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The UK domestic air transport system: how and why is it changing?

Future of Mobility: Evidence Review

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The UK domestic air transport system: how and why is it changing?

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Contents

Introduction

Scope of the review

This document reviews commercial air passenger and freight services within the UK. For the purposes of this review, 'the UK' refers to the United Kingdom of Great Britain and Northern Ireland plus the geographically proximate British Crown Dependencies of the Channel Islands[1] and Isle of Man. Air transport services between the UK and the 14 British Overseas Territories (BOTs)[2], as well as flights within and between these BOTs, are excluded. Domestic air services are defined as flights which originate and terminate within the territorial limits of the UK and remain wholly within UK sovereign airspace for their entire journey[3]. Passengers and freight travelling on internal UK flights connecting to/from international services, passengers and freight in transit or landing at one UK airport before alighting at another UK destination, and domestic business and corporate aviation flights[4] are not included.

Scale and operational characteristics of UK domestic air transport

The UK has the largest air transport market and the fifth-largest domestic market in the EU28 after Spain, Italy, France and Germany (Eurostat, 2016). In 2016, UK airports handled 230.9 million passengers. Of these, 210.3 million (91.1%) were international and 20.6 million (8.9%) were domestic – handled by 47 UK airports[5] (CAA, 2017). The 12 busiest domestic passenger routes in 2016 each carried over 500,000 people and connected a regional airport with London (CAA, 2017)[6]. The UK domestic passenger load factor in 2015 was 72.5%. The comparable figure for international services was 84.5% (DfT, 2016)[7]. UK airports also handled 2,250,000 tonnes of freight (97.8% international and 2.2% domestic) (DfT, 2016, Tables TSGB0202b/c).

Domestic services accounted for 16.5% of all Air Traffic Movements (ATMs) at UK airports in 2015 (DfT, 2016).

[1] Comprising the Bailiwick of Jersey and the Bailiwick of Guernsey – there are no airports or commercial air services to Sark, Herm, Jethou or the smaller islands in the archipelago (Source: States of Jersey and Guernsey www.gov.je and www.gov.gg, 2017).
[2] The 14 BOTs include Gibraltar, the British Virgin Islands, St Helena, Ascension and Tristan da Cunha and the Turks and Caicos Islands (Source: UK Overseas Territories, Gov.uk, 2017).
[3] National sovereignty over airspace was affirmed by the 1911 British Aerial Navigation Act and the 1944 Chicago Convention
[4] These services are generally not available for public hire and so are not included within a review of commercial operations.
[5] Airfields at Hawarden, Coningsby, Elstree, Farnborough, Marham, Waddington and Warton were excluded as the services they handled, while scheduled, were not available for public use.
[6] Domestic routes with over 500,000 passengers in 2016 were: London Heathrow to/from Edinburgh, Aberdeen, Glasgow, Manchester and Belfast City, London Gatwick to/from Belfast International, Edinburgh, Glasgow and Jersey, London City to/from Edinburgh and Stansted to/from Edinburgh and Glasgow (Source: CAA, 2017). The busiest provincial route was Belfast International to Liverpool John Lennon Airport with 465,554 passengers (CAA, 2017).
[7] Load factor is a measure of the proportion of seats sold on any given flight and hence a measure of efficiency.

Domestic air services can be classified by type (scheduled, charter, ad hoc and passenger/freight/combi[8]) and geographic profile:

Trunk routes are flights from the principal London airports to/from Manchester, Edinburgh, Glasgow, Aberdeen and Belfast. They are typically served multiple times a day with both narrow and wide-body[9] aircraft (OAG, 2017).

Provincial routes connect regional cities in the UK. They are operated less frequently than trunk routes and are usually flown by smaller aircraft (OAG, 2017).

PSO (Public Service Obligation) routes. Governed by Regulation (EC) 1008/2008 (EC, 2017), they are 22 publicly subsidised 'lifeline' flights[10] between geographically remote and/or inaccessible communities in Wales, Northern Ireland and Scotland which would not be commercially viable without public subsidy. They typically operate once a day or less frequently using small specialised aircraft and are vulnerable to weather-related disruption.

Services to/from/within the Channel Islands and the Isle of Man. These are frequent year-round services operated by commuter aircraft and regional jets which connect the UK mainland with Jersey, Guernsey, Alderney and Ronaldsway.

