What next for our aviation systems?

The Future Flight Challenge

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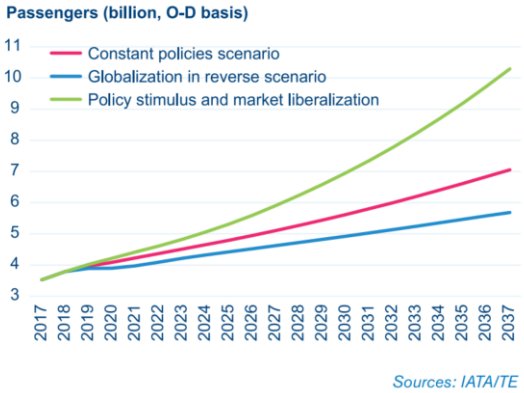
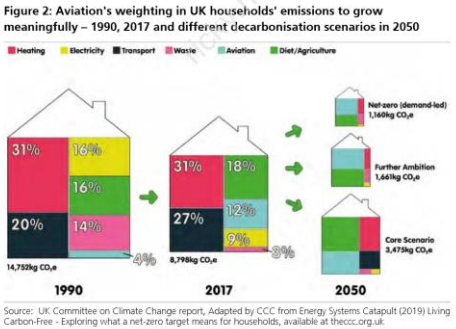
November 2019

Some certainties…..

- Aviation is a continually growing sector that grows at GDP+
- The market will remain dominated by large commercial aircraft
- The barriers to entry are high
- Aviation represents a small part of global CO_2 emissions
- Kerosene (or a substitute) will remain dominant
- Aerospace is a very long cycle business - 5/30/25



Sources: IATA/TE



Source: UK Committee on Climate Change report, Adapted by CCC from Energy Systems Catapult (2019) Living Carbon-Free - Exploring what a net-zero target means for households, available at theccc.org.uk

What could change these certainties?

Demand side dynamics

- Flygskam
- The Google test
  - Is aviation…
  - Is aviation fuel taxed?
  - Is aviation sustainable?
  - (Is aviation gin any good?)
- But others see aviation as a solution

Business | Your Money | Market Data | Companies | Economy

'Flight shame' could halve growth in air traffic

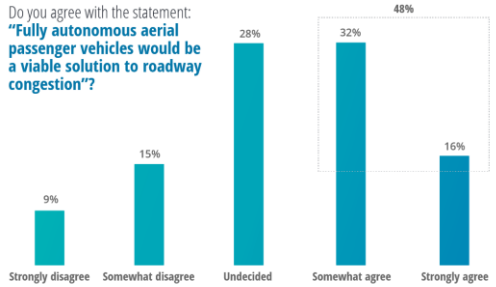
2 October 2019 Share

Climate change

Travellers are beginning to turn their backs on air travel over conc
environment, according to a survey by Swiss bank UBS.

FIGURE 3

Nearly half of survey respondents see aerial passenger vehicles as a possible way to solve roadway congestion



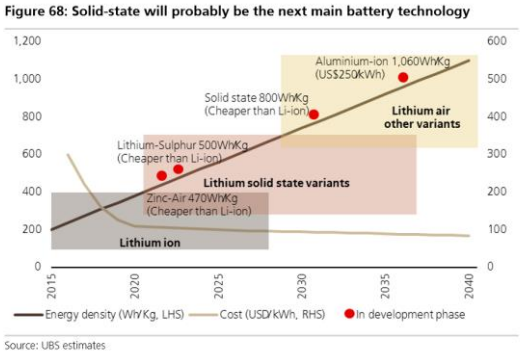
Source: Deloitte Global Auto Consumer Survey, October 2018.

How does a very long-term industry deal with this?

The evolution of power

- The battery technology for full electrification needs significant development
- Lithium Ion battery around 100-250 Wh/kg
- Developing to 800 Wh/kg by 2035?
- Kerosene 11,900 Wh/kg (and we burn it off!)
- P.S. Hydrogen is 33,000 Wh/kg

Newcomen steam engine (1710)
– around **0.5% efficient**



Lifecycles, Carbon Targets and Passenger Choices

- Start a new aircraft development in 2020
- Enter service in 2025, in production to 2055, in service until 2080
- IPCC recommendation and UK commitment to carbon zero by 2050
- Norway target of all internal flights electric by 2040
- How do we reconcile the clash of timing?

> **New Markets:** Over 50% of today's passenger traffic takes place on routes less than 500Nm, many flown by narrowbody aircraft capable of 4000Nm or more, that could be replaced by new aircraft optimised for shorter routes. By 2030, we expect to see the emergence of entirely new aviation markets in the sub-regional and urban environments.

If we could produce such a carbon-free vehicle for short range but not long range what might the market do?

New entrants and new technologies

- Around 180 organisations developing Urban Air Mobility vehicles
  - Most are new entrants, many are well-backed
- Industrial drone market estimated at $50-100bn with rapidly developing use cases
- Both are creating demand for new tech: image processing, digital, AI, control and autonomy

What opportunities and challenges does this present?

Future Flight

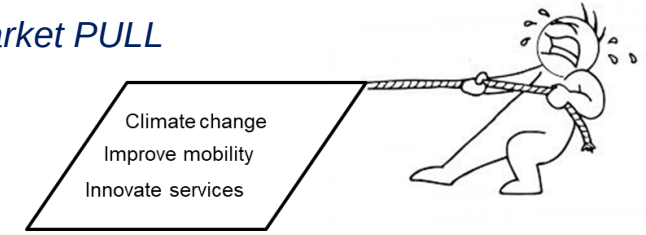
This challenge will transform mobility through flight and unlock new aviation markets, by demonstrating an innovative air transport solution that incorporates low environmental impact, autonomous air vehicles and associated airspace management requirements by 2023.

