
UK Research and Innovation

# Future Flight Vision and Roadmap August 2021

Future Flight Challenge at
UK Research and Innovation

# Introduction

**The Future Flight Challenge has set the vision for the future aviation system in 2030 and established the roadmap that will position the UK as a global leader in advanced aviation solutions.**

## Background

The Future Flight Challenge is a £300 million programme, jointly funded by the UK government and industry, to position the UK as a world-leader in the third aviation revolution. Future Flight will transform how we connect people, transport goods and deliver services in a sustainable way providing socio-economic benefits using new classes of air vehicles with novel technologies. The four-year programme is creating the future aviation system and will demonstrate the safe integration and operation of drones, advanced air mobility and regional aircraft, with advancements in electrification and autonomy by 2024.

The Future Flight Challenge has brought together stakeholders from multiple sectors beyond aviation and aerospace, building a future flight ecosystem comprised of businesses, government bodies, research and technology organisations, academia, professional institutions, local authorities, social scientists and consumers. Leveraging the UK's world-leading capabilities in aerospace and aviation, exploiting advancements in key enabling disruptive technologies such as artificial intelligence, batteries, robotics and digitalisation, and driving investment in innovation can position the UK for a share in the multi-billion-dollar market by 2030. A collective effort and collaborative approach are required by all players within this nascent ecosystem to develop the systems, products and services for future flight.

As future flight technologies and capabilities continue to advance, new classes of vehicles are being developed with novel technologies and capabilities without standardised terms. For the purpose of this study, new classes of air vehicles have been defined by three categories – drones, advanced air mobility and regional air mobility.

## Purpose

The Future Flight Roadmap has been developed to achieve the following:

- Set the strategic vision for Future Flight in the UK for 2030
- Set the strategic vision for the Future Flight Challenge for 2024
- Align Future Flight ambitions and ensure coordination of initiatives across multiple sectors
- Develop a robust understanding of the Future Flight ecosystem, its key players, roles and interdependencies
- Assess Future Flight trends, drivers, threats and opportunities
- Map the sequence of principal milestones (including technological, regulatory, societal, legislative) to achieve the UK vision and ambition by 2030
- Identify key enablers for Future Flight products, systems and services
- Determine priority areas to develop Future Flight capabilities in the UK
- Determine key demonstration examples required by 2024 as critical waypoints to achieve the 2024 and 2030 Future Flight visions
- Provide direction to stakeholders for engagement and collaboration across sectors

This report is a live document and will continue to be updated. Please contact Kerissa.Khan@innovate.ukri.org and Ian.brumby@to70.co.uk for more information.

# Contents



SECTION 1

# Setting the Future Flight vision for 2030

The Future Flight Vision and Roadmap were developed through a series of workshops with contributions from diverse stakeholders across the future flight ecosystem.

Global trends and drivers (social, political, economic and technological) were analysed for Future Flight and threats and opportunities were identified. Market opportunities for Future Flight products and services were reviewed. This highlighted the opportunities and challenges for Future Flight in the UK.

The Consumer Vision for 2030 was established. It describes how new classes of air vehicles will benefits consumers by 2030. This helps us understand the societal, environmental and economic goals to collectively work towards.

The Industry Vision for 2030 was then established to set out how the future aviation environment must operate by 2030, in order to achieve the Consumer Vision. It details the ambition that stakeholders within the future flight ecosystem must work towards achieving by 2030.

Example use cases were then used to illustrate the future aviation environment in 2030. The purpose is to showcase how the future aviation system will operate by 2030 to provide everyday benefits to consumers, supporting both consumer and industry visions. (This is not an exhaustive list of use cases and not selected based on any order of priority).

# Market opportunities

**The global market for drones, AAM and supporting services is projected to be approximately**

# $74 BILLION BY 2035

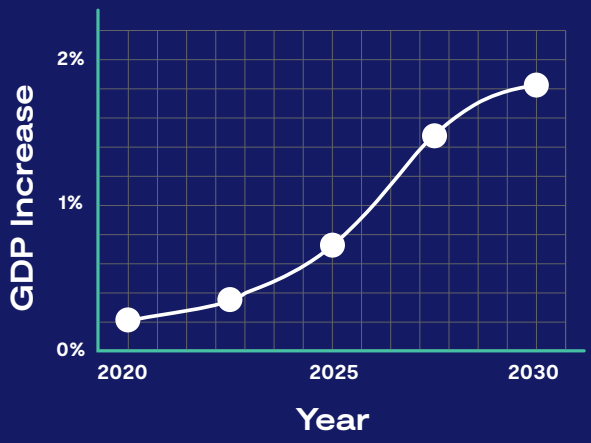
| DRONES | AAM | SERVICES |
|---|---|---|
| $38 BILLION | $32 BILLION | $4 BILLION |

**76,000 drones projected to be in use by industry in the UK by 2030**

| | | |
|---|---|---|
| 27,233 Public Defence, Health & Education | 25,732 Agriculture, Mining, Gas & Electricity | 11,008 Transport & Logistics |
| 4,816 Construction & Manufacturing | 4,541 Technology, Media & Telecoms | 2,514 Finance, Insurance & Services |

**Predicted impact on UK economy**

There is predicted to be a 1.8% increase in GBP and £16bn in net cost savings to the UK economy by 2030 through drone services



# Trends and drivers


## Threats

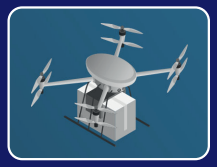
- Fast-evolving technology with a rapid obsolescence cycle making private investment more risky
- Conflicting and slow moving regulation/standards

## Opportunities

- UK has independent control over airspace and aircraft regulations which may allow rapid progression
- Changing energy system infrastructure and increasing electrification across transport
- Increasing affordability of new transport technologies
- New entrants to aviation market potentially disrupting traditional aviation business models

# Consumer vision 2030

## How new classes of air vehicles will benefit consumers in 2030



### Drones

**Unpiloted, non-passenger carrying vehicles varying in size from small to large**

**Delivery convenience**
Distribution and delivery services are rapid, convenient and within each reach for everyday goods and services

**Supporting services**
Drones support emergency services and perform complex inspections/operations

**Increased acceptability**
Drone operations are quiet, safe and acceptable as part of day-to-day life

### Advanced air mobility

**Electrical vertical take-off and landing vehicles that provide short journeys for up to 10 people**

### Regional air mobility

**10+ person electric, hydrogen or hybrid aircraft providing short-medium range hops between fixed locations**

**Reduced congestion**
Efficient use of airaspace resources reduces ground congestion (especially in urban areas)

**Improved connectivity**
Rural and traditionally disconnected regions form part of a highly distributed transport system within close proximity

