

AVIATION: the social, economic and environmental impact of flying

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1.0 Introduction

Summary: Aviation is a fast growing sector of the economy. It is associated with a number of social and economic benefits and a range of environmentally damaging consequences. It is also associated with a significant and growing contribution to the global inventory of greenhouse gases which are thought to be implicated in climate change. This report sets out to provide a clear basis of evidence for a wider and deeper public debate on these issues and concludes with a number of policy recommendations that are intended to ensure that aviation continues to contribute to the economy in a way that does not threaten environmental quality either globally or locally.

The debate about aviation and its strong growth trajectory is very poorly developed. There is an unquestioning acceptance in government that the rising demand for air travel will continue and that the land use planning implications (especially more terminals and runways) of this can be managed with minimal harm to the environment. The aviation industry has been very successful in its adoption of an environmental agenda (environmental reports, support of exotic, threatened environments, appointment of environmental managers, financial support for a professorship of "sustainable aviation") but has been less forthcoming on questions of growth and the need for reductions in greenhouse gases. The industry has benefited from a well developed system of public support. Airports can expect to be linked at public expense by very expensive infrastructure to the motorway system, aviation fuel is not taxed and a great deal of public money at EU and UK levels goes into air traffic control systems. Equally the industry does become involved in direct funding of this infrastructure eg the Heathrow Express. Nevertheless in the language of environmental economics aviation does not meet the full external costs generated by its own activities (noise and pollution) and fails to pay for direct costs generated by the activity itself (eg the motorway links to Manchester and Heathrow airports).

This report is intended to raise levels of awareness about the growth of aviation and its environmental consequences. This is especially important in the UK. The United Kingdom is one of the most important aviation markets in Europe with the biggest airline (British Airways), the largest airport (Heathrow), a very dynamic market (new low-budget airlines) and high passenger growth rates. Road based transport has recently emerged from a similar process of debate and reflection which has led to a greater understanding of the links between providing new roads and the growth in road traffic and the economic benefits of improved road access. A better understanding of both areas has resulted in a scaling down of new road construction. The time is now right for a similar process of reflection and debate for air transport.

The report is organised in six sections. Section 2 looks at the growth of aviation. There are a number of predictions of the future level of demand for aviation in the years 2015 and 2050. The growth forecasts vary but the middle of the range indicates at least a doubling of the miles flown by 2015 on a 1995 base. Section 3 describes the impact of aviation on noise and on ground level emissions (aircraft and road transport associated with airports). In both cases it reviews the evidence on the links between these environmental problems and human health. Section 4 deals with the impact of aviation on climate change and Section 5 on the economic impact of aviation and airport development. Section 6 deals with the policy implications of the analysis carried out in the first 5 sections. Currently there is no coherent policy and section 6 makes clear recommendations to fill this gap.

The report is intended to stimulate a public and a policy debate around aviation and its growth. Government policy in transport has made great progress in recent years in its recognition of the importance of integration and in its espousal of demand side and supply solutions to transport problems. It is now time to extend these principles to aviation and through an informed debate to identify the main elements of a new approach to aviation in the UK, the European Union and globally. This approach should be firmly rooted in changes to UK policy (the main target of this report) and through UK policy into European and global debates where changes also need to be made if a coherent approach to aviation is to be achieved.

2.0 The growth of aviation

Summary: Aviation demonstrates very strong growth rates. Forecasts of this growth are described and reviewed. On a 1995 base global forecasts of miles flown in the year 2015 range from a low growth of 181% to a high growth of 380%. In the UK where forecasts are made of terminal passenger numbers the latest government forecasts predict a 239% change on 1995 by 2015.

Aviation has the highest growth rates of all modes of transport. Annual global growth rates of aviation (total number of kilometres flown by all passengers) were approximately 10% in the 1960s and had values of 5% -7% in the 1990s. Between 1960 and 1995 global tonne-kilometres (total weight of freight carried multiplied by the distance flown) increased by a factor of 23, while the global gross domestic product increased by a factor of 3.8.

Global revenue passenger kilometres (RPK) rose by a factor of 4.6 between 1970 and 1995. Air traffic in and from/to North America and Europe dominates the world demand. In 1995 intra North American aviation accounted for 27.5% of global RPK, intra Europe 12.5%, North America - Europe 11%, Asia to North America and Europe 12.7%, and all the rest 36.5% of global RPK. However, the highest growth rates are found today in Asia (intra Asian RPK rose by 20% p.a. between 1970 and 1995). These data are the main input for all demand forecasts.

The UK air traffic forecasts (DETR, 1997) predict that there will be 310 million passengers going through UK airports in 2015, up from 129.6 million in 1995. This is a change of 239% and an actual increase of 180.4 million passengers, the equivalent of an extra 3-4 airports the size of Heathrow.

Several different forecasts have been produced for global aviation and these are reproduced in a technical appendix to this report. The main forecasts which have been used as an input to the IPCC report on aviation are displayed in Figure 1 and summarised in Table 1. The technical appendix contains more detailed information on the assumptions, forecasting methods and scenarios.

Insert graph of growth forecasts

It is also helpful to rank these forecasts.

Table 1 Ranking of forecasts

Rank	Identifier	Billion pkm	% change on 1995
1	Edh	9647	380
2	Eab	6115	241
3	Fa	5638	222
4	Fc	4596	181

Notes:

All forecasts are for the year 2015 on a 1995 base. The unit is passenger kilometres (pkm). The 1995 base is 2536.6 billion pkm.

Percentage forecasts (the final column) are calculated in the following way X (pkm in 2015) divided by y (pkm in 1995) $\times 100 =$ percentage change

Edh = EDF high demand/IPCC growth "d" (medium growth, low population) scenario

Eab = EDF base demand/IPCC growth "a" (medium growth and population) scenario

Fa = FESG (ICAO)/IPCC growth "a"

Fc = FESG (ICAO)/IPCC growth "c" (low growth and population) scenario

The growth of air freight activity and general aviation (recreational) deserve a special mention. In the period 1985-1995 total tonne-kilometres of freight (in billions) grew from 39.6 to 83.1 in all ICAO states. In the UK the equivalent growth was from 1.5-4.1. This is a doubling in 10 years for ICAO states as a whole and an increase by a factor of 2.7 in the UK. The US Environmental Defense Fund (EDF, 1994) estimated that civil freight accounted for 17.8% of global aviation fuel usage. Most of this freight is carried on passenger aircraft and can be expected to show increasingly high growth rates as global supply lines replace more localised production-consumption links and the world's most populous countries (India and China) move into strongly liberalised and deregulated styles of economic activity.

Recreational flying accounts for 2.8% of global aviation fuel usage (EDF, 1994). In the UK there is intense pressure to develop small airfields which are often no more than grassy strips. The example of Redhill Aerodrome (Surrey) is typical in this respect. This site was the subject of a planning inquiry in 1995 to consider its expansion proposals leading to its rejection by the planning inspector and the Secretary of State. There are 42 recreational aerodrome facilities in Suffolk, Essex, Norfolk and Cambridgeshire alone and many of these are the source of local concern over noise and pollution. As disposable income rises in advanced industrial economies and leisure pursuits become more specialised, expensive and exotic this kind of flying activity can be expected to increase dramatically and lead to more proposals for expanded facilities at small air strips.

