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MANAGEMENT AND MITIGATION OF AIRLINE EXPOSURE TO CLIMATE CHANGE RISKS: WHY AN AIRLINE DEFAULT (OR OPT-OUT) PASSENGER OFFSET SCHEME MAKES SENSE

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Working Paper No 1, June, 2007

David Hodgkinson and Alex Coram[1]

This working paper outlines a proposal for an airline default – or opt-out – passenger offset scheme and sets out all the distinct advantages and opportunities of such a scheme for airlines.

In another working paper – *Strategies for Airlines on Aircraft Emissions and Climate Change: Sustainable, Long-Term Solutions* (www.hodgkinsongroup.com/publications) – we evaluate such strategies and conclude that airlines should seriously consider supporting mandatory participation in an emissions offset market as part of a long-term strategy package – including technological, operational and management elements – and as a sustainable solution to deal with the climate impacts of aviation.

Here, however, we suggest that, as a step prior to mandatory emissions offsets – and in any event – airlines should introduce offsetting as an airline default (or *opt-out*) passenger emissions offset scheme; advantages include enabling airlines to take action in the immediate future which begins to seamlessly absorb demands that they address the climate costs of aviation, and at little cost. It would also provide airlines with much-needed information as to public/ passenger sensibilities concerning the climate impacts of aviation and environmental charges (broadly defined) ahead of any such mandatory emissions offsets.

An **executive summary** of this paper is provided at pages 3 to 6.

13 pages of footnotes to this paper begin at page 31.

Contact details, and information about The Hodgkinson Group and the paper's authors, appear at the end of the paper.

CONTENTS

		page
Executive Summary		3
1.	**Introduction**	7
2.	**Climate change, aviation and greenhouse gas emissions**	7
2.1	Climate change	7
2.2	Aviation and climate change	11
	(a) Growth in aviation markets, numbers of passengers and numbers of aircraft	
	(b) Climate impacts of aviation	
	(c) Aviation growth trends and greenhouse gas emissions reductions: "Making room for the aviation industry"	
3.	**"Difficult challenges:" Possible airline strategies for dealing with the greenhouse gas emissions problem**	26
4.	**An airline default – or opt-out – passenger emissions offset scheme**	28
5.	**Management and mitigation of airline exposure to climate change risks: Sustainable, long-term solutions for airlines**	31
Notes and references		31
Note on authors and The Hodgkinson Group		45

EXECUTIVE SUMMARY

1. Climate change (*pages 7 to 11)*

Climate change poses an urgent and significant problem for the world. Scientific evidence now overwhelmingly shows that carbon dioxide and other greenhouse gases from human activities are changing the climate, and that this poses serious long term economic and political risks.

2. Aviation and climate change – aviation growth trends and GHG emissions reductions (*pages 11 to 25*)

Aviation is one of the fastest-growing sectors of the world economy. Over the next 20 years more than 27,000 new aircraft will be delivered; the number of air travelers will double to 9 billion over the same period. Against this background of significant growth in air travel, and as a result of increasing awareness on the part of governments and the public with regard to climate change and its possible consequences, pressure is being placed on the aviation industry - and airlines in particular - to address the climate impacts of aviation.

A number of organisations such as the Intergovernmental Panel on Climate Change (IPCC), Oxford University, the Massachusetts Institute of Technology (MIT) and the Tyndall Centre, for example, have studied the impacts of aviation on the global atmosphere. These studies, together with reports from Royal Commissions and other inquiries, make the following points clear:

- the climate change impacts of aviation are significantly worse than those of its carbon dioxide emissions alone. Further, reference to aviation being responsible for 2% of global carbon dioxide emissions is misleading as the figure (a) is based on total anthropogenic carbon dioxide emissions in *1992* (as determined by the IPCC), not 2007; (b) does not take into account aviation's non-CO_2 greenhouse gas (GHG) emissions which significantly contribute to the climate change impacts of aviation; and (c) ignores growth in air travel;

- air travel demand is growing at unprecedented rates, yet substantial reductions of aviation GHG emissions are not possible in the short to medium term;

- not only are emissions from air travel increasing significantly in absolute terms but, against a background of emissions reductions from many other sources, their relative rate of increase is even greater. Put another way, "if the [recommended] reductions in carbon dioxide emissions from ground-level activities … are achieved, and the growth in air transport projected by the IPCC materialises, then air travel will become one of the major sources of anthropogenic climate change by 2050;"

- development of alternative jet fuels and aircraft technological developments, together with the development of more efficient operational practices and more efficient air traffic management systems and processes, will only partially offset the growth in aviation emissions;

- there is presently no systematic or compulsory incentive to reduce international aviation emissions;

- without government action to significantly reduce aviation growth within the UK, for example, aviation emissions may be greater than those forecast for all other sectors of the economy. As a result, aviation may exceed the carbon target for all sectors by 2050;

- as another example, "[i]f the aviation industry is allowed to grow at rates even lower than those being experienced today, the EU could see aviation accounting for between 39% and 79% of its total carbon budget by 2050, depending on the stabilisation level chosen. For the UK, the respective figures are between 50% and 100%;"

- the level of any carbon price faced by aviation should reflect the full contribution of emissions from aviation to climate change; and

- all other sectors of the economy would have to significantly decarbonise to allow the aviation industry to grow and to continue to use kerosene.

This last point is of particular concern as it raises the very real possibility of economic – and, thus, political – conflict between the airline industry and other sectors. This has the potential for unpredictable and destabilising outcomes.

3. Airline responses to the climate change problem so far (*pages 24 to 25*)

The response of the airline industry to the climate change problem has to some extent been anomalous - that is, less proactive and more subdued - compared to that of other corporate and industry sector responses (although this is perhaps more true for North American airlines than for their European counterparts). The most common airline responses have been, broadly, as follows:

- continue - more or less - with business as normal;

- argue that the problem can – to a greater or lesser extent - be dealt with by improving air transport technology and infrastructure, by developing more efficient operational practices, and by calling for more efficient air traffic management systems and processes; and/or

- argue that a global solution should be developed, working through ICAO.

4. Possible airline action and adaptation strategies on aircraft emissions and climate change (*pages 26 to 27*)

Possible airline strategies for dealing with the greenhouse gas emissions problem include the following:

- continue with business as normal;
- improve air transport technology and develop alternative jet fuels;
- develop more efficient operational practices and call for more efficient air transport management systems and processes;
- support a cap-and-trade emissions trading scheme (ETS);
- support a cap-and-trade ETS with closed purchase of allowances;
- support a cap-and-trade ETS with open purchase of an industry allowance;
- support mandatory emissions offsets (support mandatory participation in an emissions offset market);
- introduce an airline default – or *opt-out* - passenger emissions offset scheme; and/or
- introduce taxes and charges.

Another Hodgkinson Group Working Paper (*Strategies for Airlines on Aircraft Emissions and Climate Change: Sustainable, Long-Term Solutions*, Working Paper No 2, available at www.hodgkinsongroup.com/publications) evaluates these strategies and concludes that airlines should seriously consider supporting mandatory participation in an emissions offset market as part of a long-term strategy package – including technological, operational and management elements – and as a sustainable solution to deal with the climate impacts of aviation.

5. An airline default passenger offset scheme (*pages 28 to 30)*

A further airline strategy for dealing with its greenhouse gas emissions problem is to establish voluntary passenger offsets programs. We suggest here that these programs do not go far enough and that airlines should first introduce offsetting as an airline default – or *opt-out* – passenger emissions offset scheme, with the advantages of allowing airlines to take action in the immediate future which begins to seamlessly absorb demands that they address the climate costs of aviation, and at little cost.

We also suggest that airlines should introduce such a default passenger emissions offset scheme as a step prior to, and as part of support for, mandatory participation in an emissions offset market. It would, amongst other things, provide airlines with much-needed information as to public/ passenger sensibilities concerning the climate impacts of aviation and environmental charges (broadly defined) ahead of any such mandatory emissions offsets.

1. Introduction

> *Air transportation plays a substantial role in world economic activity, and society relies heavily on the benefits associated with aviation … Its customers represent every sector of the world's economy and every segment of the world's population ... [A]viation affects the lives of citizens in every country in the world, regardless of whether they fly …*
>
> *Human-generated emissions at the Earth's surface can be carried aloft and affect the global atmosphere. The unique property of aircraft is that they fly several kilometers above the Earth's surface. The effects of most aircraft emissions depend strongly on the flight altitude and whether aircraft fly in the troposphere or stratosphere. The effects on the atmosphere can be markedly different from the effects of the same emissions at ground level …The rate of growth in aviation CO_2 emission is faster than the underlying global rate of economic growth, so aviation's contribution … to total emissions resulting from human activities is likely to grow in coming years*.

- Intergovernmental Panel on Climate Change (IPCC),
Aviation and the Global Atmosphere[2]

Against a background of significant growth in air travel and aviation markets, and as a result of government and public focus on climate change and its consequences, pressure is being placed on airlines to reduce their greenhouse gas emissions. After examining the risks posed by climate change, this paper outlines the climate impacts of aviation and the difficult and unique challenges faced by airlines in dealing with their greenhouse gas emissions problem. Possible airline strategies for dealing with this problem are then listed – a separate Hodgkinson Group paper assesses and evaluates those strategies – and the introduction of offsetting as an airline default (or *opt-out*) passenger emissions offset scheme proposed.

2. Climate change, aviation and greenhouse gas emissions

2.1 Climate change

Scientific evidence now overwhelmingly shows that carbon dioxide and other greenhouse gases from human activities are changing the climate, and that this poses serious long term economic and political risks.[3] Climate change poses an urgent and significant problem for the world.[4] Put another way, climate change "is one of the greatest challenges of modern times."[5]

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), "Climate Change 2007: The Physical Science Basis," (Working Group I) concludes that

> [g]lobal atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values … The global increases in carbon dioxide concentration are due primarily to fossil fuel use and land use change ….[6]

The IPCC has a "very high confidence"[7] that the globally averaged net effect of human activities since 1750 has been one of warming.[8]

Further,

> [w]arming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level … At continental, regional and ocean basin scales, numerous long-term changes in climate have been observed. These include changes in Arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves and the intensity of tropical cyclones.[9]

The IPCC finds that "[m]ost of the observed increase in globally averaged temperatures since the mid-20th century is *very likely*[10]due to the observed increase in anthropogenic greenhouse gas concentrations … Discernible human influences now extend to other aspects of climate, including ocean warming, continental-average temperatures, temperature extremes and wind patterns."[11]

Following its summary of the physical science basis of climate change, the IPCC in April, 2007 released its assessment "of current scientific understanding of impacts of climate change on natural, managed and human systems, the capacity of these systems to adapt and their vulnerability:"[12] The IPCC concluded that "[s]ome large-scale climate events have the potential to cause very large impacts"[13] and that

> [o]bservational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate change, particularly temperature increases … Much more evidence has accumulated over the past five years to indicate that changes in many physical and biological systems are linked to anthropogenic [man-made] warming …[14]

The extent of future vulnerability to climate change depends on "development pathways" taken.[15] More extensive adaptation than is presently taking place is needed in order to reduce vulnerability to, and the projected impacts of, future climate change. Sustainable development "can reduce vulnerability to climate change by enhancing adaptive capacity and increasing resilience." Over the long term, climate change effects will likely exceed the capacity of natural, managed and human systems to adapt which

> suggests the value of a portfolio or mix of strategies that includes *mitigation*, adaptation, technological development … and research. Such portfolios could combine policies with incentive-based approaches, and actions at all levels from the individual citizen through to national governments and international organizations.[16]

The May, 2007 IPCC Working Group III report, "Climate Change 2007: Mitigation of Climate Change,"[17] finds that global greenhouse gas (GHG) emissions increased 70% between 1970 and 2004[18] and that, with "current climate change mitigation policies and related sustainable development practices, global GHG emissions will continue to grow over the next few decades."[19] With regard to mitigation in the short and medium term,[20] the report found "much evidence" from both bottom-up and top-down studies that "there is substantial economic potential for the mitigation of global GHG emissions over the coming decades, that could offset the projected growth of global emissions or reduce emissions below current levels."[21]

IPCC Working Group III considers key mitigation technologies and practices that are (a) currently commercially available; and (b) projected to be commercialised before 2030. In the transport sector there are multiple mitigation options, but the effect of those options "may be counteracted by growth in the sector." Such mitigation options "are faced with many barriers, such as consumer preferences and lack of policy frameworks."[22] In terms of the aviation sector,

> [m]edium term mitigation potential for CO_2 emissions … can come from improved fuel efficiency, which can be achieved through a variety of means, including technology, operations and air traffic management. However, such improvements are expected to only partially offset the growth of aviation emissions. *Total mitigation potential in the sector would also need to account for non-CO_2 climate impacts of aviation emissions*.[23]

For aviation, in terms of key mitigation technologies and practices either currently available or projected, the report only refers to projected higher efficiency aircraft.[24] Further, when the report considers "selected sectoral policies, measures and instruments that have shown to be environmentally effective in the respective sector in at least a number of national cases," no aviation examples are available or provided.[25]