**Increased consumer choice**
Allowing consumers to choose between cost and environmental efficiency

**Seamless journeys**
Existing transport is integrated as part of a seamless end-to-end transport network including ticketing

**Reduced journey time**
Average journey times significantly reduced

**Journey convenience**
Services are available on demand, reducing impact of travel and travel times

**Improved affordability**
Operations are affordable and widely available for the general public

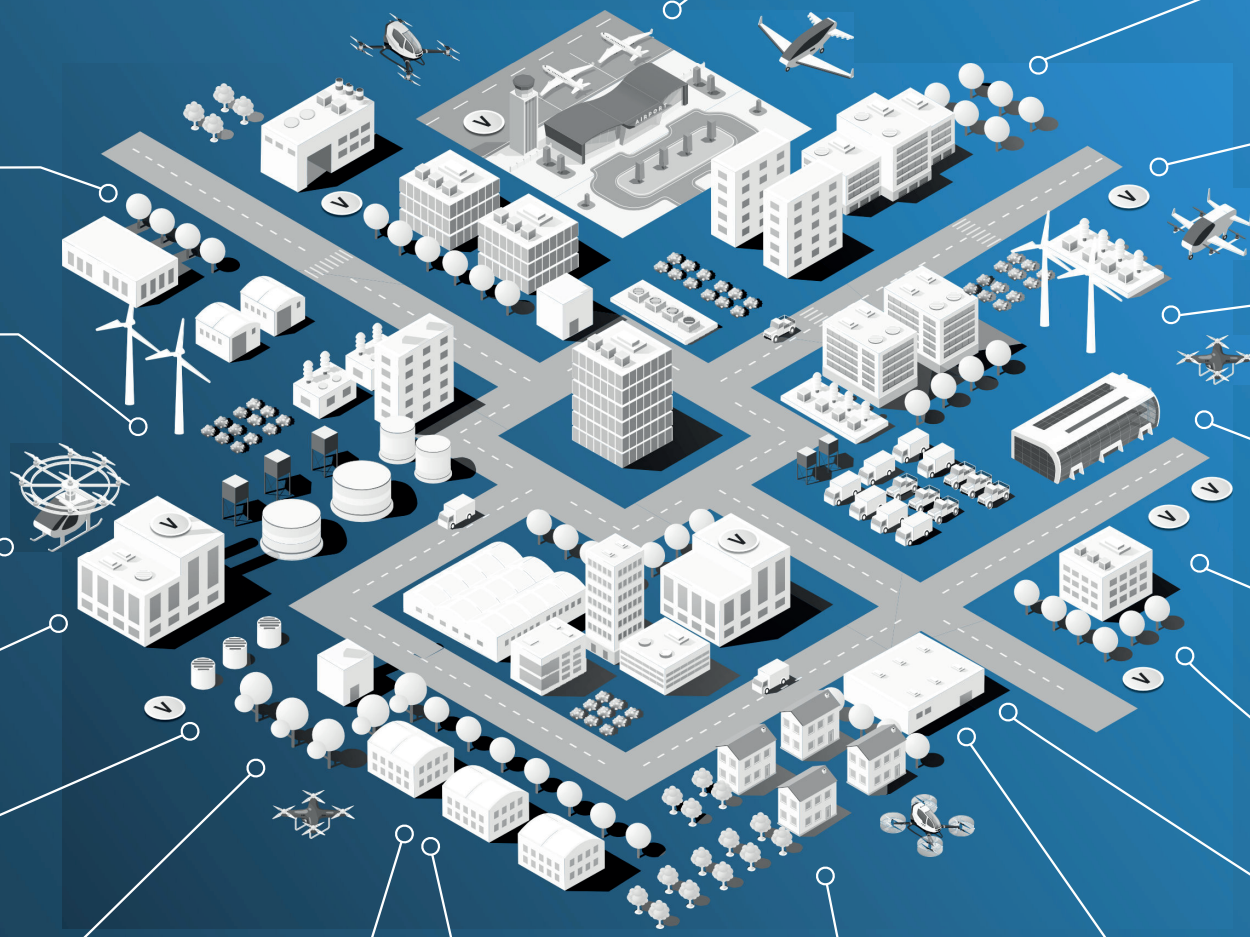
**Increased sustainability**
Operations are electric- or hydrogen-based, minimising the environmental impact

**Improved accessibility**
Improved access to services and employment opportunities for those with reduced mobility

**Benefits to the UK economony**
Predicted 1.8% increase in GDP and 628,000 jobs supported by 2030

# Industry vision 2030

## How the future aviation environment will operate in 2030 and the ambition future flight stakeholders should work towards



**Seamless**
Airports and existing transport infrastructure are integrated as part of a seamless end-to-end transport network.

**Harmonised**
Day-today operations are part of a socially accepted ecosystem.

**Secure**
Infrastructure and vehicles are protected from physical and digital threats.

**Safe**
Safety risks on the ground and in the air are mitigated.

**Equitable**
Operators have fair access to the network for services.

**Regulated**
The regulatory environment enables the industry to flourish.

**Simple**
There is reduced complexity through system consolidation.

**Distributed**
Small and regional airports feature as part of a highly distributed avation system.

**Scalable**
The system is able to scale in order to support increasing numbers of new movements.

**Inclusive**
Services are designed to increase mobility for everyone.

**Integrated**
Novel and traditional aircraft types integrate and operate within the same airspace.

**Commercially viable**
Operations are regular and financially viable.

**Flexible**
Services are available on demand, enabling Mobility-as-a-Service.

**Interoperable**
Global interoperability built into all services as standard.

**Dynamic**
Airspace can be used in a dynamic way for mixed traffic.

**Unified**
Aircraft can seamlessly transition between different airspace classes.

**Sustainable**
Operations are electric- or hydrogen-based, minimising the environmental impact.

**Predictable**
Services are planned and simulated effectively, to enable accurate forecasting.

# 2030 use cases

## Example use cases showing how new classes of air vehicles will operate in the future aviation environment by 2030 and the benefits these will bring to consumers

