Aviation and Sustainability

John Whitelegg and Howard Cambridge

SEI STOCKHOLM ENVIRONMENT INSTITUTE

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A Policy Paper

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Preface

Aviation is one of the fastest growing sectors of the global economy. It consumes significant amounts of fossil fuels and contributes to the growing problems of greenhouse gas emissions and climate change. Its impact on climate change is more significant than its proportionate responsibility for greenhouse gas emissions and is compounded by the impacts of water vapour, contrails and cirrus cloud formation.

The growth in demand for passenger and freight air travel is assisted by a generous taxation and fiscal support regime. Aviation is heavily subsidised by the taxpayer and by those who do not fly. The growth also presents policy makers with significant challenges. In the UK, official forecasts of passenger air travel over the next 30 years have assumed a tripling of passenger trips from 180 million to 500 million per annum (pa). This will require an increase in airport capacity equivalent to one extra Heathrow Airport every five years. This increase in demand is a global phenomenon and will increasingly dominate the budgets and planning systems of India and China.

This growth in demand is at odds with the principles and objectives of sustainable development. Sustainable development requires careful thought and prudence about environmental capacity, climate change and equity, and the growth in demand for aviation is threatening efforts in all these areas of policy development.

The growth in demand for aviation is not a totally new phenomenon. We have been here before. In most countries in the so-called developed world we have realised that the growth in car use at 5 per cent pa for 50 years is not sustainable. We cannot find enough space or enough money to build all the highways. A similar realisation has moved through electricity consumption. There are so many ways in which we can manage our demand for electricity that it would be seen as foolish to predict a 5 per cent pa increase in consumption and build the power stations. The same realisation has not yet surfaced in the world of aviation.

This policy paper is intended to draw the attention of the global community to the urgent need for demand management in aviation. It goes further and suggests a number of specific policy interventions and mechanisms that can do this. More importantly, the Stockholm Environment Institute would like to see a global debate about the growth of aviation and sees this policy paper as a starting point for that debate.

The policy paper is aimed primarily at the international policy-making community (e.g. UNEP, and ICAO) through to the European Union and national administrations especially in the USA, Europe and those countries that are moving rapidly up the demand curve (India and China). It is aimed at airlines and airports and is intended to stimulate a constructive debate.

The policy paper is very dependent on UK and European Union materials, statistics and arguments. The recommendations and policy conclusions in this paper are, nevertheless, global in inspiration and character and relevance. Aviation's relationship to sustainable development requires a global debate and a global context for the implementation of sustainable development policies. We look forward to that debate

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Co-ordinator, SEI Sustainable Development Programme
July 2004

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Executive Summary

Over the past 50 years global demand for air travel has risen by 9 per cent per annum (pa) and growth (at a reduced rate of 3-7 per cent) is predicted for the next 20 years. The world's airlines currently carry about 1.6 billion people and 30 million tonnes of freight each year. The number of kilometres flown is expected to triple and aircraft numbers double over the next 20 years.

The structure of the aviation industry is changing with the advent of low cost "no-frill" carriers, the growth of short-haul flights, the growth of airfreight and the decline of military aviation as a proportion of total aviation.

On a regional level, the market for air travel is growing strongly in Europe and the Asia Pacific region, as is the market for air travel between these two regions. Aviation demand in China is growing at 10 per cent pa compared to 2 per cent pa in the USA. Flying is still strongly entrenched in North America with 80 per cent of trips accounted for on domestic routes. Growth rates as high as 15 per cent pa have been reported (e.g. Vietnam). Africa currently has a very low level of aviation demand with most activity concentrated in South Africa and linked to tourism or the shipment of perishable food products to Europe.

The world's airlines burn 205 million tonnes of aviation fuel (kerosene) (OECD, 2002) a year and produce 300 million tonnes of greenhouse gases (IEA, 2002).

The environmental impact of aviation is wide-ranging and significant at the local, regional and global levels, with most attention focusing on noise (local) and climate change (global). These impacts are severe, and because growth rates in aviation are so great technological progress cannot keep up with the growth in demand. Consumption cancels out technological gain.

Aviation is responsible for 1-2 per cent of anthropogenic greenhouse gas emissions but these gases are injected at relatively high levels in the atmosphere and have a radiative forcing impact of 3. This means that the emissions are approximately three times more damaging in terms of climate change than if they had been emitted at ground level. Aviation is expected to account for up to 15 per cent of the total contribution to climate change by 2050.

Greenhouse gases from international aviation are excluded from national inventories and from the Kyoto process.

Local air pollution around airports is also an environmental and public health problem. Expansion plans for London's Heathrow Airport have been made conditional on reducing nitrogen oxide (NO_x) levels. NO_x at levels above World Health Organisation threshold values is associated with respiratory disease.

Noise is still a significant problem around the world's airports and under flight paths. It is associated with a number of health problems and also with damage to the cognitive development of children. Noise levels from individual aircraft and engines have reduced as a result of technological change and regulation, but the growth in numbers of aircraft and flights has ensured that noise levels above WHO recommended values still affect millions of people. In the UK, one in eight people is affected by aircraft noise.

The environmental and wider sustainable development impacts of aviation have largely been supported and encouraged by supportive governments through taxation advantages and through the planning system. In the UK, aviation receives an annual subsidy of £9 billion pa, and globally it benefits from no taxation on fuel, spin-off R&D from military developments and generous assistance with new airports and surface transport infrastructure. This is at odds with the principles of sustainable development, for example, the polluter pays principle, the requirement to improve public health and the requirement to reduce greenhouse gases by 60 per cent by 2050.

Managing the growth in demand for aviation, reducing growth rates and reducing absolute levels of flying have been excluded from policy debate. This is not compatible with the policy commitment to sustainable development. Demand management is a well-established part of the overall approach to dealing with the growth of car and lorry traffic and dealing with energy consumption (e.g. energy conservation and least cost planning). Demand management in aviation could embrace three main "pillars": the internalisation of external costs to make "prices tell the ecological truth"; the transfer of passengers from air trips to rail trips for those journeys where this is appropriate (45 per cent of all flights in the EU are les than 500km in length); electronic substitution and the use of videoconferencing and related technologies as a substitute for physical travel.

This report makes nine recommendations all of which are aimed at recognising the sustainable development agenda and ensuring that aviation plays its full proportionate part in delivering sustainability.

1. The establishment of a wide-ranging dialogue that brings together regulators, government, the industry, citizens and NGOs.
2. The implementation of the internalisation of external costs.
3. The adoption of World Health Organisation recommended values on noise thresholds and implementing polices to deliver a healthy noise environment.
4. The implementation of surface access strategies that can deliver at least 50 per cent of all passengers to and from airports by non-car modes of transport.
5. The adoption of the "environmental bubble" concept to give airports clear quantitative limits for a small set of pollutants.
6. A ban on night-time flights (2300-0700 hrs) to protect human health.
7. Air tickets subject to VAT (in Europe) and its equivalent in non-European countries.
8. Governmentally supported strategies delivered by clearly defined partnerships to shift passengers from air transport to rail for journeys of up to 500km in length.
9. Improved methods for recording and monitoring the greenhouse gas emissions from aviation globally, and the incorporation of aviation's emissions in national and international reduction strategies to achieve a 60 per cent reduction in greenhouse gases from aviation by 2050.

1 Aviation and Demand

GLOBAL DEMAND FOR AVIATION

Global demand for aviation has increased substantially since the first commercial jet airliner went into service in the 1950s. Over this 50 year period demand has risen 9 per cent pa or in other words by a factor of 20 (IPCC, 1999), and this trend is projected to continue over the next 20-50 years although at a lesser rate of between 3-7 per cent (Boeing, 2003; IPCC, 1999) as the market matures globally. As shown in Table 1.1, two key industry statistics used to measure aviation activity, available seat kilometres (ASK)[1] and revenue passenger kilometres (RPK)[2], are projected to increase by 2.5 times over 20 years from 3 trillion in 1999 to nearly 8 trillion (Airbus 2003) with a small increase in passenger load factors[3] from 67-71 per cent. Figure 1.1 illustrates past and projected growth in aviation since 1985. Even after events such as the twin towers attack and the Gulf Wars, and concerns over severe acute respiratory syndrome (SARS) and deep vein thrombosis (DVT), air travel continues to grow yearly although the annual growth rate is slightly lower (Boeing, 2003). The world's airlines currently carry over 1.6 billion passengers and 30 million tonnes of freight annually (ICAO, 2003) and this will continue to increase over the next 20 years as global consumption of goods and tourism expands. By 2022 the total number of aircraft will nearly double and it will include a larger number of smaller, single-aisle planes used on short-haul routes (Boeing, 2003).

Table 1.1
Key air travel statistics (Airbus 2003)

Passenger aircraft only	2002	2009	2022	% Change 2002-2022
World ASKs (billion)	4,514	7,076	11,407	**253**
World RPKs (billion)	3,166	5,100	8,473	**268**
Average flight distance (km)	1,437	1,414	1,516	**105**
Number of aircraft	10,789	14,815	20,554	**190**
Number of departures (000)	15,865	23,464	31,510	**198**
Seats per departure	163	168	200	**123**

In Europe, there has been a considerable increase in scheduled no-frills airlines which operate from secondary airports such as Stanstead (UK) or Bergamo (Italy) as opposed to international hubs such as Heathrow (UK) or Malpensa (Italy). The destinations, routes and prices on offer are attractive to the individual tourist traveller and increasingly the business passenger. Whilst fewer ASK are needed per trip, the greater frequency and shorter duration of flights means that more planes with fewer seats are required. Hence, forecasts by airline manufacturers for orders for single-aisle aircraft predict future growth in all global regional markets (Airbus 2003). To increase capacity, expansion of existing airports with new terminals and runways, and the construction of new airports altogether is required.

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1 Available Seat Kilometres (ASK) – The number of seats available for passengers times distance in kilometres

2 Revenue Passenger Kilometres (RPK) – The number of revenue passengers carried times distance in kilometers.

3 Passenger load factor – per centage of available seats occupied per flight. Or RPK divided by ASK expressed as percentage.

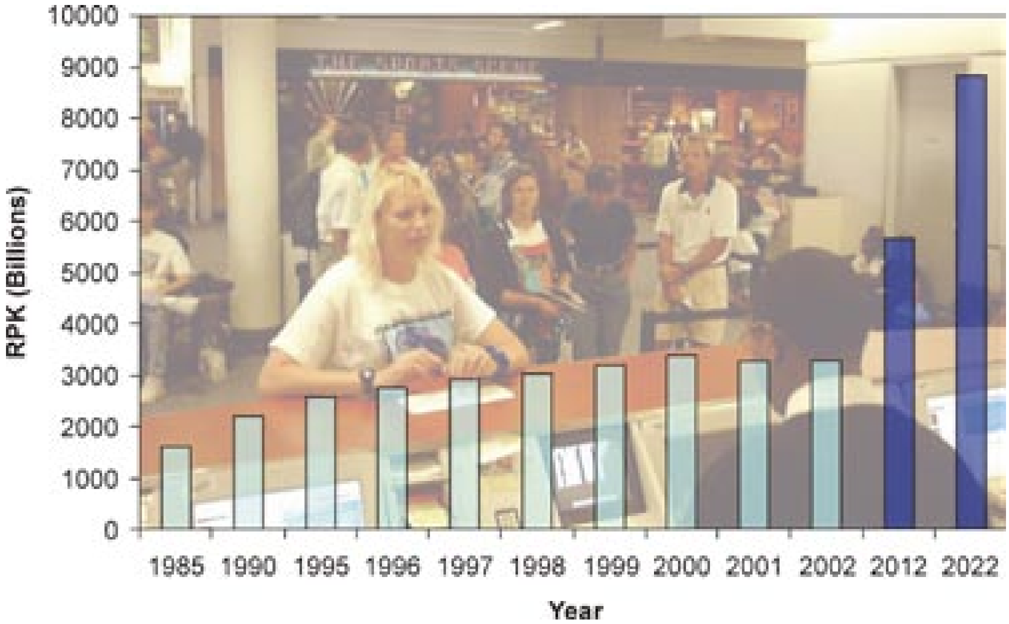


Figure 1.1
Growth in RPK
1985 to 2022
(Airbus, 2002)

Total aviation fuel (kerosene) burned has increased from 175 million tonnes in 1995 to 205 million tonnes in 2000 (OECD, 2002). Whilst improvements in aircraft engine efficiency have been made over these 20 years, total aviation fuel use including passenger, freight and military activity, is projected to increase by 3 per cent per year to over 300 million tonnes per annum in 2015 and over 400 million tonnes in 2050 (IPCC, 1999). Military aviation is declining and its share of aviation fuel consumption compared with civil aviation (passenger plus cargo) has diminished from 36 and 64 per cent respectively in 1976, to 18 and 82 per cent respectively in 1992. These figures are projected to change to 7 and 93 per cent respectively in 2015, and to 3 and 97 per cent respectively in 2050 (IPCC, 1999).

FREIGHT DEMAND

Freight is a key growth sector for aviation as global supply chains, new emerging markets in former communist countries and demand for cheaper products will increase freight tonne kilometres (FTK) by 500 per cent (Figure 1.2). Freight transport is likely to experience sustained growth of around 5-6 per cent per annum over the next 20 years (IATA, 2003), exceeding the growth rate for passenger transport and more than double the rate of GDP increase (Gillingwater, 2003). Whilst freight volume grows the total fleet carrying capacity has been reduced by the size of hold on short-haul aircraft. Consequently, there is a trend for more dedicated freight aircraft. The freighter fleet could more than double in number from present levels of about 1,500 to 3,300, with capacity increasing from 50 to 60 tonnes per aircraft (Airbus, 2003).

DEMAND DRIVER VARIABLES

The burgeoning aviation industry has brought about great economic benefits through direct employment, aircraft manufacture, global trade and airport operations services. To the individual, cheaper seats, more leisure time and exposure to different cultures have contributed to rising demand. The key demand drivers which interplay at the individual, national and global levels are shown in Box 1.