Development and regulation of UK domestic air transport

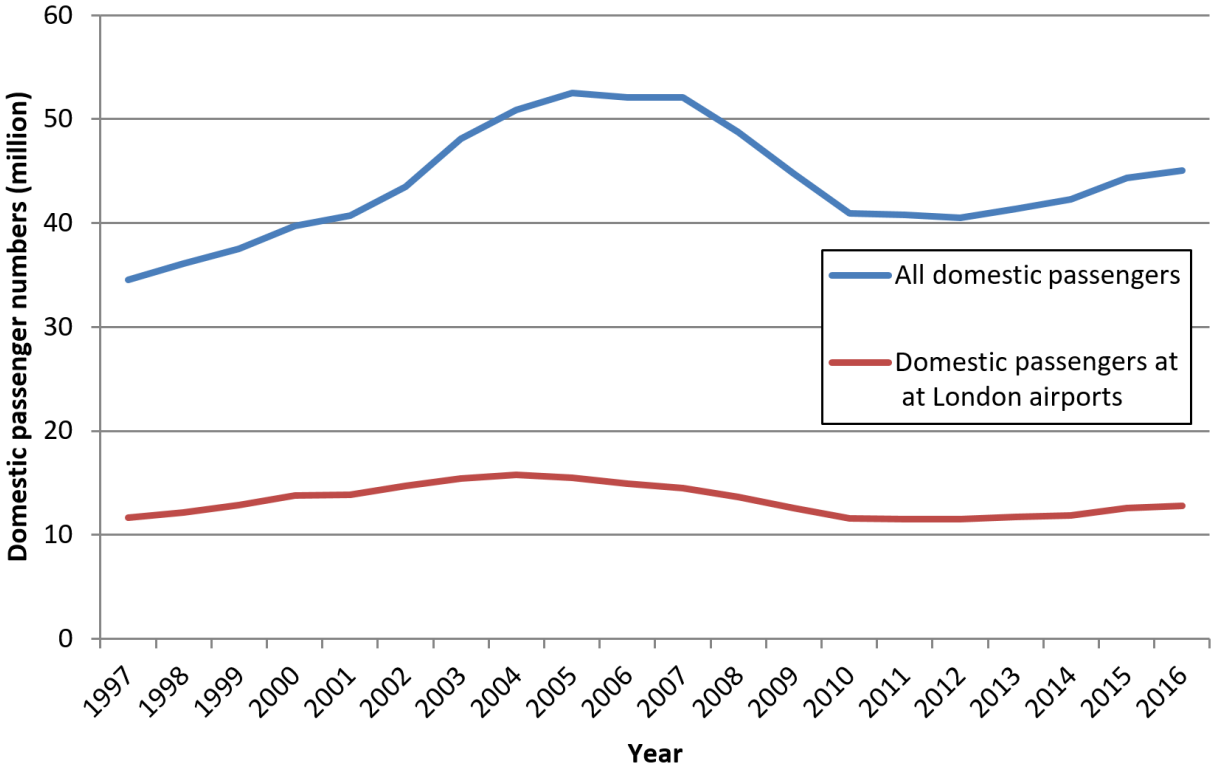
During the nationalised and regulated era (1946-1980s) the sole incumbent British national airline[11] was protected from competition on domestic trunk routes and regional carriers were only permitted to operate a limited number of provincial services. Progressive pan-European policies of air service liberalisation during the 1990s removed barriers governing market entry, fares, capacity and routes and opened the European market to competition. This led to airline consolidation[12], the privatisation of publicly-owned airports[13], a reduction in airfares and growth in both UK domestic passengers and routes.

Trends in UK domestic passenger traffic, 1997-2016

Data presented in Table 10.2 in each CAA annual airport dataset from 1997 to 2016 inclusive forms the basis of the information presented in this section.

[8] Combi (or combination) flights carry both passengers and cargo on the main deck of the aircraft.
[9] Narrow body aircraft have a single central aisle whereas wide-body aircraft have two.
[10] As of April 2017, only Greece and France within the EU28 imposed more PSO services than the UK (EC, 2017).
[11] Incumbent domestic carriers were BEA (British European Airways), which operated between 1946 -1974, and British Airways which operated from 1974-1987 as a nationalised flag carrier and from 1987 onwards as a private operator.
[12] During this time, many independent UK airlines ceased operation or were acquired by larger competitors. Examples of UK airlines that ceased trading include Dan Air, Caledonian Airways, Air UK, British Midland/bmi, Brymon, BMed, Debonair, GB Airways, and Manx Airlines.
[13] Private airport operators now own and manage the UK's busiest airports (ACI, 2016). Following a period of large-sale privatisation in the 1990s and 2000s, Prestwick and Cardiff airports have been brought back into public ownership while others have not attracted services. Airports at Sheffield City (2008), Coventry (2009), Plymouth (2011), Manston/Kent International (2014), Blackpool (closed 2014, reopened 2015) and Cambridge (2016) have either permanently closed or suspended commercial passenger operations.

Figure 1: Domestic passenger numbers at UK airports 1997-2016 (Derived from annual CAA airport statistics, Table 10.2 in each document).



Between 1997 and 2016, 876.5 million domestic passengers used UK airports. During this period domestic passenger numbers grew by 30.4%, from 34.5m to over 45m. From 1997 to 2005 inclusive, year-on-year (YoY) growth in domestic passenger demand averaged 5.4% and from 2006 to 2012 there was an average decline of 3.57% a year. Since 2013, demand has recovered with an average YoY growth of 2.7%, but not to the pre-2006 level.

Air travel is a derived demand and subject to fluctuations in economic activity. Large variations are reported in the long-run elasticity coefficients to GDP between major UK airports (see PWC, 2017)[14]. Heathrow is the airport most resilient to GDP changes with a central estimate of 0.7 (where a 1% change in GDP is associated with an average 0.7% change in passenger demand). The elasticity coefficient for Stansted, which handles many low-cost airlines and intra-EU flights, is significantly higher. This suggests the impact of any future changes to national GDP will disproportionally affect secondary and regional airports (PWC, 2017). The income elasticity of air transport markets in the developed world is estimated to be 1.3 but these elasticities vary according to the market (international or domestic and business or leisure) (IATA, 2016).