### UC8 Rapid airport transfer

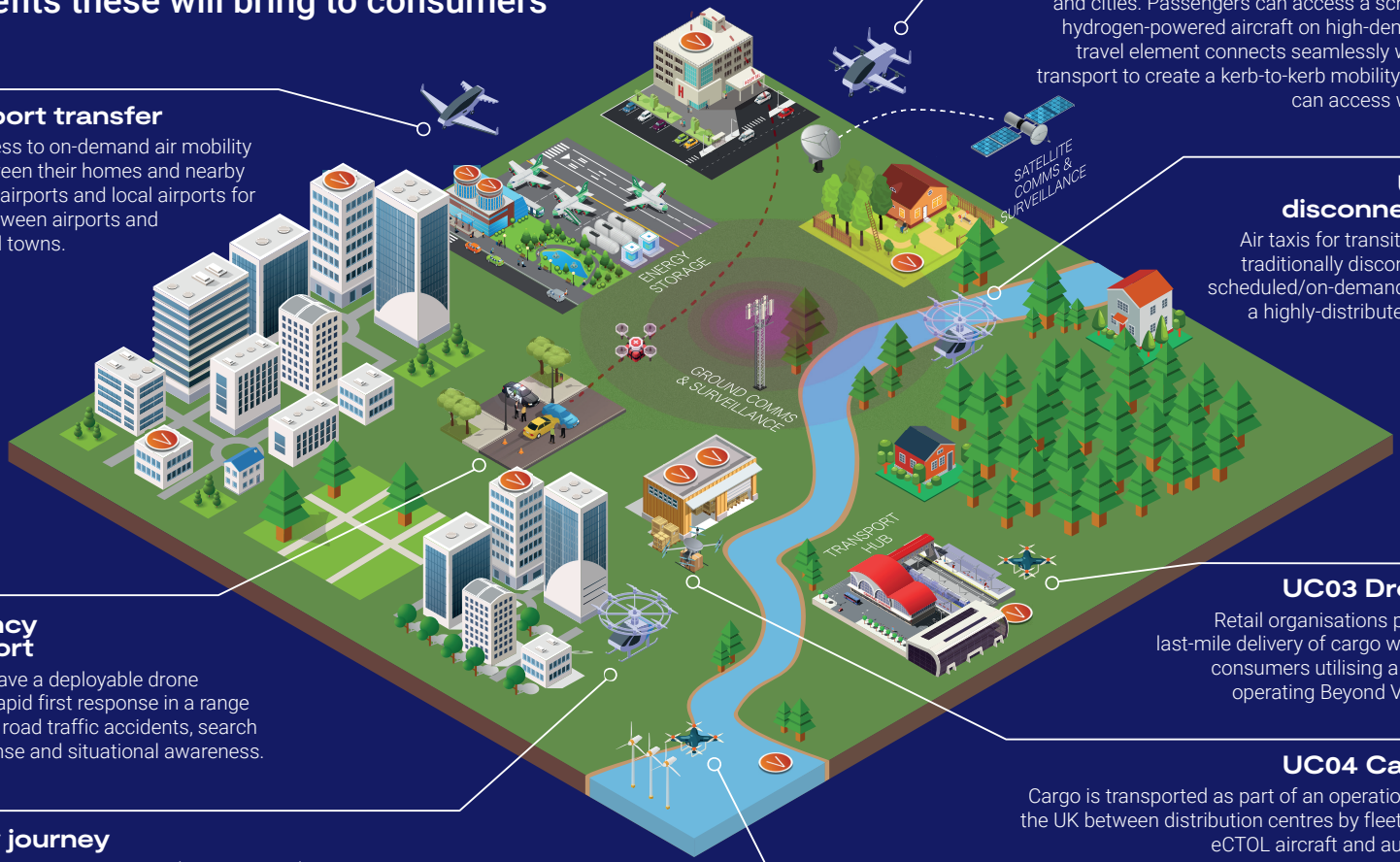
Passengers have access to on-demand air mobility to provide transit between their homes and nearby airports, between hub airports and local airports for onward transfer or between airports and high-volume cities and towns.

### UC01 Inter-town transit

Access to convenient air travel for mobility between towns and cities. Passengers can access a scheduled electric- or hydrogen-powered aircraft on high-density routes. The air travel element connects seamlessly with other forms of transport to create a kerb-to-kerb mobility system that users can access with a single ticket.

### UC02 Rural/ disconnected transit

Air taxis for transit between rural and traditionally disconnected areas on a scheduled/on-demand service as part of a highly-distributed aviation system.




### UC07 Emergency services support

Emergency services have a deployable drone operation to support rapid first response in a range of scenarios including road traffic accidents, search and rescue, fire response and situational awareness.

### UC03 Drone delivery

Retail organisations provide on-demand last-mile delivery of cargo within each reach of consumers utilising a network of drones operating Beyond Visual Line of Sight.

### UC04 Cargo delivery

Cargo is transported as part of an operational service, across the UK between distribution centres by fleets of zero emission eCTOL aircraft and automonous drones.

### UC06 Intracity journey

Passengers have access to automonous Electric Vertical Take-Off and Landing (eVTOL) vehicles for mobility between urban locations as an additional mode of transport.

### UC05 Maintenance and inspection

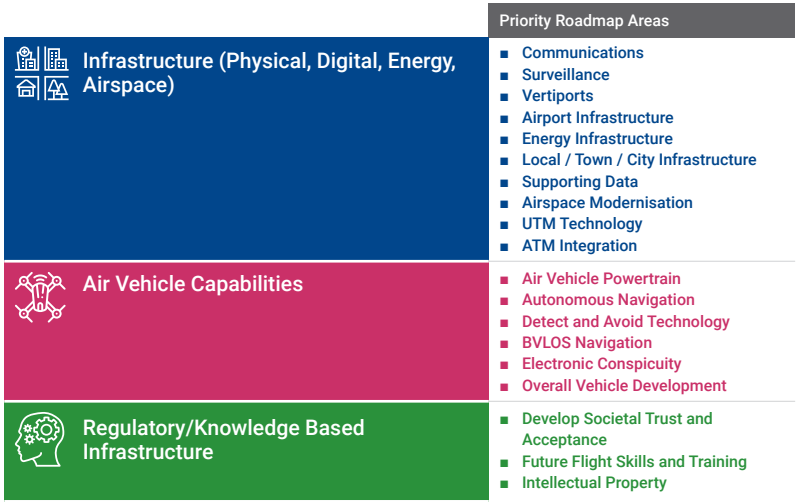
Rapidly deployed and high-endurance autonomous drones carry out maintenance and inspection operations of infrastructure in complex environments, reducing risk to personnel.

SECTION 2

# Developing the Future Flight roadmap

Future Flight products, systems, services, capabilities and enablers were assessed to determine the highest priority areas for Future Flight in the UK. These were categorised into 3 main themes for the Future Flight Roadmap:

- **Infrastructure (physical, digital, energy and airspace)**
- **Air vehicle capabilities**
- **Regulatory/knowledge based infrastructure (regulation, standards, insurance, social licence, skills, training, intellectual property)**




## Mapping the Roadmap Priority Areas to the 2030 Visions and Use Cases

Each roadmap priority area was then mapped to the example use cases to understand `Why are we doing this?', then mapped to technical requirements set out in the Industry Vision 2030 and against international frameworks to determine `What are we trying to achieve?'. We then identified 165 actions for these roadmap priority areas to determine `how are we going to deliver this?'.