Future Flight: Responding to emerging and dynamic capabilities

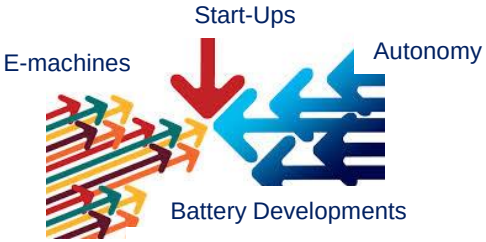
UK Research and Innovation

INDUSTRIAL STRATEGY

Market PULL



System demonstration for 3 vehicle types



Technology Convergence PUSH

What problems must be overcome?

1. Lack of digital and physical infrastructure for new classes of vehicle

2. Current Air Traffic Management Systems are not scalable and will not cope with step-change in volume, density and increasing diversity of airspace users

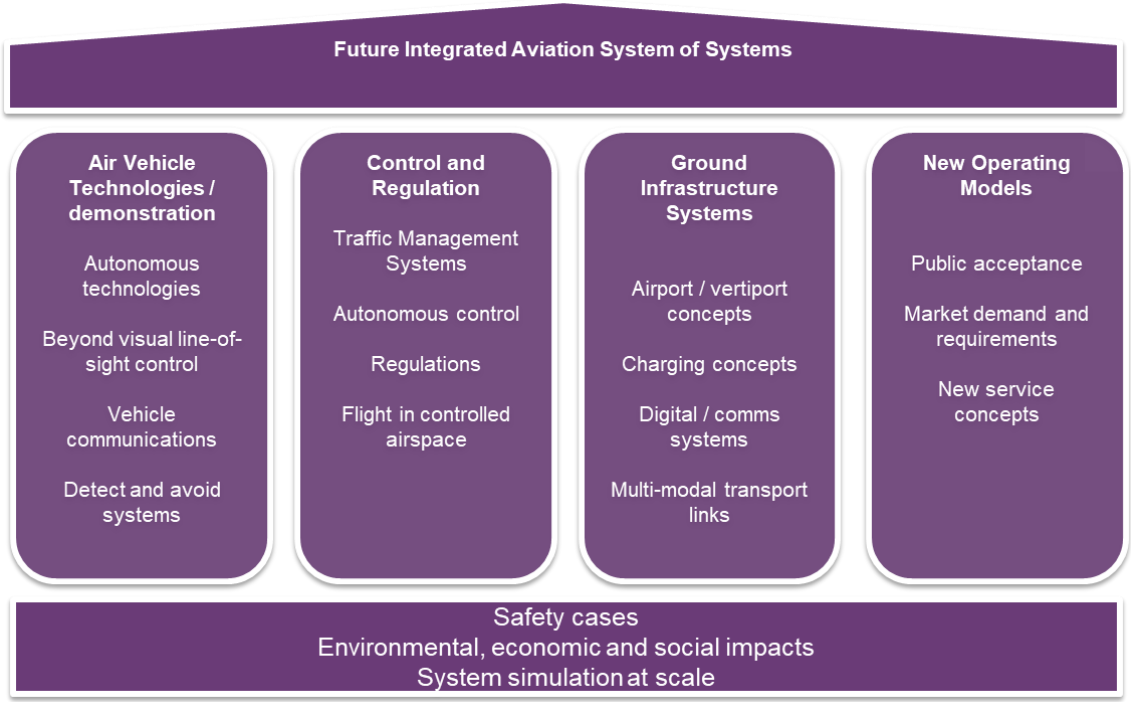
3. There are no clear technology, regulatory or operational paths from piloted to remotely piloted through to fully autonomous air vehicle operation

4. There is a need to create pathways for electrification/autonomy from urban vehicles to sub-regional to larger aircraft based on market driven technology

5. We need to create positive public engagement in new types of aviation

6. We need an aviation innovation/development environment that will allow real-life demonstration and evaluation of the new systems

The Aviation System will need to consider all or part of a broad range of themes



Building consortia to demonstrate flight in new aviation systems with real-world use cases by 2023

- In emergencies, additional visibility can support service provision

- In densely populated areas, drones provide enhanced monitoring of construction phases

What demonstrations could be modelled?

- As demand for clean energy escalates, offshore maintenance requirements increase
- Drones offer clean, efficient and effective solutions

- Highlands and Islands connectivity hindered by extortionate infrastructure costs
- Electric aviation offers clean, low cost solutions that can leverage off existing infrastructure
- Improving connectivity, supporting the economy and reducing “people drainage” from the area

- Infrastructure considerations must be made
- Planning and approvals
- Structural integrity
- Charging capabilities
- Passenger security (onboarding and inflight)

- 50% of flights worldwide are < 500 nautical miles
- 30 % are < 300 nautical miles
- Infrastructure changes to enable adoption of electric and hybrid electric capabilities need to be understood

Ambitious outcome objectives

- Accelerate the emergence of new aviation markets
- Support a more integrated aviation sector to address the global challenges
- De-risk electrical/low carbon and autonomous technologies for large aircraft
- Accelerate introduction of new technologies
- Bring together new entrants/new tech with established companies
- Repositioning how the public sees aviation – part of the solution

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