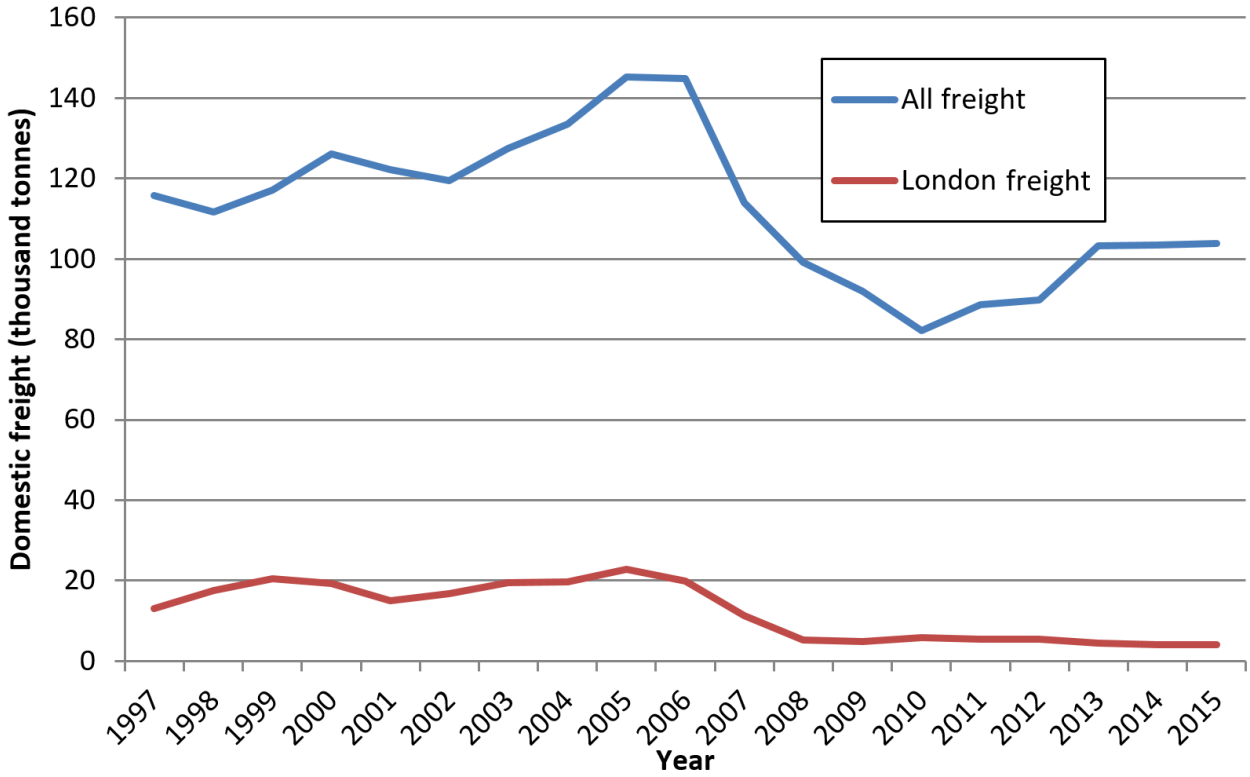
Domestic passenger demand is more vulnerable to external economic conditions than international services. In the years immediately following liberalisation, UK domestic passenger growth outpaced international traffic, but the 2007/08 downturn in economic activity caused domestic demand to decline faster and recover more slowly than international traffic (CAA statistics, 2002-2016). London airports accounted for an average of 30.2% of all passenger numbers in the period 1997-2016 inclusive. Total annual domestic passengers at London airports increased from 11.6m to 12.8m over the period.

[14] This is defined as the ratio between the % change in passenger numbers and the associated % change in national GDP.

Trends in UK domestic freight traffic, 1997-2015

Data presented in Table 14 in each annual CAA airport dataset from 1997 to 2015 inclusive forms the basis of the information presented in this section. Data from 2016 is not included here because of a reporting issue with one airport.

Figure 2: Domestic freight at UK airports, 1997-2015 (Derived from annual CAA airport statistics, Table 14 in each document).



Between 1997 and 2015 UK airports handled over 2.14 million tonnes of domestic freight and an overall 10.3% decline from over 115,700 tonnes to 103,700 tonnes. Between 1997 and 2005, year-on-year (YoY) growth in domestic freight demand averaged 3%, while in 2006 to 2012 there was an average decline of 14.6% a year. From 2013-15, average YoY growth of 5.2% was recorded. London airports handled a little over 10% of all UK domestic freight in the period 1997-2015 inclusive. Total annual domestic freight tonnage at London airports decreased by 69% (from 13,145 tonnes to 4,023 tonnes) over the period.

East Midlands airport is the UK's busiest for domestic air freight. Contributing factors to East Midlands airport's success are the doubling in size of DHL's logistics facility at the airport and the increase in demand for e-commerce and next-day-deliveries (Fisher, 2018).

Domestic airline operators

Currently, most UK domestic passenger routes are operated by UK-registered carriers. These include British Airways, Flybe, Eastern Airways, easyJet, Loganair, Blue Islands and Aurigny. Ryanair is the only non-UK carrier to operate a significant UK domestic scheduled passenger network (OAG, 2017). The situation is more complicated for freight because aircraft can currently be chartered to operate domestic freight services from a range of overseas operators. UK domestic passenger and freight services are governed by international, European and UK law. The UK is a member of the ECAA (European Common

Aviation Area) which permits EU airlines to operate domestically within the territory of another EU member state (cabotage)[15].

In the future, the UK will need to consider whether it wishes to retain existing EU airline ownership rules which restrict non-EU owners to a maximum holding of 49% of EU airline shares[16].

1. How is the domestic air transport system changing?

(i) How will the domestic air transport system evolve between now and 2040?

Domestic air transport will continue to evolve in response to changes in the political, regulatory, economic, social, physical and technological environment in which it operates. There are three potentially disruptive and/or transformative changes that will affect UK domestic air transport demand: changes to our future trading relationships; HS2 and the development of other competing surface transport modes; and new airline business models and business practices.

Future trading relationships

A source of uncertainty is the nature of Britain's future trading relationships. In the future the UK Government may have to assume greater responsibility for some or all of the following: regulatory formation and oversight, safety compliance and auditing, environmental safeguarding, airfield, airframe and aircrew licensing and certification, air service agreements with third party countries, and consumer protection and competition functions.