With regard to policies, measures and instruments to mitigate climate change, "a wide variety of national policies and instruments are available to governments to create the incentives for mitigation action" and there are advantages and disadvantages for any given instrument. For example, taxes and charges can set a price for carbon but cannot guarantee any particular emissions level. Similarly, emissions permits establish a carbon price through market mechanisms. However, "[t]he volume of allowed emissions determines their environmental effectiveness, while the allocation of permits has distributional consequences. Fluctuation in the price of carbon makes it difficult to estimate the total cost of complying with emission permits."[26]

Finally, "policies[27] that provide a real or implicit price of carbon could create incentives for producers and consumers to significantly invest in low-GHG products, technologies and processes."[28] And within each industry sector, "an effective carbon price signal could realize significant mitigation potential."[29]

Climate change, then, "presents very serious global risks."[30] In November, 2006 Sir Nicholas Stern's *The Economics of Climate Change* (the Stern Review) concluded in part that "climate change is a serious global threat, and it demands an urgent global response."[31] It finds that

> Climate change will affect the basic elements of life for people around the world – access to water, food production, health, and the environment. Hundreds of millions of people could suffer hunger, water shortages and coastal flooding as the world warms … Our actions now and over the coming decades could create risks of major disruption to economic and social activity, on a scale similar to those associated with the great wars and the economic depression of the first half of the 20th century.[32]

The Stern Review concludes that three policy elements are required for an effective global response to global warming and the resulting climate change (what the Stern Review refers to as "the greatest market failure the world has ever seen"[33]):

- the pricing of carbon (implemented through tax, trading or regulation);
- policy to support innovation and deployment of low-carbon technologies; and
- the removal of barriers to energy efficiency and to inform and educate individuals about responses to climate change.[34]

Both the Stern Review and prominent scientists refer to "dangerous" climate change. In the *Proceedings of the National Academy of Sciences*, published just before the release of the review, in September, 2006, scientists conclude

> data suggests that … probably the planet as a whole … is approximately as warm now as at the Holocene maximum and within ~1C of the maximum temperature of the past million years. We conclude that global warming of more than ~1C, relative to 2000, will constitute "dangerous" climate change as judged from likely effects on sea level and extermination of species ...[35]

The Tyndall Centre for Climate Change Research has said that avoiding dangerous climate change may ultimately require industrialised nations to cut emissions by between 80% and 95%.[36] And a 2006 report which builds on the scientific findings presented at the International Symposium on Stabilisation of Greenhouse Gas Concentrations - a conference attended by more than 200 scientists and representatives from international organisations and national governments, representing some 30 countries – examines "the long-term implications of different levels of climate change for different sectors and for the world as a whole."[37] The report, *Avoiding Dangerous Climate Change*,[38] finds that, since the release of the IPCC's Third Assessment Report in 2001,

> [t]here is greater clarity and reduced uncertainty about the impacts of climate change across a wide range of systems, sectors and societies. In many cases the risks are more serious than previously thought … Adaptation and alternative development pathways

> need to be taken into account in developing strategies to avoid dangerous anthropogenic climate change.[39]

The IEA *World Energy Outlook 2006* states that, on current energy trends, CO_2 emissions will increase by 55% between 2004 and 2030.[40] As the summary of the conference report makes clear, this "means that the world will, in the absence of urgent and strenuous mitigation actions in the next 20 years, almost certainly be committed to a temperature rise of between about 0.5 C and 2 C relative to today by 2050."[41]

A dwindling number of governments and corporations still claim that the scientific debate is not over and that action to combat climate change is not necessary, or that it is not necessary for the immediate future. These claims are, in mid-2007, no longer credible. The Royal Society, the UK's national academy of science, recently accused Exxon of misleading the public into thinking that the role of humans in climate change was still open to doubt, and of misrepresenting scientific opinion, including that expressed in an IPCC report.[42]

2.2 Aviation and climate change

(a) Growth in aviation markets, numbers of passengers and numbers of aircraft

> *[T]he airline industry is poised for an almost unprecedented boom, as a new generation of planes is combining with better business models and huge volume growth in new markets.*[43]

Air transport "is one of the fastest-growing sectors of the world economy."[44] 2006 and 2007 forecasts by Airbus, Boeing and the Airports Council International (ACI) demonstrate that there will be almost unprecedented growth in aviation markets and passenger and aircraft over the next 20 years (Boeing and Airbus) and in the number of air travellers to 2025 (ACI).

Boeing's July, 2006 forecast for 2006-2025 (its most recent[45]) is for an annualised global passenger traffic growth rate of 4.9% and cargo growth rate of 6.1% against worldwide average economic growth of 3.1%.[46] Boeing forecasts estimate that just over 27,000 new aircraft will be delivered over the next 20 years (more than doubling the current worldwide fleet of aircraft) for a total value of USD 2.6 trillion.[47] Similarly, Airbus' forecast, released at the end of 2006, stated that 22,700 new aircraft will be needed to met demand through 2025.[48]

ACI's 2007 forecast stated that the number of air travellers will double by 2025 to more than 9 billion per year; over the same period, air freight will triple.[49] Passengers travelling through its airports will grow at an average annual rate of 4%. The International Air Transport Association (IATA) forecasts international passenger traffic growth in the period 2006-2010 of 6.9% (Middle East), 5.7% (Asia Pacific) and 5.1% (Africa). For the same period, in the same regions, IATA's 2007 forecasts for international cargo growth are, respectively, 5.8%, 6% and 5%.[50]

Aviation growth will be most significant in the Asia Pacific region.[51] Indeed, for ACI, Asian air travel will increase 9% annually.[52]

It should be noted that, notwithstanding forecast growth in aviation markets and passenger and aircraft numbers, and strong 2006 revenues, a weakening of the global economy could adversely affect aviation industry performance. Potential aircraft overcapacity – record aircraft orders – may be problematic,[53] as could oil price rises.

This is a time, then, of significant actual and forecasted aviation growth in the aviation sector. Section 2.2(c) of this paper explores some of the difficulties in addressing the climate impacts of aviation at a time of such growth, specifically "how to make room for the aviation industry?"[54] In order to address this question, close consideration must be given to the actual climate impacts of aviation; this is expounded in section 2.2(b).

(b) Climate impacts of aviation[55]

A number of reports assessing the impacts of aviation on the global atmosphere, beginning with the 1999 IPCC report, are considered below. The footnotes refer to additional reports which also consider the climate impacts of aviation.

→ IPCC, *Aviation and the Global Atmosphere* (1999)[56]

In its 1999 report, the IPCC concluded that *in 1992* emissions of carbon dioxide by aircraft represented about 2% of total anthropogenic (or man-made) carbon dioxide emissions[57] about 13% of carbon dioxide emissions from all transportation sources.[58] However, during flight, in addition to carbon dioxide, aircraft engines also emit nitric oxide and nitrogen dioxide (together, NOx, which form ozone[59] at altitude), as well as oxides of sulphur, water vapour (resulting in contrails and cirrus clouds at altitude), hydrocarbons and particles. Uniquely, most of these emissions occur far above the earth's surface:[60]

> [a]ircraft emit gases and particles directly into the upper troposphere and lower stratosphere where they have an impact on atmospheric composition. These gases and particles alter the concentration of atmospheric greenhouse gases, including carbon dioxide (CO_2), ozone (O_3), and methane (CH_4); trigger formation of condensation trails (contrails); and may increase cirrus cloudiness - all of which contribute to climate change.[61]

Aircraft emissions of nitric oxide and nitrogen dioxide "are more effective at producing ozone in the upper troposphere than an equivalent amount of emission at the surface. Also increases in ozone in the upper troposphere are more effective at increasing *radiative forcing* than increases at lower altitudes."[62]

A 2006 Oxford University report by Cairns and Newson states:

> The combined effect of these other emissions is to add significantly to the climate change impacts of aviation, *over and above those caused by its CO2 emissions alone*.[63] The fact that aviation's climate impacts are 'significantly worse' than those caused by its carbon dioxide emissions is scientifically *uncontroversial*.[64]

Put another way, as stated in the May, 2007 IPCC Working Group III report, "Climate Change 2007: Mitigation of Climate Change,"[65] total climate change mitigation potential in the aviation sector "would also need to account for non-CO_2 climate impacts of aviation emissions."[66] Importantly, in an aviation context, "CO_2 is not the only gas"[67] that contributes to climate change.

As summarised in the report of a workshop held at MIT in June, 2006, which considered the impacts of aviation on climate change, "[a]ircraft emissions can alter the radiative budget of the Earth and contribute to human-induced climate change through several different ways."[68]

In order "to estimate the relative and absolute importance of various activities and emissions on climate,"[69] the IPCC uses the *climate metric* known as "radiative forcing," which is a globally averaged measure of the imbalance in radiation caused by the sudden addition of the activity or emission.[70] In the IPCC's calculation,

> [t]he Radiative Forcing Index (RFI) - the ratio of total radiative forcing to that from CO2 emissions alone - is a measure of the importance of aircraft-induced climate change *other than that from the release of fossil carbon alone*. In 1992, the RFI for aircraft is 2.7.[71]

As a result, "[t]he best estimate of the radiative forcing in 1992 is … about 3.5% of the total radiative forcing by all anthropogenic activities"[72] The 2002 Royal Commission on Environmental Pollution's *The Environmental Effects of Civil Aviation in Flight* confirmed this estimate.[73]

The major, large-scale environmental problem associated with the continuing expansion of aviation is the forcing of climate change.[74] While the IPCC calculations set out above refer to 1992, the IPCC also examined a range of growth scenarios for aviation to 2050. It concluded as follows:

> Over the period from 1992 to 2050, the overall radiative forcing by aircraft (excluding that from changes in cirrus clouds) for all scenarios in this report is a factor of 2 to 4 larger than the forcing by aircraft carbon dioxide alone. The overall radiative forcing for the sum of all human activities is estimated to be at most a factor of 1.5 larger than that of carbon dioxide alone.[75]

The 2002 Royal Commission on Environmental Pollution considered the IPCC's calculations to be conservative:

> In summary, we consider that the IPCC reference value for the climate impact of aviation is more likely to be an under-estimate rather than over-estimate. We conclude that, unless there is some reduction in the growth in the sector, or technology improves considerably more than was assumed by IPCC, by 2050 aviation will be contributing at least 6% of the total radiative forcing consistent with the necessary stabilisation of climate. A safer working hypothesis is that it will be in the range 6% - 10%.[76]

As the report of the workshop held at MIT (which considered the impacts of aviation on climate change) notes, "there has been no comprehensive attempt [since the 1999 IPCC aviation report] to update the science and the associated uncertainties [of the impacts of aviation on the global atmosphere]," although new information has become available.[77] That report, *Workshop on the Impacts of Aviation on Climate Change: A Report of Findings and Recommendations*, is considered further below.[78]

→ United States GAO,[79] *Aviation and the Environment: Aviation's Effects on the Global Atmosphere Are Potentially Significant and Expected to Grow* (2000)[80]

The United States General Accounting Office (GAO) states at the outset of its report that aviation "is one of the fastest-growing sectors of the world economy" and, thus, "the impact of aircraft emissions on the earth's atmosphere and climate is a concern for transportation planners and policymakers."[81] It concludes that aviation emissions "comprise a potentially significant and growing percentage of human-generated greenhouse gases and other emissions that are thought to contribute to global warming."[82]

For the GAO, aircraft emissions are potentially significant because:

- jet aircraft are the main source of human emissions released directly into the upper atmosphere;
- emissions (carbon dioxide and other gases and particles emitted by aircraft[83]) could have 2 to 4 times the effect of CO_2 alone on the atmosphere; and
- the IPCC concluded that "the increase in aviation emissions attributable to a growing demand for air travel would not be fully offset by reductions in emissions achieved through technological improvements alone."[84]

The GAO's conclusion is based on its assessment of the 1999 IPCC report – like other studies and reports considered here - together with "consultations with knowledgeable agency officials and other experts."[85] It also notes that while aviation, scientific and environmental experts argue that aviation will grow on a global basis and increasingly contribute to human-generated emissions, those experts differ "in the rates of growth they project and the effects they anticipate."[86]

→ Royal Commission on Environmental Pollution, *The Environmental Effects of Civil Aviation in Flight* (2002)[87]

This report is considered above in the context of the IPCC assessment.