3 **The local environmental impact of aviation**

Summary: Aviation has a number of environmental impacts that are experienced by local residents in the vicinity of airports and under flight paths. Noise has been the focus of concern over the last 20 years of growth in aviation and more recently air pollution and the health effects of air pollution from aircraft and land based transport have begun to cause concern.

3.1 Noise pollution

Noise is not just annoyance. It damages health, it detracts significantly from the quality of life, it stops local residents enjoying their gardens or simply enjoying peace and quiet, it damages wildlife, it damages the learning ability of schoolchildren and it costs a great deal of money through the costs of noise mitigation and noise abatement. Aircraft noise is a serious concern around all airports and under flight paths notwithstanding the adoption of quieter aircraft and engine technology. Aircraft noise is a controversial matter. It is frequently asserted by the aviation industry that the number of people exposed to noise problems, the so-called noise footprint, is shrinking rapidly. This is disputed by local residents and has been shown at the Heathrow Terminal 5 inquiry to be based on unreliable and out-dated data (HACAN News, December 1997). Almost every aspect of aircraft noise is the subject of disagreement. The selection of a particular measure of noise can influence the extent to which noise is recognised as a problem. Measures that average values over long time periods can show low relatively levels of noise and measures that emphasise peak events can show serious noise problems. More discussion on measurement problems and selection can be found in the technical appendix together with an illustration of typical noise levels from different activities and the levels above which most people experience communication difficulties, sleep disturbance or discomfort.

Noise is measured on the Decibel "A" Scale usually expressed as dB(A). The scale is used by public health and environmental health officials to set limits or make recommendations about limits that should not be exceeded. A limit of 55dB(A) is regarded as one which should not be exceeded to protect undisturbed sleep and sound levels above 70dB(A) make normal speech communication impossible (European Environment Agency, 1995).

A survey of noise disturbance in the Netherlands (European Environment Agency, 1995) shows that 20% of the population were "considerably annoyed" by road traffic and 12% by air traffic. There are no directly comparable figures for the UK though the size of the aviation industry in the UK and the size of the populations within 50 miles of Heathrow, Gatwick, Luton and Manchester point to a figure that would not be less than the Netherlands example. The Dobris statistical compendium (European Environment Agency, 1995) shows the following information on numbers exposed to 60dB(A) around three UK airports:

Heathrow (1989)	153,000
Gatwick (1989)	5,000
Luton (1990)	16,000

These numbers have all declined in the period 1975-1990 in response to the introduction of quieter aircraft. Average data for all German airports, however, indicate that the number of people exposed to outdoor noise levels of daytime $Leq > 67$ dB(A) has increased from 500,000 to 610,000 in the period 1980-1990, and for outdoor noise levels of $Leq > 75$ dB(A) from 100,000 to 120,000. German airports are served by the same kind of "quieter" aircraft as are UK airports and yet report a trend towards more people affected by noise. Clearly more work is needed on the UK figures and more work is needed to determine the actual extent of noise disturbance around airports and under flight paths. The discrepancy between UK and German official data suggests that there are deficiencies in the UK approach to measuring aircraft noise both in the number and location of measurement stations and in the availability of actual measurements for the late 1990s. The introduction of quieter aircraft cannot be expected to compensate in all circumstances for the vigorous growth of aviation itself, for night-time flight activity, for the increase in air freight, for the spread of commercial aviation to airports that serve quite small towns and regions and for the growth of military, commercial helicopter and recreational aircraft.

Effects of noise on humans

The World Health Organisation 1993 document, "Community Noise" (WHO, 1993) reviews the international scientific evidence on the effects of noise. These include:

- Hearing impairment
- Pain
- Perceived noisiness and annoyance
- Interference with communication and speech perception
- Sleep disturbance
- Psychophysiological reactions during sleep (including effects on heart rate, finger pulse, respiration)
- Stress
- Cardiovascular effects
- Psychoendocrine effects
- Startle reflex and orienting response
- Effects on physical health (including nausea, headache, irritability, instability, argumentativeness, reduction in sexual drive, anxiety, nervousness, insomnia, abnormal somnolence and loss of appetite)
- Mental disorders
- Task performance and productivity
- Deficits in reading acquisition among children
- Effects on social behaviour (eg willingness to help others)

Some of these effects will require long term exposure to noise sources over many years (eg living in the immediate vicinity of an airport or under a flight path) whilst others will require only one event in the middle of the night (eg sleep disturbance) and it is highly unlikely that all subjects are equally susceptible to all effects. The detail is discussed in WHO (1993).

The range of effects is much wider than has been assumed in the past and the evidence from specific studies points to clear areas of health damage eg .."environments with heavy noise (are characterised by) cardiac diseases, doctors' calls and purchase of medicine more frequently than in quiet environments" (WHO, 1993, page 83). Heavy noise in this study is defined as 67-75dB(A) and quiet environments as 46-55 dB(A). Effects on school children are also noted with reading deficits and problems with cognitive development among infants and pre-school children in noisy environments (WHO, 1993, page 99). A 1995 study of school children around Munich airport (Natural Resources Defense Council, 1996) noted that those children living in areas affected by aircraft noise had poorer long-term memory recall, reading comprehension and overall tolerance levels than did children in a comparable urban environment unaffected by aircraft noise. A study around LaGuardia and JFK International airports in the US controlled for racial, socio-economic and educational factors and concluded that high levels of environmental noise are inversely related to reading ability in primary school children.

This range of problems has led the World Health Organisation to propose a range of noise standards designed to protect human health and to recognise the importance of vulnerable groups (eg school children, the sick, the elderly). These recommendations are summarised in Table 2.

Table 2 World Health Organisation recommended noise thresholds

Context	Value	Parameter
Bedroom	30	dB(A) Leq
Balconies, terraces, gardens	55	dB(A) Leq
Outdoors at night time	45	dB(A) Leq
Schools and classrooms	35	dB(A) Leq
Outdoor playgrounds	55	dB(A) Leq
Inside hospitals	35	dB(A) Leq
Single noise event in dwelling	45	dB(A) Lmax

Source: WHO (1993)

These values are thresholds that should not be exceeded. They present planners and regulatory regimes with considerable problems. More importantly they present local residents with problems. Everyone living in the vicinity of an airport or under a flight path is potentially living in a noise regime that exceeds these thresholds. Primary schools, secondary schools, hospitals and homes for the elderly are also exposed to noise levels that exceed these WHO threshold values. The growth of aviation will make the problem worse and currently there is no governmental or industry response that can guarantee

noise reductions to safe WHO levels. The final section of this report takes up this theme of delivering solutions and identifies a number of strategies that can be employed to tackle the high rates of growth of aviation and then, as public awareness increases, reduce the absolute level of passenger kilometres (and freight carried) by air transport.