The nature of our future trading relationships could impact air traffic demand and freight demand.

The EU Single European Sky programme, particularly through the delivery of its technology pillar SESAR (Single European Sky ATM Research Programme) and UK airspace reform will enhance airspace capacity and deliver faster, safer and more direct flights (NATS, 2017) but the continued full cooperation of European partners is needed for it to realise its full operational and environmental benefits.

[15] See: Regulation (EC) 1008/2008. easyJet (a UK registered company) has taken advantage of the ECAA to develop domestic operations in other EU Member States. In July 2017 the company announced it was to open a new European headquarters and airline (easyJet Europe) in Austria to enable it to continue operations within the internal European aviation market post-Brexit.

[16] For example, as of July 2017 49% of Virgin Atlantic shares were held by US-based Delta Airlines and 31% by Air France/KLM (Reuters, 2017). Depending on the outcome of the Brexit negotiations and UK economic strength thereafter, the number and shareholdings of these foreign institutions and individuals may be impacted.

HS2 and the development of other competing surface transport modes

Research into the impact of high speed rail on air/rail mode share in Spain indicates that the development of HS2 from London to the North may impact domestic air transport demand in the UK. Although there is no data available for the UK since it does not have an operational domestic high speed rail network, competition and cooperation between air transport and HSR has been extensively explored in mainland Europe and parts of Asia. Such studies demonstrate that the provision of HSR not only shifts passengers away from air transport but also stimulates new demand (Sun *et al.*, 2017). Research by Jimenez and Betancor (2012) revealed that new high speed rail services in Spain led to a 17% fall in domestic air transport operations.

The continued use and commercial viability of domestic aerial trunk routes for mail and express parcels may be impacted by technological and policy innovations in other surface transport modes including the proposed repurposing of high speed train stock for domestic mail and express parcel delivery by rail and the introduction of electronic, connected and autonomous vehicles (Clewlow et al., 2014; Albalate et al., 2015).

New airline business models and business practices

There is likely to be further rationalisation and consolidation in the UK domestic airline sector. As in the US, the European market experienced a wave of airline start-ups in the immediate aftermath of liberalisation. However, few are still trading (see Budd et al., 2014). The UK market experienced a wave of airline entry and subsequent market exit (usually in the form of bankruptcy or mergers)[17]. This may reduce consumer choice and increase fares as airlines face reduced competitive pressure on prices (Gaggero and Piga, 2010).

Increased availability of price-competitive point-to-point services from UK regional airports to Middle Eastern and European hubs in Dubai, Doha, Frankfurt, Paris CDG and Amsterdam may lead to a decline in domestic feeder traffic into Heathrow (see O'Connell, 2011; Murel and O'Connell, 2011; and Suau-Sanchez et al., 2016). The cessation of Virgin Little Red services between Heathrow and Edinburgh, Manchester, Aberdeen and Glasgow in September 2015 after 18 months' operation indicates the financial challenges of operating such services.

Infrastructure developments at overseas hubs (see ACI, 2017) are likely to attract additional UK-resident passengers and will enable UK regional airports to develop new markets (Suau-Sanchez et al., 2016). Note: Schiphol currently has direct flights to 24 UK airports[18]; Paris Charles de Gaulle has 15[19]; Heathrow has 8[20].

[17] UK airlines no longer operating include Buzz, bmibaby, Debonair, Go, SilverJet, Flying Colours, Excalibur, JMC Air, Air 2000, Britannia, Airtours, Virgin Little Red, Business Air, GB Airways, British Mediterranean, BMI, British Caledonian, Air Scotland, and Fly Globespan.
[18] Source: www.schiphol.nl/en/route-development/airport-facts/european-destinations/
[19] Source: Airfrance.co.uk
[20] Source: www.heathrow.com/plan-and-book-your-trip/destinations-and-airlines/

(ii) What is driving these changes?

These developments will be driven by changes in the UK's economic, political, regulatory, social, environmental and technological environment and the need to ensure cost-effective practice. External changes outside the UK's immediate sphere of influence will also have an impact (for example, airport expansion overseas, geopolitical conflict in key markets and changes in global economic output).

Economic and political environment

Changes in geopolitical influence and patterns of world trade will impact future air traffic flows as growth in global airline operations increasingly shift from North America and Europe towards the Middle East and Asia (Bowen, 2014). Scarce slots at capacity-constrained airports will be used to enhance connectivity with emerging overseas markets in BRIC and CIVETS[21] countries where air service connectivity has traditionally been poor (House of Commons Transport Committee, 2013).

The nature of our future trading relationships will affect not only GDP and the sterling exchange rate but also labour mobility, migration, FDI, purchasing behaviour and the travel habits of inbound and outbound passengers (see IATA, 2016; OECD, 2016; PWC, 2017).

Many regional UK airports have developed extensive services to Eastern European airports, predominately used by EU workers living and working in the UK. Changes to EU freedom of movement laws may have economic consequences for the UK airports, airlines and regions which serve these markets (see Burrell, 2010).

Any changes to the current tax regime and levels of APD (Air Passenger Duty) by the UK Government or devolved administrations may impact future demand (see Mayor and Tol, 2007).

Regulatory environment

Whether the UK will retain membership of ECAA and the Single European Aviation market needs clarification. Until the regulatory position is addressed, it is difficult to assess the UK air transport industry's near and longer-term trajectory.

