The role of aero engineering in the sustainable development of the aviation industry

C. Thomas and D. Raper
Department of Environmental and Geographical Sciences
The Manchester Metropolitan University, Manchester, UK

SUMMARY

The aviation industry plays a critical role in modern society, supporting global, regional and local economies and facilitating long distance travel for business and leisure. However the environmental impact of the industry is significant and this threatens the sustainability of future growth and the consequential benefits which could arise from it. Technological, operational and infrastructure improvements designed to reduce emissions and noise from aircraft are continually being eroded by the rapid growth of the industry, with the result that the environmental impact of air travel is increasing. Consequently, the sustainable development of the aviation industry will require that in future, technological innovation and fleet replacement continues at a rapid pace and that the highest priority is given to achieving a 'step change' in aircraft technology.

1.0 THE ROLE OF AVIATION IN MODERN SOCIETY

The development of the global society is intrinsically linked to that of the aviation and telecommunications industries, both of which enable accessibility. The transport industry is essential for the carriage of people and goods, supports the operation and competitiveness of the economy both nationally and internationally[1] and facilitates the development and maintenance of societal, business and family networks. There is an historical and well-proven link between mobility and development. It is becoming clear however that the current trend of increasing mobility is unsustainable in the longer term due to its environmental impact. It has been suggested that Information and Communication Technologies have the potential to provide accessibility without mobility (e.g. to reduce the need to travel through videoconferencing). However, these technologies also have the potential to increase travel demand by providing more information about places to visit, by impacting upon the construction and geographic structure of social and business networks and by reducing the costs of travel.

Aviation brings very significant social and economic benefit and will have an even more important role to play in the future than it has in the past. In this context it would seem logical to assume that for nations or regions to play their full part in the global economy they will need to be linked through a network of air routes to major cities and centres of economic activity throughout the world. This will be particularly important for developing nations and transitional economies (such as Romania where economic growth is in a large part based upon routes of communication with Western European economies).

2.0 THE ENVIRONMENTAL IMPACT OF THE AIR TRANSPORT INDUSTRY

The air transport industry does however have a wide variety of adverse social and environmental impacts that have the potential to constrain its growth and hence longer-term sustainability. At a global level these centre around aircraft emissions and climate change[2] and at an airport level the impact upon the local environment[3] and the disturbance caused to residents of communities surrounding airports[4, 5].

Aircraft noise disturbance is the single most important environmental issue affecting the operation and development of airports around the world. The level of disturbance is related to the frequency and noisiness of aircraft movements and the proximity of communities relative to the airport's arrival and departure routes. The control of aircraft noise has received significant attention over the past 30 years and airframe and engine manufacturers have introduced very significant technological improvements in the past decade. However, the benefits of such action have been offset by the growth in traffic such that today the many of the World's major airports face operational or capacity constraints based upon noise[6]. Some have reached their noise capacity limits before having made full use of their infrastructure while others have failed to gain planning approval for further development despite proven demand, simply because of the noise implications of the resulting traffic growth[7]. It is paradoxical that airports that are most attractive to airlines and the travelling public, those which are closest to major centres of population, are also often the most noise sensitive. The issue of aircraft noise is therefore having a significant impact upon the growth of some airports and hence, potentially the economic development of the regions they serve. It also restricts or even prevents access to many North American and European airports by operators from developing nations simply because of the age and environmental performance of their airline fleets.

The impact of air transport upon the global atmosphere and its contribution to climate change also has the potential to constrain the growth of aviation, at the national and international level. It is estimated by the Inter-Governmental Panel on Climate Change[2] that air travel could be making a more significant contribution to climate change than was previously thought. After less than 50 years as a global industry, aviation is now believed to be responsible 3-5% of the total radiative forcing arising from all anthropogenic activities. Further, despite very significant improvements in aircraft and engine technology that reduce fuel use and emissions, traffic growth has outstripped these benefits with the result that the overall impact of the industry is increasing on a year-by-year basis. Indeed the amount of aviation fuel consumed by all aircraft is predicted to increased by 3% per annum, despite a fuel efficiency improvement calculated as

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1·3% per annum[2]. This trend is contrary to the reductions in green house gas emissions being sought in other industries through the use of new technologies, increased efficiency or alternative energy supplies.