→ Waitz et al, *Aviation and the Environment* (2004)[88]

The report by Waitz et al – a report to the United States Congress – states that there is "a compelling case for urgent national [US] action to address the environmental effects of air transportation" and notes that "environmental concerns are strong and growing."[89] It notes that, "[a]s a result of growth in air transportation, emissions of many pollutants from aviation activity are increasing against a backdrop of reductions from many other sources,"[90] and that

> non-US concerns and regulatory action are increasingly setting conditions for the world's airlines and manufacturers. For example, within the European Union the climate effects of aviation are identified as the most significant adverse impact of aviation … However, there is considerable uncertainty in assessing the climate effects of aircraft …[91]

Further, "[b]ecause of the uncertainty in understanding the impacts of aviation on climate, appropriate technological, operational and policy options for mitigation are also uncertain."[92] Such uncertainties have, since the 2004 report, been reduced, just as "[s]ince the IPCC study, the scientific understanding of some of the chemical and physical effects (particularly contrails and the cirrus clouds they may induce) has evolved."[93]

The report cites the 1999 IPCC report[94] and the Royal Commission on Environmental Pollution.[95] and summarises the challenge of reducing aviation environmental impacts as follows:

> Reducing significant aviation environmental impacts in absolute terms is a challenging goal, especially when considered in light of the projected growth in aviation traffic … [and] these reductions will be difficult to sustain as traffic grows. Further, there are areas (such as NOx emissions) where technological improvements and operational procedures combined have not been enough to offset the increase in emissions associated with traffic growth.[96]

→ Sausen et al, *Aviation Radiative Forcing in 2000: An Update on IPCC* (1999) (2005)[97]

In general terms, Sausen et al confirm the IPCC conclusion that the total radiative forcing due to aircraft is 2 to 4 times that due to carbon dioxide emissions alone.[98]

→ Cairns and Newson, *Predict and decide: Aviation, climate change and UK policy* (Environmental Change Institute, University of Oxford) (2006)[99]

While this University of Oxford report assesses the implications of aviation growth in the UK, it presents at the outset a summary of existing statistics about the scale of aviation's contribution to climate change. One report summarised, that of the IPCC, is considered above. Another, a 2004 UK Department for Transport (DfT) White Paper, *The Future of Transport*, states that

> If UK aviation is defined as all domestic services plus all international departures from the UK, then the aviation sector currently contributes about 5.5% of the UK's CO2 emissions but, because of radiative forcing, 11 per cent of total UK climate change impact. [100]

For Cairns and Newson, the authors of the report,

> studies of the emissions from aviation all indicate that its climate impacts are considerably worse than the effects of its CO2 emissions alone. Moreover, the non-CO2 emissions have a powerful short-term impact on climate. This could be particularly important, given the urgent imperative to address climate change in the short-term to avoid runaway climate change.[101]

They conclude that

> [b]y 2050, the most *conservative estimate*[102] of aviation's future significance … suggests that, between 1990 and 2050, the carbon dioxide emissions from aviation will approximately quadruple. Other forecasts suggest that the carbon dioxide from aviation could grow by more than 10 times over that period … In addition to carbon dioxide, aviation emits other substances which have a range of additional climate impacts. One estimate suggests that, *in a period of 12 months*, the damage caused by CO2 contrails and NOx emissions from aviation is 36 times as bad as that caused by CO2 alone … [T]here is no doubt that the non-CO2 emissions from aviation add significantly to the climate impacts of aviation …[103]

→ Tyndall Centre for Climate Change Research, Anderson et al, *Growth Scenarios for EU & UK Aviation: Contradictions with Climate Policy* (Tyndall Centre for Climate Change Research) (2006)[104]

Both the IPCC report, *Aviation and the Global Atmosphere*,[105] and the Royal Commission on Environmental Pollution, *The Environmental Effects of Civil Aviation in Flight*,[106] are referenced here. With regard to the IPCC study, it finds that the reference scenario used to produce the IPCC's estimate of radiative forcing from aircraft[107] in 2050 (versus 1992) – about 14% of the total radiative forcing for 1992 – "assumes both lower aviation growth than that seen in the period up to 11 September 2001, and large technological advances."[108] It cites with approval the Royal Commission on Environmental Pollution's finding that "the IPCC reference value for the climate impact of aviation [is] more likely to be an under-estimate than an over-estimate of aviation's contribution to radiative forcing."[109] And the study takes account of the IPCC's calculation of the radiative forcing caused by aviation emissions as 2.7 times higher than the radiative forcing of CO_2 emissions alone, but also provides estimates that don't take account of that 2.7 factor.[110]

The Tyndall Centre's conclusions with regard to aviation growth scenarios and trends as set out in this study, together with the conclusions of other studies, are outlined at section 2.2(c) below.

→ Next Generation Air Transportation System/Joint Planning and Development Office (NGATS/JPDO) Environmental Integrated Product Team and Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER), *Workshop on the Impacts of Aviation on Climate Change: A Report of Findings and Recommendations* (2006)[111]

The penultimate report examined here, one of the findings and recommendations of the June, 2006 MIT workshop on the impacts of aviation on climate change, has been referred to above in footnotes qualifying and expanding on some of the earlier reports considered in this working paper, and is referred to again below in the context of aircraft technological developments. The report also deals with a number of reports and studies which have been considered in this paper.

The report makes findings in three areas:

- emissions in the upper troposphere and lower stratosphere (UT/LS) and resulting chemistry effects;
- contrails and cirrus; and
- climate impacts and climate metrics.

With regard to emissions in the UT/LS, the report notes that, since the 1999 IPCC report, substantial improvements have been made "in the chemistry-transport modeling tools used to evaluate the impacts of aviation NOx emissions on O_3 and CH_4."[112] Nonetheless, it identifies uncertainties and gaps in evaluating aviation effects on climate, including:

- aircraft emissions of gases and particles;
- the fundamental NO_X and HO_X chemistry of the upper troposphere;
- lightning NO_X;
- plume processing of aircraft NO_X in the first 24 hours;
- coupling and feedbacks of tropospheric CH_4-CO-OH-O_3;

- climate change;
- "scavenging;" and
- transport and "mixing."[113]

With regard to contrails and cirrus,

> Aircraft-induced contrail-cirrus add significantly to the natural high cloud cover and have the potential, albeit with large uncertainties, for a relatively large positive radiative forcing (direct effect). Line-shaped contrails are only a portion of the total climate impact of aviation on the cloudiness. Recent correlation analyses between real-time regional-scale air traffic movements and the occurrence of contrail structures detectable with satellites, suggest the global coverage of persistent, spreading contrails (contrail-cirrus) and inferred radiative forcing might be underestimated by an order of magnitude or more, but large uncertainties remain.[114]

In terms of those uncertainties – and gaps – in contrail-cirrus and other aircraft-induced effects on cirrus clouds, they include plume particle processing; optical properties of contrails, contrail-cirrus and cirrus; detection and prediction of ice super-saturation; in-situ measurements of aerosol chemistry and small ice crystals; properties of heterogeneous ice nuclei from natural and anthropogenic sources; interactions between heterogeneous ice nuclei and cirrus clouds; incorporation of effects of aviation-induced particles and cirrus into global models; representation of aerosols and contrails in global atmospheric models; and long-term trends in contrail-cirrus and cirrus.[115]

The third part of the report deals with climate impacts and climate metrics.[116] Uncertainties and gaps identified include optical properties of contrails, contrail-cirrus, and cirrus, as well as defining metrics for trade-offs. Further,

> There remain significant uncertainties on almost all aspects of aircraft environmental effects on climate, with the exception of the radiative forcing from the CO2 emissions. The ozone and methane RFs from NOx emissions are opposite in sign, so the extent to which they offset each other is an important uncertainty. Estimates for contrails and cirrus are particularly highly uncertain … The overall conclusion from … analyses is that significant uncertainties still remain in quantifying the impacts of aviation emissions on climate.[117]

→ Stern, *The Economics of Climate Change* (the Stern Review) (2006)[118]

The Stern Review was considered above in the context of climate change generally. One conclusion of the review is that it will become increasingly important to extend the coverage of carbon pricing and other measures to international aviation, and that "there is currently no incentive to reduce international aviation emissions."[119]

In terms of the climate impacts of aviation, the Stern Review finds that "CO_2 emissions from aviation are expected to grow over three-fold in the period to 2050, making it among the fastest growing sectors"[120] and that, between 2005 and 2050, "emissions are expected to grow fastest from aviation (tripling over the period, compared to a doubling of road transport emissions)."[121] It also finds that international aviation emissions are almost twice as great as domestic emissions and, most importantly for present purposes, that aviation's impact on climate change is higher than simply the impact of its CO_2 emissions[122] (in this the review reflects similar findings in other studies referred to above), stating that

> the impact of aviation on climate change is greater than … figures suggest because of other gases released by aircraft and their effects at high altitude. For example, water vapour emitted at high altitude often triggers the formation of condensation trails, which tend to warm the earth's surface. There is also a highly uncertain global warming effect from cirrus clouds (clouds of ice crystals) that can be created by aircraft.[123]

The review cites the IPCC figures concerning the radiative forcing of aviation as 2 to 4 times greater than the effect of CO_2 emissions alone.[124]

On the non-CO_2 effects of aviation, Stern notes that "there is no internationally agreed methodology for presenting the warming effects of emissions from aviation as CO_2e so it is excluded from emission estimates."[125] The lack of an agreed international methodology gives rise to one of the key issues flowing from any study of the climate impacts of aviation: How to take account of the full contribution of aviation to climate change, not simply the impact of CO_2 emissions alone?[126]

Stern puts forward a number of possible solutions to this issue, among them setting high carbon taxes on aviation[127] and either inclusion of aviation in an existing emissions trading scheme or a closed aviation scheme:

> To account for the complete impacts of aviation within an ETS, some form of discounting could be used, analogous to the global warming potential factors that are used to convert GHG emissions to CO2 equivalent emissions. Alternatively, combining emissions trading with a tax could provide extra revenue.[128]

Put another way,

> [t]he level of the carbon price faced by aviation *should reflect the full contribution of emissions from aviation to climate change* … [T]he impact of aviation is two to four times higher than the impact of the CO2 emissions alone. This should be taken into account, either through the design of a tax or trading scheme,[129] through both in tandem, or by using additional complementary measures.[130]

The question as to how to reconcile aviation growth trends with effective, long-term climate policy is dealt with in another Hodgkinson Group paper, *Strategies for Airlines on Aircraft Emissions and Climate Change: Sustainable, Long-Term Solutions*.

(c) Aviation growth trends and carbon emissions reductions: "Making room for the aviation industry"[131]

> *If the reductions in carbon dioxide emissions from ground-level activities recommended in the Commission's Twenty-Second Report*[132] *are achieved, and the growth in air transport projected by IPCC materialises, then air travel will become one of the major sources of anthropogenic climate change by 2050.*
>
> - Royal Commission on Environmental Pollution, *The Environmental Effects of Civil Aircraft in Flight*[133]

In section 2.2(a), Airbus, Boeing, IATA and ACI forecasts with regard to growth in aviation markets, numbers of passengers and numbers of aircraft made were outlined. In section 2.2(b), a number of reports assessing aviation's contribution to climate change were considered. This section briefly examines difficulties - or dilemmas - in addressing the climate impacts of aviation at a time of significant aviation growth, both actual and forecast. For this purpose, the UK and the EU are used as examples. As this paper is part of an ongoing project which examines airline strategies on climate change in greater detail, a subsequent report which sets out the results of such examination will look at jurisdictions additional to the UK and the EU.

→ Cairns and Newson, *Predict and decide: Aviation, climate change and UK policy* (Environmental Change Institute, University of Oxford) (2006)[134]

The Cairns and Newson report considered earlier at section 2.2(b) summarises a number of UK reports[135] and makes findings with regard to aviation CO_2 emissions and how they relate to UK emissions targets. From those reports it is clear that aviation emissions doubled between 1990 and 2000[136] and that, without the application of what Cairns and Newson term "economic instruments," aviation emissions

> are forecast to at least double again between 2000 and 2050, meaning that they will quadruple during a period in which overall UK emissions are aiming to reduce by 60% … By 2050, other sectors would have to reduce their emissions by even more than forecast – specifically, by about 71% - in order to compensate for the growth in aviation.[137]

A summary of data from studies in 2003 and 2004,[138] 2005[139] and 2006[140] produces the conclusion that, by 2050, aviation CO_2 emissions would have increased by between 4 and 10 times compared to 1990 levels and, hence, "aviation could account for between 27% and 67% of all UK target emissions by that point, requiring other sectors to cut their emissions by between about 71% and 87% of 1990 levels."[141]

The non-CO_2 climate effects of aviation were outlined at section 2.2 (b).