UK airports have historically been an attractive asset class for private investors and the UK's busiest UK passenger airports are either wholly or partly privately owned (see Humphreys, 1999). The return of Prestwick and Cardiff airports from private to public ownership demonstrates the dynamic nature of airport ownership and the continued role of the state.

The commercialisation and privatisation of the UK's airports, airlines and related air services – such as approach and tower control, airport ground handling and public transport

[21] Colombia, Indonesia, Vietnam, Egypt, Turkey and South Africa.

operators – has created complex management of airport operations, development and expansion.

Air service liberalisation and concurrent airline business model innovations have led not only to the emergence of low-cost operators but also 'hybrid' carriers that combine elements of both low-cost and full-service operations (Whyte and Lohmann, 2017). This has increased the product range for consumers and made competitively-priced air services accessible from local regional airports.

Social environment

The UK's population is projected to increase from 65 million to over 74 million by mid-2039 (ONS, 2015). The population is ageing; the average median age will increase from 40 years in 2014 to 42.9 by mid-2039 (ONS, 2015).

By mid-2039, one in every 12 people will be aged 80 or above (ONS, 2015). Elderly and infirm passengers often have additional needs and require adaptive and/or assistive technologies to access air transport services which will impose additional costs (both in terms of finance and time) on operators (see Chang and Chen, 2012).

Physical environment

Concern about the impact of aircraft emissions on climate change is not new (see Chapman, 2007). UK air transport accounted for approximately 7% of the UK's total greenhouse gas emissions and 21% of total CO_2 transport emissions in 2016 (DfT, 2018a). Domestic flights account for 10% of the UK's total air transport emissions with international services accounting for the other 90% (CAA, 2017). Under the 2008 Climate Change Act, the UK is committed to reducing greenhouse gas emissions by at least 80% by 2050 compared to 1990 levels. This target includes domestic flights which land and take off in the UK but excludes emissions from international aviation, although these emissions are taken into account when setting the UK carbon budgets (DfT, 2018a).

Decarbonising UK domestic air transport will require innovations in both technology and policy. Airline interest in developing biofuels appears to be directly proportional to the current price of jet fuel (high jet fuel prices stimulate R&D in alternative fuels, but lower jet fuel prices reduce the financial imperative to innovate). IATA (2016) suggests that policy makers and the air transport industry look beyond simple economic instruments to effect change and decouple emissions from air transport growth.

Technological environment

Technological innovations including: autonomous vehicles, alternative transport modes, drones/UAVs, telepresence software, and the introduction of more fuel-efficient or potentially electric aircraft may create economic benefits but may also change the pattern of demand and create unintended challenges. Drones will become more common, particularly if they can be made autonomous. PWC estimate they could increase UK GDP by £42

billion or 2% by 2030 (PWC, 2018). Drones demonstrate commercial potential for multiple applications in the security, agriculture, healthcare, energy, telecommunications, and transport sectors (see PWC, 2016, DfT, 2018c). Although they also pose a potential collision risk to commercial, military and general aviation aircraft and may raise concerns about personal privacy and safety.

There is potential for Big Data and the Internet of Things to enhance intermodal transport provision and improve airport surface access connectivity by providing real time data to consumers and anticipating changes in passenger demand (Budd *et al.*, 2011; Ryley *et al.*, 2013).

(iii) What are the implications for decisions that must be made now?

Between now and 2040, today's decisions will have considerable, wide-ranging, unintended and unanticipated consequences. The UK Government should consider:

- The specific parts of the existing air transport regime it aspires to retain in the future and which parts it will be able to retain (and at what cost).
- The extent of any government intervention and the cost-benefit of ring-fencing airport slots for domestic services in the future[22].
- The cost-benefits of developing a UK equivalent of existing European PSO services.
- Future of APD and tax regimes in England and devolved administrations.
- How to make best use of obsolete airfield assets, be that for environmental, educational, business, residential or recreational use and development (see Gallent et al., 2000).
- The impact of HS2 on domestic air transport demand.
- Investments in future skills training (DfT, 2017).

(iv) What are the research gaps in understanding how the domestic air transport system is changing?

Air transport is a problem-rich yet data-poor research area. This is partly because of the sector's complexities and interdependencies but also because of its sheer number of commercial data points and operators, and associated issues of data confidentiality and

[22] Note: It was the EC who required British Airways to relinquish 14 daily slot pairs at Heathrow as part of the airline's acquisition of bmi in 2012 (EC, 2012). UK airport slots are currently subject to EC regulation.

collection. There is a particular need for quantitative and qualitative data in certain areas. These include:

- The relationship between GDP, domestic air transport and income elasticity. Income elasticities have been estimated for developed markets at the global level but there is a dearth of country-specific data.
- The price sensitivity of domestic passengers and the factors that influence demand.
- Understanding how and when different users engage with the domestic air transport system.
- Measuring and modelling domestic freight flows.
- Domestic air transport and its impact on regional economies. There is a need to establish the relationship between air services and regional growth, local employment and social mobility.
- The assessment of the 'real' price of air travel which considers the full range of social, cultural, economic and environmental dis/benefits.
- The effect of changing patterns of UK airport ownership on efficiency, productivity and profitability.
- The impact of future UK Government air transport policy for airlines, airports, passengers, shippers and supply chains.
- The impact of/interaction between HS2 and domestic air travel (competitive or complementary?).

2. How is the user engaging with the domestic air transport system?

(i) How will this engagement evolve between now and 2040?

Different users engage in different ways according to trip purpose and motivation, the nature of the transaction and who pays for the journey. Typically, this interaction has been a transactional one with shippers and a transactional and/or relationship one with passengers. The increased use of Big Data and customer relationship marketing will make better segmentation of passengers possible and help tailor travel to individual needs (Halpern, 2017). In terms of supply, enhanced bundling and unbundling of services will give consumers increased choice and flexibility in the elements of the air service product they purchase (Wittmer and Hinnen, 2017).