These actions were summarised and used to determine the sequence of principal milestones for future flight from now until 2030, establishing the Future Flight Roadmap.

The roadmap timeline is split into 5 segments - Development, Demonstration, Industrialisation, Scaling and Service  - Based.

# Roadmap process

1 The roadmap areas have been classified into three key priority themes based upon workshop activities

2 The roadmap has been mapped to supporting use cases

3 The Industry Vision has been validated against international frameworks (ICAO GANP, SESAR Performance Framework, ATM Masterplan)

4 The roadmap has been mapped to this Vision

5 The roadmap has been broken down into individual action areas and items (165 in total)

6 Action items have been assigned a timeframe and action owner

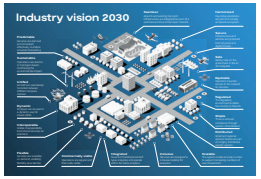
**Infrastructure (Physical, Digital, Energy, Airspace)**

**Air Vehicle Capabilities**

**Regulatory/Knowledge Based Infrastructure**

**Priority Roadmap Areas**

- Communications
- Surveillance
- Vertiports
- Airport Infrastructure
- Energy Infrastructure
- Local / Town / City Infrastructure
- Supporting Data
- Airspace Modernisation
- UTM Technology
- ATM Integration
- Air Vehicle Powertrain
- Autonomous Navigation
- Detect and Avoid Technology
- BVLOS Navigation
- Electronic Conspicuity
- Overall Vehicle Development
- Develop Societal Trust and Acceptance
- Future Flight Skills and Training
- Intellectual Property

