Engineering the Future

Developing a sustainable framework for UK aviation

Response from the engineering profession (*Engineering the Future*) which includes:

- The Royal Academy of Engineering
- The Institution of Engineering and Technology
- The Institution of Mechanical Engineers
- The Institution of Chemical Engineers
- The Engineering Council
- EngineeringUK
- The Royal Aeronautical Society

Department for Transport

October 2011

Engineering the Future is pleased to be able to respond to the Department for Transport's consultation on developing a sustainable framework for UK aviation. The consultation covers the complete operations of the air transport industry, but in this response, *Engineering the Future* has concentrated on those issues with direct relevance to engineers and engineering. Additionally, we build on work that *Engineering the Future* has carried out for DEFRA and HMT concerning resilience and interdependencies of UK infrastructure.

This response has been coordinated by the Royal Academy of Engineering, with significant input from the Royal Aeronautical Society, on behalf of *Engineering the Future*.

Engineering the Future is a broad alliance of engineering institutions and bodies which represent the UK's 450,000 professional engineers.

We provide independent expert advice and promote understanding of the contribution that engineering makes to the economy, society and to the development and delivery of national policy.

Engineering Council · EngineeringUK · IChemE Institution of Chemical Engineers · IET The Institution of Engineering and Technology · Institution of Mechanical Engineers · The Royal Academy of Engineering · Royal Aeronautical Society

Introduction

The aviation sector is an important and strategic business for the UK. Current work by The Royal Academy of Engineering considering the nature of global industrial systems, in which a number of leading industrialists were interviewed, suggested that ease of travel to and from the United Kingdom was one of the top factors in encouraging inward investment along with the English language, the good regulatory environment and the reliability of UK national infrastructure.

The consultation covers broad aspects of the aviation sector business including air transport operations and tax regimes. This response from *Engineering the Future* is restricted to engineering issues. The Royal Aeronautical Society, while being the professional body for aeronautical engineering, also covers the entire aerospace industry and the complementary response by the Society also covers those areas of the business not directly related to engineering.

1. The aviation sector

The UK is an important aviation and aerospace nation. As a manufacturer, UK aerospace is second only to the US in terms of employment and arguably possesses the most comprehensive range of aerospace capabilities in Europe (aircraft systems integration, propulsion and equipment). The UK no longer builds complete civil aircraft (except for some light aircraft and unmanned platforms) but is a leading member of international consortia in both civil and military aircraft. The UK also possesses design and development capabilities in advanced civil aero engines. This is exemplified by Rolls-Royce as one of the 3 main suppliers of civil aero engines worldwide. The UK's share of the Airbus programme, centring on wing design and manufacture, is a vital element in ensuring overall aircraft performance. Finally, UK-based manufacturers supply advanced mechanical and electronic equipment to most of the leading civil aircraft programmes. As a leading high technology manufacturing sector, the industry is a major employer and exporter of highly skilled people and products. To maintain this position, it is crucial that investment (from both private and public sources) is made within the UK aerospace sector to help research centres improve the sustainability of aircraft. This is to be achieved by taking improved systems and components from a low level technology readiness level through to a production standard. The US model shows that agencies such as NASA have more flexibility to look at technologies which are more than one product generation from the market. Examples are demonstrated in the Blended Wing Body airframes and alternative propulsion systems.

The UK air transport industry comprises a number of global players, including BA and Virgin Atlantic. The former is now part of an international grouping with Iberia. The emergence of truly global airline entities (defined in terms of ownership rather than route structure or membership of alliances) is a relatively recent development. It is of vital importance to the future of the UK aviation industry that the country is at the centre rather than the periphery of such developments, able to retain a decisive role and influence in the evolution of these global entities. The UK is also at the centre of the low cost carrier (LCC) activity, with one of the leading European players – easyJet – a British registered airline. This again has allowed the country to benefit directly from the competitive dynamism released by the LCCs. The air transport sector is also a significant employer of highly skilled aircraft maintenance engineers.

Given the importance to advanced UK manufacturing of lean techniques, access to effective and efficient air-freight services is essential. As the disruption caused by the 2010 volcanic ash cloud demonstrated, modern production depends on a continual flow of components and supplies. This capability is often delivered by dedicated airfreight carriers, but the role of commercial freight carried as belly hold as part of scheduled passenger traffic is also important. Both aspects of airfreight should be considered as part of a national air transport strategy and an important part of UK national infrastructure.

There is also an important correlation between the cities around the world where UK companies choose to trade and the direct flight connections between the UK and those cities. Any sustainable aviation policy must take into account a strategic vision of where, globally, UK businesses will want to trade in the future and provide capacity for direct flight connections with those areas.