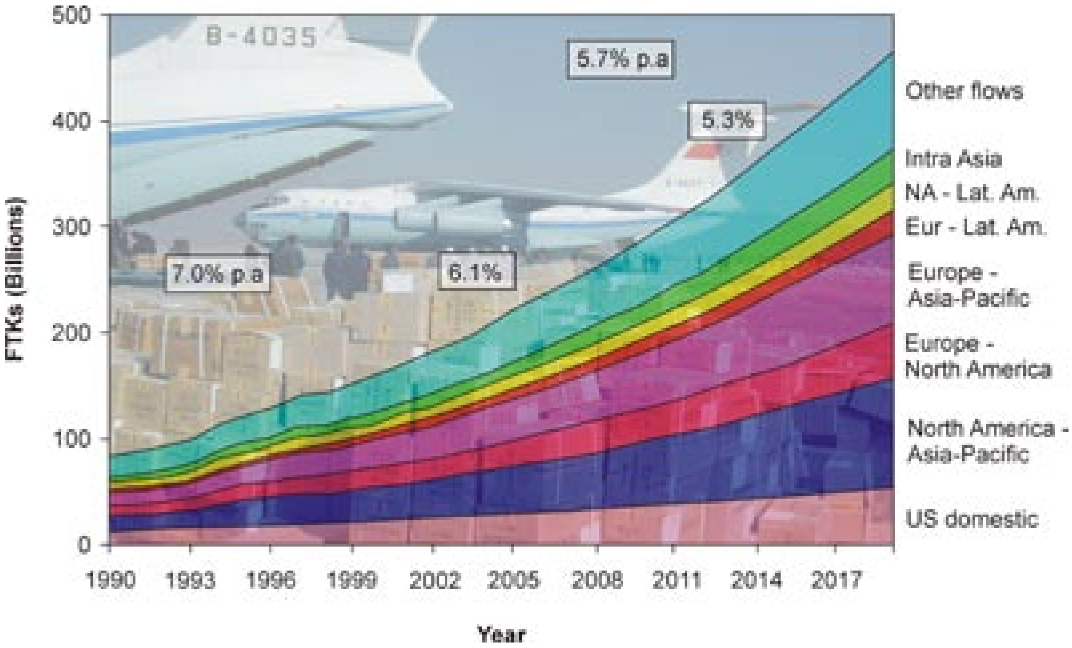


Figure 1.2
FTK growth
1990-2020
(Boeing, 2002)

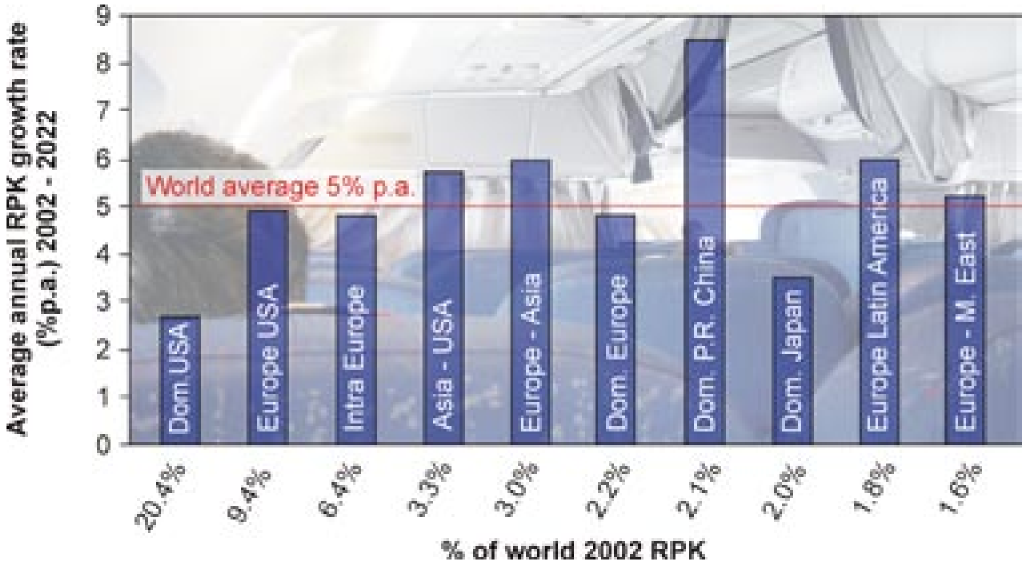
BOX 1 Driver variables for aviation demand

POLITICAL	ECONOMIC	SOCIAL
Air transport liberalisation	Increasing regional economic activity	Greater personal freedom
Deregulation	Improved aircraft efficiency	Increased leisure time
International trade	Hub-Spoke network means lower operating costs	Greater tourism exposure
Emerging/ transitional regions	Airline subsidies	Personal computers and Internet access
Political stability	Corporate travel expenditures.	Increased disposable income
EU enlargement Bi-lateral agreements	Cheaper production sources	Travel restrictions relaxed
Public Investment	Global access to raw materials	Education
	Market for high-value goods	Security
	Low cost airlines-expanding route networks	
	Airline alliances	
	Exchange rate opportunities	

REGIONAL GROWTH

Figure 1.3 shows the main regional markets where growth in aviation is likely to increase. It shows there is continued and growing demand for aviation in key domestic, international and intra-regional markets, especially in North America, Europe and Asia-Pacific. It can be seen that growth within Europe and between Europe, the USA and Asia will increase most. In particular, the Asia-Pacific region has seen growth in the numbers of flights between key city-city routes (Bowen, 2000) illustrated in Figure 1.4, as well as expanding international markets into Europe (IATA 2001).

Figure 1.3
Regional growth
in market
Source: Airbus (2003)



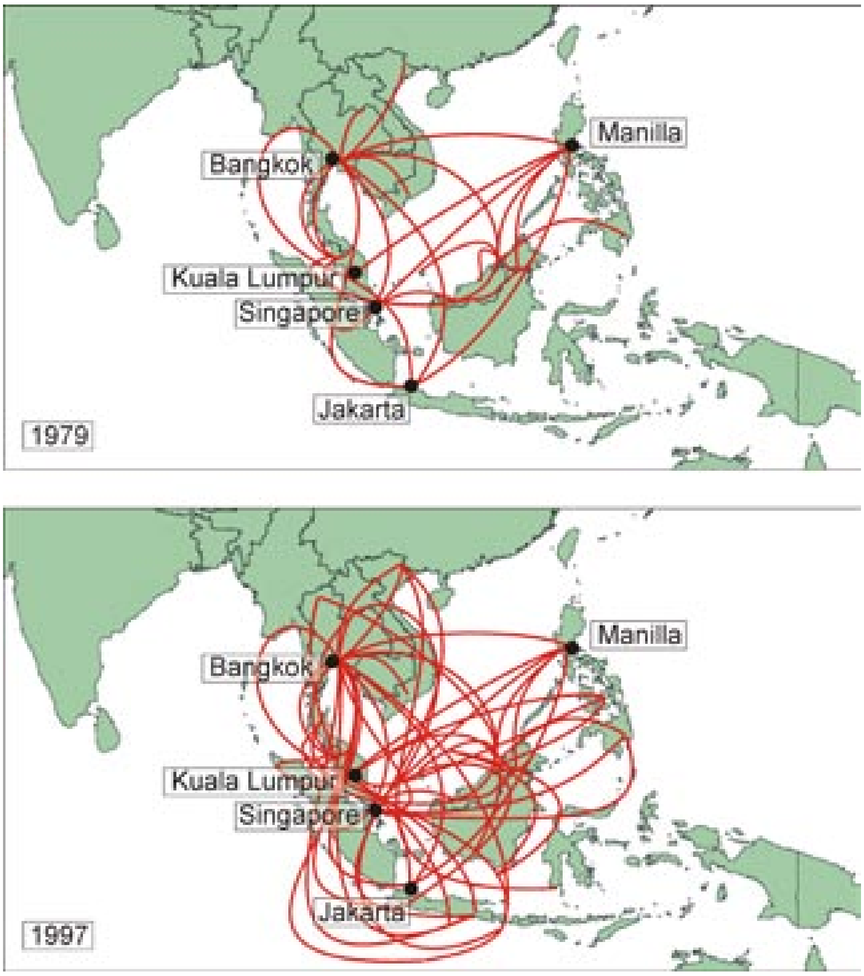
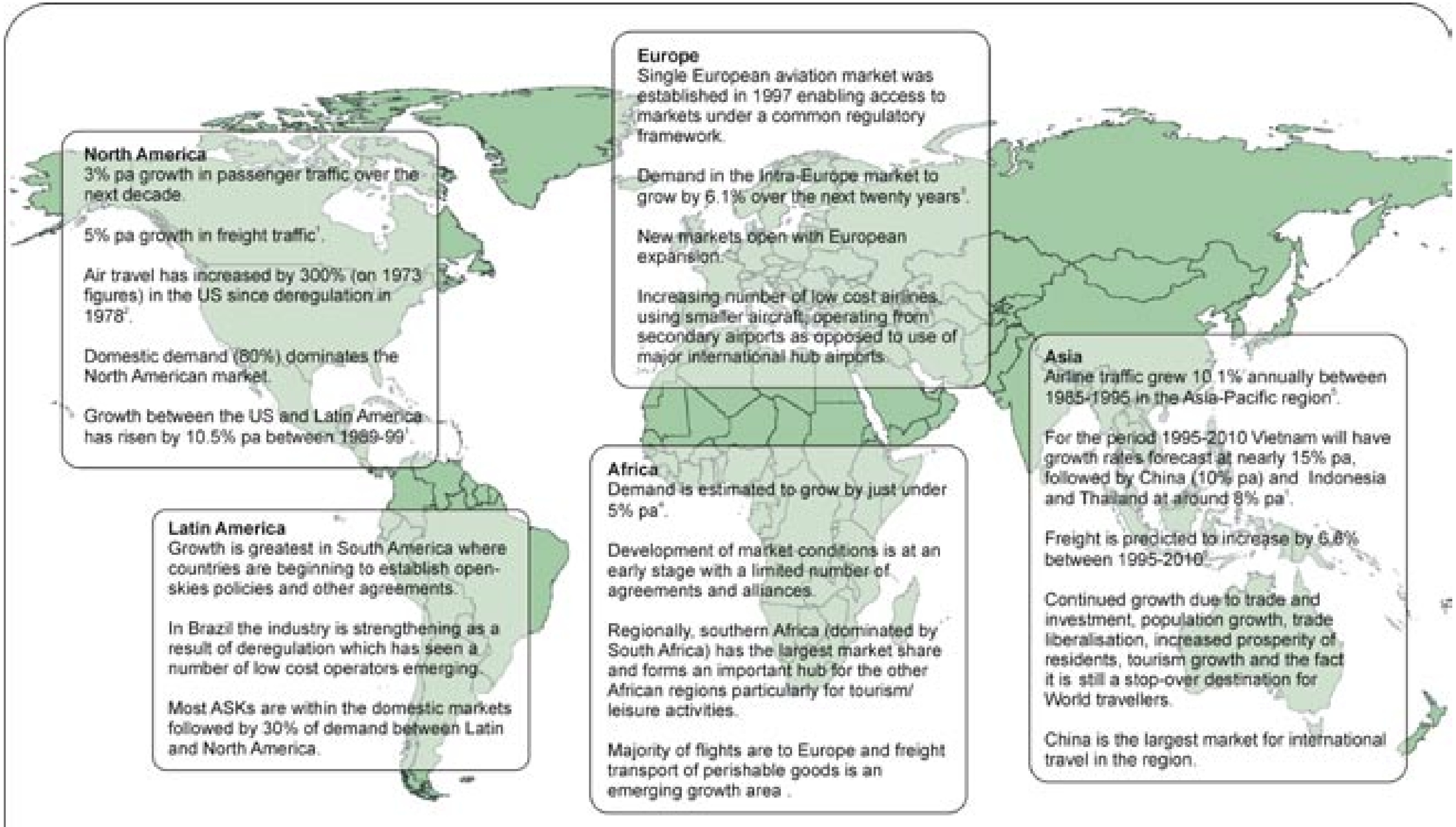


Figure 1.4
Asia market growth
1979/1997 (Bowen,
2000)

Gross GDP in developing countries is increasing at a higher rate than in developed countries and correspondingly aviation demand is higher in these regions, especially China, where growth is at a rate of between 8 and 10 per cent per annum. In contrast, domestic US growth rates are much lower than the global average, at just over 2 per cent per annum. The market in the US is more mature as the industry was deregulated in the 1970s. In contrast, the African regional market (not shown on graph) is still in early development and its growth is expected to remain low over the next 20 years.

BUSINESS DEMAND

The events of 11 September 2001 (9/11) may have been the catalyst for businesses to re-evaluate travel budgets, utilise internet communication to conduct business, as well for employees to consider security and other issues such as length of time spent away from home. The travel budgets of businesses are key indicators of how well the aviation market is performing and whilst these dipped following 9/11 they have more or less reverted back to normal levels (American Express, 2001). Boeing predicts that growth rates for this sector will continue to increase over the next 20 years, however at a lower rate (Boeing, 2003). In order to try and gain the market lost after the attack, airlines resorted to heavily discounting seats, mothballing or leasing aircraft and decreasing the number of flights or ceasing unprofitable routes altogether. Furthermore, competition from no-frills and low-cost airlines has meant that businesses are shifting away from scheduled, flag carrier airlines. This reduction in business travel is felt heavily by these airlines as business passengers typically pay a higher premium for their tickets compared to economy and tourist travellers. As a reaction, some national carriers have also launched their own no-frills airline companies to compete with the smaller independent airlines.