3.2 Ground level air emissions

US research (Natural Resources Defense Council, 1996) shows that air pollution from cars and industry has declined with time while aircraft continue to emit more ground level ozone precursors (Volatile Organic Compounds or VOCs and nitrogen oxides or NOx) with each passing year. Airports in the US are in the top four largest emitters of NOx and VOCs (depending on location), together with power plants, the chemical industry and oil refineries. These data are not readily available in the UK where published information (eg Environment Agency) does not list airports. Airports are also significant traffic generators, freight distribution centres, taxi destinations and bus stations and are responsible for significant amounts of pollution from the exhaust emissions of land based transport. They also have large amounts of fixed and mobile generating equipment to supply aircraft with power whilst they are on the stand and large scale maintenance facilities for engines and aircraft. They are also large fuel depots with storage tanks, fuel lines and refuelling facilities all contributing evaporative emissions of VOCs to atmosphere.

The proposal to build a 5th terminal at Heathrow Airport has generated Britain's longest ever public inquiry and an impressive amount of detailed material on the environmental impact of the airport and its new terminal. This material gives an insight into the impact of an airport on emissions to atmosphere and this is summarised in Table 3 below. This table summarises emissions for four categories of pollutant and for three time points: a 1991 base year; 2016 with Terminal 5 and 2016 without Terminal 5. The 1991 base data is now rather dated but remains unrivalled in its detail and scientific validity.

Table 3 Summary of airport emissions in tonnes per annum

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NOx levels are 110% higher in 2016 (T5) compared with 1991 and 45% higher in 2016 (T4) compared with the same base year. This is a very significant increase (from an already high base line) in a pollutant which is directly associated with smog formation and with damaging human health impacts. The other pollutants (VOCs, CO and SO2) also show increases even without T5.

The scale of the emissions from Heathrow Airport can be evaluated by reference to Environment Agency data on local pollution. This information has been summarised by Friends of the Earth and is available on their web site. The data are official data from the Environment Agency and not data from Friends of the Earth or any other environmental organisation. They are presented in the form of

regional rankings of polluting factories and rankings of polluting factories by chemical released to atmosphere. In the case of VOCs Heathrow with Terminal 5 (in the year 2016) is predicted to produce 2052 tonnes of VOCs (the 1991 total for VOCs was 2224 tonnes and the reduction is due to predicted improvements in vehicle emissions). This would make it the second largest polluter for this chemical in England and Wales, after BASF on Teesside. Heathrow contributes about 10% of the England and Wales total of VOCs and yet does not figure in the Environment Agency list of point sources and is not controlled on a site basis. Airports in the UK are specifically excluded from the provisions of Integrated Pollution Control.

US data show that Kennedy Airport is the largest source of NOx in New York and the second largest source of VOCs. Both these chemicals combine to form ground level ozone which in its turn damages the respiratory system of humans and causes breathing difficulties, increased mortality and increased hospital admissions. Scientific studies reported in Natural Resources Defense Council (1996) report that exposure to ozone at "relatively low" levels significantly reduces lung function and induces respiratory inflammation in healthy people during moderate exercise. Chest pain, coughing, nausea and pulmonary congestion often accompany this decrease in lung function. Other studies cited show that "repeated exposure to ozone for months to years can produce permanent structural damage in the lungs and accelerate the rate of lung function decline. NOx also contributes to particulate matter which in the US produces 64,000 premature deaths every year".

VOC emissions include a number of toxic pollutants which in addition to their role in ozone formation at ground level have a direct impact on human health. These include formaldehyde, benzene and 1,3 butadiene. A 1993 study carried out by the US Environmental Protection Agency (EPA) concluded that these pollutants contributed to elevated rates of cancer incidence in the vicinity of Midway Airport (SW Chicago). Midway's arriving and departing planes contribute far more of these toxic pollutants than other industrial sources within a pre-defined 16 square mile study area. The EPA study estimates that aircraft engines are responsible for 10.5% of the cancer cases in SW Chicago caused by toxic air pollution. There are no studies of cancer incidence and toxic pollution around UK airports, several of which are much larger than Midway.

The impact of these pollutants on human health can be summarised as follows:

Carbon Monoxide (CO): at high levels it causes headaches, drowsiness, nausea, slowed reflexes and at very high levels, death. At low levels it can impair concentration and nervous system function and may cause exercise-related heart pain in people with coronary heart disease

Nitrogen Oxides (NOx): impair respiratory cell function and damage blood capillaries and cells of the immune system. They may increase susceptibility to infection and aggravate asthma. In children exposure may result in coughs, colds, phlegm, shortness of breath, chronic wheezing and respiratory diseases including bronchitis.

Ozone: ground level ozone reduces lung function in healthy people as well as those with asthma. It may increase susceptibility to infection and responsiveness to allergens such as pollens and house dust mites. It may cause coughs, eye, nose and throat irritation, headaches, nausea, chest pain and loss of lung efficiency and increases in the likelihood of asthma attacks.

Particulate matter (PM): strongly associated with a wide range of symptoms such as coughs, colds, phlegm, sinusitis, shortness of breath, chronic wheezing, chest pain, asthma, bronchitis, emphysema and loss of lung efficiency. As many as 15% of asthma and 7% of Chronic Obstructive Pulmonary Disease cases in the urban population are estimated to be possibly related to prolonged exposure to high concentrations of PM. Long term exposure is associated with increased risk of death from heart and lung diseases. PM may carry carcinogens such as polycyclic aromatic hydrocarbons (PAHs), hence may increase the risk of developing cancer.

Volatile Organic Compounds (VOC): This category of pollutant includes thousands of different chemicals many of which are hydrocarbons (HC). They may cause skin irritation and breathing difficulties; long term exposure may impair lung function. Many individual compounds are carcinogenic (including benzene). Benzene can cause leukaemia. Those most at risk are people exposed to benzene at work or who live or work in the vicinity of petrol filling stations or general vehicle activity.

Sulphur Dioxide (SO₂): SO₂ irritates the lungs and is associated with chronic bronchitis. People with asthma are particularly vulnerable and a few minute's exposure to the pollutant may trigger an attack. However the most serious effect occurs when SO₂ is absorbed by particulate matter which is then inhaled deep into the lungs. At high doses it can release sulphuric acid on reaction with moisture in the lungs. This can result in widespread death and illness, for example, it is likely to have been the main cause of the 4000 deaths during the notorious 1952 London smog.

Source: British Lung Foundation (1998) Transport and Pollution: the health costs

The official view of the UK government expressed in its evidence to the T5 inquiry is that aviation contributes very little to local air pollution. The US data quoted above clearly contradicts this view and local inventories of emissions around Zurich Airport and Stockholm Arlanda Airport show that aviation contributes a significant share of total emissions within a well-defined geographical area. The information for Zurich and Stockholm is available because both these airports are capped in terms of the pollutants they can produce. The Zurich data is presented below in Table 4.