Cairns and Newson conclude as follows:

> [T]he carbon dioxide emissions from aviation are forecast to reach between 17.4 million and 44.4 million tonnes of carbon, at a time when the UK is attempting to limit the carbon emissions of all its activities to only 65 million tonnes of carbon. In addition, *the impacts of aviation will be significantly worse than those of its carbon dioxide emissions alone*. Hence, the implication is that a significant reduction in the projected growth of aviation is required and it will be impossible to reduce the UK's climate change impacts to the extent needed to meet international aspirations unless action is taken to curb aviation growth.[142]

Thus, the study concludes that there is an urgent need to introduce a policy of "demand restraint."[143]

→ Tyndall Centre for Climate Change Research, *Decarbonising the UK: Energy for a Climate Conscious Future* (Tyndall Centre for Climate Change Research) (2005)[144]

The Tyndall Centre study produces a number of "decarbonising the UK" scenarios with the aim of providing "a whole system understanding" of how the UK government can achieve a "true" 60% CO_2 reduction target by 2050.[145] With regard to aviation, its research "clearly demonstrates" that, absent government action to significantly reduce aviation growth, emissions from aviation will outstrip carbon reductions envisaged for all other economy sectors[146] - what it calls (with reference to both the UK *and the EU*) "a looming problem in the skies."[147]

In terms of its UK aviation scenario, the study states current aviation industry growth of about 8% per annum. Contrasting emission reduction profiles for both 550 and 450 ppmv atmospheric concentration of CO_2 with increasing aviation emissions,[148] it concludes that there are "severe" implications of allowing even "moderate" growth in aviation for the UK's carbon reduction obligation; 50% of the 550ppmv emissions is subsumed by aviation, and as against a 450ppmv stabilisation level, aviation "will exceed the carbon target *for all sectors* by 2050.[149] For more than any other industry sector, aviation "with its continued reliance on kerosene and its high growth rate, threatens the integrity of the UK long-term climate change target."[150] Moreover, it concludes that

> The [2003 UK Government's Aviation] White Paper supports continued aviation growth, with plans for new runways at Birmingham, Edinburgh, Stansted and Heathrow airports,[151] along with new terminals and runway extensions throughout the UK.[152] Within the earlier 2003 Energy White Paper, the UK Government outlined its plans to reduce carbon emissions by 60% by 2050. However, given the absence of an international agreement on how to apportion aviation emissions between nations, only domestic aviation emissions were included within this 60% target. Omitting the fastest growing emissions sector from the target cannot be reconciled with the Government's claim that the target relates to stabilising carbon dioxide concentrations at 550ppmv. In other words, international aviation must be included if the UK Government is to make its 'fair' contribution towards the 550ppmv target."[153]

In terms of its EU aviation scenario, the study states current aviation industry growth at mean of 7.7% per annum. Contrasting emission reduction profiles for both 550 and 450 ppmv atmospheric concentration of CO_2 with increasing aviation emissions, it concludes that the EU 25's aviation sector takes up almost 40% of the total permissible emissions for all sectors in 2050 (the 550ppmv regime) and as much as 80% (the 450ppmv regime).[154] The projections "highlight … the conflict between a contracting carbon target and the EU's expanding aviation industry."[155]

After finding that technical and operational improvements will only offer small reductions in fuel burn, the Tyndall study further finds that the aviation industry "is in the unenviable position of *seeing the demand for its services grow at unprecedented rates, whilst at the same time being unable to achieve substantial levels of decarbonisation in the short to medium-term*."[156] Moreover, the Tyndall Centre views as revealing

> the enormous disparity between both the UK and EU positions on carbon reductions and their singular inability to seriously recognise and adequately respond to the rapidly escalating emissions from aviation. Indeed, the UK typifies the EU in actively planning and thereby encouraging continued high levels of growth in aviation, whilst simultaneously asserting that they are committed to a policy of substantially reducing carbon emissions. The research conducted within this project not only quantifies the contradictory nature of these twin goals, but also illustrates how constrained the responses are. Given that it may be many years before … a comprehensive international emissions trading system tied to an adequate emissions cap [is operational], ultimately the UK and the EU face a stark choice: to permit high levels of aviation growth whilst continuing with their climate change rhetoric or to convert the rhetoric into reality and substantially curtail aviation growth.[157]

→ Anderson et al, *Growth Scenarios for EU & UK Aviation: Contradictions with Climate Policy* (Tyndall Centre for Climate Change Research) (2006) [158]

This report develops aircraft emissions scenarios for the period 2002-2050 for each EU state[159] and compares those scenarios with national carbon "contraction and convergence" profiles[160] for 450 ppmv and 550 ppmv[161] CO_2 concentration stabilisation levels for EU member states.[162] The results

> show that a significant portion of annual emissions budget will be attributable to the aviation industry for the aggregated EU 125 nations, as is also the case when separated into the original EU 15 nations, the 10 new accession states and looking at the UK alone. If the aviation industry is allowed to grow at rates even lower than those being experienced today, the EU could see aviation accounting for between 39% and 79% of its total carbon budget by 2050, depending on the stabilisation level chosen. For the UK, the respective figures are between 50% and 100%.[163]

The study also finds that if the EU commits to "substantial long-term cuts" in CO_2 emissions, implemented on a contraction and conversion basis,[164] "it is unlikely that the level of UK aviation growth projected by DfT in the aviation White Paper will be accommodated within a European ETS alone."[165]

Moreover, applying the IPCC 2.7 uplift factor, the aviation industry's proportion of human-induced climate change significantly increases.

> Uplifted EU aviation emissions alone would exceed the 550ppmv contraction and convergence target for the EU by 2050, leaving no emissions space for any other sectors. Even by 2030, application of the 2.7 uplift factor shows aircraft taking 34% of the EU carbon allowance under the 550ppmv regime and 50% for the 450ppmv regime. As it appears unlikely that any alternative to kerosene as an aviation fuel will be in widespread use by 2030, permitting these emissions would require either major changes to EU energy supply and consumption or a commensurate purchase of emissions credits from elsewhere in the world.[166]

For Anderson et al, reconciling aviation emissions growth, economic growth on a global basis of more than 4% annually, and climate change targets at the level of 550ppmv or less "must be in doubt" and is a matter which "requires urgent investigation," even within any global emissions trading system.[167]

On the analysis as presented in this report, "all of the other sectors of the economy must significantly decarbonise to allow the aviation industry to grow and to continue to use kerosene up to 2050."[168]

→ Bows and Anderson, "Policy Clash: Can Projected Aviation Growth be Reconciled with the UK Government's 60% Carbon-Reduction Target," *Transport Policy* (2007)[169]

Although not a detailed study or report,[170] this paper is included because it both updates 2005 and 2006 studies from the Tyndall Centre and deals with the impact of aviation growth from today to 2050 for both the UK and the EU, as well as with the implications for aviation and its inclusion in the EU ETS.

The paper's main points (in the order in which they are made) are as follows:

- CO_2 emissions from the EU's aviation industries are growing rapidly, and the UK's aviation industry is the fastest growing source of CO_2 emissions of any sector of the UK economy;[171]

- aviation industry emissions between now and 2040 are expected to grow rapidly, and such emissions growth "will have a profound effect on the UK as it attempts to significantly reduce its emissions from the economy as a whole;"[172]

- the UK government endorses a target of reducing UK CO_2 emissions by 60% by 2050. Inclusion of aviation in that target "has dramatic consequences for other key sectors of the economy, many of which also have increasing emissions;"[173]

- "explicitly facilitating growth in aviation, where no short- to medium-term alternatives to using kerosene or step changes in fuel efficiency improvements are envisaged, will undoubtedly seriously constrain the emission space available in other sectors. Furthermore … [indications are] that under the 450ppmv stabilisation profile, *all* other sectors of the economy will need to significantly, possibly completely, decarbonise by 2050 if the respective carbon-reduction target is not to be exceeded;"[174] and

- emissions from international aviation are excluded from Kyoto and all other national and international climate change targets; "effective climate change targets must include, urgently, emissions from aviation … In the absence of explicit policies to curb aviation growth, global emissions from this sector will continue to grow rapidly as passenger demand outstrips substantially improvements in both fuel efficiency and carbon intensity … [T]he current very high emissions growth rates will result in the aviation industry being increasingly responsible for a large proportion of the EU's total carbon budget."[175]

→ European Federation for Transport and Environment and Climate Action Network Europe, *Clearing the Air: The Myth and Reality of Aviation and Climate Change* (2006)[176]

This July, 2006 report summarises the findings of a number of recent studies, some of which have been considered above. It examines 12 questions about the climate impacts of aviation in two parts - (a) the impact of aviation on climate change;[177] and (b) climate policy measures for aviation presently under consideration[178] - and is concerned with separating the "myth from the reality" in these areas.

On the climate impacts of aviation, the study concludes as follows:

> [I]n 2000, aviation was responsible for 4 to 9 per cent of the climate change impact of global human activity – the range reflecting uncertainty surrounding the effect of cirrus clouds … aviation has by far the greatest climate impact of any transport mode, whether measured per passenger kilometre, per tonne kilometre, per € spent, or per hour spend … [and] the importance of aviation for the economy and employment is far less than its importance for climate change.[179]

With regard to the climate impacts of aviation the most common airline responses have been, broadly, as follows:

- continue - more or less - with business as normal. In this regard, compared with other industry and corporate responses to the problem, the airline industry response has been less proactive and more subdued;[180]

- argue that the problem can – to a greater or lesser extent - be dealt with by improving air transport technology and infrastructure, by developing more efficient operational practices, and by calling for more efficient air traffic management systems and processes; and/or

- argue that a global solution should be developed, working through the International Civil Aviation Organisation (ICAO) (IATA "urges" States "not to jump the gun on emissions trading but to wait for the ICAO Assembly's recommendations in September, 2007"[181]).

Contrasted with other corporate and industry sector responses to the climate change problem, those of the airline industry have to some extent been anomalous - that is, less proactive and more limited – although perhaps more true for North American airlines[182] than for their European counterparts.[183] *Aviation Week* noted in March, 2007 that "the reaction by the aviation industry to the climate change issue so far has been subdued"[184] (although it also noted that the industry's tone - IATA's tone – "has become more strident"[185]). In mid-May, 2007, however, the Star Alliance

> endeavoured to take some control over the increasingly volatile discussion concerning commercial aviation's impact on the environment, announcing a transport and marketing partnership with leading conservation organizations while acknowledging that more forceful and unified communication is needed to defend the [airline] industry's position.[186]

Marion C Blakey, the FAA Administrator, has acknowledged "[t]here's a perception that somehow aviation doesn't care about the environment … Aviation must effectively manage its environmental impacts. There's nothing murky about that."[187] And in a different speech she stated that "[t]he fact of the matter in Europe is more and more often environmentalists are calling aviation a 'rogue industry,' lumped together alongside Big Tobacco …It's presumptuous to assume it won't happen here [in the US]." For Ms Blakey, together with congested airspace, "aircraft emissions may be the most serious barrier to aviation growth, at least in the long term."[188] In the view of the Chairman and CEO of US Airways, "[w]e have to get out in front and educate the consumer."[189]

Possible strategies for airlines on climate change and aircraft GHG emissions are set out below.

3. "Difficult challenges:" Possible airline strategies for dealing with the greenhouse gas emissions problem

Aviation faces some difficult challenges. Whilst there is potential for incremental improvements in efficiency to continue, more radical options for emissions cuts are very limited. The international nature of aviation also makes the choice of carbon pricing instrument complex … and … [i]nternationally coordinated taxes are difficult to implement … the choice of tax, trading or other instruments is likely to be driven as much by political viability as by the economics …

- Sir Nicholas Stern,
The Economics of Climate Change (2006)[190]

Possible airline strategies for dealing with the greenhouse gas emissions problem are as follows:

- continue with business as normal;
- improve air transport technology and develop alternative jet fuels;
- develop more efficient operational practices and call for more efficient air transport management systems and processes;
- support a cap-and-trade ETS: airlines would be allocated allowances according to a baseline, and would be able to either sell their unused portion or would have to buy credits to ensure that their emissions are covered. Such schemes might either be closed or open. In a closed scheme, purchases have to be made from the same industry; in an open scheme, purchases can be made on an open market. The EC proposes to include aviation in the EU ETS in two phases, from 2011 and 2012;
- support a cap-and-trade ETS with closed purchase of allowances: aviation operators would be required to purchase the initial allowance, with the amount purchased determined by a baseline;
- support a cap-and-trade ETS with open purchase of an industry allowance: the industry would be allocated an allowance; individual airlines, however, would have to bid for their share;
- support mandatory emissions offsets (support mandatory participation in an emissions offset market);

- as a preliminary step to support of mandatory emissions offsets, introduce an airline default – or opt-out - passenger emissions offset scheme; and

- introduce taxes and charges.

These strategies are evaluated in another Hodgkinson Group paper referred to earlier, *Strategies for Airlines on Aircraft Emissions and Climate Change: Sustainable, Long-Term Solutions* (at www.hodgkinsongroup.com/publications).

An aircraft default passenger emissions offset scheme as a means by which airlines can begin to manage and mitigate their exposure to climate change risks is outlined in the next section of the paper.

4 An airline default – or opt-out – passenger emissions offset scheme

One way in which airlines could begin to incorporate offsetting into any more inclusive strategy would be to introduce it as an airline default – or opt-out – passenger emissions offset scheme. This would allow airlines to take action in the immediate future, thus absorbing demands that they address the climate costs of aviation in a least cost manner. It would also provide airlines with much-needed information as to public/ passenger sensibilities concerning the climate impacts of aviation and environmental charges (broadly defined) ahead of mandatory emissions offsets.

In outline, under this scheme, a distinct and separate surcharge for the full carbon cost (or, alternatively, full GHG cost) of the flight would be made or levied in addition to the cost of the fare. Each passenger could *clearly* choose to pay any proportion of this surcharge. *If no action is taken by the passenger to waive some proportion it remains at 100%.* The details of the scheme would be completely transparent, and would be brought to the attention of the potential passenger at various points, or stages, in the booking/ ticket purchasing process; its terms would be made clear to those purchasing tickets at a point in time when they can make a meaningful decision. Formal acknowledgement would be made by a prospective purchaser that she or he has been informed, understands and accepts the surcharge (or a specified portion of it).

This is different from present schemes under which individuals can seek to buy offsets through or from some airlines[191] or third parties on a variable or ad hoc basis. Part of the difference is psychological. Studies show that there is a significant difference in presentation of options; most people choose the default setting. An opt-out offset scheme would demand a conscious decision.

Such a scheme might also be expected to cause the travelling public to be more aware of the potential climate impacts of air travel, although such awareness has increased and is increasing dramatically. Why is public awareness a benefit to airlines? It appears to us that *airlines would be well served with educated passengers (in terms of the potential climate impacts of air travel) that are treated as partners and that understand the airlines' position*.

Our proposal – our proposed preliminary step for airlines with regard to emissions offsets – has the following properties:

- *Flexible*: The scheme could start, for example, with the possibility of a 100% waiver. As, or if, it became necessary for an airline or airlines to increase contributions to the climate change costs of air travel, the existing systems would allow a seamless and gradual increase to any desired level.