1. ICAO, 2000; 2. Debbage and Delk, 2001; 3. Airbus, 2003; 4. Boeing, 2002; 5. Li, 1998; 6. IATA, 2001

Figure 1.5 Global demand for aviation

2 Impacts of Aviation

OVERVIEW

The environmental, social and economic impacts of the aviation industry include those from aircraft themselves and from airports and their supporting infrastructure, such as maintenance and servicing of the aircraft, freight distribution and terminal facilities such as shopping malls. The spatial scale and type of impact by aviation on stakeholders including climate change, local air pollution, noise, health, as well as other socio-economic effects is shown in Figure 2.1. Climate change impacts include increased risks to human health, a rise in the sea level, and other adverse changes to plant and animal habitats. As new and emerging markets for aviation open up in Eastern Europe and developing countries there are opportunities to develop regulations and policies before similar serious and potentially irreversible problems occur.

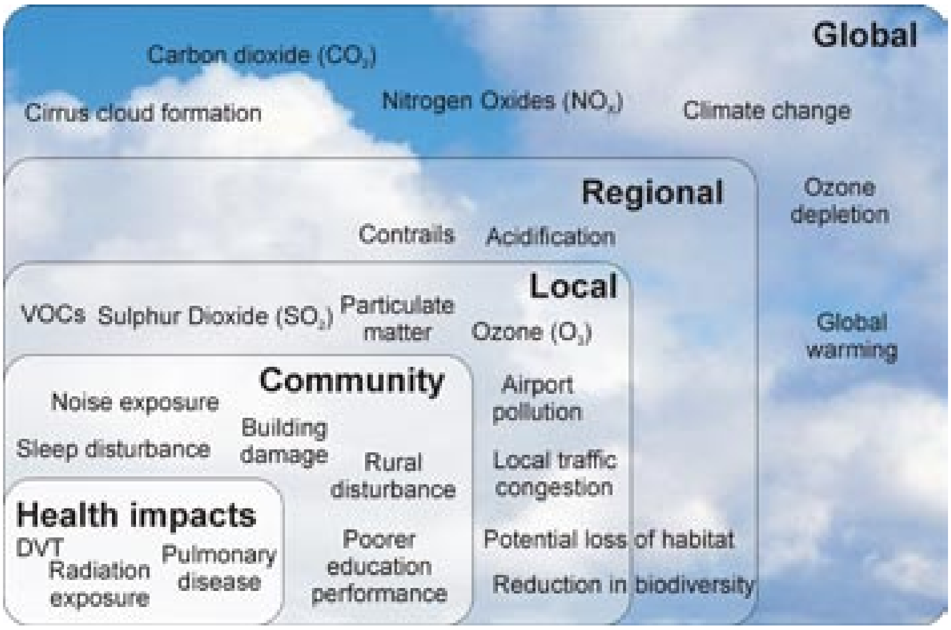


Figure 2.1
Impacts of aviation on different stakeholders

IMPACTS FROM AIRCRAFT EMISSIONS

The principal emissions from aircraft shown in Figure 2.2 include the greenhouse gases[4] carbon dioxide (CO_2) and water vapour (H_2O). Other major emissions are nitric oxide (NO) and nitrogen dioxide (NO_2) (which together are termed NO_x), sulphur

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[4] Greenhouse gases are chemically stable staying in the atmosphere for years (a few decades to many centuries). As a result, the quantity of each of these gases in the atmosphere is large relative to annual fluxes so the atmospheric concentration changes slowly and impacts associated with given concentrations persist for a long time. These gases allow sunlight, to enter the atmosphere unimpeded. When sunlight hits the earth's surface, some is reflected as infrared radiation or heat. Greenhouse gases tend to absorb this infrared radiation, trapping the heat in the atmosphere by the process known as the "greenhouse effect". This maintains a fairly stable average earth surface temperature around 15°C as opposed to -18°C and so life can exist.

oxides (SO_x), and soot. Aircraft emissions are produced from the oxidation of carbon, sulphur and hydrogen in kerosene, as well as the formation of other compounds during combustion. Further reactions in the atmosphere produce secondary pollutants such as tropospheric ozone (O_3) which is harmful to humans and plants. In the stratosphere, O_3 is depleted meaning more harmful sunlight can enter the atmosphere. Aircraft emissions of nitrogen oxides (NO_x), carbon dioxide (CO_2) and water vapour (H_2O) are largely concentrated in northern latitudes between 30° and 60° North, which includes Europe and North America. Aircraft emissions can form condensation trails (contrails) which may increase cirrus cloud cover.

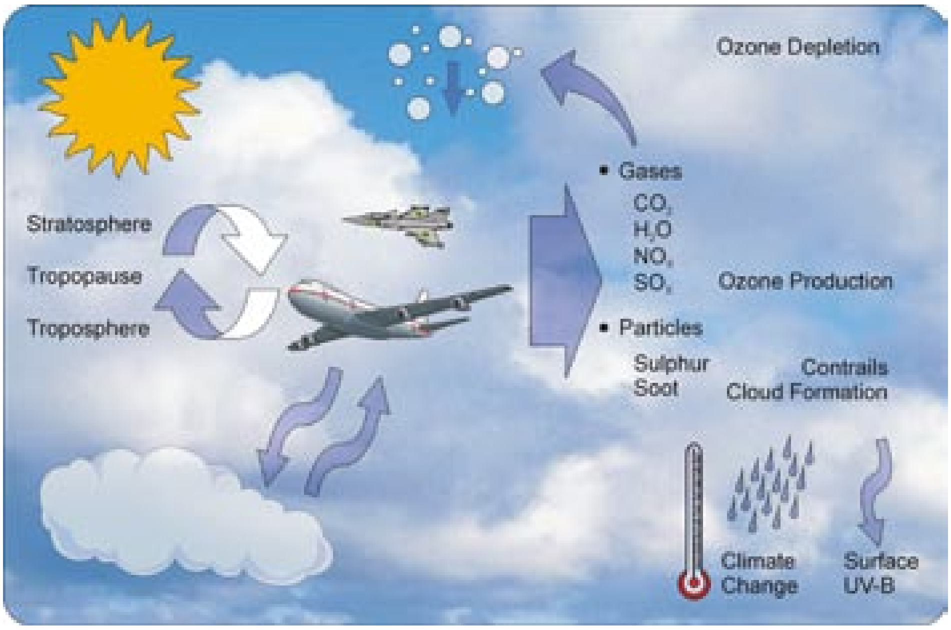

Figure 2.2
Impacts related to aviation at different altitudes (IPCC, 1999)

Water vapour is the most common greenhouse gas and contributes to some 60 per cent of the greenhouse effect. However, the greenhouse gases regulated by the Kyoto Protocol[5] are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O). Other more potent greenhouse gases such as HFCs and PFCs are the most heat-absorbent but are only emitted in relatively small quantities and so their overall impact is smaller.

GLOBAL WARMING POTENTIAL

Global warming potential (GWP) is the impact a greenhouse gas has on global warming expressed over a 100-year time period. The GWP of each greenhouse gas depends on its ability to absorb heat in the atmosphere. By definition, CO_2 is used as reference case, with a GWP of 1. Global warming potential values enable an increase or reduction of any of the greenhouse gases to be expressed as an equivalent

[5] Kyoto Protocol
The 1997 U.N. conference in Kyoto, Japan established the Kyoto Protocol which set out emission reduction or limitation commitments for 38 industrialized countries by 5.2 per cent of 1990 levels during the five-year period 2008-2012. The commitments apply to emissions of the following greenhouse gases by the specified sources: Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and Sulphur hexafluoride (SF_6). 120 nations have ratified the pact or acceded to it with the notable exception of the United States.

reduction of CO_2 over a 100 year period. Table 2.1 lists the GWP of the greenhouse gases covered by Kyoto as well as those others related to aviation emissions. Aviation emissions account for around 3.5 per cent of man's contribution to global warming from fossil fuel use. By 2050, this percentage could grow to between 4 per cent and 15 per cent (IPCC, 1999).

Table 2.1 Global warming potentials of greenhouse gases (GWP)

Greenhouse Gas	Chemical Formula	Global Warming Potential 100 year time horizon
Carbon Dioxide	CO_2	1
Methane	CH_4	21
Nitrous Oxide	N_2O	310
Perfluorobutane	C_4F_{10}	7,000
Perfluorocylcobutane	$c\text{-}C_4F_8$	8,700
Sulphur Hexafluoride	SF_6	23,900

Source: Intergovernmental Panel on Climate Change, *Climate Change 1995: The Science of Climate Change* (Cambridge, UK: Cambridge University Press, 1996), Table 2-9, "Radiative Forcing of Climate Change," p. 120.

Radiative forcing[6] is used as a globally averaged measure for the potential effect of different pollutants to cause climate change (RCEP, 2000). Aviation is the source of about 13 per cent of transport-derived CO_2 emissions (Whitelegg, 2000) and is responsible for between 1 per cent and 2 per cent of total anthropogenic CO_2 emissions (Olsthoorn, 2001, IPCC,1999)

However, a total radiative forcing effect of 3 means that potentially the impact of all aircraft emissions at altitude is three times more damaging than CO_2 emitted at ground level. Figure 2.3 compares current levels of radiative forcing (expressed in W/m^2) to predicted levels in 2050 under the IPCC reference scenario[7].

International aviation emissions are excluded from the Kyoto Protocol; therefore, whilst many countries committed themselves to reducing greenhouse gas emissions by 5 per cent of 1990 levels by 2012, international aviation enjoys the freedom to continue to pollute the atmosphere. It has been an on-going conundrum to decide how to apportion emissions from international aviation to individual countries. It has now been recognised by the UK Government that if aircraft emissions are taken into account, it will not be able to meet its target of a 60 per cent reduction in greenhouse gases by 2050 (HMSO, 2004).

Nearly three-quarters of all new flight routes in Europe and North America are under 2000 km. Aircraft use most fuel and produce greatest emissions during the take-off and landing phases when maximum power is required. On shorter journeys the ratio of fuel used per km to total distance is high. For example, on a flight from London to Edinburgh up to 25 per cent of fuel is burned during this phase. Take-off

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6 Radiative Forcing (RF), is defined as the ratio of total radiative forcing to that from CO_2 emissions alone. Total radiative forcing induced by aircraft is the sum of all forcings, including direct emissions (e.g., CO_2, soot) and indirect atmospheric responses (e.g., CH_4, O_3, sulphate, contrails), IPCC,1999. A positive radiative forcing leads to warming of the climate, while a negative radiative forcing leads to cooling. RF is expressed as W/m^2 which is the amount of solar radiant energy received by a unit area of the earth's surface.

7 Reference scenario developed by ICAO Forecasting and Economic Support Group (FESG); mid-range economic growth from, technology for both improved fuel efficiency and NO_x reduction IPCC (1999).

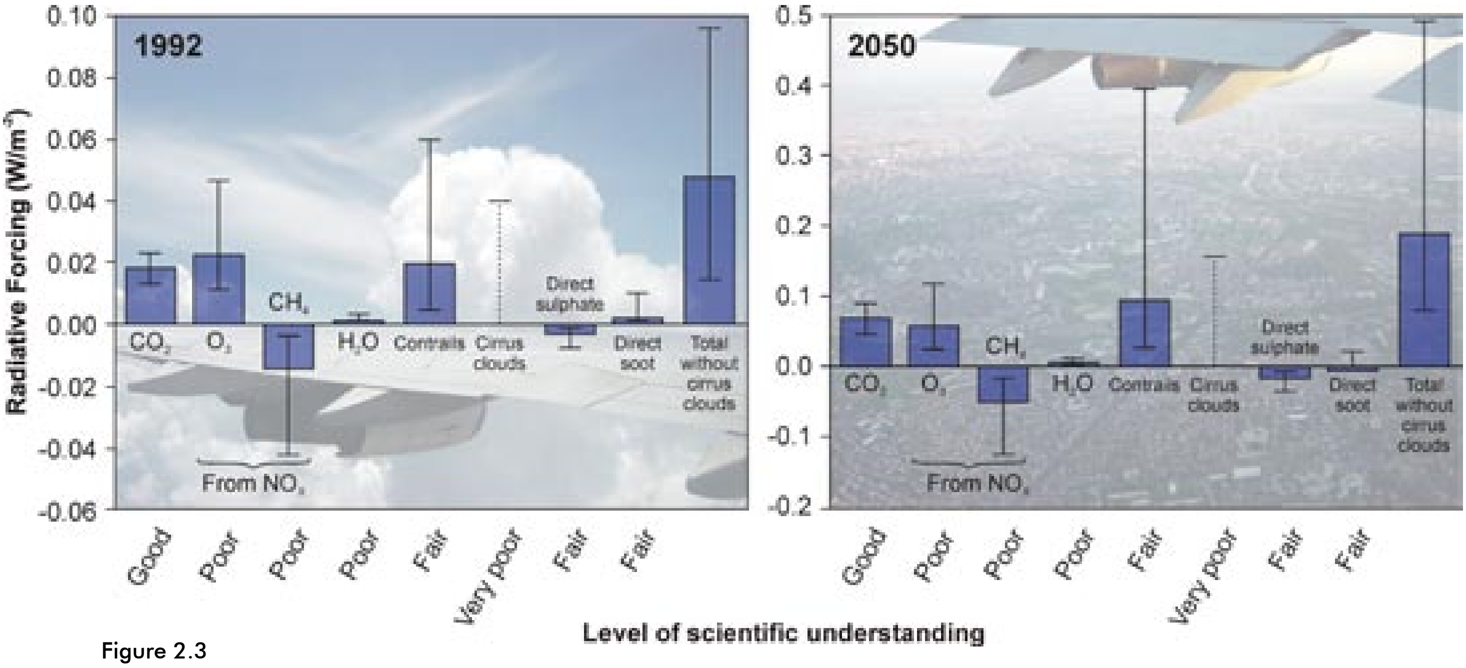

Figure 2.3 Radiative forcing by main aircraft emissions (IPCC, 1999)

and landing become less significant as the flight distance increases (RCEP, 2002) and emissions become a smaller fraction of the total. The most fuel-efficient flight distance is around 4,300 km (2,300 nautical miles or 2,700 miles) corresponding, for example, to flights from Europe to the east coast of North America (RCEP (2002), e.g. from Manchester to Boston. Long-haul flights, to Australia for example, need to carry vast amounts of fuel making them heavier and so a disproportionate amount is used just to take-off. A comparison of emissions by different modes is shown in Figure 2.4 and it clearly demonstrates that short-haul flights produce the greatest CO_2 emissions per passenger kilometre (van Essen *et al.* , 2003).