Table 4 Zurich Airport: emissions to atmosphere (t=tonnes)

	Airport Regional Perimeter				Canton of Zurich			
	NO _x		HC		NO _x		HC	
Air traffic	475t	60%	380t	50%	950t	51%	415t	43%
Ground transport vehicles	105t	13%	50t	7%	705t	38%	220t	23%
Other activities (eg generators, plant and machinery)	210t	27%	330t	43%	210t	11%	330t	34%
Total Airport	790t	100%	760t	100%	1865t	100%	965t	100%
Total emissions (all sources)	2,800t		N/a		21,160t		39,390t	
Contribution of airport	28%				9%		2.5%	

Notes

Airport regional perimeter is defined as an area 9x12 kms around the airport

The Canton of Zurich is taken to mean the area covered by the internationally defined landing and take off or LTO cycle

Source: Airports and the Environment edited by Anne Paylor, MDIS Publications Ltd, Chichester, West Sussex, 1994

A report on Frankfurt Airport (Rhein-Main-Flughafens Frankfurt/Main) and its environmental impact compared the airport's contribution to total NOx, unburnt hydrocarbon, carbon monoxide and sulphur dioxide emissions in the Frankfurt area. The results are shown in Table 5.

Table 5 Frankfurt Airport's percentage contribution to total pollution in the Frankfurt area

NO2	40
CO	44
Unburnt Hydrocarbon	74
SO2	44

NB the data are from 1979

Source: Konzepte Studie zur Umweltsituation des Rhein-Main -Flughafens Frankfurt/Main, TUV Rheinland Gruppe, 1992

The Heathrow Terminal 5 Public Inquiry produced similar data from the evidence presented by the British Airports Authority (BAA). Table 6 summarises this information.

Table 6 Percentage Contribution of Heathrow Airport to annual emissions of four pollutants in the near Heathrow region

Case	NOx	CO	VOC	SO2
1991	59	45	48	76
2016 4T 50mppa	76	57	46	66
2016 4T 60mppa	77	57	46	67
2016 5T 80mppa	81	63	53	73
2016 5T 100mppa	82	61	53	74

NB The near Heathrow region is an area 8kmx6km centred on the airport, an area close to but excluding the airport

4T= four terminals (the present number)

5T= five terminals (the decision on the 5th terminal is still awaited)

mppa= million passengers per annum

Source: evidence presented by Tabitha Stebbings on behalf of the Local Authorities opposed to T5 (LAHT5) at the public inquiry

Emissions are not the same thing as air quality around airports. The evidence on air pollution around major European airports is very clear indeed. Airports are significant contributors to air pollution and to elevated levels of particulate pollutants that are known to cause damage to human health. The London Borough of Hounslow which borders on Heathrow Airport and is responsible for air pollution monitoring is of the view that "further expansion of the airport and associated road traffic congestion could lead to significant worsening of local air quality (Source: www.hounslow.gov.uk/es/monitor.html). In a press release dated 10.8.99 the same London Borough concludes "It is clear that the use of motor vehicles and the operation of Heathrow Airport heavily influence the levels of air pollution in Hounslow". Pease (1999) describes the situation around Gatwick:

"The Gatwick Study reveals a dramatic rise in aircraft derived emissions-particularly NOx. For this pollutant at least, it will mean that air quality in neighbouring Horley will remain above National Air Quality Strategy levels beyond 2005 despite the dramatic drop in road vehicle emissions....particulate pollution is high in and around Gatwick. It reaches 85mg/m3 at the centre of the airport and exceeds the 50mg/m3 guidance level for many miles beyond".

4 Larger Scale Impacts: flying and climate change

Summary: This section describes the atmospheric impact of pollution from aviation with a special emphasis on greenhouse gases and climate change. Much of this material is derived from the work of the Intergovernmental Panel on Climate Change (IPCC) and its report "Aviation and the Global Atmosphere" published in June 1999. The section is in two parts. First we look at the projected growth of pollution on a number of different scenarios and second we examine the impact of this pollution on climate change.

4.1 Projected growth of pollution

The most important pollutants in terms of their impact on the atmosphere are NOx and CO2. The total quantities of these emissions (globally) have been predicted in a number of different scenarios for the years 2015 and 2050 and this information is reproduced and discussed in more detail in the technical appendix.

The base line for these predictions is 1992 with CO2 from aviation in the range 408-565 million tonnes and NOx in the range 1.67-1.96 million tonnes. The forecasts for 2015 and 2050 are summarised in Table 7.

Table 7 Summary of predictions of emissions to 2015 and 2050

	CO2	NOx
Average of estimates for 1992	476 mt	1.78 mt
Average of 2015 forecasts	1232 mt	4.04 mt
% change 1992-2015	258%	226%
Average of 2050 forecasts	2802 mt	7.33 mt
% change 2015-2050	227%	181%
% change 1992-2050	588%	411%

All the forecasts point to large increases in the global inventory of pollutants from aviation: the percentage change for CO₂ in the period 1992-2050 is 588% or an increase by a factor of 5.88. the equivalent NO_x increase for the same period is 411% or an increase by factor of 4.11

4.2 Impacts of Emissions

Aircraft emit their exhaust gas pollutants directly in the upper troposphere and lower stratosphere. These emissions interact in these sensitive parts of the atmosphere and are responsible for changes in ozone and methane concentration thus forming contrails (see below). The specific impact on the atmosphere of aviation emissions has been the subject of several major research projects by NASA, the European Commission and the German Ministry of Research. The recent IPCC "Special Report on Aviation and the Global Atmosphere" compiled the available evidence and brought more light to the topic. The concept of radiative forcing (expressed in watts per square metre - W/m²) is used in the IPCC report to compare the effects of different pollutants and different scenarios. Radiative forcing is a measure of the contribution of aircraft emissions to climate change.

The most important aviation-derived factors influencing the atmosphere are:

- carbon dioxide
- ozone (enhanced by NO_x levels)
- methane (CH₄)
- water vapour
- contrails
- cirrus clouds
- sulphates
- soot aerosols

The IPCC special report concluded that aircraft emissions in 1992 were responsible for 3.5% of the total radiative forcing by all anthropogenic (created by people) activities. To many, this number could be seen as relatively small. However, the number is comparable with the entire impact of Canada's CO₂ emissions from all sources. A single source like aviation has the same impact and furthermore is one of the fastest growing economic sectors. In the following sections the impact of the individual factors is discussed.

Carbon dioxide

CO₂ emissions from aviation have the same impact on the climate as those from other sources: they accumulate in the atmosphere and have a direct radiative forcing effect, irrespective of the site and height of emission. Aviation today is the source of about 13% of transport-derived CO₂ emissions and 2% of CO₂ emissions from all anthropogenic sources. Transport as a whole is responsible for 25% of CO₂ emissions in the European Union. Depending on the assumed scenario this share will rise (see Table 8).