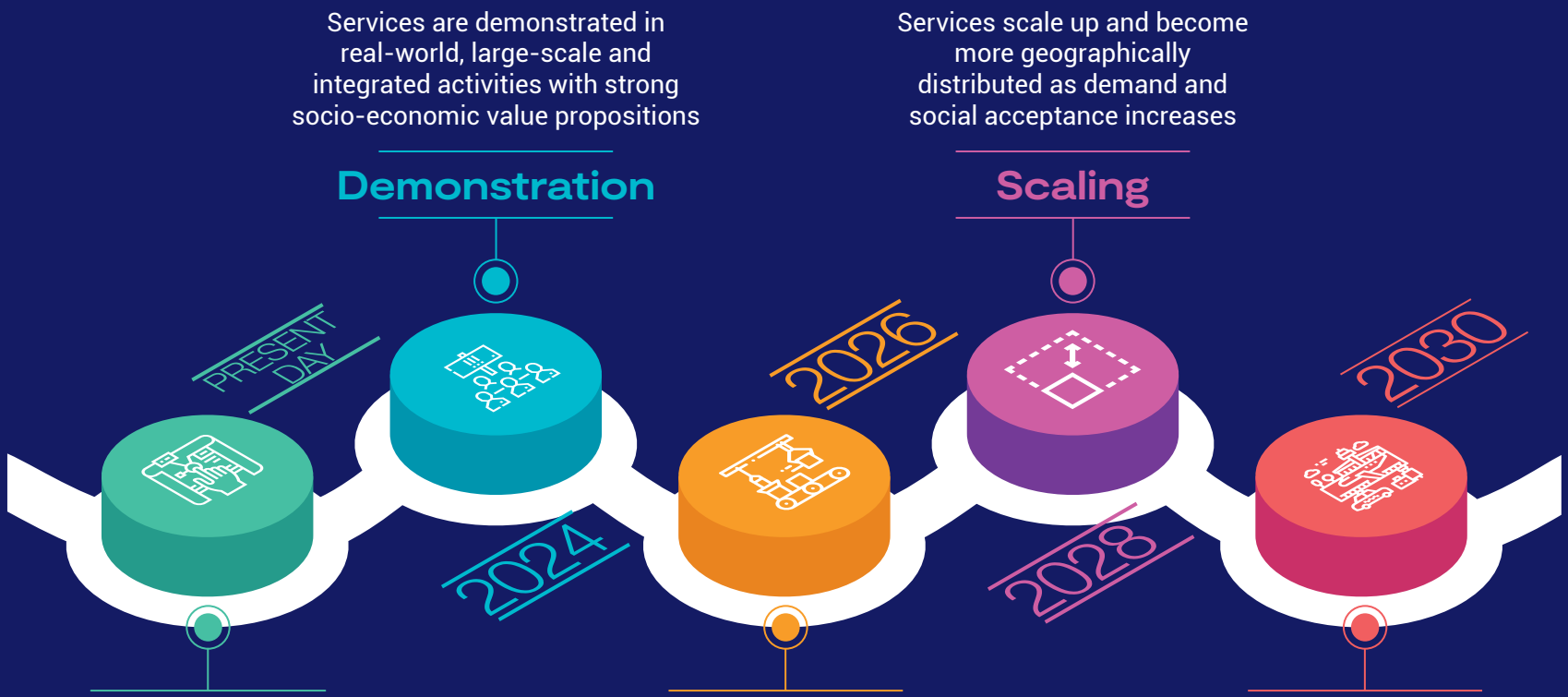

**Support to 2030 use cases**
'Why we are doing this'

**Technical requirements**
'What we are trying to achieve'

**Action areas**
'How are we going to do this'

| Roadmap ID | Roadmap Theme | Roadmap Area | UC01 Inter-Town Transit | UC02 Cargo Delivery | UC03 Medical Delivery | UC04 Intra-City Journey | UC05 Pop-Up Vertiport | UC06 Emergency Services Support | UC07 Drone Delivery Service | UC08 Remote Inspection, Monitoring | UC09 Rural/Disconnected Transit | UC10 Airport Transfer | UC11 Sightseeing | UC12 Humanitarian Aid | V01 Harmonised | V02 Secure | V03 Safe | V04 Equitable | V05 Regulated | V06 Simple | V07 Scalable | V08 Distributed | V09 Inclusive | V010 Integrated | V011 Commercially Viable | V012 Flexible | V013 Interoperable | V014 Unified | V015 Sustainable | V016 Seamless | A01 Detailed Action Plan | A02 Simulated Demonstrations | A03 Live Demonstrations | A04 Technology Development | A05 Modernisation | A06 Electrification | A07 Digitisation | A08 Technology Rollout | A09 Investment | A10 New Regulation | A11 Certification | A12 Societal Acceptance | A13 Public Consultation | A14 Study/Market Research | A15 Stakeholder Engagement | A16 Stakeholder Acceptance | A17 New/Agreed Standards | A18 Training | A19 New System/Data Integration | A20 Insurance/Liability/Legal | A21 New Policy/Legislation | A22 Redundancy Options |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R01 | Infrastructure | Communications | ■ | ■ | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | ■ | ■ | | ■ | ■ | ■ | | | | | ■ | ■ | | | ■ | | | | 1 | | | 2 | | | | 2 | | | | | | 1 | | | | 2 |
| R02 | Infrastructure | Surveillance | ■ | ■ | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | ■ | ■ | | ■ | ■ | ■ | | | | | ■ | ■ | | | ■ | | | | | | | 3 | | | | 2 | | | | | | | | | | 2 |
| R03 | Infrastructure | Vertiports | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | ■ | ■ | ■ | ■ | ■ | | ■ | ■ | ■ | ■ | | 1 | 1 | 2 | | 1 | | 1 | | | 1 | | | 1 | | 1 | | | | 1 |
| R04 | Infrastructure | Airport Infrastructure | ■ | ■ | | | | | | | | | ■ | | ■ | ■ | ■ | | | | ■ | ■ | ■ | ■ | ■ | | ■ | ■ | ■ | ■ | | | | 2 | 2 | 2 | | | | 1 | | | | | 1 | | 1 | | 1 | | | |
| R05 | Infrastructure | Energy Infrastructure | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | ■ | ■ | ■ | | | | ■ | | | | ■ | | | ■ | | ■ | | | | | | | 2 | 1 | | | | | | | | | | | | | |
| R06 | Infrastructure | Local/Town/City Infrastructure | ■ | | ■ | ■ | ■ | | ■ | ■ | ■ | | ■ | | ■ | ■ | | | | | | ■ | ■ | ■ | ■ | | | | ■ | ■ | | | | | | | | 1 | | | | | | | | 1 | | | 1 | 2 | |
| R07 | Infrastructure | Data Services | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | ■ | ■ | | ■ | | | | | | | | | 2 | | | | | | | | | | | | | | | | | |
| R08 | Infrastructure | Airspace Modernisation | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | ■ | | ■ | ■ | ■ | ■ | ■ | | | | | ■ | ■ | | | ■ | | | ■ | 1 | 2 | 1 | 1 | 2 | | | | | 1 | | | 1 | | | | | | | |
| R09 | Infrastructure | UTM Technology | | ■ | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | ■ | ■ | ■ | ■ | | | ■ | | 1 | 6 | 3 | | | | | | | 1 | | | | | 1 | 2 | | | 1 |
| R10 | Infrastructure | ATM Integration | ■ | ■ | | | | ■ | ■ | | ■ | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | | ■ | 1 | | | 1 | 1 | | | | | | | | | | | 1 | 2 | | | |
| R11 | Infrastructure | Mobility-as-a-Service, Ticketing, Seamless Travel | ■ | | ■ | ■ | | | ■ | ■ | ■ | ■ | ■ | | ■ | ■ | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | ■ | | | 1 | | | 2 | 1 | | | | | | | | 1 | 1 | | |
| R12 | Air Vehicle Capabilities | Air Vehicle Powertrain | ■ | ■ | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | ■ | | ■ | | | | ■ | | | | ■ | | ■ | | | 1 | 5 | | | | | 1 | | 4 | | | | | | | | | |
| R13 | Air Vehicle Capabilities | Autonomous Navigation | | ■ | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | ■ | | | | ■ | | ■ | | | 1 | 2 | | | | | | | 7 | 1 | | | | | | | 2 | |
| R14 | Air Vehicle Capabilities | Detect and Avoid Technology | | ■ | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | ■ | | | | ■ | | ■ | | | | 3 | | | | | | | 3 | | | | | | | | | |
| R15 | Air Vehicle Capabilities | BVLOS Navigation | | ■ | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | ■ | | | | ■ | | ■ | | | | | | | | | | 2 | 2 | 1 | | | | | | 2 | |
| R16 | Air Vehicle Capabilities | Electronic Conspicuity | ■ | ■ | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | ■ | ■ | | | ■ | ■ | | | ■ | | ■ | | | | | | | 2 | 1 | 2 | | | | 1 | | | | | | |
| R17 | Air Vehicle Capabilities | Overall Vehicle Development | ■ | ■ | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | ■ | | | ■ | | ■ | | | | ■ | | ■ | | 1 | 1 | 5 | | | | | 1 | 2 | 4 | | | | | 1 | | | | |
| R18 | Knowledge Based Infrastructure | Develop Societal Trust and Acceptance | | | ■ | ■ | ■ | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | | | | ■ | | | ■ | | | | | | ■ | | | | | 2 | 1 | | | | 1 | | 1 | | 3 | 1 | 1 | 2 | | | | 1 | |
| R19 | Knowledge Based Infrastructure | Future Flight Skills and Training | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | ■ | | | | | | | | | 1 | | | | | | | | | | | | | 2 | | | 3 | | | |
| R20 | Knowledge Based Infrastructure | Intellectual Property | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | ■ | | | | | | | | | 1 | | | | | | | | 1 | 1 | 1 | | | | 1 | | 2 | | | |

# Future Flight timeline




## Development

Services are developed and simulated, unlocking a path to certification and social acceptance

## Demonstration

Services are demonstrated in real-world, large-scale and integrated activities with strong socio-economic value propositions

## Industrialisation

Services become more commercially viable, fostering investment. Increased levels of production brings costs down

## Scaling

Services scale up and become more geographically distributed as demand and social acceptance increases

## Service Based

Fully integrated Mobility-as-a-Service operations provide seamless, sustainable and rapid transport for all