There is therefore a clear case for introducing policies that reduce the demand for these less efficient trips, such as shifting to cleaner modes of transport or using technology to substitute trips. These are covered in Chapter 3.

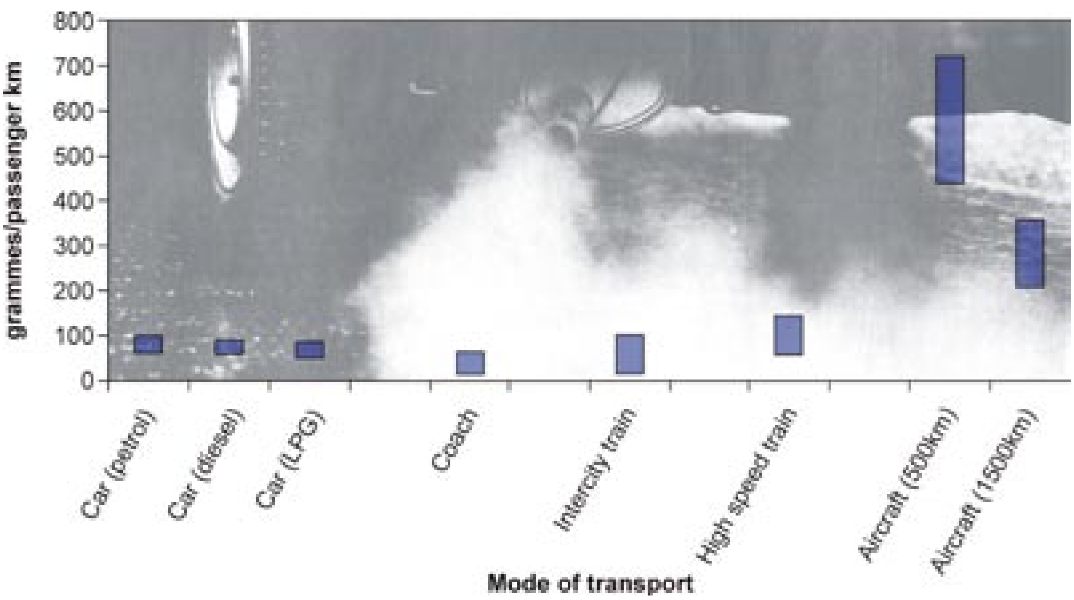

Figure 2.4 Modal comparison of CO_2 emissions for long distance travel (van Essen et al, 2003)

Principal aviation pollutants

Carbon Dioxide(CO_2)

CO_2 affects the atmosphere directly and depending on the concentrations of molecules it affects the ability of the earth to absorb outgoing radiation emitted by the earth's surface and lower atmosphere. Aviation is responsible for 2 per cent of total anthropogenic CO_2 emissions. In terms of global warming this is of great concern as CO_2 can reside in the atmosphere for hundreds of years. The CO_2 emitted by aircraft is mixed with CO_2 from other sources; however, as jet aircraft have only been in service over the last 50 years, CO_2 concentrations from aircraft alone are difficult to assess.

Nitrogen Oxides (NO_x)

NO_x is a common term used to refer to three species of oxides of nitrogen: nitric oxide (NO), nitrogen dioxide (NO_2) and nitrous oxide (N_2O) a greenhouse gas which accumulates in the atmosphere with other greenhouse gases leading to a rise in the earth's temperature over time. NO_2 is a strong oxidizing agent that reacts in the air to form corrosive nitric acid, as well as toxic organic nitrates. It also plays a major role in the atmospheric reactions that produce ground-level ozone or photochemical smog. Apart from lightning, aircraft are responsible for all NO_x emissions at 8-15km altitudes. NO_x can react with other substances in the air to form acids which are deposited as rain, fog, snow (wet deposition) or dry particles (dry deposition). It can be carried by wind for hundreds of kilometres causing transboundary air pollution impacts such as acid rain damage to material, buildings and historical monuments, and the acidification and eutrophication of lakes and streams.

Ozone (O_3)

O_3 is a greenhouse gas formed as a result of photo-chemical reactions between NO_x and the atmosphere. O_3, most of which resides in the stratosphere, shields the planet against solar ultraviolet radiation. It can exert a significant effect on the earth's energy budget of the atmosphere controlling how much harmful ultra-violet radiation reaches the surface. In the stratosphere, NO_x can lead to ozone depletion by as much as 3 per cent (VCÖ, 1997). At lower levels, in the troposphere and tropopause (lower than 9 km altitude), O_3 can be harmful to humans (respiratory problems) and plants through reduced yield and other symptoms. Tropospheric ozone impacts from aircraft alone, however, are difficult to estimate as there will be significant concentrations from other sources of NO_x such as city traffic.

Methane (CH_4)

In addition to increasing tropospheric ozone concentrations, aircraft NO_x emissions indirectly decrease the concentration of methane, which is also a greenhouse gas. CH_4 reductions will tend to cool the surface of the earth but not by the same extent as the warming potential of other GHGs (IPCC, 1999).

Cirrus cloud, water vapour (H_2O) and contrails

Cirrus clouds are thin and wispy high-level clouds typically found at heights greater than 6km. They are composed of ice crystals formed from the freezing of super-cooled water droplets. Water vapour is a greenhouse gas and is formed as a by-product of the combustion of kerosene and at high altitude condenses to form thin cloud trails

Figure 2.5 Contrails and cirrus clouds over East Yorkshire

(contrails) in the sky (Figure 2.5). Contrails cover about 0.1 per cent of the earth's surface on an annually averaged basis, with larger regional values (IPCC, 1999).

Depending on meteorological conditions (such as air temperature and prevailing wind) these can persist visibly for many hours often spreading out to join with other mature contrails which may then influence the formation of cirrus clouds. Moreover, water vapour can reside in the troposphere for up to nine days and in the stratosphere can last weeks or months, adding to the potential radiative forcing effect over this period

Approximately 10-20 per cent of all jet aircraft flights occur in air masses that are humid enough to cause contrails. Figure 2.6 illustrates this with a 'snap-shot' of the situation over Northern Europe. With increasing flights in Europe the potential for more cirrus cloud formation, and as a consequence climate warming, is raised. According to the IPCC reference scenario, the contrail cover is projected to grow to 0.5 per cent by 2050 (IPCC, 1999).

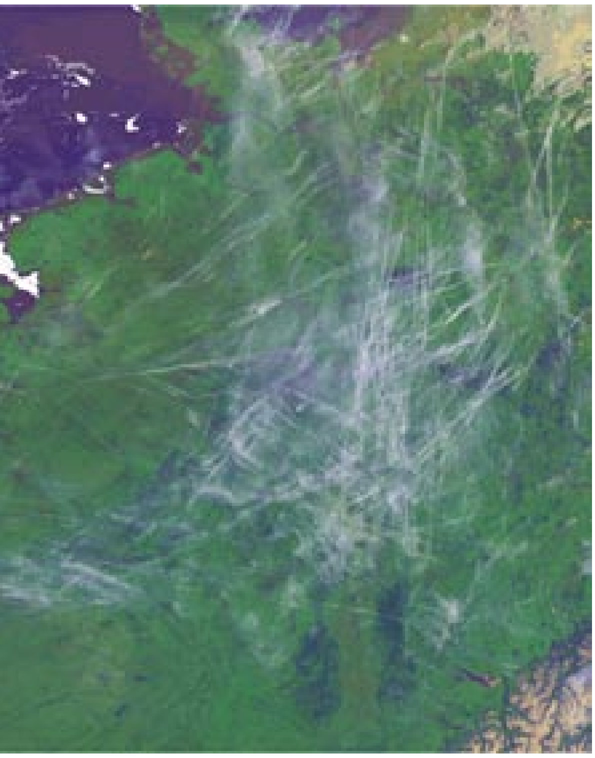

Figure 2.6 Contrails formed over Northern Europe, 1995 (Deutschen Zentrum für Luft- und Raumfahrt (DLR))

Following the 9/11 terrorist attacks in the US, almost all aircraft were grounded for 24-48 hours. Over the following days diurnal temperatures were between 1 and 2 degrees C higher than normal (Travis *et al.*, 2002). This may be explained because contrails were not produced in that period and so did not contribute to cirrus cloud formation. This allowed sunlight to enter the earth's atmosphere unimpeded, raising daytime temperature, and, as the returning radiation was not trapped by the cloud, lowering night-time temperature.

Sulphur Dioxide (SO_2)

Sulphur in the fuel is oxidised when burnt to form SO_2, an acidic, colourless gas. It can react with water to form contrails and may be deposited in the form of sulphate (H_2SO_4) or acid rain. SO_2 at ground level can cause human health impacts such as respiratory problems, lung disease and impaired function, asthma effects, as well as affecting plants and causing damage to buildings.

Carbon Monoxide (CO)

CO is an intermediate product caused through combustion and tends to be produced when aircraft are on the ground. Depending on the concentration and exposure serious human health problems can be experienced.

Volatile Organic Compounds (VOCs)

VOCs include many different chemicals, many of which are linked to human health problems. These compounds include hyrdrocarbons such as ethanes, isoprenes, benzene and toluene and are the result of unburnt or partially-burnt fuel. Some such as benzene are linked to increasing risk of adult leukaemia and others have the potential to cause global warming when they react in the atmosphere to form ozone.

LOCAL AIR QUALITY

Aircraft are not the only sources of air pollution at local levels. Passengers, airlines, airport companies both landside and airside, as well as aircraft maintenance areas, all contribute to total levels of air pollution within a 15-20 km radius of the airport. The main pollutants are VOCs, PM_{10}, SO_2 and NO_x, and they are identified as causing health problems for local residents and airport workers. They also contribute significantly to local air pollution. Whilst many symptoms are not particularly visible, long-term exposure poses a great health risk. At ground level, particulate matter emitted by aircraft and airport vehicles can cause higher incidences of localised health problems such as asthma and pulmonary disease.

Surface access to airports also causes significant emissions as most people tend to travel by private car. Some countries in Europe have efficient public transport systems which link major cities to airports. In Switzerland, for example, 65 per cent of passengers use public transport to and from the airport. This is contrasted with a figure of less than 10 per cent for the UK (Figure 2.7), with the exception of Heathrow and Gatwick which have direct rail links (DETR, 2000). Also, low cost airlines use regional airports located far from city centres. They create greater surface transport emissions as people tend to drive to the terminals. More efficient public transport could alleviate some of these air pollution problems and so surface access strategies should be considered by policy-makers.

If air travel demand increases as predicted and there is no shift to public transport, congestion around airports is likely to increase. This burden is borne by local businesses and residents. Therefore, policies such as local transport plans are clearly needed to address these local transport issues. Airport operating companies can take steps to reduce impacts by using cleaner fleets, bussing in employees and advocating the use of public transport through information campaigns.

AIRPORT IMPACTS

A number of impacts are associated with the operation of airports. Firstly, a significant amount of land is required to build the runways, terminals, car parks, services areas and transport networks. Airports are typically located on the outskirts of the cities near to the countryside, and as more and more capacity is required to meet demand for aviation more land is used, encroaching further on the countryside with the direct loss of important habitats and possible reduction in biodiversity. Furthermore, losses could be caused by the pollution emanating from the airport including the waste generated by millions of

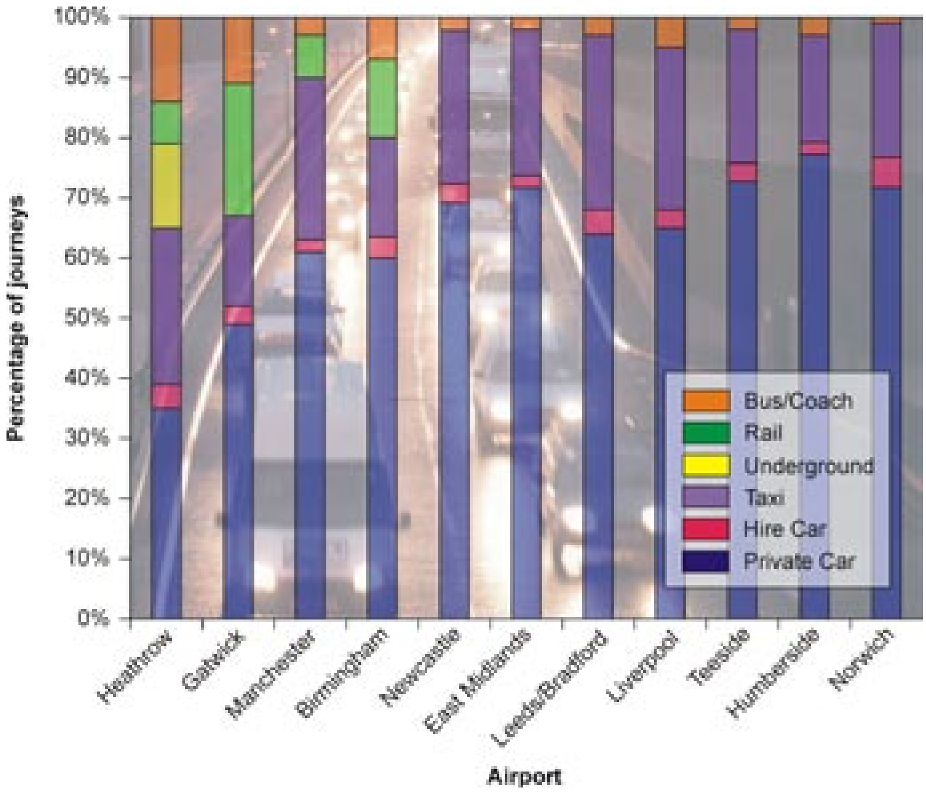

Figure 2.7
Transport to UK airports
(1999 – latest figures available – Overson, 1999)

passenger movements and by the airport employees' commute. In addition, airport operations such as the maintenance and servicing contribute to local air quality and surface water pollution. For example, during freezing weather aircraft need de-icing fluid, part of which ends up washed into local water sources.