Table 8 Aviation's share of global CO₂ emissions

% of total CO ₂	1992	2015	2050
FESG a tech. 1	2.0	2.6	2.8
FESG a tech. 2	2.0	2.6	2.9
EDF a base	2.0	2.4	6.8
EDF d high	2.0	3.6	10.0

reference: IPCC special report, author's calculations

Nitrogen oxides (NO_x)

In contrast to CO₂, NO_x emissions from aircraft have a very different impact depending on the location of the emission. In the Northern hemisphere NO_x emissions from aircraft are increasing ozone concentrations at cruise level in the upper troposphere and lower stratosphere. Calculations predict increases in summer in the principal traffic areas of about 6%. Ozone is a very potent greenhouse gas.

Contrails

When modern jet aircraft burn fuel at altitudes of 10-12 km the water vapour that is produced is injected into the atmosphere where temperatures are approximately -40 C. The water vapour then freezes to produce tiny ice particles (sometimes in association with particulates) which form the familiar trails behind aircraft when viewed from the ground. These are known as "contrails". They can be long lasting depending on weather conditions and spread to a width of tens of kilometres. In frequently flown flight corridors (eg Europe and the North Atlantic) contrails can cover 5% of the sky area annually. Below the flight corridors where air traffic is concentrated, contrails could have a greater greenhouse effect than all greenhouse gas emissions together (T&E, 1999).

Conclusion

Aviation is one of the most dynamic sectors of the global economy. Technological and operational improvements lag behind its growth. The consequence will be a sustained and significant increase in emissions for the foreseeable future (CO₂ 3.3 - 13-fold increase, NO_x 2.7 - 7 fold increase by 2050). The radiative forcing of aviation may rise by a factor of 4 - 12 by 2050 compared to 1992. Aviation may be responsible for 5% - 15% of radiative forcing in 2050, compared with 3.5% today (and this forecast is a lower bound because not all potential effects are included). The threat of climate change is more important for the Northern hemisphere because of changes in ozone concentration.

5.0 The economic impact of aviation and airport development

Summary: The case for expanding airports and supporting the growth of aviation is frequently supported by evidence on the economic gains (especially jobs) associated with this growth. These arguments are examined in this section and are found to be inconsistent and flawed. Traditional economic arguments also fail to include a consideration of the economic impacts of environmental deterioration, health damage and climate change. If these considerations are factored in it may well be the case that a reduction in the demand for air travel will have positive economic benefits.

Given the established harmful environmental effects of air travel, there is a case to restrict its growth. Advocates for the aviation industry and a predict-and-provide response to rising demand often use economic arguments to resist such restriction, especially with regard to job creation, and claim that any restrictions on predicted levels of air travel will have serious effects on economic growth. The available evidence indicates that restricting expansion in air travel is unlikely to have significant negative effects on economic growth or employment, and that on the contrary there may be economic advantages accruing from such restrictions as well as environmental and quality of life gains.

The evidence

Two reports were published in 1999 dealing specifically with these issues, but which came to different conclusions:

1. *The Contribution of the Aviation Industry to the UK Economy* was prepared by Oxford Economic Forecasting (OEF) for a consortium of the UK's major airport operators and airlines and DETR.
2. *Transport and the Economy* was prepared by the Standing Advisory Committee on Trunk Road Assessment (SACTRA) for DETR. Although SACTRA's general remit deals with road transport, this report addresses the impact of all transport modes.

The OEF Report

OEF argue that there are important functional links between economic growth and aviation. These are derived from:

- the contribution aviation makes in its own right in terms of employment, production, exports, value added, investment and Exchequer contributions
- the impact aviation has on the performance of other industries as a facilitator of economic growth and rising productivity.

They produce quantitative estimates of the negative economic effects of restricting air travel, including the claim that restricting passenger growth to 3.5% per annum rather than the predicted 4% would reduce UK GDP by 2.5% by 2015, or £30 billion at 1998 prices. They estimate that over the last 10 years the impact of aviation growth in the UK economy has been to increase output in the whole economy by about £550 million per year. Their general conclusion is that there are significant economic implications of restricting the growth of aviation. They state that the environmental effects of air travel have an economic cost, but their terms of reference explicitly exclude these from their analysis.

The SACTRA Report

The SACTRA report was commissioned in 1996 "to consider the effects on the performance of the economy which might be caused by transport projects and policies, including new infrastructure, changing prices, demand measures and measures to reduce traffic". The origins of the report lie in the debate about roads and the economy but its relevance is far wider than roads: "Our terms of reference go beyond the specific questions of trunk road schemes and, therefore, the Committee has aimed at a general approach which treats even-handedly all types of transport investment or policy initiative, for all modes".

There is a statistical correlation between increased traffic flows and economic growth, but this does not necessarily mean that there is a causal link whereby improved transport facilities necessarily lead to more economic activity. The increased levels of travel could be a consequence of economic growth rather than the other way round. The SACTRA report concludes that although there are theoretical reasons why improved transport infrastructure could lead to more economic activity, the empirical evidence for this is weak. In particular, they conclude that in a mature economy with well developed transport systems such as the UK, any contribution to economic growth from improved transport is likely to be modest (para 12, p.17).

The report also concludes that it is not possible to give a complete and unbiased estimate of the economic impact of transport without an assessment of environmental costs, which the OEF Report does not do because of its terms of reference.

Finally, the report makes the point that transport improvements connect different locations and areas, and that the benefits do not necessarily accrue evenly (para 40, p.22). There may be losers as well as winners as a result of more competitive areas gaining improved access to weaker areas. Improved access could thus in some cases lead to loss of employment at particular locations. This applies at all scales from local through regional to national and international, and to all transport modes.

Evaluation

Given the different assessments of these two reports, what conclusions can be drawn concerning the economic impact of aviation? The following points are relevant.

First, the terms of reference for the OEF Report explicitly exclude consideration of environmental costs. The Report therefore presents an incomplete analysis and it is not possible to conclude whether or not the economic benefits of new investment are greater or smaller than the economic disbenefits associated with environmental damage. This introduces a significant element of uncertainty into the discussion as the economic benefits themselves may not be as large as is claimed.

Second, the OEF use their own forecasting model of the economy and input data from the UK National Accounts and other sources. Some of these data are estimates of the required variables (such as the indirect employment caused by aviation, see Appendix) and moreover the methodology used makes assumptions about the nature of the links between aviation and the economy which the SACTRA Report reveals to be complex and themselves context dependent and geographically variable. The use of these data and assumptions in a model of the national economy is therefore dubious.

Third, even within their own narrow terms of reference OEF conclude (as do SACTRA) that the economic effects of aviation do not benefit everyone everywhere to the same extent. This is particularly significant with respect to tourism. Much of the growth of air travel has been generated by tourism, 66% of all passengers using UK airports being leisure travellers. In 1997 UK air travellers abroad spent £13.4 billion whereas foreign travellers by air to the UK spent £9.9 billion, giving a deficit of £3.5 billion. If air travel were to be restricted by TDM it is possible that the net economic effect in terms of spending and employment on the UK economy would be positive.

