefits are negative at -£238m over 30 years. This is because the monetized journey time savings is less than the increase in ticket price. This does not mean that there is no demand. The demand model is a probability model and does not only consider time and cost when determining whether a person will switch to eVTOL.

*All benefits are appraised over 30 years and discounted.

*Per passenger benefits are the total benefit over 30 years divided by the annual mode shift (under the simplifying assumption that the same passengers shift each year

ANNEXURE 4: ROUTE ANALYSIS

INTER-CITY

3. London Skyports to Woking

Annual route demand (2035): 59.46m. Annual mode shift (2035):

882,351 eVTOL passengers shifting from: 739,945 rail passengers, and 142,406 car passengers

	Business		Leisure		Total	Per Passenger
	Rail	Car	Rail	Car		
MECs		£3.4m		£37.4m	£40.8m	£287
VoT	£330.8m	£37.5m	£1,501m	£408.1m	£2,278m	£2,582
RA	£218.3m		£990.5m		£1,208m	£1633

- This route is one of the busiest, with nearly 900,000 passengers making the journey per year.
- It also has one of the highest VoT benefits (both in total and per passenger), due to the large time saving (50% faster) of travelling via eVTOL greatly outweighing the cost difference.
- As most passengers (83%) are switching from rail, there is a substantial extraction of revenue from rail operators - £1.2 billion over 30 years.

*All benefits are appraised over 30 years and discounted.

*Per passenger benefits are the total benefit over 30 years divided by the annual mode shift (under the simplifying assumption that the same passengers shift each year

ANNEXURE 4: ROUTE ANALYSIS

INTRA-CITY AIRPORT TRANSFER

4. Heathrow to London City

Annual route demand (2035): 91.1m. Annual mode shift (2035):

1,023,036 eVTOL passengers shifting from: 767,680 rail passengers, and 255,356 car passengers

	Business		Leisure		Total	Per Passenger
	Rail	Car	Rail	Car		
MECs		£3.5m		£18.7m	£22.1m	£87
VoT	£395.6m	£47m	£1,039.5m	£253.7m	£1,735m	£1,697
RA	£96.1m		£252.7		£348.8m	£454

- This route has the largest mode annual mode shift of over 1 million passengers per year.
- At over £22m, there is a considerable monetized benefit from removing over a quarter of a million cars off the road each year, however this only accounts for a benefit of £87 per passenger over 30 years. This is because this route is the shortest by car, so taking a car off the road is not as impactful as on other routes which have longer car journeys.
- Despite the high mode shift, this route has the lowest rail revenue abstraction at the per passenger level. This is due to the route having the lowest rail cost (£13)

*All benefits are appraised over 30 years and discounted.

*Per passenger benefits are the total benefit over 30 years divided by the annual mode shift (under the simplifying assumption that the same passengers shift each year

ANNEXURE 4: ROUTE ANALYSIS

INTRA-CITY AIRPORT TRANSFER

5. Heathrow to Gatwick

Annual route demand (2035): 13.44m. Annual mode shift (2035):

97,674 eVTOL passengers shifting from: 6,468 rail passengers, and 91,206 car passengers

	Business		Leisure		Total	Per Passenger
	Rail	Car	Rail	Car		
MECs		£1.1m		£9.9m	£11m	£121
VoT	£11.4m	£14.8m	£33.6m	£130.1m	£190m	£1,945
RA	£4.1m		£11.9m		£16m	£2,474

- This is one of the few routes which has a majority (~90%) of mode shift coming from car passengers. This is simply because, due to a faster travel time and lower cost, more people are travelling by car than rail prior to the introduction of eVTOL services.
- Nearly 100,000 passengers switching to eVTOL generates around £190m of VoT benefits over 30 years, and £11m of MECs benefits.
- There is £16m of revenue being abstracted from rail operators on this route (£2,500 per passenger). This is relatively high when compared with the demand, due to the high rail cost on this route.

*All benefits are appraised over 30 years and discounted.

*Per passenger benefits are the total benefit over 30 years divided by the annual mode shift (under the simplifying assumption that the same passengers shift each year

ANNEXURE 4: ROUTE ANALYSIS

STATION TO STATION

6. Birmingham New Street to Euston

Annual route demand (2035): 4.16m. Annual mode shift (2035):

14,484 eVTOL passengers shifting from: 13,101 rail passengers, and 1,384 car passengers

	Business		Leisure		Total	Per Passenger
	Rail	Car	Rail	Car		
MECs		£0m		£0.6m	£0.7m	£506
VoT	-£4.5m	-£0.1m	-£80m	-£5.5m	-£90.5m	-£6,248
RA	£3.1m		£56.4m		£59.6m	£4,549

- For Birmingham New Street to Euston, a vast majority (~90%) of mode shift comes from rail.
- This route also has the highest per passenger rail revenue abstraction at over £4,500 over 30 years.
- This is due to the origin and destination zones both being the location of two of the busiest rail stations connecting the two biggest cities.
- There is a negative VoT benefit, which is a result of the route's high eVTOL ticket cost, and the relatively low time savings.

*All benefits are appraised over 30 years and discounted.