HEALTH IMPACTS

In this section, the report will focus on community health impacts which are largely related to the exposure to noise. It is acknowledged that other direct health effects can be attributed to aviation; these include deep vein thrombosis, radiation exposure and transmission of illness and disease. The noise impacts are important because they can affect the more sensitive people in society, in particular children. In addition, people who live near to airports often have no choice as to where they live and are less likely to utilise air services themselves.

Community exposure to noise

Aircraft noise is one of the major environmental and social impacts faced by communities (Berglund and Lindvall, 1995). An example of the scale of this problem in Europe is shown in Table 2.2. As aviation growth continues one of the major challenges facing airport operators and airlines is how to reduce noise levels. In the UK, one in eight people is affected by noise from aircraft (Transport 2000). Whilst there have been considerable reductions in noise emanating from aircraft (airframe and engines) this has largely been off-set by increasing capacity and the increasing number of flight movements.

Table 2.2 Number of people exposed to noise levels over 55 L_{DN} dB around selected airports

Airport	Number of people
Heathrow, London	440 000
Fuhlsbüttel, Hamburg	123 000
Charles de Gaulle, France	120 000
Schiphol, Amsterdam	69 000
Kastrup, Copenhagen	54 000
Barajas, Madrid	33 000

Source: M+P Raadgevende ingenieurs, 1999

Aircraft noise is primarily produced by the engine as air is sucked into the turbo fan and exits in the exhaust at high velocity. Noise is also created by the airframe and during landing. Air resistance, engine reverse-thrust and wheel friction may cause additional noise. Noise levels vary over distance and are also affected by atmospheric conditions including relative humidity, wind speed and turbulence.

Direct adverse health effects from noise exposure include cardio-vascular disease, impaired hearing and communication performance, especially non-auditory physiological effects, noise-induced disturbance of sleep and community annoyance (Berglund and Lindvall, 1995). Secondary effects include increased risks of accidents by noise-exposed individuals, reduction in productivity at work, and related social behavioural effects, although these are difficult to quantify (Berglund and Lindvall, 1995).

Measures do exist to punish airlines that breach noise thresholds and airport companies do control, monitor and map noise exposure. For example, between 1998 and 1999, 340 fines were imposed at London Heathrow.

Communities are not only exposed to the noise of aircraft but also to background noise from vehicles and commercial operations in and around airports as well as from local industries, and thus noise levels from aircraft are difficult to isolate. Aircraft noise is largely considered a local phenomenon. However, noise in rural areas from over-flying aircraft, whilst not exceeding WHO limits can, nevertheless, contribute to background noise levels and as a consequence, spoil areas that are usually tranquil. As air traffic corridors become increasingly full and new ones are opened this situation is likely to deteriorate. Other factors related to this type of noise irritation are noise frequency range and loudness, repetition, duration, time of day, activity of listener and psychological factors that an individual is predisposed.

Of particular importance is the impact on sleep and the individual's right to a night's sleep. Clearly, noise occurring during sleep can provoke awakenings. Noise can also affect an individual's sleep pattern and quality, heart rate, immune system, performance and psychological state (Passchier-Vermeer, 2000). A study based around the development of the airport in Munich indicates several significant health impacts in children, which, whilst not immediately life threatening, could lead to problems later in adulthood. The study by Evans et al. (1998) showed that children exposed to chronic noise suffered increased heart rates and higher levels of stress related hormones, both of which are precursors to possible heart problems when they are older.

Children are one of the groups most at risk from noise and this can manifest itself in several ways, including cognitive effects such as problems with reading, attention span and memory function, and recall and stress annoyance. A study of schoolchildren at schools around Heathrow carried out by Stansfield et al. (2002) found that schoolchildren subject to chronic noise exposure were disadvantaged through impaired reading performance, depending on the subject, and that annoyance was a significant effect compared to schoolchildren at other schools. However, aircraft noise did not increase stress in children or affect memory performance.

NOISE POLICY

Since 2002, many of the older, noisier aircraft categorised as Chapter 2 and Chapter 3 aircraft by ICAO (ICAO, 1993) including those built before 1975 (including types such as Boeing 707, Boeing 737-300, BAC1-11, McDonnell Douglas DC8) have been or are due to be phased out through international regulation brought about by ICAO[8]. In Europe, many of these aircraft have ceased flying since 2002 (EC Directive 92/14). In addition, a number of older models had engines fitted with 'hushkits' to reduce noise impacts. There are some exceptions to this, notably airlines from developing countries; also, military aviation tends to use older variants for transport and refuelling.

The recent EC directive 2002/49/EC on the assessment and management of environmental noise includes aviation along with other transport sources and standardises noise assessments using comparable indicators L_{den} (including L_{day}, $L_{evening}$ and L_{night})[8] (EC, 2002). From 2005, and every five years subsequent, member states are obliged to supply the Commission with noise maps for major airports based on these indicators. By 2008, member states are required to draw up noise management plans which are aimed at protecting towns and cities with more than 250,000 inhabitants. This is extended to action plans which address other noise problems such as those in open areas.

Many airports regulate activity at night-time. Some airports, such as Frankfurt, impose a total night ban between 11pm and 5am. Several European airports, e.g. Hamburg, Orly in Paris, and Geneva, use the midnight to 6am curfew. The Italian government prohibits night flights at any Italian airport between the hours of 11pm to 6am. At Manchester airport, night noise quotas between 11.30pm and 6am are imposed and limits placed on the number of movements depending on aircraft type.

A number of measures can be implemented to reduce the impact of aircraft noise, however, unless the overall number of flights is reduced through other demand management approaches, they will largely be negated. They include improved air traffic management in the form of noise preference routes avoiding more densely populated areas, continued descent approaches (CDA) which keep aircraft higher for longer, and runway alternation if it's possible and other punitive and restrictive measures such as noise charging at airports, flight off-track penalties and banning of engine testing.

Clear policy objectives are required at national and European level to reduce the impact of aviation noise, so that the costs are not borne by those people who are more vulnerable or at risk rather than by those who actually cause the noise. The challenge to the aviation industry and government is to fully engage all stakeholders in decisions affecting future noise impacts, such as new runways, airport expansion, night-time quotas etc. Participation by all stakeholder groups can lead to greater social inclusion and such dialogue may provide additional synergies in terms of economic and social benefits to a community. One such way forward is described by Thomas and Lever (2003), who suggest that airports could sponsor education programmes which increase the employment opportunities (in airport industries) of local citizens from poorer backgrounds.

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[8] L_{eq}: (equivalent sound level) an energy-averaging measure for a stated period of time and is the international standard for assessing noise exposure and hearing damage risk (Berglund and Lindvall, 1995) The period of time considered by the UK government is the 16 hours between 0700 to 2300 hours (L_{eq}7h-23h). Outside 57db(A)L_{eq} is regarded as the threshold above which people start becoming annoyed.

L_{den} - day-evening-night indicator used as a general indicator of annoyance.

L_{day}, $L_{evening}$, L_{night} for which the time periods used for this basis are 07.00-19.00, 19.00-23.00 and 23.00-07.00. (EC 2002)

3 A Demand Management Strategy for Aviation

INTRODUCTION

Sustainable development has proved to be a very elusive concept especially when directly applied to a specific policy area. In spite of these difficulties there are a number of broadly accepted conclusions that can be used to inform policy debates. They can be summarised as follows:

- Policies that lead directly to year on year increases in greenhouse gases are unlikely to be in conformity with the need to reduce these gases by 60 per cent on a 2000 base by 2050.
- Policies that increase the size of our ecological footprint (see Box 2) are unlikely to be in conformity with the principles of sustainable development, especially as they apply to global equity and social justice.
- Policies that produce local air pollution, or noise levels that exceed internationally agreed levels designed to protect human health, are unlikely to be in conformity with sustainable development.

The growth of aviation presents what is perhaps the severest challenge to all our basic notions around sustainable development. The industry is growing fast, is likely to grow even faster in the future and there is very little, if any, debate about demand management. Demand management is crucial to the delivery of sustainable development. It addresses key areas of satisfying human needs within a framework of doing more with less, reducing pollution and reducing the use of finite raw materials and resources. This concept is well understood in the debate around sustainable development but is particularly well described in the “Factor 4” debate (Weizsaecker, Lovins and Lovins, 1997).

In this chapter we show how demand management can be incorporated into a new aviation paradigm.

BOX 2

The ecological footprint provides an aggregated indicator of natural resource consumption (energy and materials) in much the same way that economic indicators (such as Gross Domestic Product or the Retail Prices Index) have been adopted as a way of representing dimensions of the financial economy.

The ecological footprint is a simple accounting tool that adds up human impacts on the natural environment. It determines the amount of land that is required to provide a given population with all their resources to support their current lifestyles and to absorb all the pollution and waste they create. The ecological footprint calculates the amount of energy and materials used in food, packaging, housing, transport, supply of water and infrastructure that are used and consumed by a given population. It takes into account the emissions of carbon dioxide (CO_2) and other gases from the burning of oil, coal and gas, which contribute to global warming which is responsible for changes in the global climate. The ecological footprint enables us to understand the pressure placed on natural resources and the earth’s ability to absorb pollution.

A study by SEI for the South East region of the UK showed that passenger transport creates an ecological footprint of 0.78 global hectares per capita. Car travel is responsible for 62 per cent of the total environmental impact of all South East passenger transport followed by air travel with 32 per cent. All other modes of transport together account for just 6 per cent of the total footprint (Barrett et al, 2003).

THE PROVENANCE OF DEMAND MANAGEMENT

The clearest case for demand management in aviation has been made by the UK Royal Commission on Environmental Pollution in its 1994 report "Transport and the Environment" (RCEP, 1994):

> *"A reduction in the rate of growth of air travel would help considerably towards reducing, or at least stabilising, emissions from aircraft. It would also reduce the scale of the other environmentally damaging effects of air transport, such as noise and the loss of land for airports and surface links"*
>
> RCEP (1994), paragraph 5.38, page 74

> *"An unquestioning attitude towards future growth in air travel and an acceptance that the projected demand for additional facilities and services must be met, are incompatible with the aims of sustainable development, just as acceptance that there will be a continuing growth in demand for energy would be incompatible"*
>
> RCEP (1994), paragraph 5.39, page 75

We have shown in Chapter 2 that the aviation industry is the source of serious environmental problems especially through its contribution to greenhouse gas emissions and the rate at which these are expected to grow over the next 20-30 years. The aviation industry has not ignored its environmental responsibilities and there are many examples of technical and organisational innovation within the industry that are intended to reduce waste, reduce noise, reduce fuel use, reduce emissions to atmosphere and conserve resources. British Airways has a long history of developing and introducing environmental awareness, training and strategies. Not surprisingly, the industry is very reluctant to accept the possibility that lower levels of output (i.e. less flying) is one of a number of possible measures for dealing with the predicted levels of greenhouse gas emissions and airport expansion in the next 2-3 decades.

This misses a major dimension of the ways in which environmental problems can be overcome and progress towards sustainable development accelerated. The Royal Commission on Environmental Pollution was concerned with aviation specifically because its rate of growth was large enough to cancel out other gains:

> *"This rate of improvement (in fuel efficiency) would not be sufficient to offset the growth of traffic forecasts by the industry: emissions of carbon dioxide and water vapour can therefore be expected to increase by 2-3 per cent a year between now and 2010"*
>
> RCEP (1994), paragraph 5.30, page 72

Aviation is a prime candidate for demand management precisely because its rate of growth is large enough to cancel out gains from technical improvements.

In this section of the report we will explore the rationale for a demand management strategy (i.e. less flying) and examine some of the methods that have been proposed to achieve a reduction (or more likely a decline in the rate of growth) of passenger and freight transport by air.

DEMAND MANAGEMENT STRATEGIES IN SURFACE TRANSPORT

In February 2003 the Mayor of London put in place a radical congestion charging scheme to reduce the amount of traffic using the road system of central London. This was a controversial measure but was also part of the election manifesto on which Ken Livingstone was elected. The charge of £5 per day to cross a cordon line into central London was predicted to reduce traffic volumes by about 15 per cent. Six months later it was clear that traffic volumes had reduced by about 18 per cent, cycling had tripled and bus times and reliability had improved considerably. This is one example of demand management. Transport trends that had previously been thought to be intractable, irreversible and intimately linked to economic growth can be steered in a completely new direction and in a way that does not damage individuals, businesses or the economy in general. This is the challenge for aviation.

Demand management is now a well-established part of transport planning in the UK. In the 1970s and 1980s the UK road building programme increased in size by a factor of 5 and roads were proposed, funded and built on the argument that predicted levels of traffic required extra road capacity. This approach has been dubbed "predict and provide". In the early 1990s it became apparent that this approach was not working. New roads did not alleviate congestion and the environmental and financial costs of a large road building programme were deemed to be unacceptable. Predict and provide was replaced by "predict and prevent". In policy terms this has been given considerable emphasis and weight through Planning Policy Guidance Note 13, Transport, published by central government (usually referred to as PPG13).

PPG13 clearly connects transport policy to sustainable development objectives and seeks to use the planning process to assist in achieving sustainable development policies. PPG13 acknowledges the importance of transport for quality of life, access and prosperity but goes on to say:

> *"But the way we travel and the continued growth in road traffic is damaging our towns, harming our countryside and contributing to global warming"*
>
> PPG13, paragraph 1

This statement is equally correct for the case of international aviation.