Fourth, the aviation industry is heavily subsidised (van de Pol 1998) and given the high level of labour productivity in the industry it can be strongly argued that jobs could be created more cost effectively in other ways. Meeting predicted demand by expanding infrastructure (such as Heathrow Terminal 5) will absorb large amounts of resources which could arguably be better used in other ways. Removal of the subsidies and investment of the resources gained in more sustainable employment would have both economic and environmental advantages. Examples of subsidy in the European Union include 17.5 billion Euros per annum because there is no taxation on aviation fuel, 6.5 billion Euros because tickets are zero rated for VAT purposes and direct subsidies such as 3.4 billion Euros to Air France in 1994 and 2.11 billion Euros to Olympic Airways in the same year.

Fifth, the theoretical justifications made by OER for the links between aviation and economic growth are weak. It is claimed for example that excellent air services are a key factor in foreign direct investment (FDI) decisions and that the UK leads Europe in terms of FDI at least partly because of excellent accessibility by air. No convincing evidence has been produced to justify this claim. Good air services are necessary but any incremental enhancement from an already high level is unlikely to make a significant difference compared with other advantages that the UK offers such as language and financial incentives (Airports Policy Consortium 1999). There is a further weakness in the FDI argument which relates to regional airports. Assuming for the moment that the UK continues to be successful in terms of FDI there is a strong likelihood that regional airports will have to devote more resources and marketing effort to compete for available FDI. This will produce increases in capacity which are then used by tourists and package holidays. Liverpool airport has long used regional development arguments to support its expansion and its biggest user is now EasyJet providing very low cost tourist flights. The regional development arguments in Liverpool have increased the demand for air travel in a way that does not bring any FDI benefits.

Sixth, although the aviation industry is responsible for large numbers of jobs both directly and indirectly (180,000 and 200,000 respectively in 1998 in the UK according to OEF, see Appendix), it is an industry with high productivity (25% higher output per job than in the chemical industry according to the OEF report). The arguments in favour of aviation on job creation criteria are, as a consequence, less persuasive than for an industry that can generate more jobs more unit of investment. See the box below for a discussion of airport expansion and local economic benefits.

Taking these arguments into consideration, the bullish claims made in the OEF Report lack credibility. Moreover, given the negative economic effects of the environmental impact of aviation (for example defensive health expenditures) and the large resource take that would be required to cope with predicted levels of air travel, it is by no means clear that unrestricted growth of air travel would benefit the economy. It is more probable that a restriction of air travel would have beneficial economic effects in addition to environmental and quality of life gains. These would include the following:

- reduced defensive health expenditures as a result of reduced pollution
- a more efficient allocation of resources, especially if subsidies to aviation are reduced
- reduced congestion, labour market inflation and housing market inflation at and near major airports.

INSERT BOX:

Airport Expansion and local employment

Employment as a consequence of airport expansion can be categorised as *direct* (employment directly related to aviation services and which must be located on airport), *indirect* (employment derived from the provision of goods and services procured by the firms involved in aviation) and *induced* (employment supported by spending derived from direct and indirect employment). The easiest employment to measure is direct employment, surveyed routinely by airport operators. Indirect employment is more difficult to measure, mainly because many of the suppliers will have non-aviation business in addition to aviation business. Hotels near airports for example may have clients who are not travelling by air. The most difficult category to estimate is induced employment.

Two examples taken together illustrate the ambiguities that arise in this context. The first concerns the building of a second runway at Manchester Airport, the second the building of Terminal 5 at Heathrow. Consultants arguing in favour of Manchester's second runway estimated an induced employment of 10,000 from extra direct and indirect employment of 20,000, assuming a multiplier of 0.5. Consultants arguing in favour of Terminal 5 estimated an induced employment of 17,700 from direct and indirect employment of 65,600, assuming a multiplier of 0.27. No justifications were given for the multipliers used, but it is perhaps significant that Heathrow is located in a region of low unemployment with high labour demand whereas Manchester is located in a region where unemployment is considerably higher. Objections to the construction of Terminal 5 have come from those concerned with (amongst other matters, notably environmental costs) the effect on an already pressured local labour market of a large increase in the demand for labour; BAA's estimates of the increased employment generated by T5 have been lower than for airport expansions elsewhere. For Manchester on the other hand, the Airport Company have used high estimates of job creation as a justification for the airport expansion. There are no obvious reasons why expansion at Manchester should create more jobs pro rata than expansion at Heathrow.

6 Policy measures: the role of transport demand management in aviation

Summary: This section explores the policy measures that are available for reducing the growth in demand for air travel in line with "polluter pays" principles and the internalisation of external cost. There are a number of approaches to this policy issue including emission charges, fuel taxation and landing/seat charges. It is also important to consider any existing biases in the way that airport expansion is funded when compared to other modes and to explore the possibility of other forms of transport or technology substituting for air travel. Currently there is very little coherent aviation policy and an urgent need to fill this gap.

The continuing growth of demand for passenger and freight air travel is not inevitable. Nor can this growth remain aloof from a policy discussion. If international organisations, the European Union and national governments have agreed sustainable development strategies and/or greenhouse gas reduction strategies then it follows that aviation, like any other commercial activity, should be expected to play its part in delivering those policies. Recent years have seen major changes in land-based transport where traffic reduction is now part (even if imperfectly) of most policy agendas. The electricity supply industry is, on the whole aware of the need for conservation strategies and is supportive of strategies that reduce demand and promote renewable source of energy. The construction industry has begun to address the challenge of sustainable development within a framework informed by the need to reduce the use of virgin raw materials, increase the energy efficiency of buildings, recycle land and utilise compact city concepts (CIB, 1998). Individual organisations eg the British Council have adopted

challenging environmental policies that include a commitment to reduce the amount of flying done by their staff.

There is currently in the UK an element of incoherence in aviation policy. Existing policy dates from the mid 1980s and is out of date. The decision about whether or not to proceed with Heathrow Terminal 5 will have a considerable impact on UK aviation outside of a national policy context and regional airport studies will arrive at their conclusions without the advantages of a framework that a national aviation policy would provide. All of these factors point to the urgent need for a national policy context to be set before its main elements are put in place by the accumulation of a large number of site specific and geographically specific decisions.