*Per passenger benefits are the total benefit over 30 years divided by the annual mode shift (under the simplifying assumption that the same passengers shift each year

ANNEXURE 4: ROUTE ANALYSIS

INTER-CITY AIRPORT TRANSFER

7. Birmingham Airport to Heathrow

Annual route demand (2035): 662,000. Annual mode shift (2035):

7,231 eVTOL passengers shifting from: 542 rail passengers, and 6,689 car passengers

	Business		Leisure		Total	Per Passenger
	Rail	Car	Rail	Car		
MECs		£0.1m		£2.4m	£2.4m	£359
VoT	£0.3m	£0.5m	£1.8m	£21.2m	£23.7m	£3278
RA	£0.2m		£1.6m		£1.9m	£3,506

- Despite a high eVTOL ticket cost, this route has the highest per passenger VoT benefits due to the large time savings from both rail and road mode shift.
- Revenue abstraction per passenger is also high due to the route's high rail ticket price.
- The overall mode shift is low at just over 7,000 people per year expected to use eVTOL between Birmingham Airport and Heathrow, this results in comparably low total benefits.

*All benefits are appraised over 30 years and discounted.

*Per passenger benefits are the total benefit over 30 years divided by the annual mode shift (under the simplifying assumption that the same passengers shift each year

ANNEXURE 4: ROUTE ANALYSIS

INTER-CITY

8. Southampton to Portsmouth

Annual route demand (2035): 2.25m. Annual mode shift (2035):

6,777 eVTOL passengers shifting from: 5,510 rail passengers, and 1,267 car passengers

	Business		Leisure		Total	Per Passenger
	Rail	Car	Rail	Car		
MECs		£0		£0.1m	£0.1m	£79
VoT	£1.6m	-£0m	£13.2m	-£3.7m	£11m	£1,623
RA	£0.5m		£3.9m		£4.4m	£799

- Southampton and Portsmouth are geographically close and easily accessible to each other by car, meaning that mode shift is quite low (less than 7,000 passengers per year), and a there are very low MECs benefits per passenger (£79 over 30 years).
- The VoT benefits is derived from rail passengers switching to eVTOL to take advantage of the faster travel time, whilst there is a negative VoT benefits for people shifting from cars.

*All benefits are appraised over 30 years and discounted.

*Per passenger benefits are the total benefit over 30 years divided by the annual mode shift (under the simplifying assumption that the same passengers shift each year

ANNEXURE 4: ROUTE ANALYSIS

URBAN - RURAL

9. Bristol to Cornwall

Annual route demand (2035): 722,000. Annual mode shift (2035):

337 eVTOL passengers shifting from: 116 rail passengers, and 221 car passengers

	Business		Leisure		Total	Per Passenger
	Rail	Car	Rail	Car		
MECs		£0		£0.1m	£0.1m	£452
VoT	£0	-£0.1m	-£0.1m	-£1.4m	-£1.6m	-£4,747
RA	£0		£0.5m		£0.5m	£4,310

- Bristol to Cornwall is, by a considerable amount, the least popular route, with only 337 annual eVTOL passengers forecast, a third switching from rail and two thirds switching from car.
- The MECs benefits per passenger is one of the largest on this route. The route is the largest by road, meaning that removing one car off the road has a larger impact than removing one car on a shorter route.
- Rail abstraction, though low overall due to demand, is high at a per passenger level due to the expensive rail fare between the two zones.

*All benefits are appraised over 30 years and discounted.

*Per passenger benefits are the total benefit over 30 years divided by the annual mode shift (under the simplifying assumption that the same passengers shift each year

ANNEXURE 4: ROUTE ANALYSIS

Discussion

This analysis has focused on the direct user impacts of eVTOL service introduction, and across the three benefit categories a general idea of the scale of the impact of each route can be inferred. However, there are simplifying assumptions that have been made due to data availability meaning that these figures should not be taken as complete. Other factors that might change the benefits include:

- Induced demand: only mode shift was considered when undertaking the demand modelling, with induced demand (that is, people making new journeys as a result of eVTOL introduction) not being included. eVTOLs can provide new transport links to and from areas which may not currently have sufficient transport infrastructure and thus might get overlooked when only considering mode shift.
- Crowding benefit: this analysis considers the cost to rail operators of losing passengers to eVTOL, however a benefit of this is the reduction of crowding. If eVTOL services are able to move a sufficient number of people from rail to AAM, there is a benefit to the remaining rail passengers who are more likely to get on the first train/get a seat.

There are other impacts that are direct user impacts but are considered separately in WP2.8:

- Journey quality: eVTOLs are expected to be comfortable and private, and for many travellers this offers an advantage against existing modes. The impact is looked at in WP2.8.
- Reliability: due to the avoidance of traffic, eVTOLs are expected to be very reliable. This offers a benefit to travellers who are making time-critical journeys. This is considered in WP2.8.
- Option value: option value refers to the benefit derived simply due to the existence of an additional transport mode. After AAM introduction a person may continue to take the train to work every day, but they have the reassurance of eVTOL services if their train was cancelled.

Other impacts beyond direct user impacts, such as agglomeration, employment, productivity etc. are also analysed in the rest of WP2.8.

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Senior stakeholder engagements

UKRI Innovate UK, Department for Transport, UK Civil Aviation Authority

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Email us **info@cp.catapult.org.uk**

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