The RCEP report published in 1994 is very clear that a way has to be found to influence demand. The same parallel is made with road transport "a comparable change in attitude towards the growth of air transport is needed, only in this case on an international scale". The Royal Commission regards the growth in demand for aviation as incompatible with sustainable development and largely the result of distortion in pricing:

> *"the demand for air transport might not be growing at the present rate if airlines and their customers had to face the costs of the damage they are causing to the environment"*
>
> RCEP (1994), paragraph 5.39, page 75

Interestingly, aviation also receives very large direct subsidies through the absence of taxation on fuel or other services and through infrastructure support for transport links to airports and job creation support to the manufacturing of aircraft (Bishop and Grayling, 2003). This combination of direct financial assistance from the state and very large environmental disbenefits creates an artificial world of cheap air fares which further stimulate demand. We return to this theme in the next section.

DEMAND MANAGEMENT METHODOLOGIES

The literature on transport, the environment and aviation focuses on three main approaches to demand management:

1 The internalisation of external costs which is a re-formulation of the well known "polluter pays principle" and suggests that "prices should tell the ecological truth" (Weizsaecker, 1994, Earth Politics, page 119). The price of an air ticket would rise to reflect the degree to which the activity is generating substantial environmental costs and this rise would in its turn reduce demand.

2 Transfer of passengers from air services to high speed trains, sleeper trains and better quality trains. This would be referred to as a modal shift strategy and is directly analogous to the road transport debate where government policy is encouraging a shift from the car to more sustainable alternatives.

3 Electronic substitution. Can videoconferencing, teleconferencing and related technologies substitute for air travel?

The internalisation of external costs

In an extensive review of the literature on externalities the authors (Wit et al, 2002) recommend the following definition of external effects:

> *"external effects are economically relevant impacts that Agent A imposes on Agent B without recognising or accounting for them. Note that external effects are thus not synonymous with 'damage', but with 'costs unaccounted for' "*
>
> Wit et al. (2002), page 13

This definition captures the importance of externalities, which has been well understood since the work of Pigou in 1920. Pigou describes the example of:

> *"the uncompensated disservices of a smoke producing factory for this smoke in large towns inflicts a heavy uncharged loss on the community, an injury to buildings and vegetables, expenses for washing clothes and cleaning rooms, expenses for the provision of artificial light, and in many other ways"*
>
> Quoted in Wit et al. (2002), page 7

This is very relevant indeed to the world of transport. When an individual drives to work in the morning rush hour in any European city, he or she (or possibly a family member or employer) will have paid for the car, the fuel, the maintenance of the car, insurance and other tangible payments involving direct cash transfer. The car will be running on a paved road surface which has been provided and maintained by the state (usually) and will have been paid for (in part) by taxation on fuel, car ownership and purchase and general taxation. The car will produce its share of the total emissions of health damaging pollutants, greenhouse gases and noise and will be responsible for its share of the totality of road traffic accidents, injuries, death and the costs associated with courts and policing systems. Many (but not all) of these environmental disbenefits are categorised as externalities. They are costs that are not paid for by the individual benefiting from the activity (the car trip) and the costs are "picked up" by a number of public and private agencies. In the UK these externalities (from road transport) have been valued at £45.9-£52.9 billion (et al, 1996, page 144).

The equivalent situation in aviation has been documented in considerable detail by CE in the Netherlands (Wit et al, 2002). Figure 3.1 summarises the results.

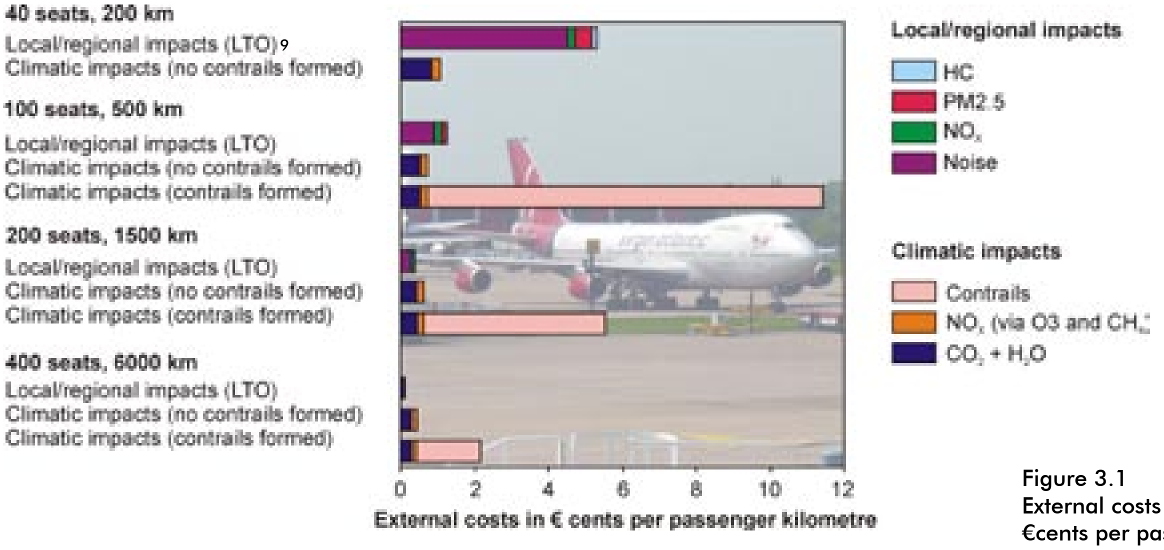

Figure 3.1
External costs in €cents per passenger-kilometre: fleet-average aircraft technology, $C0_2$ emissions valued at €30/tonne (from Wit et al, 2002)

An earlier calculation of aviation's externalities (IWW and INFRAS, 1995) estimated that in 1991 the total environmental external costs of aviation in 17 European countries was 12 billion ECU for passengers and 4 billion ECU for freight, a total of 16 billion ECU (the old ECU or European Currency Unit translates fairly well into the Euro for 2002 comparisons).

Very clearly European aviation is not "paying its way". An air ticket is under-priced when compared with the "true costs" of air transport.

Implementing internalisation

The demand for aviation can be reduced by policies that build into the cost of a flight (or a unit of freight/passenger travel) the full cost of that flight. Such a policy is already accepted for the transport sector as a whole where the internalisation of external costs or the implementation of the polluter pays principle is already an agreed European Union policy. The European Union has agreed a phased programme of harmonisation of all taxes and duties paid by lorries and for these taxes and charges to be set in relation to the total external costs of lorry activity in member states (European Commission, 1999).

The internalisation of external costs in aviation can be achieved by a number of different methods including fuel charges, emission charges, landing charges and seat/ticket charges. Internalisation can be achieved in full or in part depending on the objectives of the policy and depending on the relationship between price signals and changes in behaviour. It is European Union policy to introduce a system of tariffs for airport infrastructures in the period 2001-2004 to ensure that these tariffs are harmonised on an EU basis and that the tariffs deliver the "user-pays" principle (Eur-Op News, 3/98).

The Dutch Centre for Energy Conservation and Environmental Technology (Bleijenberg and Wit, 1998) has carried out a study into the feasibility of a Europe-wide aviation charge aimed at reducing air pollution from this sector. The objective of a charge would be to reduce air pollution from aviation, covering emissions during the whole flight. The purpose of this reduction is to reduce the impact of

[9] LTO – landing and take-off.

aviation on climate change, ozone layer destruction, acidification and ground level ozone formation. The study identifies a target level of charging based on the need to reduce air pollution (and greenhouse gases). It goes on to identify five different ways of applying the charge and reviews the legality and difficulties of applying such a charge. This information is summarised in Table 3.1 below.

Table 3.1
Five charge options

OPTION	CHARGE BASE	CHARGE LEVEL[a]	REVENUE ALLOCATION
1 Emission charge	Calculated emissions	0.03-0.12 $/kg CO_2 3.10-12.40 $/kg NO_x(low) 2.60-10.40 $/kg NO_x (high) 2.40-9.80 $/kg SO_2 3.10-12.40 $/kg VOC	To European level. Redistributed to national states via allocation rules.
2 Revenue-neutral emission charge	Calculated emissions	See option 1	To airline companies. Proportional to their production in EEA air space.
3 LTO emissions charge	Calculated emissions during LTO	See option 1	To national states
4 Fuel charge package	Fuel bunkers	0.10-0.40 $/litre	To national states
5 Ticket charge[b]	Movements	2.00-9.00 $/passenger for EEA departures 4.00-1800 $/ passenger for non-EEA departures	To national states

[a] Working assumption equivalent to 0.10-0.40 US$ per litre fuel

[b] The package includes a charge on LTO emissions and emission standards. These additional instruments are to avoid higher fuel efficiency being achieved at the expense of higher emissions of NO_x and VOC

Source: Bleijenberg and Wit, 1998.

The study concludes that a European aviation charge is "both environmentally effective and feasible". A charge level equivalent to 0.20 US$/litre of fuel is expected to roughly halve the projected growth in emissions from civil aviation in Europe. A charge on calculated emissions is expected to be the most efficient and the least likely to distort competition or precipitate a transfer of passengers and/or operations to airports just outside European air space. The authors of the study also conclude that the emission charge would not infringe the Chicago Convention[10] regulating international civil aviation and often quoted as a barrier to the introduction of charges of any kind. This is an important conclusion. An emission charge is not a tax on fuel, which is currently not possible under the Chicago Convention, which is binding on the UK and all other participating states. An emission charge, on the other hand, is possible and could be introduced throughout the European Union under existing competencies.

[10] Chicago Convention
The International Civil Aviation Organization (ICAO) was set up in 1947 as a specialised agency covering all aspects of aviation including standards and law.. It has a Legal Committee that prepares and drafts international treaties and conventions on air law, and later submits them for approval to diplomatic conferences. It was created under the Convention on International Civil Aviation (the Chicago Convention).

Other work carried out independently of the Dutch Centre for Energy Conservation and Environmental Technology arrives at similar conclusions (Brockhagen and Lienemeyer, 1998). They investigate a number of alternative models of pricing and charging to achieve the objective of reducing the global warming impact of aviation in line with Kyoto Protocol decisions. Their conclusions are:

1. An environmental charge on aviation is the only convincing instrument to achieve this objective.
2. The charge should be implemented at the EU level.
3. The rationale given by the aviation industry for all current tax exemptions on air transport is not justified. It underestimates the ecological necessity for a charge and exaggerates the problems in international law. The Chicago Convention and bilateral air service agreements (BASA) do not represent an obstacle to the introduction of a specially designed European air transport charge.
4. The environmental charge should take the form of a charge on emissions from commercial jets. This would apply to carbon dioxide (CO_2) and nitrogen oxides (NO_x). The amount of the emissions will be determined by measuring the fuel consumed and by subsequent calculations.
5. The charge would be applied to all airlines (including those based outside of the EU) for all flights connected with an airport in the EU. The polluter pays principle points to the airline as the organisation that must pay.
6. The design of the charge avoids distortions of competition (it will apply to all flights) and it removes the possibility of undesired consequences associated with other charges, for example, a fuel charge would encourage “tankering” whereby airlines would fill up with fuel outside the EU, carry more fuel than necessary and produce more pollution as a result.
7. The charge shall be based on Article 130s of the EC Treaty and the revenue used to create a European fund for greenhouse gas abatement measures. This conforms with the EC Treaty. It is a market based mechanism for combating an environmental problem and the revenue will be used to tackle the same problem.
8. The introduction of the proposed charge is politically feasible. It can be implemented by the co-decision procedure (Amsterdam Treaty) and only qualified majority voting in the Council of Ministers. The charge does not require unanimity because it is not a tax in the sense of Article 130 s#2.

The authors suggest a CO_2 charge of 0.09 Euros per kg of fuel consumed, to be increased by 0.03 Euros per year until a limit of 0.3 Euros is reached after seven years. For NO_x emissions the charge would be the amount of fuel consumed multiplied by the NO_x emission index determined by an EU database. The charge levied shall be 4.3 Euros per kg NO_x and be increased by 1.43 Euros per year until after seven years a limit of 14.31 Euros per kg of NO_x is reached.

The authors present a worked example to show how the charge would operate:

A flight from London Heathrow to New York

Distance: 5700kms

Aircraft: Boeing 747-400 of American Airlines with 310 passengers on board

Actual fuel consumed: 57,000 kg

CO_2 charge: 57,000 x 0.3 Euros = 17,100 Euros

NO_x charge: according to the AREONOX report the NO_x emission index for this aircraft with its specific engines on a distance of this magnitude is 14.3 g/kg. Therefore the final NO_x charge is: 57,000 x 14.3g/kg (NO_x emission index) x 14.31 Euros/kg = 11,664 Euros (AERONOX, 2002).

The total charge is 28,764 Euros and is levied on the departing aircraft (i.e. at Heathrow). As there is no equivalent US aviation charge the full charge has to be paid by American airlines to the British authorities. On the return the same amount would be due again. If the USA introduced an equivalent charge the EU would forego 50 per cent of the total amount. If the charge were passed on in full to the passengers it would result in an additional 92.8 Euros for each passenger on the one way transatlantic flight.

Transfer of passengers from air services to high speed trains

Forty-five per cent of all European flights are over distances of less than 500kms. Many of these journeys have the potential to transfer to rail. Some of these transfers would be to high speed rail but others could easily be accommodated on night trains, sleeper trains and ordinary (not high speed) inter city train services. There is surprisingly very little research on the substitution potential between these two modes, though much is made of the decline of air services between Paris and Lyons after the introduction of the first TGV services in France over 20 years ago (Patterson and Perl, 1999). More recently the OECD has produced an “Environmentally Sustainable Transport” scenario showing a significant shift away from air transport and towards rail transport over the next 20 years (OECD, 2002).