In this section we propose a new approach to aviation policy (NAAP). The elements of this approach are mapped in Figure 2 and are dealt with under four main headings:

Transport demand management: pricing policies, fiscal distortions and substitution

Regulation: more stringent noise and emission standards for engines, changes in slot allocation regimes and the inclusion of airports in the Integrated Pollution Control system as set out in the 1990 Environment Protection Act

Planning: bubble concepts, s 106 agreements and surface access strategies

Information and monitoring: bring the UK up best practice with local environmental data on greenhouse gases, air pollutants and noise footprints

Transport Demand Management (TDM)

The starting point for this discussion is the logical necessity of moving towards a transport demand strategy (TDM) for aviation. There are no policies in place implying that aviation has a special, protected and unusual status in sustainable development policy and greenhouse gas reduction policy therefore it must play its part in international and national GHG reduction. It must also address the very serious issues raised in section 3 of this report. The aviation industry, however, does have some distinctive characteristics that have a bearing on the detailed design of a TDM strategy:

- 1 Aviation serves long distance markets and these are the markets where alternative forms of travel are non-existent (but a lot of aviation is well within substitutable range)
- 2 A large proportion of the demand for aviation is from tourism and leisure and the experience of this sector of travel demand (eg car use to national parks in the UK) is that TDM is more difficult than in the case of commuter travel
- 3 Aviation has deeply embedded life style connotations which both support rapid business growth and work against the arguments for TDM

None of these characteristics represent an argument against TDM. They point to the need for careful timing, education and awareness campaigns and linkage with other policy areas, especially in tourism. The growing awareness around the ecological and cultural damage caused by tourism is already

creating a climate of opinion that can embrace alternatives to the traditional flight-based package holiday. Linkages are also important in business. Business travel is an important part of business itself but many of the routine exchanges that take place in business can be achieved by substituting electronic media for the air journey. An aviation TDM policy is far more likely to prosper alongside a tourism policy that encourages alternatives to flying and a business development policy that encourages creative use of electronic media. In what follows we concentrate on aviation sector policies only.

Pricing policies

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 (European Commission, 1995), 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 a 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, 1996).

The internalisation of external costs in aviation can be achieved by a number of different methods including fuel 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 (CE, 1998) has carried out a study into the feasibility of a European-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 aviation on climate change, destruction of the ozone layer, acidification and ground level ozone formation (smog). 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 9.

Table 9 Five charge options

Insert table 4.1 from page 86 of Dutch study "A European environmental aviation charge"

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 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.

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 greenhouse gas emissions from commercial jets. This would apply to carbon dioxide (CO₂) 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 eg a fuel charge would encourage "tankering" whereby airline 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 CO₂ 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 shall 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

CO2 charge: $57,000 \times 0.3$ Euros = 17,100 Euros

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

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% 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.

Removing fiscal distortions and unfair competition

A European aviation charge is an important step in the direction of "full and fair" pricing which is an EU policy goal. It does not, however, address a number of other issues that locate aviation in a very privileged position. It is normal for airports to be connected at public expense to the public road and rail systems and for those systems to be expanded when demand rises (eg motorway widening in the vicinity of Heathrow Airport and extensive railway infrastructure to connect German airports to their adjacent city centres). More recently the industry has become involved in funding its own infrastructure requirements as in the case of the £450 million Heathrow Express service to Paddington and funded entirely by BAA.

Airlines receive large amounts of funds from their national governments for "restructuring" and air traffic control costs are funded partly if not wholly from public funds (including European Union R&D funds). These funds are direct payments as in the case of Air France and Olympic Airways and indirect as in the case of the slots at Heathrow Airport allocated to British Airways. Slots are a valuable commodity conferring historic "rights" to profitable routes and are not allocated by any market mechanism.

Aircraft research and development and manufacture is also subsidised as in the March 2000 decision of the UK government to offer approximately £500 million to British Aerospace to develop the next generation of very large aircraft. All these methods of shifting the costs of aviation away from users and on to the taxpayer whether he or she flies or not are economic distortions and should be ended together with fuel tax exemption and zero-rated VAT on airline tickets. The Dutch aviation campaigning group "Right price for Air Travel" have calculated that EU taxpayers subsidise the aviation industry by 45 billion Euros per annum (and this figure excludes surface access data because they are not available).

The European Union is deeply involved in funding the expansion of aviation facilities. The majority of this funding is from the European Investment Bank (EIB) which in 1998 provided 5.4 billion Euros in loans to transport infrastructure projects of which 1.25 billion Euros was for air and maritime transport. These loans funded increases in capacity at Hanover, Edinburgh, Heathrow, Gatwick, Bologna, Athens, Reunion and Madeira airports. They also funded airline fleet renewals in Austria, Spain, Portugal, Luxembourg and Sweden. These large sums of money are provided under very favourable terms and conditions to the aviation industry:

"the bank is prepared to extend the terms of its loans and the grace periods in respect of repayment of principal, and even payment of interest, beyond the customary limits and arrange financial engineering to help reduce the risks incurred by the various players involved, for instance by means of refinancing facilities, making advance funding available or drawing up, also in advance, framework financing agreements. A growing number of projects, especially priority schemes, have already benefited from the measures provided for under this window such as...the new Milan-Malpensa airport and Athens Spata airport.."

EIB (1998), page 22

A list of projects funded by the EIB in 1998 is included in the technical appendix. In the UK alone 152 million Euros (out of a total of 956 million Euros) was provided for expansion and modernisation at Edinburgh, Heathrow and Gatwick airports. The total of 956.9 million Euros for aviation in one year is much larger than the total loans made to all small and medium enterprises in Europe in all sectors of the economy in one year (600 million Euros).

This system of favourable loans made in support of European Union policies on transport and regional development acts as both an insulator from the normal rigours of free market financing and acts as strong force pushing up the supply of infrastructure and stimulating growth in demand. In this sense aviation does not conform in any way to a free market model of business development. The removal of these unnecessary privileges and subsidies is a key component of any strategy to reduce the demand for flying.

The European Federation for Transport and the Environment (T&E, 1998) have taken up this same theme. T&E proposes five measures for introducing sustainability into the aviation sector:

- 1 A European ban on any form of direct and indirect financial support to the aviation sector. This is line with economic theory, European Union policy and ecological efficiency
- 2 Abolition of all tax benefits for the air transport sector. This would mean the ending of VAT exemption on air tickets and the ending of aviation fuel exemption from excise duty. This is in line with competition rules and the polluter pays principle
- 3 Introduction of a European environmental aviation charge as recommended by CE (1998) and Brockhagen and Lienemeyer (1998)
- 4 Communication on the environmental effects of aviation. More information is needed on this subject especially on the internet (see for example www.benjhm.free-online.co.uk/flying/)
- 5 Tightening of aircraft emissions and noise standards. An environmental charge will stimulate technological improvements to reduce emissions but stricter standards are also needed, especially on noise which is not included in the aviation charge proposals. There should be a night time flight ban and noise landing charges with revenues feeding back into the damaged communities to stimulate progress in this area

Substitution

The market for air travel is far from homogenous and there are a number of possibilities for substituting alternative forms of transport or alternative methods of exchange for the air journey. High speed rail (HSR) transport has been the subject of a great deal of discussion in this respect (Whitelegg, Hulten and Flink, 1993). The availability of HSR in France has produced a well documented decline in internal air travel and Eurostar services between London and Brussels/Paris have had a similar effect. This substitution of rail for air journeys has not reduced the overall level of demand for air transport and is actually helpful in congested skies in allowing other forms of air transport (longer distance, package holidays) to grow faster than they would have done without the assistance of this substitution effect. More importantly the availability of high speed rail services in Germany, France, Japan, Sweden and Italy has encouraged a shift in the spatial structure of economic activity so that trips are made more frequently over longer distances than was formerly the case. In terms of sustainable development objectives the substitution of longer distance trips for shorter distance trips or two separate trips for one with an overnight stay can have negative consequences. High speed rail makes demands on land and energy consumption and there is not a straightforward environmental gain to be won from a shift from air to rail, unless that shift is associated with a fixed level of demand.