(ii) What is driving these changes?

The factors driving these changes are:

- Demand for seamless end-to-end journeys and enhanced convenience and connectivity.
- Changing customer expectations about the pre-flight, in-flight and post-flight experience and the unbundling of service products.
- Changes in technology, particularly digital media and user-generated content.
- Commercial incentive for companies to better understand and anticipate consumer needs.
- An ageing passenger demographic and a need to invest in assistive and adaptive technologies (Chang and Chen, 2011).
- Changes in air transport security regulations, technologies and protocols (Quddus, 2017, DfT, 2018b).
- Obsolescence and overcrowding of existing UK airport infrastructure. Much of this originally dates from the 1970s and is not suited to current aircraft types, passenger flows and traffic mix. This will mean that some aircraft manoeuvring areas, terminal buildings, roads and rail connections may need to be reconfigured. Such development is likely to raise concerns among local communities and a balance will need to be struck between community concerns and the operational needs of airport and aircraft operators.
- Research by Budd and Ison (2017) has shown that UK airports have no standard system to capture noise complaints, and it may be desirable to have an independent system that covers all airports.

(iii) What are the implications for decisions that must be made now?

Decisions should consider:

- Which elements of the existing air transport regulatory regime the UK wishes to retain.
- The trade-off between aircraft noise, local air quality and climate change.
- Issues concerning data protection and confidentiality both within and beyond the UK (especially when companies are majority foreign owned).
- Future levels of investment in staff, security technologies and environmental safeguarding.

(iv) What are the research gaps in understanding how users will engage with domestic air transport?

There are several research gaps in understanding how users will engage with domestic air transport. There needs to be a better understanding of customer perceptions/use of apps, digital technologies, and how researchers methodologically capture consumer expectations and experiences. Further, there is a lack of research on passenger perceptions of security and security screening, and the uptake and acceptance of biometrics. Finally, there is a need to better understand the complex interdependencies both within the domestic air transport system and between domestic air services and other transport modes.

3. How is the technology changing the domestic air transport system?

(i) Between now and 2040, which areas of domestic air transport are going to be most affected by technological change, and why?

The Government's recent Aviation Strategy (DfT, 2018a) highlights the importance of technological change to the domestic and international air transport system. It details how data and digitalisation are bringing new capabilities to air transport, providing smarter and connected aircraft. Automation is creating opportunities and enhancing safety in commercial aviation but is also posing challenges relating to integration with existing traffic control and around public perception. The shift to electrification seen elsewhere in transport may offer possibilities to mitigate the negative environmental impacts of air travel. Last year, Rolls Royce, Airbus and Siemens announced a collaboration to develop hybrid electric technology (Airbus, 2017). The Government's Industrial Strategy and Future of Mobility Grand Challenge aims to drive innovation in the air transport sector and tackle future challenges by working with industry.

High speed rail may reduce domestic air transport's share of the internal transport market. Drones may impact domestic freight demand. Air traffic control will increasingly rely on remote towers (Merkert, 2017). These will yield efficiency gains but require job restructuring. Consideration will need to be given to the cost/benefits of opening up air traffic services to international competition[23]. Growing use of autonomous vehicles between now and 2040 should, in theory, lead to more reliable and less congested journeys. This will lower emissions, but since car parks are a major income stream for airports, it will have an impact on airport operating revenues. This will also have important implications for land use in and around airports.

Security checks will be faster and less intrusive and feature pre-checks, bio-recognition and enhanced screening technologies. Known-traveller programmes could be expanded. RFID

[23] Note: DFS, a German company, already provides tower services at London Gatwick.

(radio frequency identification) and electronic airway bills will enhance the efficiency of baggage handling and freight operations and improve security. In the air, the availability of more direct routes and user-defined trajectories will lead to more efficient operations. Big Data and customer relationship marketing (CRM) will understand and anticipate consumer needs and behaviour more efficiently. More efficient airport buildings will lead to lower energy consumption, costs and environmental impact. Ticketing will be more streamlined and transactions will routinely occur on digital platforms. Impact of proposed development of space travel and vertiport infrastructure[24] on UK airfields (see Reddy et al., 2012).

Use of beacon and geofencing technologies (which impose a virtual boundary on a real environment) could both enhance passenger experiences of journeys and provide commercially valuable data on consumer behaviour by tracking their movements and use of airport space (see Budd and Vorley, 2013). Biofuel use may require construction of new storage and distribution facilities (Gegg et al., 2014). Innovations in smart, connected and electric or hybrid powered aircraft will also lead to the development of new quieter, cleaner, safer and more efficient forms of propulsion.

(ii) Which areas are going to be least affected and why?

The areas least affected will be Lifeline PSO and services to the Channel Islands and Isle of Man. Lifeline PSO services will continue due to the unique social, cultural and medical needs of remote communities. Services to the Channel Islands and Isle of Man will continue for as long as sea travel remains a slower, less reliable and more disruption-prone option.

(iii) What are the implications for decisions that must be made now?

The decisions that must be made now should consider:

1. How to monitor the use and development of new technology;
2. Resilience to cyber-attacks and infrastructure safeguarding;
3. The social implications of changes in domestic connectivity.

(iv) What are the research gaps in understanding how technology will change the domestic air transport system?