2. The trade-off between growth of the aviation sector and pollutant emissions

Pollution and noise in the vicinity of airports are currently subject to regulation, both internationally and in some cases locally. These impacts are being progressively reduced, despite traffic growth, through the replacement of older aircraft by newer, cleaner and quieter types. Advances in technology – low NO_X combustors and higher bypass ratio engines – will reduce these impacts further. The improvements will be captured in more stringent regulation. The possible introduction of contra-rotating propellers on the next generation of short to medium-haul aircraft, in order to minimise fuel burn and CO_2 emission, would result in aircraft noisier than equivalent turbofan powered aircraft but still comfortably within the current noise regulations. Stricter local regulation is unlikely to constrain traffic growth, although local political pressures may in some cases limit traffic growth at a particular location, diverting some of that growth to other airports.

It is worth noting that local pollution effects around airports are caused by a combination of air transport operations and high concentrations of road traffic requiring access to airports. A coherent transport policy needs to address alternative means of bringing passengers and cargo to and from airports to help mitigate this local pollution.

From an environmental standpoint, there is a case for regulation to reduce fuel burn and CO_2 emissions. Higher fuel prices should play a significant part in reducing CO_2 emissions. New technological concepts could substantially reduce CO_2 emissions.[1] But the degree to which radical design improvements will be introduced into the world fleet will depend on airline business models and the trade-off between the cost of new equipment and the long term savings and improvement in emissions as well as rate at which the fleet is renewed. Regulation may be required in order fully to exploit the full potential of these advances in order to increase the relative cost of operating conventional aircraft[2]. Because of the time required to develop, test and introduce new commercial airliners, if there is an intention to regulate, it will be important to signal it now in order to influence key design decisions to be made on A320 and B737 successors. Otherwise, an opportunity to influence the climate impact of this important class of next generation of aircraft will have been lost.

---

1 Henderson, R.P., Martins, J.R.R.A. and Perez, R.E. Aircraft Conceptual Design for Optimal Environmental Performance, to be published in The Aeronautical Journal.
2 Dallara, E.S. and Kroo, I.M. Aircraft Design for Reduced Climate Impact, AIAA Paper 2011-265,.

2.1. Trade-off between aviation and other emissions

There is a trade-off between local noise pollution, CO_2 and NO_X emissions in the vicinity of airports. Noise abatement departures often involve a higher thrust take-off and higher initial rate of climb than is operationally necessary – trading noise against other pollutants. There is a debate to be had with local communities about the relative importance of reducing greenhouse gas emission versus noise when current commercial aircraft are considerably quieter than their predecessors and still getting quieter.

There is unlikely to be a suitable alternative to kerosene as an aviation fuel for the foreseeable future. If this is accepted, the likely penetration of bio-kerosene needs to be considered and how much bio-kerosene can be made available for air transport needs when there is likely to high demands for other bio-fuels from other industry sectors and users made from the same limited resource of bio-mass.

It is highly likely that there will be significant competition within the UK (and global) economy for the biofuels that can be produced in industrial quantities in a sustainable manner. Because of the higher technical and safety driven demands of the aviation market, there is a danger that suppliers will choose to supply only those markets where technical standards can be met at lower cost (such as road transport fuel) rather than meet the demands of the aviation industry. If it is considered more economical to give priority of bio-fuel supply to sectors with less exacting technical demands, then this must be recognised in any CO_2 regulatory measures applied to aviation.

3. Should some aspects of UK aviation be considered to be of strategic national interest?

The entire UK national infrastructure is of strategic national interest. Airports and air traffic control form part of that national infrastructure and the only question to be considered is whether the current setup of UK aviation infrastructure serves the UK's strategic interests optimally and what, if any, changes might make it serve national interests better. As was discussed in Section 1, the direct international air connections available from the UK have a significant influence on where, how and how much business UK based firms are able to compete in the global economy.

3.1. International connectivity and hub airports

The Royal Academy of Engineering will shortly publish a report on industrial systems, a part of which draws evidence for structured interviews with leading industrialists. Those interviews found that a key factor in attracting UK inward investment was the reliability of UK infrastructure in terms of skills, energy, communication and transport, but particularly direct connectivity with major centres of trade around the world.

It has been argued in a number of fora that the predicted exhaustion of runway capacity in the London area currently predicted from 2030 will damage the competitiveness of UK industry and the ability of the South East to attract inward investment.

3.2. Does it matter if people and goods can still reach desired destinations in the UK if they use a foreign rather than a UK hub?

The additional CO_2 emissions caused by short haul flights are significantly higher, in terms of grams per km, than flights which cover more optimal distances for the aircraft's design. Hub and spoke operations with hubs elsewhere in Europe will necessarily increase the number of passenger km flown on short haul flights into and out of the UK.

While the inconvenience of non-direct flights will impact on leisure flights, as has been discussed above, it will have a direct effect on the attractiveness of UK to inward investment. If foreign investors can travel and communicate more easily with mainland Europe, the UK's attractiveness by comparison will be diminished. Also, the opportunities for UK companies to do business globally will be curtailed as the number of direct connections diminishes.