# Future Flight roadmap
## Infrastructure

| | Present Day<br>Development | 2024<br>Demonstration | 2026<br>Industrialisation | 2028<br>Scaling | 2030<br>Service-Based |
|---|---|---|---|---|---|
| **Infra-structure (Physical, Digital, Energy, Airspace)** | ■ Rapid progress in development of battery supply chain and recharging infrastructure.<br>■ Development of alternative fuels and supporting infrastructure driven by low carbon initiatives.<br>■ R&D in integration of energy infrastructure solutions for airports and vertiports.<br>■ Modelling and simulation of physical and airspace environments to support feasibility studies.<br>■ Development of digital twins to increase maturity of representative environment.<br>■ Development of secure digital infrastructure driven by new and disruptive technology.<br>■ Development of data exchange services (including weather predictability).<br>■ Emergence of UTM capabilities building upon an existing and established ATM system.<br>■ Development of future airspace CONOPS.<br>■ Rollout of ground-based surveillance (e.g., ADS-B) to support future electronic conspicuity requirements. | ■ Initial vertiport(s) deployed operationally and available to use for operations.<br>■ New interoperable energy infrastructure (e.g., storage, charging points) integrated into vertiports and airports.<br>■ Viability of Regional Air Mobility demonstrated through pilot projects across selected airfields.<br>■ Certified and interoperable UTM services available. Consistent and centralised drone registrations. Approved/ permitted operations through UTM provider.<br>■ Increasing integration of UTM with evolving ATM systems.<br>■ 5G or other suitable communication solution rollout complete to sufficient level to support complex, low latency operations in defined regions.<br>■ Airspace made available for complex use case demonstrations (e.g., mixed traffic outside of TDA framework).<br>■ Flight routes for AAM and drones established and integrated with existing protocols and mechanisms.<br>■ Public consultation complete on future airspace and changed to the Airspace Change Process (ACP).<br>■ Future airspace changes agreed to support higher volume, widespread UTM operations.<br>■ Legislation in place to support integration of drones / AAM into infrastructure development of new buildings.<br>■ Standards agreed for interoperability of 'single ticket' solutions for mixed-mode journeys.<br>■ Integrated multi-modal transport system demonstrated (e.g., living labs).<br>■ Systematic counter-drone capabilities enabled. | ■ Long range communication systems (beyond 5G) established and operational.<br>■ Development of vertiport technology to support automated unloading/ loading of cargo.<br>■ Modernisation of existing small airfields including hydrogen delivery, storage, refuelling solutions to support expanding RAM operations.<br>■ Higher volume of UTM traffic safely enabled through strategic deconfliction and efficiency planning.<br>■ Secure and reliable communication and surveillance systems, leveraging existing national infrastructure.<br>■ Integration of AAM and drone operators with airport systems (e.g., CDM) and airport Air Traffic Control systems.<br>■ Rollout of satellite-based surveillance solutions to support areas lacking ground-based surveillance. | ■ Digitisation and integration of all ticketing technology enabling a 'one ticket' solution for seamless multi-modal journeys.<br>■ Increasing number of existing airfields modernised and vertiports deployed supporting a highly distributed aviation network.<br>■ Increasing number of existing airports modernised to support digital mobility-as-a-service operations.<br>■ New airspace categories in place enabling large scale UTM operations.<br>■ Competitive market established for end-to-end energy solutions: hydrogen producers / suppliers, battery recharging providers, battery maintenance / replacement services. | ■ Highly distributed network of airports / vertiports.<br>■ Transport hubs feature as part of a highly connected transport system.<br>■ Fully integrated ATM and UTM service of autonomous systems with global interoperability for high volume use of different / multiple classes of air vehicles.<br>■ Increased digitisation of air operations.<br>■ Mobile / on-demand booking solutions available for AAM vehicles. |

# Future Flight roadmap

## Air vehicle capabilities

| | **Present Day** Development | **2024** Demonstration | **2026** Industrialisation | **2028** Scaling | **2030** Service-Based |
|---|---|---|---|---|---|
| **Air Vehicle Capabilities** | ■ Development towards net-zero aviation system accelerated by UK funded initiatives.<br>■ Development of battery technology for aerospace ramped up by aviation industry.<br>■ Testing and development of hydrogen / hybrid propulsion systems.<br>■ Approved regulations and criteria for BVLOS activity outside of Temporary Danger Areas (TDAs).<br>■ Identification and trials of useful real-world use cases for remotely piloted drones.<br>■ Simulations of AAM movements inform feasibility studies on future operations. | ■ Advancements in electric / battery technology enables increased range and payload for drones / AAM.<br>■ Demonstration of different air vehicle classes with hybrid hydrogen / hydrocarbon- based solutions.<br>■ Certification of detect and avoid technology supporting autonomous drone and AAM operations.<br>■ Demonstration of autonomous drone capabilities in designated airspace.<br>■ Mandated electronic conspicuity deployed across all aircraft utilising designated unified airspace.<br>■ Increased operation of BVLOS drones for multiple use cases over populated areas.<br>■ Single piloted AAM vehicles with highly automated capabilities certified and enter into service.<br>■ Regional aircraft retrofitted with electric / hybrid solutions available.<br>■ Air vehicle developments enable operation in close proximity with structures / assets.<br>■ Air vehicle developments support operations in all weather scenarios. | ■ Advances in hydrogen / hybrid powertrain technology increases air vehicle range and payload.<br>■ Electronic conspicuity requirements agreed and enforced for all airspace users.<br>■ Single piloted AAM vehicles with autonomous capabilities enter into service.<br>■ Certified drones with autonomous navigation capabilities for use in airspace with multiple vehicle types over populated areas.<br>■ Competitive manufacturing of AAM vehicles.<br>■ Private investment secured for larger air vehicle development (beyond 2024) to support regional operations. | ■ Competitive manufacturing of battery technology drive reduced cost of services for drones and AAM.<br>■ Autonomous AAM operations with single pilot onboard monitoring enter service.<br>■ Increasing volume of autonomous drones in operation. | ■ Full electric / hydrogen air vehicles are commercially viable for passenger carrying regional flights.<br>■ Certification of autonomous AAM operations with remote pilot at control centre in mixed airspace.<br>■ On-demand AAM services fully operational as part of a highly distributed aviation system.<br>■ Quiet, safe drone services form part of day-to-day life. |