High speed rail transport in the UK as currently proposed by Virgin West Coast and Railtrack for the West Coast Main Line may well make a contribution to the reduction of domestic air trips in the UK. Equally the rejection of Eurostar services to the regions removes another possibility for shifting air journeys to rail for trips from Manchester, Liverpool, Birmingham or Newcastle and Leeds to Paris and Brussels. In the absence of measures to manage the growth of aviation in tourism and leisure the gains to be had from HSR substitution will be negated (in environmental terms) by expansion in air travel elsewhere.

The possibilities for substituting electronic means of exchange for the physical transport trip have been rehearsed in several publications (Hepworth and Ducatel, 1992; World Transport Policy and Practice, 1996). There is evidence that for many forms of interaction the use of e-mail, data transfer, video link up etc can reduce the need for physical travel especially over the distances served by air transport. It is also cheaper and makes better use of time. Evidence on the extent to which this is happening is scarce but the experience of telework in the European Union where the substitution is for the journey to work by car shows that the potential is there to be exploited when cultural and organisational issues are resolved (<http://www.telework-mirti.org>)

Regulation

There is a continuing and urgent need to develop cleaner engines and quieter aircraft (T&E, 2000) but all within a TDM framework so that the gains generated by technology are not negated by growth in numbers of aircraft. There is also an urgent need in the UK to remedy the anomaly whereby airports are excluded from the provisions of the Integrated Pollution Control system set out in the 1990 Environment Protection Act. Airports are significant sources of emissions and pollution and environmental protection would be better served by this simple change in the categories of process/activities within the remit of the IPC system. There is also a need to overhaul the system of historic "grandfather" rights at Heathrow Airport whereby valuable slots (rights to particular routes) are allocated to a particular airline. This confers substantial commercial advantages on the recipient airline(s) and acts as a stimulus for higher levels of demand for air journeys.

The Planning System

The UK sustainable development strategy makes it clear that the planning system has a major role to play in delivering sustainable development. There are indications that currently this is not happening in aviation. The public inquiries into Manchester Runway 2 and Heathrow Terminal 5 were

unsatisfactory in many respects. In the case of Manchester's second runway both the inspector and the government minister were of the opinion that the environmental damage of this development was acceptable when compared to the economic advantages of the proposal. Such a view was only possible because climate change was ignored in that discussion and exaggerated views of the economic gains were accepted without question. The land use planning system needs to change to ensure that independent auditing of economic justifications can take place at the same time as full weight is given to the climate change and human health issues. It is not acceptable that these important areas can be dismissed so easily. The global impact of the growth of aviation is a key issue when an individual proposal is under consideration.

For the same reason any growth in capacity at Heathrow Airport should be set in an overall policy context determined by the need to reduce greenhouse gas emissions and reduce local air pollution. The Terminal 5 proposal is intended to allow Heathrow to grow from 52 mppa to >80 mppa without any clear indication of the likely limits to this growth at Heathrow or in the SE of England.

More importantly there is still, in the UK, no clear guidance on what is acceptable or otherwise in terms of total emissions around an airport. There is a real need to develop what has become known as the "bubble concept" or "air quality capacity constraints" (Paylor, 1994). The bubble concept sets an overall limit for a defined geographical area around and including an airport and sets total emission limits that must not be exceeded. Such a system is currently in place in Zurich Klotten airport and Stockholm Arlanda airport. Limits are set for greenhouse gases and for NO_x and it is then up to the industry to decide its own policy on how to achieve them. This gives maximum flexibility to the industry whilst still delivering clear environmental improvements for local communities.

The planning system can also intervene (as in the case of Heathrow airport in the discussion around Terminal 5) to set terms and conditions for developments through section 106 agreements and to set demanding targets for surface access so that car use for access to airports diminishes over time. Similar demanding targets could be set for HGV traffic which is also rising very steeply to and from airports.

Monitoring and information

Bubble concepts and, indeed, basic environmental protection require improved monitoring and environmental data. It is a source of concern that it is easier to obtain these data for Frankfurt or Dusseldorf airports than it is for Manchester or Gatwick. Information on air pollution, emissions, greenhouse gases and noise footprints is an important input into the public debate about aviation and airports and is, indeed, a primary requirement of any stakeholding exercise conducted in pursuit of Local Agenda 21 strategies. Independently verified data bases that can be accessed by local residents is a minimum requirement.

7 Conclusion

The growth of aviation and its local and global impacts has created serious problems that must now be resolved. The publication in late 1999 of the United Nations review of the global environment (UNEP, 1999) showed just how serious these problems are. It would be perverse and contrary to UK and EU sustainable development policy not to find a way that can manage the impacts of aviation within a framework that reduces growth, reduces impacts and protects health and environment. We have shown that there are a number of ways in which this can be done. Aviation is not an example of the intractable international industry that cannot be part of the solution. The development of demand management in aviation should be associated with a full package of measures:

- An environmental charge based on emissions
- The ending of all subsidies and tax exemptions
- More stringent noise and emission standards for aircraft and for geographical areas around airports
- More research and best practice guidance on substitution
- Better levels of local environmental data and environmental monitoring to inform local populations about air and noise quality

These measures should be introduced in an incremental fashion to give the industry and consumers time to adjust to the changes. Incrementalism is already built into the environmental charge but will need development in the area of standards.

Education and awareness is very important indeed in aviation. There will be many airline customers who have never thought of airports and flying as an environmental problem. Information should be widely available so that these groups have the background information they need to understand the changing circumstances of aviation. Informed choice is a key component of transport demand management and environmental policy.

The latest scientific evidence on the state of the global environment (UNEP, 1999) and on the contribution of aviation to global inventories of greenhouse gases reviewed in this report point to the need for a fundamental change in public policy towards aviation. The current impact of aviation and the forecasts of future impacts bring into sharp focus the need for a policy that is based on science and that can bring about a re-positioning of aviation within the context of sustainable development and overall environmental objectives. The science is clear, the policy measures that are available are clear. All that remains to be put in place is a clear aviation policy.

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GLOSSARY

EDF= Environmental Defense Fund

IPCC= Intergovernmental panel on Climate Change

FESG= Forecast and Economic Support Group of ICAO

ICAO= International Civil Aviation Organisation

PC Airports Policy Consortium

ATM air traffic movement

BAA British Airports Authority

IATA International Air Travel Association

mppa million passengers per annum

TTWA travel to work area