3.0 SUSTAINABLE DEVELOPMENT

At the Rio Earth Summit in 1992, Governments accepted that there have to be limits to growth, or at least the environmental implications of growth and that they should seek through policy and regulatory control to promote sustainable development. In 1998, the EU committed at Kyoto to reduce its CO_2 emissions by 8% over a period of 15-20 years and it is be looking to European industry and citizens to support the achievement of that goal. Over this same time period it is estimated that emissions from the European aviation industry will not decline, but will actually double. It is known that the EU has no intention of trying to specify target reductions for CO_2 emissions by different industries as they believe an 'across the board' target would cause economic chaos. They have, however indicated that any industry which fails to achieve those targets would have to show that it was doing everything reasonable to reduce its emissions. It is understood that the EU position is that for aviation, 'business as usual' would not be deemed a politically acceptable approach to addressing the issue of climate change.

The EU in developing its Common Transport Policy has acknowledged a basic freedom to travel, it recognises the continuing growth of the transport industry and need for a comprehensive transport infrastructure as a key to the development of the single market and sustainable mobility. It recognises the key role of aviation, but also the environmental impact of different modes of transport and the need to make use of the appropriate mode for the task required.

If the freedom for people and goods to travel by air is not to be artificially constrained by Government intervention then the environmental and social consequences of the air transport industry will have to be reduced significantly to offset the effects of its continuing growth. The decisions taken by Governments at Kyoto reflect one of the first attempts to introduce constraints upon the global environmental impact of human activities in order to prevent significant environmental damage. Previous action included the Montreal convention on CFCs and decisions made at the Rio Earth Summit. The response of the aviation industry to the challenge of Global Climate Change is therefore of significance and is a measure of its potential to support the principles of sustainable development without external regulation.

It is exactly this challenge which the European Commission (EC) has attempted to address in its recent communication 'Air Transport and the Environment – Towards meeting the challenges of sustainable government development'[8] which concentrates primarily upon the two key impacts of aircraft noise and aircraft engine emissions. It is also the major concern being addressed by the UK Government Department of the Environment, Transport and the Regions review of air transport policy that is currently underway.

4.0 TECHNOLOGICAL INNOVATION

The environmental performance of the air transport industry will be enhanced through improved technology, better operational practices, the development of a supporting infrastructure which will permit inter-modal transfer of some services from air to high speed rail and through the development of more sustainable air route networks. A variety of regulatory and market forces are available to encourage such change, the most significant being ICAO noise and emissions certification requirements[9-11]. These set standards which new aircraft types must meet and dates by which non-compliant aircraft must be taken out of service. However, given the fact that the aviation industry is doubling in size every 10-15 years[12, 13] the combined effect of all the above improvements will only bring limited benefits for the short term.

The rate of technological development of airframes and aircraft engines has in recent years been significant, both in terms of noise and engine emissions. It is generally believed however, that in both fields, engineering solutions are starting to reach a plateau and that future gains will be more difficult and costly to achieve. In this context it is clear that sustainable development for the aviation industry will require a technological step change, such as the move to the use of non fossil fuel propellants such as hydrogen, where the main by product of flight is water. Even then, injection of water vapour into the lower stratosphere will have some warming effect[2]. Further, even when new technologies have been developed, it takes many years for new aircraft or engine types or variants of existing models to be certified and approved for commercial use. It can be anticipated that the time taken to bring totally new (step change) technologies to the marketplace will be particularly long.

The high cost of research and development and consequential high cost of aircraft further restricts the rate at which they can be introduced into commercial fleets. Airlines and aircraft leasing companies already own large numbers of very expensive aircraft that are completely airworthy. The commercial argument for taking such technologies out of service and investing in new aircraft simply for environmental reasons is difficult to articulate, particularly given the high demand that exists for growth in air transport and difficulty of putting a commercial value upon environmental impact and future capacity constraints.