  It also, of course, precludes neither devotion of resources to improve air transport technology and infrastructure nor development of more efficient air transport operational practices. Indeed, its flexibility and simplicity are such that it is easy to replace.

Moreover, it reinforces the need to deal with the aviation emissions problem through several mechanisms. It does not, of course, prevent airlines from simultaneously devoting effort to such mechanisms.

- *Informative*: What airlines presently lack is information on the sensibility of the public to offsets. This scheme would provide feedback on this issue and also on issues of the environmental price sensitivity of demand.

- *Efficient*: Not only would the scheme be relatively inexpensive for an airline to run, it would build in all the usual gains from efficiency. An airline that can devise ways to cut its total emissions per passenger will be in a position to offer cheaper carbon offsets than its rivals.

- *Responsible*: It is clear that airlines are increasingly being held responsible for the social costs of their actions. This initiative gives airlines a simple and workable means of accepting this responsibility before any decision is forced on them *and* provides a lead-in or a step prior to mandatory emissions offsets.

  It affords an opportunity for airlines to get out ahead.

- *Fair*: Finally, any scheme for altering air travel should be seen to be fair. As things presently stand those who travel least are implicitly subsidising those who travel most. An equitable balance of costs can only be reached through some sort of user pays scheme.

  It might be claimed that an increase in costs gives the wealthier members of society privileged access. While correct, this concern is misplaced. It is well established in economic thought that problems of inequality should be solved directly, and not through indirect transfers.

Such a scheme as we propose is simple for airlines to implement with minimal delays and cost. It would not present any first mover disadvantages; the emissions cost is set out separately from the price of the fare. In fact, *we believe that this proposal may present a first mover airline with distinct advantages and opportunities*. Not only would it be doing something positive, it would be seen to be doing something positive. This may have the effect of generating more support from private and business travelers.

There are a number of other issues relating to an airline default – or opt-out – passenger emissions offset scheme which are not considered here. Such issues include implementation strategies, the operation of the scheme, specific offset arrangements and ensuring an appropriate means of guaranteeing purchasers that the scheme provides full offsets in a cost-effective manner (a Hodgkinson Group working paper referred to earlier- *Strategies for Airlines on Aircraft Emissions and Climate Change: Sustainable, Long-Term Solutions* – examines the voluntary carbon market in some detail). They also include legal and taxation matters as well as the operation of a default offset scheme in the context of successive carriage, interlining and code-sharing.

These issues have been considered in detail by us and form the basis of a forthcoming paper.

5. Management and mitigation of airline exposure to climate change risks: Sustainable, long-term solutions for airlines

It is our view that airlines should not wait for but should move ahead of governments; airlines should steer the process of change to build a cleaner sky. It makes economic sense for airlines to adopt a proactive stance towards the risks and uncertainties presented by climate change – to develop a long-term, forward-looking strategy package and sustainable solutions to deal with the aviation emissions problem.

We propose such sustainable solutions.

In this paper we outline a proposal for an airline default passenger offset scheme, and set out its advantages for airlines. Elsewhere (see www.hodgkinsongroup.com/publications) we evaluate strategies for airlines on aircraft emissions and climate change and conclude that airlines should seriously consider supporting mandatory participation in an emissions offset market as part of a long-term strategy package and as a sustainable solution to deal with the climate impacts of aviation. Here we suggest that, as a step prior to mandatory emissions offsets – and in any event – airlines should introduce offsetting as an airline default (or *opt-out*) passenger emissions offset scheme; advantages include enabling airlines to take action in the immediate future which begins to seamlessly absorb demands that they address the climate costs of aviation, and at little cost.

Such a scheme would also provide airlines with much-needed information as to public/ passenger sensibilities concerning the climate impacts of aviation and environmental charges ahead of any such mandatory emissions offset scheme. It would, as part of a long-term strategy package, enable airlines to begin to manage and mitigate their exposure to climate change risks.

Notes and references

1 David Hodgkinson and Professor Alex Coram are members of The Hodgkinson Group (www.hodgkinsongroup.com). The Group has advisors located around the world (see note on authors and The Hodgkinson Group at the end of the paper). **David Hodgkinson** was formerly Director of Legal Services at IATA, the organisation of the world's international scheduled airlines, in Montreal; **Alex Coram** is Professor of Political Economy, Aberdeen Business School, Robert Gordon University, Scotland. Detailed profiles can be found at the end of the paper.

2 Intergovernmental Panel on Climate Change (IPCC), *Aviation and the Global Atmosphere*, Joyce E Penner et al (Cambridge, Cambridge University Press, 1999): http://www.grida.no/climate/ipcc/aviation/index.htm. See http://www.grida.no/climate/ipcc/aviation/015.htm; http://www.grida.no/climate/ipcc/aviation/014.htm; and http://www.grida.no/climate/ipcc/aviation/016.htm.

3 Put another way, "The overwhelming scientific consensus is that anthropogenic climate change is a reality. Given that this is so, there is an urgent need to reduce greenhouse gas emissions and stabilise the concentrations of greenhouse gases in the atmosphere:" Kevin Anderson et al, *Growth*

scenarios for EU & UK aviation: contradictions with climate policy, Tyndall Centre for Climate Change Research, Working Paper 84 (Norwich, Tyndall Centre for Climate Change Research, 2006), p 11: http://www.tyndall.ac.uk/publications/working_papers/wp84.pdf.

4 Elizabeth Kolbert titles her groundbreaking book on climate change *Field Notes From a Catastrophe* (New York, Bloomsbury 2006).

5 Carbon Trust, *The Carbon Trust three stage approach to developing a robust offsetting strategy* (London, The Carbon Trust, 2006), p 2: http://www.carbontrust.co.uk/Publications/publicationdetail.htm?productid=CTC621.

6 IPCC, *Climate Change 2007: The Physical Science Basis – Summary for Policymakers*, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (http://www.ipcc.ch/SPM2feb07.pdf), p 2. The IPCC was established by the WMO and the UNEP "to assess scientific, technical and socio- economic information relevant for the understanding of climate change, its potential impacts and options for adaptation and mitigation" (http://www.ipcc.ch). Its Fourth Assessment Report "Climate Change 2007," presently being finalised, will include, in addition to the Working Group I, II and III reports considered here (the Working Group II report, "Impacts, Adaptation and Vulnerability," released 6 April, 2007, and the Working Group III report, "Mitigation of Climate Change," released 4 May, 2007, are considered briefly below), a Synthesis Report. The three Working Group reports "provide a comprehensive and up-to-date assessment of the current state of knowledge on climate change" (*supra*). The IPCC "remains the closest thing to a barometer for tracking the level of scientific understanding of the causes and consequences of global warming:" James Kanter and Andrew C Revkin, "Scientists Detail Climate Changes, Poles to Tropics," *The New York Times*, 7 April, 2007.

In addition to the IPCC Fourth Assessment Report and its predecessors, other scientific reports and studies include Frank Ackerman and Elizabeth Stanton, *Climate Change – the Costs of Inaction* (Boston, Global Development and Environment Institute, Tufts University, 2006): http://www.ase.tufts.edu/gdae/policy_research/CostsofInaction.html; James Hansen et al, "Global temperature change," *Proceedings of the National Academy of Sciences*, vol 103, no 39, 26 September, 2006, pp 14288-14293; Jim Hansen, "Global Climate Change: Is There Still Time to Avoid Disastrous Effects?" California Energy Commission and California Environmental Protection Agency, Third Annual Climate Change Research Conference, *Climate Scenarios, Impacts, and Adaptation Options in California: Status of Research Avtivites*, 13-15 September, 2006: http://www.climatechange.ca.gov/events/2006_conference/presentations/2006-09-13/2006-09-13_HANSEN.PDF; National Research Council, Committee on Surface Temperature Reconstructions for the Last 2,000 Years, *Surface Temperature Reconstructions for the Last 2,000 Years* (Washington, DC, National Academies Press, 2006); and Thomas R Karl et al (eds), *Temperature Trends in the Lower Atmosphere: Steps for Understanding and Reconciling Differences* (Washington, DC, Climate Change Science Program and the Subcommittee on Global Change Research, 2006): http://www.climatescience.gov/Library/sap/sap1-1/finalreport/default.htm. And see also S Pacala and R Socolow, "Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies," *Science*, vol 305, 13 August, 2004, pp 968-972.

For more popular studies and articles on climate change see Jim Hansen, "The Threat to the Planet," *The New York Review*, 13 July, 2006, pp 12-16; Elizabeth Kolbert, *Field Notes From a Catastrophe: Man, Nature, and Climate Change* (New York, Bloomsbury 2006); Eugene Linden, *The Winds of Change: Climate, Weather, and the Destruction of Civilizations* (New York, Simon and Schuster, 2006); Tim Flannery, *The Weather Makers: The History and Future Impact of Climate Change* (Melbourne, Text Publishing, 2005); Donald Kennedy et al (eds), *Science Magazine's State of the Planet 2006-2007* (Washington, DC, Island Press, 2006); Al Gore, *An Inconvenient Truth: The Planetary Emergency of Global Warming and What We Can Do About It* (New York, Rodale, 2006); "The heat is on: A survey of climate change," *The Economist*, 9 September, 2006; George Monbiot, *Heat: How to Stop the Planet From Burning* (Doubleday Canada, 2006); and Jared Diamond, *Collapse: How Societies Choose to Fail or Succeed* (New York, Viking, 2005).

7 At least a 9 out of 10 chance of being correct.

[8] IPCC, *supra*, note 6, p 5.

[9] *Supra*, pp 5 and 8. See also Hansen et al, *supra*, note 6, p 14288; the authors conclude "that global warming is a real climate change."

[10] That is, a likelihood greater than 90%: *Supra*, note 6, p 4.

[11] *Supra*, p 10. The IPCC states that "[c]ontinued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would *very likely* [a likelihood greater than 90%] be larger than those observed during the 20th century …Anthropogenic warming and sea level rise would continue for centuries due to the timescales associated with climate processes and feedbacks, even if greenhouse gas concentrations were to be stabilized … Both past and future anthropogenic carbon dioxide emissions will continue to contribute to warming and sea level rise for more than a millennium, due to the timescales required for removal of this gas from the atmosphere:" *Supra*, pp 13 and 17. Summaries of and commentaries on the IPCC February, 2007 report include *The Economist*, "Climate Change: Heating Up," 10 February, 2007; Richard A Kerr, "Scientists Tell Policymakers We're All Warming the World," *Science*, vol 315, 9 February, 2007, pp 754-757; and Elisabeth Rosenthal and Andrew C Revkin, "Science Panel Calls Global Warming 'Unequivocal,'" *The New York Times*, 3 February, 2007.

[12] IPCC, *Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability – Summary for Policymakers*, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change: http://www.ipcc.ch/SPM13apr07.pdf.

[13] *Supra*, p 17.

[14] *Supra*, pp 2-3.

[15] *Supra*, p 19.

[16] *Supra*, p 19 (emphasis added). Summaries of and commentaries on the IPCC April, 2007 report include Agence France Presse, "Climate change impacts: Main points from IPCC summary," 6 April, 2007; James Kanter and Andrew C Revkin, "Scientists Detail Climate Changes, Poles to Tropics," *The New York Times*, 7 April, 2007; and the Science and Development Network, "Report sees 'climate divide' between rich and poor," 6 April, 2007: http://www.scidev.net/content/news/eng/report-sees-climate-divide-between-rich-and-poor.cfm.

[17] IPCC, *Climate Change 2007: Mitigation of Climate Change – Summary for Policymakers*, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 4 May, 2007: http://www.ipcc.ch/SPM040507.pdf. Summaries of and commentaries on the IPCC May, 2007 report include Andrew C Revkin and Seth Mydans, "Climate Panel Reaches Consensus on the Need to Reduce Harmful Emissions," *The New York Times*, 4 May, 2007; and IPCC, Contribution of Working Group III to the Fourth Assessment Report of the IPCC, *Presentation by the co-chairs*, 4 May, 2007: http://www.ipcc.ch/WG3_press_presentation.pdf

[18] And that GHG emissions have grown since pre-industrial times: *supra*, note 17, p 2.

[19] *Supra*, p 3.

[20] That is, until 2030. For mitigation in the long term (after 2030), see pages 21-27 (*supra*).

[21] *Supra*, p 10; "[i]n 2030 macro-economic costs for multi-gas mitigation, consistent with emissions trajectories towards stabilization between 445 and 710 ppm CO2-eq, are estimated at between a 3% decrease of global GDP and a small increase, compared to the baseline … However, regional costs may differ significantly from global averages" (*supra*, p 15).

[22] *Supra*, p 18.

[23] *Supra*; emphasis added.

[24] *Supra*, p 13.

[25] *Supra*, p 30.

[26] *Supra*, pp 27-28.

[27] Economic instruments, government funding and regulation.

[28] *Supra*, note 17, p 28.

[29] *Supra*.

[30] Sir Nicholas Stern, *The Economics of Climate Change*, p i: http://www.hm-treasury.gov.uk/media/8AC/F7/Executive_Summary.pdf. The Stern Review can be found at http://www.hm-

treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm.

31 *Supra*, http://www.hm-treasury.gov.uk/media/8A8/C1/Summary_of_Conclusions.pdf, p vi.