The Paris-Lyon TGV service was introduced in 1981. In 1981-84 there was annual average fall of 17 per cent in Paris-Lyon air passenger traffic (Patterson and Perl, 1999). Pavaux (1991) has calculated that if the train alternative to air takes less than 3 hours then the train will capture 75 per cent of the market formerly held by air carriers and non-high speed trains. Figure 3.2 shows a general relationship between distance and the market share of air and rail transport. Quite clearly rail can take up a significant proportion of the market for air passenger transport.

The history and achievements of high speed trains in over a dozen countries have been summarised by Whitelegg et al. (1993). There is no doubt that these trains can offer a quality of service equal to or better than the air equivalent over distances of up to 500 km. The advantages of the rail alternative can also grow over time as air traffic delays, congestion in and near airports and increasing security concerns (and longer check-in times) add to the time penalty of flying and make rail even more attractive.

A transfer from air to rail services will not happen by chance. It requires a clear policy direction and a much improved decision making and evaluation procedure to be put in place when airport expansion is under discussion. If Heathrow Airport was connected to a high speed rail route to other UK cities this may well dampen down the need to expand regional airports. At the moment this policy option is not under discussion.

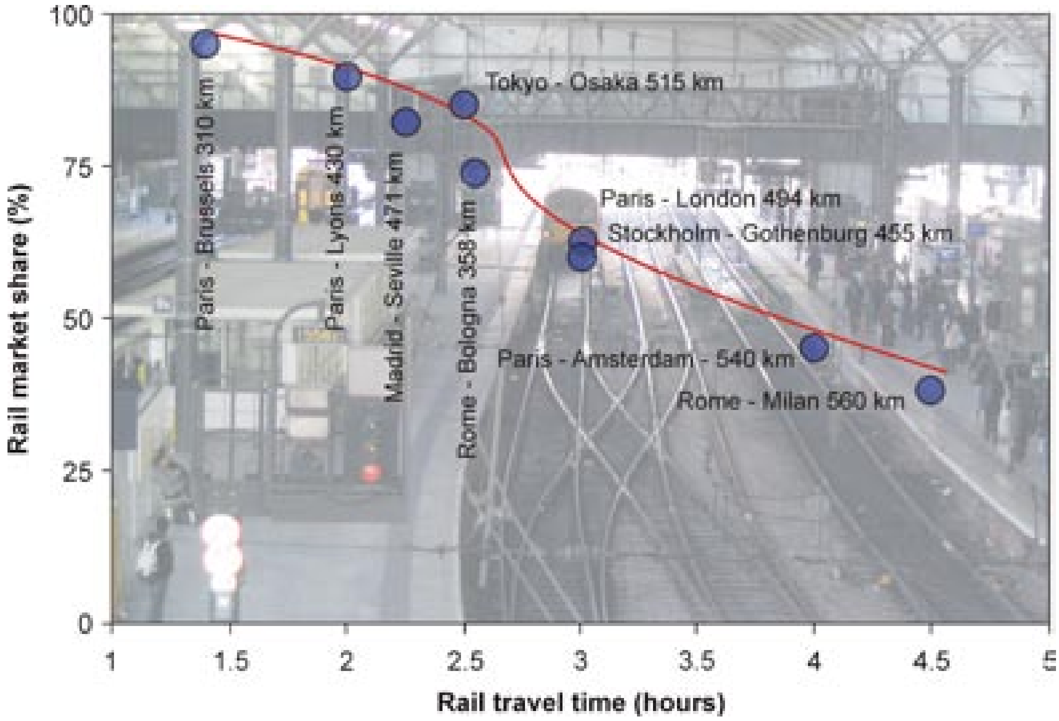

Figure 3.2
Rail/air modal split UIC, 1999

Demand for air travel is set to increase at a rate of 9 per cent per annum for the foreseeable future, of which an increasing percentage will be short-haul flights. The case is therefore put forward that reducing the number of shorter flights could make greater reductions. However, a significant reduction in emissions can be achieved through modal substitution. German experience has shown drastic reductions can be made by using rail instead of plane for journeys less than 500 km. It must be acknowledged that a modal shift will only be forthcoming if an efficient and convenient alternative such as rail is available.

Total emissions related to air travel are often underestimated as passengers can make round-trips of up to 750 km, if one takes into account the trip to and from the airport. Many of these trips are made in cars, therefore a significant component of the total emissions from a journey is attributable to car use. Research carried out by the UK Department for Transport DfT (Overson, 1999) shows that most passengers travel to airports by car (or taxi and private hire vehicle). There has also been decline in use of buses and trains except where new train lines have been introduced. An example is given below in Table 3.2 which shows that the emissions burden can shift from the transport modes that pollute more (air and car) to rail.

Table 3.2 Comparison of modal emissions and ecological footprint for two journeys.

Example: A businessman's travels from Stoke-on-Trent, UK to a meeting in the City of London.

	Segment	Mode	Distance (km)	CO_2 grammes	NO_x grammes	EF (m)*
1	Stoke-on-Trent–Manchester Airport	Car	57	10032	60	62
	Manchester Airport–Heathrow Airport	Plane	242	32428	85	276
	Heathrow Airport–Paddington	Train	20	1000	2	8
	Paddington–City of London	Taxi	13	2775	11	22
	Total		332	46235	158	368
	Total (assume same round trip)		664	92470	316	736
2	Stoke-on-Trent–Paddington	Train	250	7370	25	100
	Paddington–City of London	Taxi	13	2775	11	22
	Total		263	10145	36	122
	Total (assume same round trip)		526	20290	62	244

* based on Barrett et al. (2003)

Emission factors in g/km used for calculation (van Essen et al. 2003):

Mode	CO_2	NO_x
Car	176	1.06 (city centre) 0.86 (motorway)
Taxi	222	0.86
Plane	134	0.35
Local train	50	0.1
Intercity train	30	0.1

Therefore, the public need to be aware and informed of the choices available to them to reduce emissions for their whole journey. There are 160 planned or existing air-rail networks world-wide carrying passengers between airports and cities. Many of these are high-speed connections, such as Heathrow Express and Arlanda Express, connecting city-centre termini to airport departure/arrival lounges. A number of these encourage air passengers to take the train instead of car by providing check-in facilities, executive lounges and shops at the station. Alitalia and KLM provide free rail tickets to be used on the Malpensa Airport service. Frankfurt Airport leads air-rail inter-modal transportation, both for passenger and cargo services, with a new state-of-the-art railway station designed exclusively for long-distance services such as Germany's InterCity Express (ICE) high-speed trains. This also benefits air passengers by linking them directly to the trans-European high-speed railway network. Elsewhere, public transport initiatives have led to some improvements in passenger modal choice to and from airports. Manchester Airport is served by a new station and rail link, Heathrow Airport by the overground rail link. "Heathrow Express" carries about 5,000,000 passengers a year (10 per cent of airport passenger traffic). This represents a reduction of about 3,000 vehicles a day travelling to and from the airport. The Brisbane Airport Rail Link is currently being constructed to link the city's domestic and international airports to the city centres and to the Gold Coast, removing significant numbers of vehicles (10,000) from the road[11]. Of particular note is the promotion of public transport including trains for use by employees. The workforce at major airports account for many of the daily road trips so provision of

[11] (http://www.transfield.com.au/brisairportraillink/index.htm)

suitable rail links and a free bus service will reduce both congestion and emissions arising from commuters.

However, there are also potential negative impacts associated with air-rail collaborations, particularly whilst demand for air travel continues to grow means available capacity will be squeezed as much as possible. Firstly, whilst a certain number of trips by car have been replaced by people leaving their cars at home or choosing to use public transport to reach their destination, there is now capacity for the road space to be filled by other air travellers. Secondly, providing quicker access to airports through improvements to the rail network extending the catchment area means more people will be able to fly, particularly with the proliferation of low cost, short-haul city breaks.

Electronic substitution. Can videoconferencing substitute for air travel?

Over the last twenty years information technology has helped reduce the need for physical travel. Telecommuting and teleworking has been substituted in place of the early morning train or rush-hour drive. Increasing numbers of people work from home or from a purpose-built and equipped "telecentre" that is nearer home. These arrangements often suit the business in terms of improvements in efficiency as much as the benefits to the individual including flexible hours and reduced fuel consumption. An EC research project has summarised much of this experience (www.telework-mirti.org). Much less is known about electronic media as a substitution for the business trip by air within the UK, Europe or globally.

Experience since 11 September 2001 shows that in Europe businesses are prepared to switch a proportion of business trips from the physical to the electronic mode. This also happened during the Gulf Crisis in 1991 where there was a significant decrease in demand for air travel when war broke out. However, within 12 months the market had re-established itself to levels comparable to before the event. One of the main differences in the decade since then has been the widespread use of technology for business communication.

It is therefore quite conceivable that a number of businesses have substituted technology for travel (even if considering it as a short-term option) and have found it offers a number of significant benefits such as improved operational efficiency, reduced travel budgets and improved employee satisfaction as they spend less time away from family. Table 3.3 shows that whilst there was a significant downturn in transatlantic traffic as a result of 11 September, the domestic market (and predominantly business traffic) remained buoyant. Reasons for this need to be explored but may be partly explained by improved accessibility of flights, cheaper air fares and poor quality of services by alternatives such as rail travel as well as differences in national perceptions of risk and security.

Table 3.3
Passenger statistics by type of flight

BAA UK Passenger Statistics	Total March 2000 (000s)	Total March 2001 (000s)	% Change	Total April 2001 (000s)	Total April 2002 (000s)	% Change
Domestic	1,866	1,948	4.4	1,867	1,944	4.1
Eire	437	515	17.9	470	489	4.0
European Scheduled	3,622	3,741	3.3	3,912	3,821	-2.3
European Charter	695	797	14.7	824	673	-18.4
North Atlantic	1,521	1,439	-5.4	1,592	1,395	-12.4
Other Long Haul	1,591	1,617	1.7	1,534	1,415	-7.7

Many business journeys are necessary such as those for closing deals, product-testing and corporate presentations. However, in many cases journeys could be replaced by the use of communications technology for software support and help-desk functions, interim report presentations, and contract preparations. Substituting air travel can provide both economic and environmental benefits to an individual, the business and to the nation as a whole. Chief amongst these is the potential for reductions in carbon dioxide emissions from transport. REGUS (1998)[12] have produced comparative cost information for UK businesses showing that the use of videoconferencing facilities can reduce costs by up to 80 per cent for a range of destinations. This cost reduction translates directly into a greenhouse gas reduction as well as reductions in traffic congestion and air pollution around airports, such as Heathrow, raising the possibility that internalised cost reductions also produce generalised societal gains (reduced congestion, air pollution and noise). These benefits could equally be applied to other European countries.

An average company spends significant sums of money every year on air travel, hotels and subsistence and taxi fares. If a company were to reduce the total number of business trips (note, we are not saying all trips) by substituting technology such as videoconferencing this would significantly reduce their costs and could lead to bigger profit margins. The greatest saving of all, however, would often be in employee time, with much less time spent driving up and down motorways or sitting on planes. Savings achieved by videoconferencing increase dramatically in line with increases in the number of people and the distances between meeting points. The opposite is true of air travel. If ten people were to conduct a videoconference between London and Chicago (two hours) the cost would be ∈3,439.78, whereas air travel expenses for the same meeting would reach ∈65,755.48 (REGUS, 1998)

Videoconferencing will never replace the need for some 'real' face-to-face business meetings, and research highlights the need for an initial 'physical' meeting, as well other social and psychological hurdles which have to be overcome, before videoconferencing is widely accepted. However, this is somewhat contradicted by the number of other business transactions and interactions taking place on-line without the need for any kind of direct personal contact, for example, purchasing of equipment and the provision of on-line training. These types of non-physical interactions occur in both business-to-business and business-to-consumer sectors. There are a number of

12 REGUS (1998) The Real Cost Of Business Travel. A Report by Chartered Institute of Purchasing & Supply

real benefits to individuals and business as well as the environment that are achievable without any major shift of organisational policy. For example, videoconferencing can benefit a company's competitiveness as meetings tend to be structured more carefully and decision-making is faster as participants focus on the matter to hand, especially when conference room services are being rented on an hourly basis. It can help to create and deliver products and services such as training more rapidly to customers. It is also possible to increase the productive potential of firms through travel time and costs reductions that flow from reducing physical travel.

The environmental burden associated with aviation is large and any switch to electronic media would provide a welcome contribution to the management of these impacts. It would also provide an excellent case study of the "win-win" scenario often advanced in economic and sustainability discussions (i.e. economic gains bringing social and environmental gains and vice versa).

SYNERGY

In the above discussion, we have identified three well-grounded sets of measures for bringing aviation into the existing policy environment of sustainable development and into a much more creative and open debate about the wider societal benefits of using alternatives to flying. Logically, and in terms of sustainable development thinking, there is no justification for isolating aviation from a discussion of how we can reduce the amount of flying. The future of aviation policy lies in this wider debate and in the full application of internalisation of external costs at the same time as the alternatives and substitution options are developed. The benefits to the economy, the environment and climate change specifically of moving rapidly in this direction can only be revealed by exploiting the synergistic potential of all sets of measures implemented in Europe at the same time.

4 Conclusions and Recommendations

HOW TO DEAL WITH SUSTAINABILITY

The growth in demand for air transport is a problem for the global and local environment. There are, moreover, fundamental conflicts with sustainable development objectives. The contribution of global aviation to greenhouse gas emissions is significant (IPCC, 1999). There are currently no mechanisms in place to manage this growth in greenhouse gases from aviation and the industry is in receipt of substantial subsidies which conflict with demand management objectives and artificially stimulate demand (RCEP, 2003).