# Future Flight roadmap

## Regulatory/knowledge based infrastructure

| | **Present Day** Development | **2024** Demonstration | **2026** Industrialisation | **2028** Scaling | **2030** Service-Based |
|---|---|---|---|---|---|
| **Regulatory/ Knowledge Based Infra-structure** | ■ Engagement with local community support future use cases such as vertiport deployment.<br>■ Need for UK public consultation identified to understand acceptability of autonomous technology for drones / passenger carrying AAM.<br>■ Regulatory body sandbox established to support rapid innovation.<br>■ UK social licence study on key considerations to build public trust available.<br>■ Need for skills to support future aviation agenda identified.<br>■ Acceleration of development, certification and approval with the use of modelling and simulation (including the use of digital twins) for aircraft, systems and services.<br>■ Engagement with relevant licensing authorities for AAM service in local communities.<br>■ Need for diverse and inclusive engagement with community and schools identified.<br>■ Investment in key development projects for Future Flight builds UK IP. | ■ New legislation documents for acceptable levels of noise and privacy available.<br>■ Demonstration of positive and safe use cases of drones and AAM continues to build public trust.<br>■ UK supply chain is recognised as a global leader in development and deployment of advanced future flight capabilities.<br>■ UK plays a key role in harmonising international standards and demonstrates preliminary adherence.<br>■ New jobs created and filled supporting a future flight agenda.<br>■ UK PLC export strategy defined and implemented for future flight services, consultancy, technology, international partnerships and academic liaison.<br>■ Future Flight skills roadmap and gap analysis completed.<br>■ Implementation of Future Flight apprenticeships, academic courses and skills programmes accredited by professional institutions.<br>■ Future flight STEAM and ED&I outreach programmes implemented.<br>■ Key training programmes rolled out to support industry scaling .<br>■ AAM pilot training programmes available.<br>■ AAM operators licenced by local councils for commercial operations on a trial basis.<br>■ Agreed insurance and liability considerations for Future Flight operations. Emergence of specialist insurance market.<br>■ Demonstration of strong strategic cross government alignment to accelerate innovation (e.g., DfT, BEIS, DIT, DCMS, Ofcom and end-user sectors).<br>■ New regulatory framework(s) support rapid and safe introduction of new technology / concepts e.g., new airworthiness standards. | ■ Increased use of built-upon regulation and standards. UK is fully compliant and harmonised with international standards.<br>■ Further implementation of updated UK PLC export strategy for future flight services, consultancy, technology, international partnerships and academic liaison.<br>■ Increased volume and availability of commercial drone and AAM operations build public trust.<br>■ Wider UK rollout of AAM operators licenced by local councils for commercial operations.<br>■ Training programmes fulfil the demand for future skills. | ■ Demonstration of safe autonomous operations (including AAM and driverless cars) builds wider public trust.<br>■ Development of new economic ties between traditionally disconnected areas enabled by increased connectivity.<br>■ Wider public adoption of future flight services. | ■ Mobility-as-a-Service operations form part of day-to-day life due to increased public trust.<br>■ Service quality across drones and AAM is equitable across all locations (urban, rural, traditionally disconnected).<br>■ UK is a world-leader in future flight services, consultancy, technology, international partnerships and academic liaison.<br>■ A leading knowledge-based infrastructure (regulatory and standards systems) in place that underpins safe, clean and inclusive Future Flight products and services. |

SECTION 3

# The Future Flight vision and ambition for 2024

The Future Flight Roadmap sets out the sequence of principal milestones from now until 2030 to achieve the Future Flight Consumer and Industry Visions. The Future Flight Challenge programme is within the Development and Demonstration timeframe on the roadmap between now and 2024.

The principal milestones in the Demonstration segment of the roadmap were further analysed for each roadmap priority area to establish the Future Flight Vision and Ambition for 2024.

Key examples of demonstration objectives have been outlined for stakeholders across the Future Flight ecosystem to deliver by 2024, putting the UK on the critical path to achieving the 2030 vision for industry and consumers.

# 2024 Infrastructure vision

| Roadmap Area | 2024 Vision |
|---|---|
| Communications | 5G or other suitable communication solution rollout complete to sufficient level to support complex, low latency operations in defined regions. |
| Surveillance | ADS-B / 5G ground infrastructure, or other suitable surveillance solution rollout completed to sufficient level to support complete situational awareness in defined regions. |
| Vertiports | Initial vertiport(s) deployed operationally and available to use for operations. |
| Airport Infrastructure | Roadmap to airport electrification / modernisation complete. Multiple small airfields have agreed investment. |
| Energy Infrastructure | New interoperable energy infrastructure designed (e.g., storage, charging points, battery swapping) and integrated into vertiports and airports. Some airport(s) have airport hydrogen / electric integration to support demonstration use cases. |
| Local / Town / City Infrastructure | New legislation to support integration of drones / AAM for new buildings. Increased number of local authorities supporting infrastructure development including ground infrastructure and building. AAM operators licenced by local councils for commercial operations on a trial basis. |
| Data Services | Standardised and high integrity data exchange services (e.g., weather, geographic, flight information) are available for integration into services. |
| Airspace Modernisation | UTM is recognised as a viable solution for safe integration of new airspace users into shared airspace. Future airspace changes and process agreed to support high volume, widespread UTM operations. Public consultation complete on future airspace. |
| UTM Technology | UTM services available, certified and interoperable, drone registration is consistent and centralised. Operations are approved / permitted through UTM provider. |
| ATM Integration | Approved CONOPS adopted by industry. Agreed standards adopted for remotely piloted drone communication with ATC. Flight plan filing services available and integrated for use of controlled airspace. |
| Mobility-as-a-Service, Ticketing, Seamless Travel | Standards for interoperability agreed for 'single ticket' solutions for mixed-mode journeys. On-demand AAM booking systems are being developed and prototyped. Integrated multi-modal transport system demonstrated (e.g., living labs). |

# 2024 Infrastructure demonstration objectives

| ID | Demonstration Objective |
|---|---|
| S01 | Demonstrate multi-operator interoperability of UTM e.g., strategic deconfliction between drone operations of two different UTM providers within the same airspace |
| S02 | Demonstrate interoperability of UTM and ATM e.g., ability to manage a single flight plan across UTM and ATM designated airspace |
| S03 | Demonstrate a mixed vehicle class use case where aircraft of different types are integrated to provide an end-to-end solution to a customer problem (e.g. cargo delivery to distribution centre and onwards) |
| S04 | Demonstrate planning of UTM operations with strategic deconfliction and demand balancing to ensure efficiency |
| S05 | Demonstrate mobile, on-demand AAM booking services |
| S06 | Identify and demonstrate airspace solutions to support UTM activities |
| S07 | Demonstrate drones flying airside whilst maintaining existing traditional aircraft operations |
| S08 | Demonstrate physical airport energy systems integration for full turnaround e.g., interoperability charging infrastructure, storage, maintenance and charging delivery for new powertrain technology |
| S09 | Demonstrate vertiport deployment with local transport and building infrastructure integration e.g., connected transport |
| S10 | Demonstrate rapid (e.g., 24 hours) vertiport deployment to support activities such as disaster scenarios |
| S11 | Demonstrate secure digital airport integration e.g., single identification / ticket |
| S12 | Demonstrate infrastructure development and use of small UK airfields |
| S13 | Demonstrate co-ordination between multiple airports for flight and efficiency planning |
| S14 | Demonstrate aircraft operations transiting between controlled and uncontrolled airspace |
| S15 | Demonstrate coordination with local airports on flight planning |
| S16 | Demonstrate co-operative and non-co-operative surveillance capability for aircraft detection under 400ft |
| S17 | Demonstrate command and control links with aircraft |
| S18 | Demonstrate airspace design for new vertiport deployment or changes to support new vehicle movements at existing airfields |
| S19 | Demonstrate use of unlicensed aerodromes for aircraft operations |
| S20 | Demonstrate exchange of information between flight operations, airport and traffic management services to manage predictability of operations |
| S21 | Demonstrate strategic and tactical route flight planning in urban areas to manage safety and environmental concerns |
| S22 | Demonstrate flight planning coordination between other airspace users |
| S23 | Demonstrate approval of technical infrastructure in critical environments to ensure no interference issues (e.g., at an airport where safe-guarding of existing systems is required). |
| S24 | Demonstrate high-integrity, low-latency data exchange for digital infrastructure |
| S25 | Demonstrate automated recharge of electric / hydrogen / hybrid vehicle during turnaround |
| S26 | Demonstrate whole journey clearance and approval in advance for operations |