32 *Supra*. The Review also finds that "[a]ll countries will be affected [by climate change]. The most vulnerable … will suffer earliest and most … The costs of extreme weather, including floods, droughts and storms, are already rising, including for rich countries:" *supra*, p vii.

33 *Supra*, p viii.

34 *Supra*. On the Stern Review generally see *The Economist*, "Economics of Climate Change: Stern Warning," 4 November, 2006; John Cassidy, "High Costs," *The New Yorker*, 13 November, 2006; and Martin Wolf, "Climate change: no real energy for global action," *The Australian*, 9 November, 2006. For a critique of the Stern Review see Bjorn Lomborg, "The dodgy numbers behind the latest warming scare," *The Wall Street Journal*, 2 November, 2006 (http://www.opinionjournal.com/forms/printThis.html?id=110009182) and Paul Baer and Michael Mastrandrea, *High Stakes: Designing emissions pathways to reduce the risk of dangerous climate change* (London, Institute for Public Policy Research (IPPR), 2006). The IPPR study was commissioned "to develop estimates of emissions pathways that have a high likelihood of keeping the rise in the world's average surface temperatures above pre-industrial levels to below 2 degrees Celsius" (p 4). Its conclusions "go further than the Stern Review, which proposes a long-term goal to stabilize greenhouse gases at between the equivalent of 450 and 550 ppm CO2. That range has a medium to high risk of exceeding a 2 degree Celsius rise in temperature" (p 5). The report "suggests Lord Stern's analysis was too conservative and governments need to move further and faster. To minimize the risk of a 2C rise – seen as the threshold for dangerous climate change – the authors say global carbon dioxide emissions would need to peak between 2010 and 2013:" James Randerson, "Only a decade left to avoid climate change, says think tank," *Guardian*, 9 November, 2006.

35 James Hansen et al, "Global temperature change," *Proceedings of the National Academy of Sciences*, vol 103, no 39, 26 September, 2006, p 14288. Further, the US National Oceanic and Atmospheric Administration (NOAA) reported on 15 March, 2007 that the northern winter just ended was the warmest on record, and that the December, 2006-February, 2007 period was the warmest on record around the globe for land surface temperature: NOAA News Releases 2007, "NOAA Says U.S. Winter Temperature Near Average. Global December-February Temperature Warmest on Record," 15 March, 2007: http://www.publicaffairs.noaa.gov/releases2007/mar07/noaa07-016.html. And scientists from the US National Snow and Ice Data Centre and the National Center for Atmospheric Research reported research in March, 2007 in which a review of computer climate models suggested that global warming could transform the North Pole into an ice-free expanse of open ocean at the end of each summer by 2100: see Mark C Serreze et al, "Perspectives on the Arctic's Shrinking Sea-Ice Cover," *Science*, vol 315, 16 March, 2007, pp 1533-1536. See also Andrew Shepherd and Duncan Wingham, "Recent Sea-Level Contributions of the Antarctic and Greenland Ice Sheets," *Science*, vol 315, 16 March, 2007, pp 1529-1532.

36 Tyndall Centre for Climate Change Research, *Constructing energy futures*, Research Programme 1: http://www.tyndall.ac.uk/research/programme2/programme2.shtml. See also James Hansen et al, "Global temperature change," *Proceedings of the National Academy of Sciences*, vol 103, no 39, 26 September, 2006, pp 14288-14293, where the authors conclude that "data suggests that … probably the planet as a whole … is approximately as warm now as at the Holocene maximum and within ~1C of the maximum temperature of the past million years. We conclude that global warming of more than ~1C, relative to 2000, will constitute "dangerous" climate change as judged from likely effects on sea level and extermination of species" (at p 14288).

37 International Scientific Steering Committee, *Avoiding Dangerous Climate Change: Scientific Symposium on Stabilisation of Greenhouse Gases - Executive Summary of the Conference Report* (London, Department for Environment, Food and Rural Affairs, 2006), p 1: http://www.defra.gov.uk/environment/climatechange/research/dangerous-cc/pdf/avoid-dangercc-execsumm.pdf.

38 Hans Joachim Schellnhuber et al, *Avoiding Dangerous Climate Change* (Cambridge, Cambridge University Press, 2006): http://www.defra.gov.uk/environment/climatechange/research/dangerous-cc/pdf/avoid-dangercc.pdf.

39 International Scientific Steering Committee, *supra*, note 37, pp 1, 3.

40 0r 40 gigatonnes in 2030, an increase of 14 gigatonnes over the level in 2004: See International Energy Agency, *World Energy Outlook 2006: Summary and Conclusions* (Paris, OECD/IEA, 2006), p 5: http://www.worldenergyoutlook.org/summaries2006/English.pdf.

41 "Above a one degree Celcius increase, risks increase significantly, often rapidly for vulnerable ecosystems and species. In the one to two degree range, risks across the board increase significantly, and at a regional level are often substantial. Above two degrees the risks increase very substantially, involving potentially large numbers of extinctions or even ecosystem collapses, major increases in hunger and water shortage risks as well as socio-economic damages, particularly in developing countries:" Bill Hare, Potsdam Institute of Climate Impact Research, Germany (BBC News, "Climate report: the main points," 30 January, 2006: http://newsvote.bbc.co.uk/mpapps/pagetools/print/news.bbc.co.uk/1/hi/sci/tech/4661830.stm. The 2006 report, *Avoiding Dangerous Climate Change*, views a rise of 2 degrees celcius as sufficient to cause, amongst other things, decreasing crop yields in the developing and developed world, tripling of poor harvests in Russia and Europe, up to 2.8 billion people at risk of water shortage, total loss of summer Arctic sea ice, 97% loss or coral reefs and the spread of malaria in North America and Africa (*supra*, note 37).

42 Gerard Wynn, "Exxon misleads on climate change: UK Royal Society," *Reuters*, 20 September, 2006: http://go.reuters.com/newsArticle.jhtml?type=scienceNews&storyID=13553084&src=rss/scienceNews.

43 "Lining up for profits," *The Economist*, 12 November, 2005, p 73.

44 United States General Accounting Office, *Aviation and the Environment: Aviation's Effects on the Global Atmosphere Are Potentially Significant and Expected to Grow* (Report to the Honorable James L. Oberstar, Ranking Democratic Member, Committee on Transportation and Infrastructure, House of Representatives, GAO/RCED-00-57)(Washington, DC, United States General Accounting Office, 2000) p 4: http://www.gao.gov/archive/2000/rc00057.pdf.

45 As of March, 2007.

46 Boeing, 2006 *Current Market Outlook*: http://boeing.com/commercial/cmo/highlights.html.

47 Boeing, *supra*; the world airline fleet, according to Boeing, will grow from 17,330 to 35,970 aircraft. See also Boeing, *New Airplanes*: http://boeing.com/commercial/cmo/new.html.

48 Daniel Michaels, "Airbus, Boeing Forecast Clear Skies," *The Wall Street Journal*, 24 November, 2006.

49 Reuters, "Air travel rates expected to double," 31 January, 2007.

50 IATA, *Fact Sheet: Industry Statistics*, March, 2007: http://www1.iata.org/NR/rdonlyres/6B5FE6C7-7346-4728-8C16-E038D5E29676/0/FactSheetIndustryFactsMAR2007.pdf.

51 See Boeing, *2006 Current Market Outlook*: http://www.boeing.com/commercial/cmo/regions.html; http://www.boeing.com/commercial/cmo/index.html; http://www.iata.org/pressroom/pr/2005-10-31-01.htm; http://www.iata.org/pressroom/speeches/2006-02-20-01.htm; and http://www.iata.org/pressroom/speeches/2006-06-05-01.htm (IATA).

52 Reuters, *supra*, note 49.

53 See Jens Flottau and Robert Wall, "Reasons to worry: Good news on revenues could mask the next crisis for airlines," *Aviation Week and Space Technology*, 12 June, 2006, p 39.

54 Anderson et al, *supra*, note 3, p 6; the precise citation is "so as to make room for the aviation industry."

55 Section 2.1 above, in part, also considers aviation and climate change in the context of the May, 2007 IPCC Working Group III report, "Climate Change 2007: Mitigation of Climate Change," and the medium term mitigation potential for CO2 emissions from the aviation sector, together with the need for total mitigation potential in the sector to account for non CO2 climate impacts of aviation emissions.

56 IPCC, *supra*, note 2.

57 IATA states – incorrectly - in a variety of fora that "aviation is responsible for 2% of global carbon dioxide emissions" (IATA, "Climate Change: Aviation's Climate Change Impact is Small:" http://www1.iata.org/whatwedo/environment/climate_change.htm); "[i]n all, aviation is only responsible for 2% of global CO2 emissions …" (IATA, "IATA industry-wide strategy to address climate change:" http://www1.iata.org/NR/rdonlyres/80F7AA1C-2CE1-40B0-A2D5-C9AE38259AC2/0/4153400Climatechangeflyer4.pdf); "[a]ir transport contributes a small part of global CO2 emissions – 2%" (IATA, "Debunking Some Persistent Myths about Air Transport and the Environment:" http://www.iata.org/nr/rdonlyres/11804248-06a7-44a2-a160-62f1953d9e44/0/bedunkingsomepersistentmythsaboutairtransportandtheenvironment.pdf); "[t]he UN attributes 2% of global carbon emissions to aviation" (IATA, "Orient Aviation – Green Skies Conference Hong Kong: Remarks by Giovanni Bisignani," 29 March, 2007: http://www1.iata.org/pressroom/speeches/2007-03-29-01.htm); "[i]t's 2 percent but it's 2 percent and 2 percent is still 2 percent …." (Andrew Drysdale, IATA vice-president, cited in "Aviation industry mounts efforts to answer critics and head-off emission curbs," Greenwire, 7 May, 2007: http://www.wbcsd.org/plugins/DocSearch/details.asp?type=DocDet&ObjectId=MjQ1Mjc); "[a]ir transport produces 2% of global CO2 emissions" (IATA, "Danger CO2W," advertisement: http://www1.iata.org/whatwedo/environment/campaign/index.htm; and "[a]viation currently represents 2 per cent of global anthropogenic carbon dioxide (CO2) emissions" (Andreas Hardeman, "A Common Approach to Aviation Emissions Trading," *Air & Space Law*, vol 32, no 1, February, 2007, p 3; Hardeman also states that, where his paper uses the term 'emissions' "this means 'carbon dioxide (CO2) emissions:'" *supra*). Again, emissions of carbon dioxide by aircraft represented about 2% of total anthropogenic carbon dioxide emissions in 1992 - not 2007 - as determined by the IPCC; see Intergovernmental Panel on Climate Change, *supra*, note 2: http://www.grida.no/climate/ipcc/aviation/006.htm. The 2007 figure, given growth in air travel in the ensuing 15 years, is higher than 2%, the figure currently cited by IATA.

58 IPCC, *supra*, note 2 (ch 2).

59 A greenhouse gas.

60 As the Tyndall Centre notes, "[a]viation emissions are unusual in the altitude of their emission. Atmospheric chemistry at this altitude has particular characteristics, and aviation emissions have particular effects:" Anderson et al, *supra*, note 3, p 11.

61 IPCC, *supra*, note 2: http://www.grida.no/climate/ipcc/aviation/004.htm. The Tyndall Centre for Climate Change Research notes that "[p]rovisional research suggests that lowering flight altitude could significantly reduce contrail formation and hence cirrus production. However, operating at a lower altitude would probably increase fuel burn and hence increase carbon emissions. Whilst in terms of instantaneous radiative forcing there would be benefits in flying at lower altitudes, the small increase in long-lived carbon dioxide (100+ years compared hours/days for contrails and cirrus) would essentially increase the global warming potential. Given the different time scales, deciding whether the benefits of lower flight outweigh the disbenefits cannot be a solely scientific decision:" Tyndall Centre for Climate Change Research, *Decarbonising the UK: Energy for a Climate Conscious Future* (Norwich, Tyndall Centre for Climate Change Research, 2005), p 50: http://www.tyndall.ac.uk/media/news/tyndall_decarbonising_the_uk.pdf. The report of a workshop at MIT in June, 2006, which considered the impacts of aviation on climate change noted that "[a]lthough current fuel use from aviation is only a few percent of all combustion sources of carbon dioxide, the expectation is that this percentage will increase because of projected increase in aviation and the likely decrease in other combustion sources as the world moves away from fossil fuels towards renewable energy sources. In addition, aircraft nitrogen oxides released in the upper troposphere and lower stratosphere generally has a larger climate impact than those emitted at the surface, although some of the much larger surface emissions from energy and transportation sources also reach the upper troposphere:" Next Generation Air Transportation System/ Joint Planning and Development Office (NGATS/ JPDO) Environmental Integrated Product Team and Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER), *Workshop on the Impacts of Aviation on Climate Change: A Report of Findings and Recommendations*, Report No Partner-COE-2006-004, August, 2006, p 13: http://web.mit.edu/aeroastro/partner/reports/climatewrksp-rpt-0806.pdf.

[62] Emphasis added; IPCC, *supra*, http://www.grida.no/climate/ipcc/aviation/006.htm. In addition to increasing tropospheric ozone concentrations, aircraft NOx emissions decrease the concentration of methane, another greenhouse gas (*supra*).

[63] Emphasis added.