More research needs to be done to improve our understanding of how technology will change the domestic air transport system. One of the research gaps is the potential applications of, and data protection safeguards arising from, the use of Big Data and the

[24] A vertiport is an airport designed for aircraft which take off and land vertically

Internet of Things. Another research gap is the mode shift potential and implications for UK domestic air transport that will arise from the use of drones, HGV platoons and autonomous vehicles. Similarly, user acceptance and dissemination of new technologies needs to be better understood.

It is also important to improve our understanding of how to address the (cyber)security risks associated with new technologies such as remote towers, drones and autonomous surface access vehicles. The UK Government's 2018 aviation cyber security strategy recognises the need to "keep the civil aviation sector secure and resilient against malicious and unintended interference with information and communication systems" (Department for Transport, 2018b p6)

While air transport is similar in some ways to other transport modes – in that it is a derived demand concerned with the movement of people and goods from A to B, and vulnerable to a changing economic climate – it has a number of characteristics that pose unique challenges, not least its security, commercial and physical environment.

4. Conclusions

The UK has the largest air transport market and the fifth-largest domestic air transport market in the EU28 (Eurostat, 2016). 20.6 million domestic passengers (8.9% of the total) used a total of 47 UK airports in 2016 (CAA, 2017). The busiest domestic passenger routes carry over 500,000 people a year and connect seven regional airports with London (CAA, 2017)[25]. Other domestic services link geographically distant cities such as Exeter, Southampton, Belfast and Inverness that surface transport cannot as rapidly or as practicably serve. Domestic services accounted for 16.5% of all air traffic movements at UK airports in 2015 and at some airports were the dominant type of traffic (DfT, 2016). The domestic passenger load factor (a measure of utilisation), at 72.5% in 2015, is lower than the comparable figure for international flights.

UK domestic air transport will continue to face a number of challenges and opportunities. The challenges primarily concern the future economic wellbeing of the nation as domestic air travel demand is closely aligned to economic growth, competition from proposed new surface modes such as HS2 and changes in the cost base. Opportunities revolve around the development of new aircraft, engine and air traffic control technologies – potentially making domestic air transport operations cleaner and cheaper – as well as possible changes to the regulatory regime resulting from future trading arrangements.

[25] Belfast City, Belfast International, Edinburgh, Glasgow, Manchester, Jersey and Aberdeen.

5. References

Airbus (2017) *Airbus, Rolls-Royce, and Siemens team up for electric future Partnership launches E-Fan X hybrid-electric flight demonstrator.* November 2017. Available at: https://www.airbus.com/newsroom/press-releases/en/2017/11/airbus--rolls-royce--and-siemens-team-up-for-electric-future-par.html

Airports Council International (2017) *Airport Business Development Phase.* Available at: www.airport-business.com/development-phase/page/10/

Airports Council International Europe [ACI] (2016) *The ownership of Europe's Airports 2016.* Brussels: ACI Europe.

Albalate, D., Bel, G. and Fageda, X. (2015) Competition and cooperation between high speed rail and air transportation services in Europe. *Journal of Transport Geography* 42, 166-174.

Bowen, J.T. (2014) 'The Economic Geography of Air Transport' in Goetz, A. and Budd, L. (eds.) *The Geographies of Air Transport*. Farnham: Ashgate, pp.41-59.

Budd, L. and Ison, S. (2017) Capturing aircraft noise complaints: A survey of current practices at UK airports. *Journal of Airport Management* 11(3).

Budd, L. and Vorley, T. (2013) Airlines, apps and business travel: a critical examination. *Research in Transportation Business and Management* 9, pp.41-49.

Budd, T., Ison, S. and Ryley, T. (2011) Airport surface access management: Issues and Policies. *Journal of Airport Management* 6(1), pp.80-97.

Burrell, K. (2010) Going steerage on Ryanair: culture of migrant air travel between Poland and the UK. *Journal of Transport Geography* 19(5), pp.1023-1030.

Chang, Y.-C. and Chen, C.-F (2011) Identifying mobility service needs for disabled air passengers. *Tourism Management* 32(5), pp.1214-1217.

Chang, Y.-C. and Chen, C.-F. (2012) Service needs of elderly air passengers. *Journal of Air Transport Management* 18(1), pp.26-29.

Chapman, L. (2007) Transport and Climate Change: A Review. *Journal of Transport Geography* 15(5), pp.354-367.

CAA [Civil Aviation Authority] (1973-2016, various dates) *Airport statistics.* Available at: www.caa.co.uk

CAA (2017) *Information on aviation's environmental impact: CAP1524.* West Sussex, CAA

Clewlow, R., Sussman, J., and Balakrishnan, H (2014) The impact of high-speed rail and low-cost carriers on European air passenger traffic. *Transport Policy* 33, pp.136-143.

Department for Transport (2016) *Transport Statistics Great Britain 2016.* London, DfT December.

Department for Transport (2017) *Beyond the Horizon: The future of UK Aviation. A call for evidence on a new strategy.* London: DfT.

Department for Transport (2018a) *Beyond the Horizon: The future of UK Aviation. Next steps towards an Aviation Strategy.* London: DfT.

Department for Transport (2018b) *Aviation Cyber Security Strategy* London, DfT Available at: https://www.gov.uk/government/publications/aviation-cyber-security-strategy

Department for Transport (2018c) Taking Flight: The Future of Drones in the UK Moving Britain Ahead.