3.3. How will UK's connectivity needs change in light of global developments in the medium and long term (20 to 50 years)?

The Royal Academy of Engineering's work on industrial systems suggests that connectivity will be most important to the cities and regions where UK owned and based companies trade or regions where inwards investment is likely to come from. With the rise of the sovereign wealth fund as a significant source of inward investment, connections to the Middle East, Far East and China could become strategically more important.

As UK manufacturing industry moves to higher value added products, air freight distribution to international markets may also become more important and these markets are likely to be in the BRIC economies (Brazil, Russia, India and China). Connection to regions with lower manufacturing cost bases for the supply of off-plan manufactured parts will also be critical, but the necessity of direct connections may not be as critical. These supply chains are likely to be in regions such as the Far East and increasingly India and South America.

While the business connectivity mentioned above are likely to become more important, it is unlikely that connectivity with North America will become less important as the trade in goods, people, services and ideas with the USA is unlikely to diminish.

4. Regional connectivity and regional airports

4.1. How could the benefits from any future high speed rail network be maximised for aviation?

Engineering the Future has recently responded to the Department for Transport consultation on HS2. In that response[3], the case was made that, because of the high speed nature of HS2 and the aerodynamic interference effects of running for large distances in tunnels and the tendency for a high-speed line to increase overall travel volumes, HS2 may not, in the end, have better CO_2 emissions than regional aviation. If environmental performance is to be a key driver for UK transport policy, the

3 http://www.raeng.org.uk/societygov/policy/responses/pdf/Response_from_the_IET_and_RAEng_to_High_Speed_Rail.pdf

environmental performance of each part of the infrastructure must be assessed thoroughly before strategic decisions are made on modal splits.

5. Climate change impacts

5.1. What are the most significant impacts of aviation on climate change?

The three most significant contributors from aviation to climate change are the emission of CO_2, the emission of NO_X at altitude and the formation of contrails in regions of supersaturated air, leading to the formation of cirrus cloud.

5.1.1. NO_X

NO_X is understood to have the smallest impact. It is not in itself a greenhouse gas but its emission at altitude leads to the creation of ozone, a strong but short-lived greenhouse gas, and the destruction of methane, a relatively long-lived greenhouse gas. The net effect is currently believed to be an increase in global warming; but there is still significant uncertainty about this because the effect of the short-lived ozone is confined to regions of heavy air traffic while the effect of the depletion of long-lived methane is global.

Moreover, the NO_X emissions of future generations of aircraft will be substantially lower than at present, and thus it is unlikely to be an important contributor to climate impact in the future. Nevertheless, it is still important to develop a fuller understanding of the scientific aspects of its impact on the climate, particularly at the regional and global levels. Its effect on climate depends strongly on cruise altitude and, for the current generation of aircraft, it could be reduced by reducing cruise altitude and cruise Mach number. This would increase fuel burn, CO_2 emissions and airline operating costs. However, the atmospheric science is not at this stage sufficiently robust to allow trade-off studies that could provide a basis for addressing this question with the world's airlines.

5.1.2. Contrail Cirrus

Although contrail cirrus is very short-lived, recent German studies[4] have provided evidence that the radiative forcing effects currently exceeds that of aviation CO_2 .The formation of contrail cirrus can be avoided by flying above, below or around regions of supersaturated air. As with the avoidance of NO_x emissions, this will cause an increase in fuel burn, CO_2 emission and airline costs and will increase the load on air traffic management and disrupt schedules. These adverse effects can be kept to a minimum by making use of current meteorological information to take evasive action only when necessary. Because contrail avoidance will increase CO_2 emission, the environmental optimum will not be the total avoidance of contrail formation but an operational strategy which entails a substantial reduction, but not the elimination, of contrail formation.

---

4 Burkhardt, U and Kärcher, B, Global radiative forcing from contrail cirrus, Nature Climate Change, Vol 1, April 2011, www.nature.com/natureclimatechange

5.1.3. CO_2

The persistence of CO_2 in the atmosphere makes it the most significant climate change affecting emission from aviation in the long term. A recent study[5] showed that, if all aviation ceased today, the increase in the surface temperature of the earth caused by aviation emissions would continue to increase for a further 50 years, doubling existing levels of aviation related CO_2. Reducing fuel burn has been an important goal for the airlines and the aircraft and engine manufacturers for the past 50 years. The rise in fuel prices over the past decade, combined with increased political pressure to reduce climate impact, has led to greater emphasis on reducing fuel burn and there are now substantial research programmes aimed at this on both sides of the Atlantic.

5 Greener by Design Annual Report, 2009-2010, Fig 8, Royal Aeronautical Society, www.greenerbydesign.org.uk/resources