[64] Sally Cairns and Carey Newson, *Predict and decide: Aviation, climate change and UK policy*, Environmental Change Institute, University of Oxford (Oxford, Oxford University Press, 2006), p 16. The authors then set out why putting a precise value on "significantly worse" is problematic. The report of the MIT workshop in June, 2006 noted that "[b]ecause the IPCC identified contrails, contrail-cirrus, and modifications of cirrus by aircraft exhaust as the most uncertain components of the aviation impact on climate, the majority of recent studies have focussed on cloud processes, while a limited number of studies also addressed chemical effects:" Next Generation Air Transportation System/ Joint Planning and Development Office (NGATS/ JPDO) Environmental Integrated Product Team and Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER), *supra*, note 61, p 20.

[65] IPCC, *supra*, note 17.

[66] *Supra*, p 18.

[67] Keith P Shine and William T Sturges, "CO2 Is Not the Only Gas," *Science*, vol 315, 30 March, 2007, pp 1804-1805. Shine and Sturges write that "An increase in the concentration of a greenhouse gas causes a change in Earth's energy balance. This change, or radiative forcing, is a simple indicator of the climate change impact. The largest single contributor to radiative forcing is CO2 ... (p 1804).

"[The Kyoto Protocol] recognizes the importance of non-CO2 greenhouse gases. Emission targets for signatories to the Convention are given in terms of CO2-equivalent emissions; the signatories can choose to control emissions of several gases … to meet their targets. There remain issues concerning what emissions are included and excluded in the Kyoto Protocol and the method by which emissions of different gases are placed on a common "carbon-equivalent" scale. Nevertheless, it is clear that controlling non-CO2 greenhouse gas emissions can play a very important role in attempts to limit future climate change (*supra*).

"The contribution of a given non-CO2 greenhouse gas to radiative forcing depends on its ability to absorb infrared radiation emitted by Earth's surface and atmosphere … (*supra*).

"CO2 undoubtedly remains the single most important contributor to greenhouse gas radiative forcing, but the non-CO2 greenhouse gases are important both collectively and individually …" (*supra*, p 1805) (footnotes omitted).

[68] Next Generation Air Transportation System/ Joint Planning and Development Office (NGATS/ JPDO) Environmental Integrated Product Team and Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER), *supra*, note 61, p 17. "Aircraft engines emit CO2 and water vapor, important greenhouse gases, that directly affect climate through their absorption and reemission of infrared radiation; [a]ircraft emit NOx (and HOx produced from water vapor emissions into the stratosphere) that modifies atmospheric ozone concentrations. Ozone affects the radiative balance of the climate system through both its shortwave and infrared (greenhouse effect) absorption; [t]hrough its resulting net production of upper tropospheric and lower stratospheric ozone, NOx emissions from subsonic aircraft also reduce the atmospheric abundance of CH4, another important greenhouse gas, through feedback effects on concentrations of tropospheric hydroxyl radicals (OH), the primary reactant for destruction of methane; [a]ircraft emit aerosols in the form of liquid particles containing sulfate and organics, and soot particles; … [and u]nder the right meteorological conditions, aircraft emissions of water vapor (and aerosols) can lead to formation of contrails and possibly result in effects on upper tropospheric cirrus clouds - these effects may exert spatially inhomogeneous radiative impacts on climate … The effect of aircraft emissions on atmospheric ozone concentration depends on the altitude at which the emissions are injected;" *supra*.

[69] Royal Commission on Environmental Pollution, *The Environmental Effects of Civil Aircraft in Flight* (London, Royal Commission on Environmental Pollution, 2002), p 14: http://www.rcep.org.uk/aviation/av12-txt.pdf.

[70] The IPCC describes radiative forcing as "the global, annual mean radiative imbalance to the Earth's climate system caused by human activities:" IPCC, *supra*, note 2,

http://www.grida.no/climate/ipcc/aviation/064.htm. The report of the MIT workshop in June, 2006, which considered the impacts of aviation on climate change noted that "[e]missions by aviation are responsible for a range of atmospheric changes that perturb the radiation budget and hence force climate change. In assessing the overall impact of aviation on climate, and to quantify the potential trade-offs in the climate impact of changes in aircraft technology, operations, or even the amount of aircraft traffic, it is important to place these different climate forcings on some kind of common scale. We refer to methods that attempt to achieve this as "metrics". Although their existing application to aircraft issues is much more limited, the general usefulness and uncertainties associated with metrics for climate change has been the subject of many published research studies. There are many difficulties in developing such metrics, which while not unique to aviation, are certainly exacerbated by the nature of aviation's impacts on climate … The most straightforward metric is the traditional one, namely radiative forcing (RF) at some given time due to the cumulative impact (both direct and indirect) of aviation emissions during some prior time period … For comparison of the climate impact of emissions, a whole class of metrics has been proposed … These aim to provide an exchange rate, so that each emission can be given a CO2-equivalence. The Kyoto Protocol to the UN Framework Convention on Climate Change has adopted the Global Warming Potential (GWP) concept as developed for the IPCC climate assessments to provide this equivalence ... it accounts for both the radiative strength of the climate change agent and its persistence in the atmosphere … [C]omplexity [associated with the GWP] led IPCC (1999) to reject the possibility of applying GWPs for aviation, although they did not recommend any alternatives …:" Next Generation Air Transportation System/Joint Planning and Development Office (NGATS/ JPDO) Environmental Integrated Product Team and Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER), *supra*, note 61, pp 24-26.

71 IPCC, *supra*. Emphasis added.

72 *Supra*: http://www.grida.no/climate/ipcc/aviation/008.htm.

73 Royal Commission on Environmental Pollution, *supra*, note 69, p 15.

74 *Supra*, p 18.

75 IPCC, *supra*, note 2: http://www.grida.no/climate/ipcc/aviation/008.htm. As Bows and Anderson state, "[c]arbon dioxide emissions from the [aviation] industry are well understood, and therefore easy to compare with other sectors. However, aviation's full contribution to climate change has, potentially, a much greater impact than that of the carbon dioxide emissions alone; nitrous oxide, soot and water vapour, released at different altitudes in the atmosphere, cause additional warming. Combined with the production of condensation trails (contrails), under certain atmospheric conditions, and the likely consequent formation of cirrus clouds, aviation's instantaneous warming impact is estimated to be between 2 and 4 times that of the carbon dioxide emitted:" Alice Bows and Kevin L Anderson, "Policy Clash: Can Projected Aviation Growth be Reconciled with the UK Government's 60% Carbon-Reduction Target?," *Transport Policy* 14 (2007), pp 103-104.

76 Royal Commission on Environmental Pollution, *supra*, note 69, p 19.

77 Next Generation Air Transportation System/Joint Planning and Development Office (NGATS/ JPDO) Environmental Integrated Product Team and Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER), *supra*, note 61, p 5.

78 See pages 18-19.

79 General Accounting Office.

80 United States General Accounting Office (GAO), *Aviation and the Environment: Aviation's Effects on the Global Atmosphere Are Potentially Significant and Expected to Grow* (Report to the Honorable James L. Oberstar, Ranking Democratic Member, Committee on Transportation and Infrastructure, House of Representatives, GAO/RCED-00-57)(Washington, DC, United States General Accounting Office, 2000) p 4: http://www.gao.gov/archive/2000/rc00057.pdf.

81 *Supra*, p 4. The report also notes (at p 4) that global aviation emissions of carbon dioxide "are roughly equivalent to the carbon emissions of certain industrialized countries …"

82 *Supra*.

83 Water vapour, nitrogen oxide and nitrogen dioxide (together, NOx), soot and sulphate.

84 US GAO, *supra*, note 80, p 5.

85 *Supra*, p 25. The GAO also "carefully considered where jet aircraft deposit the bulk of their emissions, what types of emissions they produce, and how these emissions affect the atmosphere, both by themselves and in combination with each other:" *supra*.

86 *Supra*, p 5.

87 Royal Commission on Environmental Pollution, *supra*, note 69.

88 Ian Waitz et al, *Aviation and the Environment: A National Vision Statement, Framework for Goals and Recommended Actions*, Report to the United States Congress (Boston, Massachusetts Institute of Technology, 2004), a study mandated by the US Congress in December, 2003 as part of the *Vision 100 – Century of Aviation Reauthorization Act* (HR 2115, Public Law 108-176), p 4: see http://web.mit.edu/aeroastro/partner/reports/congrept_aviation_envirn.pdf. Stakeholders who participated in the study proposed a "National Vision for Aviation and the Environment" which, in part, states that "In 2025, significant … impacts of aviation community … local air quality emissions will be reduced in absolute terms, *notwithstanding the anticipated growth in aviation*. Uncertainties regarding both the contribution of aviation to climate change, and the impacts of aviation particulate matter and hazardous air pollutants, will be reduced to levels that enable appropriate action," *supra* (emphasis added). The vision statement is stated to be aspirational (*supra*, p 5).

89 *Supra*, p 11.

90 *Supra*.

91 *Supra*, p 12.

92 *Supra*, p 18

93 *Supra*.

94 *Supra*, note 2.

95 *Supra*, note 69.

96 Waitz, s*upra*, note 88, pp 4-5.

97 R Sausen et al, "Aviation radiative forcing in 2000: an update on IPCC (1999)," *Meteorologische Zeitschrift*, vol 14, no 4, pp 555-561 (the EU TRADEOFF project).

98 The report of the June, 2006 MIT workshop notes that, with reference to the Sausen et al study, "[a]n update of the IPCC (1999) radiative forcing (RF) from aviation for the "current" time period finds that, with one exception, the IPCC findings have not significantly changed, apart from the increase in air traffic from 1992 to 2000 (Sausen et al., 2005). The exception is RF from linear contrails, which appear to be at least a factor of three smaller. There is still no reliable estimate of RF from aviation-induced cirrus clouds. Based on recent correlation analyses some authors suggest that this RF might be dominating all other aircraft effects. It is critical that appropriate metrics be established before assuming relative climate impacts for various contributions based on potentially inappropriate metrics:" Next Generation Air Transportation System/Joint Planning and Development Office (NGATS/ JPDO) Environmental Integrated Product Team and Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER), *supra*, note 61, p 11: http://web.mit.edu/aeroastro/partner/reports/climatewrksp-rpt-0806.pdf.

99 Cairns and Newson, *supra*, note 64. For summaries and analysis of the report see BBC News, "UK 'must act' on plane emissions," 17 October, 2006: http://news.bbc.co.uk/2/hi/science/nature/6056620.stm and Reuters, "Britain Must Cut Flights or Miss CO2 Targets," 17 October, 2006.

100 Department for Transport, *The future of transport – White Paper*, CM 6234 (London, The Stationery Office, 2004): http://www.dft.gov.uk/about/strategy/whitepapers/fot/.

101 Cairns and Newson, *supra*, note 64, p 17.

102 Emphasis added.

103 Cairns and Newson, *supra*, note 64, p 21.

104 Anderson et al, *supra*, note 3.

105 IPCC, *supra*, note 2.

106 Royal Commission on Environmental Pollution, *supra*, note 69.

107 Excluding cirrus clouds.

108 Anderson et al, *supra*, note 3, p 11.

109 *Supra*.

110 *Supra*.

111 Next Generation Air Transportation System/Joint Planning and Development Office (NGATS/ JPDO) Environmental Integrated Product Team and Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER), *supra*, note 61.

112 *Supra*, p 6.

113 *Supra*; and pp 19-20, 28-29 and 42-46.

114 *Supra*, p 8.

115 *Supra*, pp 8-9 and 20-22, 29-37 and 46-52.

116 The report notes that, "[i]n assessing the overall impact of aviation on climate, and to quantify the potential trade-offs on the climate impact of changes in aircraft technology or operations, metrics for climate change are needed to place these different climate forcings on some kind of common scale. Radiative forcing (RF) has been used as a proxy for climate impact for well-mixed greenhouse gases. However, recent analyses have demonstrated that a unit radiative forcing from different climate change mechanisms does not necessarily lead to the same global mean temperature change (or to the same regional climate impacts). The concept of efficacy (E) has been introduced to account for this (i.e., E depends on the specific perturbation to the climate system, such as changes in ozone or aerosol distributions related to aircraft emissions). Hence, it is the product of E and RF that should be evaluated and intercompared for the various climate impacts from aviation. However, RF is not an emissions metric capable of comparing the future impact of different aviation emissions. The applicability of emission metrics, such as Global Warming Potentials (GWPs), have not been adequately tested and evaluated:" *supra*, pp 10-11, 22-27, 37-38 and 52-54.

117 *Supra*, pp 11, 22.

118 See Stern, *supra*, note 30.

119 *Supra*, p 485.

120 *Supra*, p 172, box 7.1.

121 *Supra*, Annex 7.c.

122 *Supra*, p 485.

123 *Supra*, p 342 (box 15.6).

124 *Supra*, p 342. The review, however, states that "this could be an *overestimate* because recent research … suggests the warming ratio is closer to 2. It could be an *underestimate* because both estimates exclude the highly uncertain possible warming effects of cirrus clouds" (342)(emphasis added). Moreover, "[t]he uncertainties over the overall impact of aviation on climate change mean that there is currently no internationally recognised method of converting CO2 emissions into the full CO2 equivalent quantity" (p 342, box 15.6).

125 *Supra*, Annex 7.c.