With regard to aircraft noise, one solution to the high cost of fleet replacement has involved retro-fitting with improved engine technologies. Hush-kits for jet engines were first developed and fitted to the oldest noisiest aircraft in the 1980s to make them compliant with new ICAO regulations relating to more stringent (Chapter 2) noise standards. In 2002, ICAO requirements will see a large number of older (Chapter 2) jet aircraft phased out of service because they fail to meet the latest (Chapter 3) certification levels. A number of manufacturers have produced new hush-kits which would make those aircraft compliant with Chapter 3 noise standards. However, these standards are now 20 years old and latest generation of aircraft exceed the noise requirements by a considerable amount. In contrast, the proposed hush-kitted Chapter 2 aircraft would only be marginally compliant and have a performance which is in no way comparable with the latest aircraft and are therefore of limited value in environmental terms. The challenge for aircraft and engine manufacturers is to develop the next generation of retro-fit technology so that it brings the performance of the older aircraft up to present days standards.

It is clear that if the speed of fleet replacement is too slow, or the rate of technological development too limited then in regard to climate change, governments will be more likely to intervene in the development of the industry. Governments in the future will face very difficult choices between the need to protect the global environment and the need to encourage economic growth. In this regard, imposing constraints upon aviation may not be economically or politically feasible. This could for example lead to the introduction of a system of carbon emission trading in which a global limit is set and further growth of aviation can only be achieved through buying 'the right to pollute' from other industries. But it must be recognised that the impact of aviation on global atmosphere is not limited to carbon emissions but includes for example O_3, H_20, contrails, soot and cirrus clouds. Consequently such additional impacts will have to be factored into the economic and environmental equation.

5.0 CONCLUSION

Environmental pressures will continue to build upon the aviation industry, constraining its growth and hence the social and economic

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benefits it can bring. This has implications for economic regions, for developing nations and indeed for the development of the Global economy. Current and anticipated demand for growth is strong and this is negating the technological and operational improvements designed to reduce the environmental impact of air travel. The key to the sustainability of the aviation industry is therefore to be found in reducing the pollution at source through:

1. The more rapid development of new airframes and power plants.
2. Systems which permit faster approval, certification and introduction into service of such technologies.
3. The development of retrofit technologies which will extend the life of existing aircraft but bring their environmental performance up to the standards of the most modern aircraft and engines.
4. Reducing the cost of new technologies to enable more rapid fleet replacement.
5. Significant investment in advanced research and development designed to achieve a step change in technologies and to remove the reliance of aviation on fossil fuels.

REFERENCES

1. ACI Creating Employment and prosperity in Europe, a study by ACI Europe of the social and economic impacts of airports, ACI EUROPE, PPS Publications, Reigate, 1998.
2. IPCC *Aviation and the Global Atmosphere Intergovernmental Panel on Climate Change Special Report*, Cambridge University Press, Cambridge, 1999.
3. TUNSTALL-PEDOE, N., RAPER, D.W. and HOLDEN, J. (Eds) *Airport and the Environment — liabilities and social responsibilities*, Thomas Telford, London, 1996.
4. ZAPOROZHETS, O.L. and TOKAREV, V.I. Predicted flight procedures for minimum noise impact, *J Applied Acoustics*, 1998, **55**, (2), pp 129-143.
5. ZAPOROZHETS, O.L. and TOKAREV, V.I. Aircraft noise modelling for environmental assessment around airports, *J Applied Acoustics*, 1998, **55**, (2), pp 99-127.
6. AIRPORTS COUNCIL INTERNATIONAL *Environmental Handbook*, ACI Europe, PPS Publications, Reigate, 1995.
7. THOMAS, C.S. A survey of environmental measures at Europe's airports, Airports Council International Annual Congress, Malta, 1995.
8. EC Air Transport and the Environment — Towards meeting the challenges of sustainable development, COM (1999) 640 — European Commission, Brussels.
9. ICAO International Standards and Recommended Practices — Environmental Protection; Annex 16, Vol II — Aircraft engine emissions, 1st edition, 1981.
10. ICAO International Standards and Recommended Practices — Environmental Protection; Annex 16, Vol II — Noise, 3rd edition, 1993.
11. ICAO International Standards and Recommended Practices — Environmental Protection; Annex 16, Vol II — Aircraft engine emissions, 2nd edition, 1993.
12. AIRBUS Global market forcast 1997-2016, confirming very large demand, Toulouse, France, 1997.
13. BOEING Current Market Outlook, World travel demand and aeroplane supply requirements, Boeing, Seattle, Washington, USA, 1997.