The growth of aviation presents serious challenges to governments, consumers and to the industry. Lifestyles in rich countries have adjusted to the availability of inexpensive flights and rail travellers have discovered that in some circumstances air travel can be more reliable and cheaper than the rail alternative. Local authorities across Europe have realised that investment in airports offers the promise of economic gains through tourism, direct job creation and the possibility of further direct investment as a result of improved accessibility. More fundamentally, aviation brings the promise of a modern and dynamic image that can be developed through targeted marketing campaigns. In an increasingly competitive and globalised economy there may well be penalties associated with not having an international airport and not developing air service links and its associated infrastructure. This is a difficult environment for the delivery of sustainable development policies. Both the European White Paper on transport (EC, 2002) and the recent UK White Paper on aviation policy (DfT, 2003) have rejected the option of intervening to manage the demand for air transport and have accepted the case for growth. In the UK the government's view is very clear:

> *"All the evidence suggests that air travel will continue growing over the next 30 years. But if we want to continue enjoying its benefits, we have to increase capacity"*
>
> DfT (2003) Summary Document, page 2

It is very difficult to reconcile this policy commitment with the implications of sustainable development. Sustainability considerations are generally understood to require:

- measures that can contribute to achieving reductions in greenhouse gases and eliminating or reducing the negative consequences of climate change;
- measures that can reduce the size of the ecological footprint of nations;
- measures that remove fiscal biases in favour of consumption (internalise external cost and "make the polluter pay");
- measures that protect human health; and
- measures that embrace equity considerations, especially as these relate to developing countries and to future generations.

The growth of aviation over the next 30 years will add to greenhouse gases, add to problems associated with climate change which will damage the interest of the world's poor (e.g. loss of agricultural land in Bangladesh), increase the size of the ecological footprint (Barrett et al, 2003), damage the health of the population (Berglund et al, 2001) and require huge financial subsidies from government (Bishop and Grayling, 2003).

ESTABLISHING A DIALOGUE

Currently discussions around aviation are not embracing sustainability considerations. Government and industry are in denial and are pinning their hopes on new technologies (e.g. fuel efficiency, air frame and engine design). There is also a desire to implement some form of emission trading (especially in the EU) so that those organisations that can reduce greenhouse gases can sell their "gains" to organisations such as airlines that find it difficult to reduce greenhouse gases. Sustainability requires a wide-ranging discussion/dialogue involving the industry, legislators, passengers and customers and those who live around airports and under flight paths. Currently, the debate around airport expansion is showing classic signs of entrenchment and conflict and this is not in the public interest. Bringing all interests together in a professional, consensus building format can deepen the understanding of the problem and assist in identifying solutions with "buy-in".

We recommend that a wide stakeholder dialogue be established. This will need funding from national governments and from the European Commission if it is to be successful but the level of funding would be very small in comparison to the level of investment proposed for aviation over the next 30 years. The outcomes from such a dialogue should be used to inform national and EU level policy.

IMPLEMENTING EXISTING POLICIES

At present there is a policy implementation deficit. The European Union currently has a commitment to the internalisation of external costs in transport. This includes aviation (EC, 2001). Internalisation of external costs is seen as both an effective way to shift behaviour towards the more environmentally friendly modes and a logical and rational way of bringing demand and supply into better balance (avoiding congestion). Very little progress has been made at EU level with this policy principle.

We recommend that internalisation of external costs be achieved as quickly as possible. There are several authoritative and scientific assessments of the scale of costs that would apply to aviation and we do not consider that there is a need for further work in this area. This was also the view of the European Commission Expert Working Group on Sustainable Urban Transport that reported to the Commission in January 2004. Our preferred method of achieving this internalisation is through emission charges (discussed in Chapter 3). This is because we are of the opinion that such charges do not require the approval of ICAO, do not require the renegotiation of bilateral or multi-lateral treaties and do not trigger the discussions and arguments associated with taxing aviation fuel. In our view emissions charges should replace all other forms of taxation (passenger tax, airport tax).

We also recommend that World Health Organisation guidelines on community noise (Berglund et al., 2001) be implemented as quickly as possible around all EU airports. These include:

- Outdoors daytime limit of 55 dB L_{aeq} (steady state continuous noise)
- Outdoors night-time 45 dB L_{aeq}

Berglund et al. (2001) makes the point that sustainable development is intended to improve the situation with respect to human health. Unless the noise environment is improving it is not in conformity with the principles of sustainable development.

SPECIFIC POLICIES THAT CAN REINFORCE EXISTING POLICIES

Surface access strategies

Airports are responsible for significant amounts of extra car based and lorry traffic around airports. We recommend that airports implement surface access strategies to achieve at least a 50/50 modal split for passengers. 50 per cent of all passenger trips should arrive at the airport by bus/train/metro. In the case of commercial traffic (vans and lorries) all airports should produce plans to increase the utilisation of vehicles, reduce the number of vehicles and switch traffic to rail and multi-modal transport where possible. Recent German experience in "Urban Logistics" shows a great deal of potential for reducing the vehicle kilometres of lorries and delivery vehicles (Whitelegg and Kirkbride, 2003). Surface access strategies should include detailed plans for decommissioning car parking spaces. Car parking space numbers should reflect the aspirations and targets of the modal shift targets. The success of a surface access strategy can be "tracked" through the diminishing requirement for car parking spaces and the reallocation of that space/land to other uses.

Bubble Concept

We recommend that all EU airports produce emission inventories and strategies and in close collaboration with city and regional authorities design thresholds (capping) for greenhouse gases and the main air pollutants. This scheme could be modelled on the Zurich (Kloten) airport bubble concept which sets physical limits on all emissions from all aviation related sources in a given year. These sources include:

- road passenger and freight traffic;
- all emissions from take off and landing of aircraft;
- all power units serving aircraft on the stand;
- all airport vehicles;
- all plant and machinery including heating/cooling and air conditioning; and
- all aircraft engine running and testing including taxiing aircraft.

This approach to monitoring and reducing emissions allows airports to make their own decisions about how to achieve public policy objectives. It would be possible, for example, for Manchester Airport to reduce pollutants and greenhouse gases through a demanding urban logistics project and then "use" the extra "space" created to accommodate extra flights. It would not be possible to pursue the Business As Usual case, which is to expand everything (more runways, terminals, car parking and road space).

Night-time ban

We recommend that all EU airports operate a total night-time ban on aircraft take off and landings. This recommendation is based on WHO health impact thresholds and the strong evidence in WHO documentation and Berglund et al. (2001) that damage to sleep has strongly negative health consequences. The night-time period should be 2300-0700 hrs.

VAT

We recommend that VAT should be added to the price of air tickets on journeys within the European Union. This recommendation is based on simple logic. Most goods and services attract VAT and not to add VAT raises the burden on other items of consumption as well as giving a strong price signal in favour of flying. This is in line with the need to eliminate "perverse subsidies".

Strategies to transfer short-haul passengers to rail transport

Forty-five per cent of air trips in the EU are less than 500km in length. Many of these can transfer to rail including overnight, sleeper services and high-speed rail. We recommend an integrated approach to rail and air transport development based on specific corridors and on national and EU investment strategies to transfer passengers to the more environmentally friendly modes. Currently this does not happen and there is no EU-wide or national transport investment methodology that can integrate thinking in a multi-modal, corridor transport plan. We recommend that an air-rail transfer plan be adopted for every pairing of EU cities that are connected by direct flights and are approximately 500 kms distant from each other. The transfer plan should include strategic environmental assessment (SEA) of all options for passenger travel and of all investment proposals whether public or private.

Measures needed to improve the recording and monitoring of aviation's greenhouse gas emissions

The recording of greenhouse gas emissions from aviation is unsatisfactory. If we are to have a well-informed global debate on aviation and climate change it is important to rectify the deficiencies. We recommend that ICAO institute a formal recording procedure for greenhouse gases that can report annually on the following categories of aviation activity:

- by civil airline (scheduled and charter);
- by country, to include all domestic flights and all international flights for the whole length of the flight from origin airport to destination airport (this is to avoid the under-reporting associated with arbitrary cut-offs at national boundaries or air space boundaries);
- by country pairs (e.g. all flights from the USA to the UK and vice versa);
- by region (e.g. all flights within the EU and all flights within NAFTA);
- all inter-region flights (e.g. all flights from the NAFTA area to the EU);
- all military flights by country;
- all recreational flying activity by country; and
- all helicopter activity by country.

We further recommend that this recording and reporting be done annually and published no later than 6 months in arrears.

RISK ANALYSIS

Economic risks

Aviation at current levels of output provides a number of economic benefits. If levels of output rise (more air passengers and more air freight) it is likely that the level of benefits (and disbenefits) will also rise. This raises issues around the risks associated with both the growth of aviation and the possibility that aviation will cease to grow or grow at a declining rate.

This is a difficult area for policy makers because it involves making assessments over long time periods, over very different geographies (local, regional, national, global) and over different groups of people (air travellers versus those who live under flight paths and near airports). There is also disagreement and uncertainty which is focused on two main areas:

- Do transport investments (rail, road and air capacity) stimulate economic development and job creation?
- Does aviation produce net benefits to local, regional and national economies?

On transport investments the report of the UK government body, the Standing Advisory Committee on Trunk Road Assessment, is very clear (SACTRA, 1999). SACTRA was clear that there are no automatic links between investment and economic development or jobs. Transport investments can be “consumed” in reallocating jobs between locations, and in a mature economy like the UK additional transport infrastructure may not add very much to the general level of economic activity. These are complex issues but there is enough uncertainty in the evidence of economic impacts to be wary of “crude” economic gain arguments. There are strong counter views, for example, Oxford Economic Forecasting (1999). The OEF report argues that there are substantial direct and indirect economic and job creation effects that follow from the expansion of airport capacity. From a broader public policy perspective there is no systematic or rigorous evaluation of net social and economic benefits that could be derived from (say) £1 billion spent on airport capacity as compared with renewable energy, public transport improvements, recycling or energy efficiency in buildings.

Recent work on net benefits (Whitelegg, 2003) indicates that aviation may not be so efficient at capturing economic benefits at a particular geographical scale. There is a substantial deficit in terms of tourism expenditures. Tourists originating in the UK spend far more abroad than do inbound tourists. Similarly it would be unwise to claim economic benefits from inward investment (linked to better international accessibility) when the total of UK investment in the rest of the world is greater than the rest of the world in the UK.

Our conclusion is that much more research is required into these economic arguments and on current levels of knowledge it would be very risky to commit substantial public and private resources to aviation expansion. In our view there are unlikely to be severe adverse economic consequences from reducing the demand for air transport.

Climate risks

There can be little doubt that one of the greatest risks currently being addressed by policy makers is provided by climate change. The recent statement by the UK government's chief scientific adviser, Sir David King, that climate change is a bigger risk to humanity than international terrorism (King, 2004) adds weight to this viewpoint. Aviation is a significant producer of greenhouse gases and these gases have a significant climate change impact. The anticipated growth of aviation over the next 20-30 years indicates at the very least a tripling of global warming effect from this economic activity. In our view this is not compatible with the urgent need to reduce greenhouse gases, avoid the worst consequences of climate change and deliver viable alternatives to flying over distances and journey purposes that are amenable to a shift in mode.

The current silence of governments and the industry on how to reduce greenhouse gases from aviation is simply not compatible with any interpretation of sustainability. We strongly recommend the adoption of an aviation climate change strategy that can reduce greenhouse gases in each of the next 10 years. This reduction can be achieved by a combination of measures:

- better air traffic control;
- better fuel efficiency and aerodynamic design;
- a transfer of passenger demand to electronic media (e.g. video/teleconferencing);
- a transfer of passengers to rail over appropriate distances;
- full internalisation of external costs and consequent increases in the price of air travel;
- greater exploitation of the regional potential for food production to avoid long distance transport of food; and
- surface access strategies to all airports to increase the use of public transport to at least 50 per cent of all trips.

We recommend that global aviation achieves a full proportionate reduction in its greenhouse gas emissions in line with IPCC reductions (a 60 per cent cut by 2050). We anticipate that emissions trading (ET) will assist aviation in the process of adapting to this scale of reduction but ET systems cannot be a substitute for fundamental organisational and sectoral change.

In our view there are likely to be severe adverse consequences from not reducing the demand for air transport.

Economic and climate change risks

There are dangers in stereotyping policy choices into a set of options that appear to support economic activity whilst carrying environmental risks and setting these in opposition to those policies that deal with environmental risks whilst possibly damaging the economy. This is a false dichotomy. Climate change risks are economic risks. The insurance industry has already put the total cost of economic damage arising from climate change risks (storms, floods etc) up to $600 billion over the next 10 years[13]. This will damage the economy of the EU and put EU industry and economic activity generally at a competitive disadvantage. The risks globally are also severe. For example, the loss of agricultural land in Bangladesh, the loss of agricultural productivity in the tropics and the loss of Pacific nations all bring large costs and trigger greater risks of large-scale environmental migration. Reducing greenhouse gases and managing climate change is a sound and precautionary economic strategy.

Similarly we need to reflect on the purely economic arguments. Society has changed a great deal in the last 20 years and will change even more in the next 20 years. The nature of work is itself changing, changes of career are becoming the norm, hours spent at work are declining and there is a strong sense of a need to change the work–life balance. The very definition of employment will change and under these circumstances we will need a radical re-think of traditional, neo-classical economic theory that pins so much on increases in output. Put crudely it is possible and desirable to improve quality of life, reduce environmental disbenefits provide varied employment opportunities and deliver better value on public and private investments at reduced levels of output in aviation. Under these circumstances it would be unwise to develop a 21st century industry (aviation) on a 19th century model of industrial output (Henry Ford and car production).

The challenge of dealing with aviation in the 21st century is to put sustainability at the heart of aviation policy, reduce output, contribute to climate change objectives and contribute to a broader transformation of society. This transformation would be marked by a decline in the demand for transport, a move away from year on year increases in GDP/GNP and a much more diversified pattern of employment, tourism, social and cultural activities that do not depend on long distance travel and on the consumption of fossil fuels.

[13] Based on projections using Munich Re data (www.munichre.com).

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