# 2024 Air vehicle capabilities vision and demonstration objectives

| Roadmap Area | 2024 Vision |
|---|---|
| Air Vehicle Powertrain | Advancements in electric / battery technology enables increased range and payload for drones / AAM / RAM. Demonstration of different air vehicle classes with hybrid based solutions. |
| Autonomous Navigation | Demonstrated autonomous navigation technology for non passenger carrying operations in class G airspace. Potential for monitored AAM with pilot. Regulatory frameworks in place by regulators and policy makers to certify autonomous navigation systems. |
| Detect and Avoid Technology | Developed and certified detect and avoid technology increases the level of integration into UK airspace of drones and AAM operations. |
| BVLOS Navigation | Approved regulation and criteria for increased BVLOS activity outside of Temporary Danger Areas (TDAs) and over populated areas. |
| Electronic Conspicuity | Electronic conspicuity mandated and deployed across all aircraft utilising designated unified airspace. |
| Overall Vehicle Development | AAM vehicles developed and certified for single piloted use. Viability of RAM demonstrated through pilot projects across selected airfields and with retrofitted electric / hybrid solutions. Drones support operations in all weather scenarios. |

| ID | Demonstration Objective |
|---|---|
| S27 | Demonstration of monitored (single pilot) autonomous AAM services with passenger(s) |
| S28 | Demonstrate drones operating in controlled airspace with Air Traffic Management awareness and communication (e.g., VHF / CPDLC) for BVLOS operations outside of a Temporary Danger Area (TDA) |
| S29 | Demonstrate transition from remotely piloted (command centre or ground control) to autonomous control (BVLOS) for drone operations |
| S30 | Demonstrate automated tactical deconfliction with objects and terrain (detect and avoid) capabilities outside of a Temporary Danger Area (TDA) and over populated areas |
| S31 | Demonstrate management of complex approach operations (e.g., short runway, difficult approach, management of weather or aerodynamic effects) |
| S32 | Demonstrate piloted or remotely piloted AAM / RAM operations (with passengers). Show how traditional see-and-avoid rules interact with autonomous detect-and-avoid technology |
| S33 | Demonstrate tactical deconfliction between aircraft of different types (e.g., drone and regional aircraft) using pilot and automated traffic collision avoidance / alerting service |
| S34 | Demonstrate planned Drone / AAM operations alongside existing General Aviation traffic, with conflict management systems/ability to adapt |

# 2024 Regulatory/knowledge based infrastructure vision and demonstration objectives

| Roadmap Area | 2024 Vision |
|---|---|
| Develop Societal Trust and Acceptance | Use cases demonstrate social value and safe operations to build public trust. Necessary policies, standards and legislation developed to address social factors (including noise and privacy). |
| Future Flight Skills and Training | Future flight skills roadmap and gap analysis completed. New jobs are being created and filled supporting a future flight agenda. Future flight STEAM and ED&I outreach programmes implemented. |
| Intellectual Property | UK is recognised as a global leader in development and deployment of advanced drone / AAM / RAM solutions. UK PLC export strategy defined and implemented for future flight services. |

| ID | Demonstration Objective |
|---|---|
| S35 | Demonstrate BVLOS use cases over populated areas, outside of a Temporary Danger Area and with increased range |
| S36 | Demonstrate BVLOS use cases within Class G airspace, outside of Temporary Danger Area framework with mixed traffic |
| S37 | Demonstrate development and use of new regulatory framework(s) to support rapid and safe introduction of new technology / concepts e.g. new airworthiness standards |
| S38 | Demonstrate increasing volume of mixed traffic (drone, AAM, RAM) operations in designated airspace |
| S39 | Demonstrate large scale network of drone delivery both point to point and adhoc delivery |
| S40 | Demonstrate the ability for approved flying at low altitude over populated areas for AAM |
| S41 | Demonstrate community engagement on flight planning for environmental and safety impacts |
| S42 | Demonstrate information exchange between stakeholders to manage response to drone infringement |
| S43 | Demonstrate protection of critical infrastructure sites from nuisance and malicious drone operation |
| S44 | Demonstrate major air vehicle technology & infrastructure failure case e.g. in communication and/or navigation. Demonstrate how contingency scenarios will operate and how services will continue |
| S45 | Demonstrate drone loss of common and control link scenarios e.g., parachute down, return to base |
| S46 | Demonstrate use cases that actively engage with the public, provide social benefits and support social acceptability |

# Contributors

- ADS Group
- Aerospace Growth Partnership
- Aerospace Technology Institute
- Airbus
- Altitude Angel
- Ampaire
- Angus City Council
- The Association of Remotely Piloted Aircraft Systems (ARPAS)
- Babcock International
- Blue Bear Systems
- British Standards Institute
- Civil Aviation Authority
- Connected Places Catapult
- Coventry City Council
- Cranfield University
- Drone Industry Action Group
- EGIS Group
- Embraer
- Engineering and Physical Sciences Research Council
- Economic and Social Research Council
- Frazer Nash Consultancy
- Heathrow Airport
- Highlands and Islands Airport
- HMG Department for Business, Energy and Industrial Strategy
- HMG Department for Digital, Media, Culture and Sport
- HMG Department for Transport
- National Air Traffic Services (NATS)
- Ocado
- PwC
- Royal Aeronautical Society
- Seesai Limited
- Strategic Aviation Specialist Interest Group
- Swanson Consultancy
- Thales
- UKRI – ISCF Faraday Battery Challenge
- UKRI – ISCF Driving the Electric Revolution
- UKRI – ISCF Robotics Challenge
- University of Birmingham
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- Vertical Aerospace
- Workshops facilitated by The Institute for Manufacturing, University of Cambridge
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