EC (2012) *Mergers: Commission approves acquisition of British Midlands <sic> (bmi) by IAG subject to conditions*. European Commission press release. Available at: http://europa.eu/rapid/press-release_IP-12-338_en.htm

EC (2017) *PSO inventory table. List of routes (178) with public service obligations (last update: April 2017)*. Available at: https://ec.europa.eu/transport/sites/transport/files/modes/air/internal_market/doc/

Eurostat (2016) *Air Transport Statistics.* Available at: www.ec.europa.eu/

Fisher, S (2018) *Record levels of cargo at East Midlands airport.* East Midlands Business Link. Available at: https://www.eastmidlandsbusinesslink.co.uk/mag/news/record-levels-of-cargo-at-east-midlands-airport/

Gaggero, A. and Piga, C. (2010) Airline Competition in the British Isles. *Logistics and Transportation Review* 46(2), pp.270-279.

Gegg, P., Budd, L and Ison, S. (2014) The market development of aviation biofuel: Drivers and constraints. *Journal of Air Transport Management* 39, pp.34-40.

Gallent, N., Howe, J. and Bell, P. (2000) New uses for England's old airfields. *Area* 32(4), pp.383-394.

Halpern, N. (2017) 'Air Transport Marketing' in Budd, L. and Ison, S. (eds.) *Air Transport Management: An International Perspective.* Abingdon: Routledge, pp.321-338.

HM Government (2017) *UK Overseas Territories.* Available at: www.gov.uk/government/policies/uk-overseas-territories

House of Commons Transport Committee (2013) *Aviation Strategy First Report of Session 2013-14.* Vol 1 HC78-I. London: HMSO.

Humphreys, I. (1999) Privatisation and commercialisation: Changes in UK airport ownership patterns. *Journal of Transport Geography* 7(2), pp.121-134.

IATA [International Air Transport Association] (2016) *The impact of 'BREXIT' on UK Air Transport.* Spain: IATA Economics.

Jimenez, J.L. and Betancor, O. (2012) When trains go faster than planes: The strategic reaction of airlines in Spain. *Transport Policy* 23, pp.34-41.

Mayor, K. and Tol, R.S.J. (2007) The impact of the UK aviation tax on carbon dioxide emissions and visitor numbers. *Transport Policy* 14(6), pp.507-513.

Merkert, R. (2017) 'Air transport in remote regions' in Budd, L. and Ison, S. (eds.) *Air Transport Management: An International Perspective.* Abingdon: Routledge, pp.339-355.

Murel, M. and O'connell, J.F. (2011) Potential for Abu Dhabi, Doha and Dubai airports to reach their traffic objectives*. Research in Transportation Business and Management* 1(1), pp.36-46.

Nats (2017) *Airspace*. Available at: www.nats.aero/services/airspace/

OAG [Official Airline Guide] (2017) *OAG flight guide worldwide: August.* Dunstable: OAG Worldwide.

O'connell, J.F. (2011) The rise of the Arabian Gulf carriers: An insight into the business model of Emirates airline*. Journal of Air Transport Management* 17(6), pp.339-346.

OECD (2016) *The Economic Consequences of Brexit: A Taxing Decision.* OECD Economic Policy Paper No 16. Paris: OECD.

ONS [Office for National Statistics] (2015) *National Population Projections: 2014-based Statistical Bulletin*. Available at: www.ons.gov.uk/peopleandcommnunity/populationandmigration

PricewaterhouseCoopers (2016) C*larity from above PwC global report on the commercial applications of drone technology* May 2016 Polska, PwC Available at: www.pwc.pl/pdf/clarity-from-above.pdf

PricewaterhouseCoopers (2017) *Connectivity and growth The Brexit Issue.* London: PwC.

PricewaterhouseCoopers (2018) *The impact of drones on the UK economy*. Available at: https://www.pwc.co.uk/dronesreport

Quddus, M. (2017) 'Aviation safety and security' in BUDD, L. and ISON, S. (eds) *Air Transport Management: An International Perspective.* Abingdon: Routledge, pp.191-213.

Reddy, M., Nica, M. and Wilkes, K. (2012) Space tourism: Research recommendations for the future of the industry and perspectives of potential participants. *Tourism Management* 33(5), pp.1093-1102.

Reuters (2017) *Air France-KLM agrees option for Virgin Atlantic ownership in event of hard Brexit*. Available at: https://www.reuters.com/article/us-air-france-klm-alliance-virgin-

atlant/air-france-klm-agrees-option-for-virgin-atlantic-ownership-in-event-of-hard-brexit-idUSKBN1AD0UE 28/07/2017.

Ryley, T., Elmirghani, J., Budd, T., Miyoshi, C., Mason, K., Moxon, R., Ahmed, I., Qazi, B. and Zanni, A. (2013) Sustainable development and airport surface access: The role of technological and behavioural change. *Sustainability* 5(4), pp.1617-1631.

Scottish Government (2017) *Air discount scheme.* Available at: www.airdiscountscheme.com

States of Guernsey (2017). Available at: www.gov.gg

States of Jersey (2017) Available at: www.gov.je

Suau-Sanchez, P., Voltes-Dorta, A. and Rodríguez-Déniz, H. (2016) The role of London airports in providing connectivity for the UK: regional dependence on foreign hubs. *Journal of Transport Geography* 50, pp.94-104.

Sun, X., Zhang, Y. and Wandelt, S. (2017) Air transport versus high-speed rail: An overview and research agenda. *Journal of Advanced Transportation*, 2017, Article ID 8426926, 18 pp.

Whyte. R, and Lohmann, G. (2017) 'Airline Business Models' in Budd, L. and Ison, S. (eds.) *Air Transport Management: An International Perspective.* Abingdon: Routledge, pp.107-121.

Wittmer, A. and Hinnen, G. (2017) 'Airline passengers' in Budd, L. and Ison, S. (eds) *Air Transport Management: An International Perspective*. Abingdon: Routledge, pp.139-150.

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