126 The IPCC noted in May, 2007 that "total mitigation potential in the [aviation] sector would also need to account for non-CO2 climate impacts of aviation emissions:" *supra*, note 17, p 18.

127 Whilst recognizing the difficulty in coordinating international aviation taxation: Stern, *supra*, p 485.

128 *Supra*.

129 The 2002 Royal Commission on Environmental Pollution notes on this point that "[a]ny inclusion of aviation emissions in an emissions trading scheme will also have to take into account the fact that the total radiative forcing of aviation is about three times that of the carbon dioxide emitted … Just as non-carbon dioxide greenhouse gases are accounted in terms of their global warming potential compared to carbon dioxide, so aviation emissions will need to be accounted to reflect their true contribution to climate change." For the Royal Commission, this means that "the aviation industry should acquire three carbon emission permits for each unit of carbon that it actually emits:" *supra*, note 69, p 36.

130 Stern, *supra*, p 341. Emphasis added.

131 Anderson et al, *supra*, note 3, p 6; the precise citation is "so as to make room for the aviation industry."

132 Royal Commission on Environmental Pollution, *Energy – The Changing Climate* (London, Royal Commission on Environmental Pollution, 2000): http://www.rcep.org.uk/newenergy.htm.

133 Royal Commission on Environmental Pollution, *supra*, note 69, p 37. Interestingly, at a May, 2007 ICAO Colloquium on Aviation Emissions, the ICAO Council president, Roberto Kobeh

Gonzalez, opined that recent studies showed that the climate impacts of aviation emissions were not as severe as previously thought: Aimee Turner, "ICAO aims to clarify impact of aviation on environment," *Flight International*, 22 May, 2007.

134 Cairns and Newson, *supra*, note 64.

135 Department of Trade and Industry, *Our energy future – creating a low carbon economy*, Energy White Paper (London, The Stationery Office, 2003): http://www.dti.gov.uk/files/file10719.pdf; Department of Trade and Industry, *The energy challenge*, Energy Review Report (London, DTI Publications, 2006): http://www.dti.gov.uk/files/file31890.pdf; Department of Trade and Industry, *Updated emissions projections: Final projections to inform the National Allocation Plan* (London, DTI Publications, 2004): http://www.dti.gov.uk/files/file26377.pdf; Department for Transport, *Aviation and global warming* (London, Department for Transport 2004): http://www.dft.gov.uk/about/strategy/whitepapers/air/docs/aviationandglobalwarmingreport; and Department for Transport, *The future of air transport,* Aviation White Paper (London, Department for Transport, 2003): http://www.dft.gov.uk/about/strategy/whitepapers/air/thefutureofairtransportwhite5694.

136 While emissions from other activities fell by approximately 9%.

137 Cairns and Newson, *supra*, note 64, p 14.

138 Department for Transport, *The future of air transport*, *supra*, note 135, and Department for Transport, *Aviation and global warming*, *supra*, note 135.

139 Tyndall Centre for Climate Change Research, *supra*, note 61.

140 B Owen and D Lee, *Allocation of International Aviation Emissions from Scheduled Air Traffic – Future Cases, 2005–2050 (Report 3 of 3)*, Final Report to DEFRA Global Atmosphere Division (Manchester, Manchester Metropolitan University, Centre for Air Transport and the Environment, 2006): http://www.defra.gov.uk/science/project_data/DocumentLibrary/GA01060/GA01060_3754_FRP.pdf.

141 Cairns and Newson, *supra*, note 64, p. 15, noting that "[t]here are clearly some significant differences in these estimates, which partly derive from their assumptions about future aviation growth rates, improvements in technological efficiency and improvements in air traffic management" (*supra*). And, again, these are simply estimates of aviation's carbon dioxide impacts. As Cairns and Newson state, "aviation emits a range of other substances whose impacts on the climate are potentially very powerful:" *supra*, p 15.

142 *Supra*, note 64, p 22. Emphasis added.

143 *Supra*, p 97.

144 Tyndall Centre, *supra*, note 61. The EU is also considered in the Tyndall Centre study.

145 *Supra*, p 4. As part of its introduction, it states that "[t]he failure of governments to account for emissions from international aviation … has led to a serious underestimation of the actions necessary to achieve a true 60% reduction. Within the UK this is particularly evident; whilst the Government's Energy White Paper emphasizes the need for significant carbon reductions, the Aviation White Paper supports considerable growth in air travel. Research conducted … demonstrates the urgent need for coherent climate policy …:" *supra*.

146 *Supra*, p 47.

147 *Supra*.

148 Results of the study for both the UK and the EU are for carbon emissions alone. The study notes that "the altitude at which aircraft fly significantly exacerbates the warming created by carbon dioxide emissions. For example, contrails, cirrus clouds and greenhouse gases formed by aircraft induce additional warming effects which amplify the climate impact of the aviation industry. Such effects are omitted here due to both the very substantial scientific uncertainty associated with the size of the multiplier and disagreements about how, or indeed whether, such a multiplier should be applied. Where the multiplier is used as a simple "uplift" to carbon emissions, it is commonly in the order of 2.0 to 3.5 times the impact of carbon alone However, strictly speaking, such a comparison does not compare like with like:" *supra*, p 50.

149 *Supra*, p 49.

150 *Supra*.

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151 Airport expansion, of course, is not limited to the UK; it is a global phenomenon. In the US, for example, a May, 2007 FAA report concluded that "[a] number of major US cities must expand existing airports in the next two decades, build new ones or find other solutions to meet an increasing demand for air travel:" see US Department of Transportation, Federal Aviation Administration, *Capacity Needs in the National Airspace System, 2007-2025: An Analysis of Airports and Metropolitan Area Demand and Operational Capacity in the Future*, May, 2007 (Washington, DC, US Department of Transportation, Federal Aviation Administration, 2007): http://www.faa.gov/airports_airtraffic/airports/resources/publications/reports/media/fact_2.pdf; see also Errin Haines, "FAA: US airports must expand to meet demand," *USA Today*, 15 May, 2007. Further, US Transportation Secretary Mary E Peters said in May, 2007 that Atlanta should consider having multiple commercial airports and that, by 2025, airports in Atlanta, Chicago, Las Vegas and San Diego could be overwhelmed by passenger demand: Jim Tharper, "Atlanta told to consider second airport," *The Atlanta-Journal Constitution*, 15 May, 2007.

152 Department for Transport, *The future of air transport*, *supra*, note 135. Specifically, the White Paper stated: "7.3 The availability of sufficient airport capacity has the potential to become an important constraint on future growth across the UK without adequate and timely investment. Many airports in the UK are becoming increasingly congested as they attempt to cope with rising passenger numbers. In some cases, the capacity of terminals and runways is at, or near, saturation point ... 7.13 The Air Transport White Paper … supports the provision of two new runways in the South East in the period to 2030 - the first at Stansted (2011-12) and the second at Heathrow (2015-20) … Land at Gatwick will be safeguarded for a new runway in case conditions attached to a new Heathrow runway cannot be met ... 7.14 The White Paper also supports development at other airports including a new runway at Birmingham, around 2016 … It supports safeguarding land at Edinburgh for a new runway around 2020. And it supports additional terminal and airside development to make maximum use of existing runway infrastructure at a number of the larger regional airports, and additional terminal capacity at many of them ...": http://www.dft.gov.uk/about/strategy/whitepapers/fot/chapter7aviationandshippingd5705.

153 Tyndall Centre, *supra*, note 61, p 48.

154 *Supra*, p 49.

155 *Supra*. The European Commission states that aviation "contributes to global climate change, and its contribution is increasing. While the EU's total greenhouse gas emissions fell by 3 % from 1990 to 2002, emissions from international aviation increased by almost 70 %. Even though there has been significant improvement in aircraft technology and operational efficiency this has not been enough to neutralise the effect of increased traffic, and the growth in emissions is likely to continue in the decades to come:" http://ec.europa.eu/environment/climat/aviation_en.htm. Toward the end of 2005, the Commission adopted a Communication, "Reducing the Climate Change Impact of Aviation," (Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions, *Reducing the Climate Change Impact of Aviation*, COM(2005) 459, 27.9.2005; http://eur-lex.europa.eu/LexUriServ/site/en/com/2005/com2005_0459en01.pdf) which included an impact assessment and considered policy options. That Communication concluded, in part, that "the rapid growth [of aviation] undermines progress made in other sectors. If the growth continues as up to now, *emissions from international flights from EU airports will by 2012 have increased by 150 % since 1990. This growth in the EU's international aviation emissions would offset more than a quarter of the reductions required by the Community's target under the Kyoto Protocol.* In the longer run, aviation emissions will become a major contributor if current trends continue" (*supra*, p 2). The Commission, therefore, decided to pursue a new market-based instrument at Community level (as opposed to the levying of taxes and charges) and concluded that "the best way forward … lies in including the climate impact of the aviation sector in the EU emissions trading scheme" (Commission Staff Working Document, *Summary of the Impact Assessment: Inclusion of Aviation in the EU Greenhouse Gas Emissions Trading Scheme (EU ETS)*, COM(2006) 818, 20.12.2006, p 2; http://ec.europa.eu/environment/climat/pdf/aviation/sec_2006_1685_en.pdf). On 20 December, 2006, the Commission adopted a proposal for legislation to include aviation in the EU ETS. The EU's stated overall objective "is to address aviation's growing climate impact and ensure that it contributes to the EU's overall objective of limiting the increase in the global annual mean surface

temperature to a maximum of 2°C above pre-industrial levels." Its operational objective "is to include aviation in the EU ETS" (Commission Staff Working Document, *supra*, p 3). This proposal is examined in more detail in our consideration of strategies for airlines on emissions and climate change at 4.4 below.

156 *Supra*, p 50 ; emphasis added..

157 *Supra*.

158 Anderson et al, *supra*, note 3.

159 In so doing it takes into account fuel efficiency improvements and applies "uplift" factors with regard to radiative forcing. As stated earlier in this paper, the IPCC uses the metric, "radiative forcing," a globally averaged measure of the imbalance in radiation caused by the sudden addition of the relevant activity or emission. The IPCC calculated that the total radiative forcing caused by aviation in 1992 was approximately 2.7 times that caused by CO2 emissions alone; "uplift" is simply that 2.7 factor when applied. Anderson et al note that "there is substantial scientific uncertainty relating to both the size of the uplift factor that should be used, as well as to the method of simply "uplifting" carbon values for comparison with carbon emission profiles. Strictly speaking, such a comparison does not compare like with like:" *supra*, p 6.

160 The "contraction and convergence" principle "has gained increasing support as a method for apportioning global emissions to the national level. Under contraction and convergence, all nations work together to achieve collectively an annual contraction in emissions. Furthermore, nations converge over time towards equal per-capita allocation of emissions:" Tyndall Centre for Climate Change Research, *supra*, note 61, p 47. Bows and Anderson note that "[c]ontraction and convergence is an international framework for apportioning equitably a contracting global carbon dioxide emissions budget. Within this framework, the world's nations work together to set and achieve a global annual emissions target – contraction. In addition, nations converge towards equal per-capita emissions by an expressly defined year – convergence. By simultaneously 'contracting and converging,' such a policy requires all nations to impose targets from the outset:" *Supra*, note 75, p 104. See also J Cameron and A Evans, "What happens after Kyoto? More of the same or 'Contraction and Convergence'?," *New Economy*, vol 10, no 3 (2003), pp 128-131.

161 ppmv = parts per million by volume.

162 For the UK, "the 550ppmv contraction and convergence profile is consistent with the UK government's 2050 target of reducing carbon emissions by 60%:" Anderson et al, *supra*, note 3, p 6.

163 *Supra*. Further, "the scenarios for the UK were investigated in the context of what the impact on the other sectors of the economy might be. The scenarios show that all of the other sectors of the UK economy would need to reduce their carbon emissions significantly to allow the aviation industry to grow at even moderate rates. This would require a much more substantial investment in renewable energy, carbon sequestration, nuclear power, hydrogen and energy efficiency than would be the case with a low growth aviation sector:" *supra*.

164 On contraction and convergence see note 160.

165 Anderson et al, *supra*, note 3, p 7. The DfT's aviation White Paper has been examined in a number of reports and studies considered in section 2.2(b) above.

166 *Supra*, p 56.

167 *Supra*, pp 55-56.

168 *Supra*, p 58. The report concludes that "[d]espite the EU having a policy commitment to sustainable mobility, globally, air passenger kilometres have risen steadily over several decades and the UK has recently embarked on an extended period of government-backed aviation growth. This report shows the stark disjunction between aviation growth trends and effective, long term climate policy in both the UK and the wider EU:" *supra*, p 14.

169 *Supra*, note 75.

170 At least as against earlier Tyndall Centre reports.

171 Bows and Anderson, *supra*, note 169, p 103.

172 *Supra*, pp 105-106.

173 *Supra*, pp 104, 107.

174 *Supra*, p 107.

175 *Supra*, p 109.

176 European Federation for Transport and Environment (T&E) and Climate Action Network Europe (CAN-Europe), *Clearing the Air: The Myth and Reality of Aviation and Climate Change* (Brussels, T&E and CAN-Europe, 2006): http://www.transportenvironment.org/docs/Publications/2006/2006-06_aviation_clearing_the_air_myths_reality.pdf.

177 The questions asked in part 1 are: How much does air transport contribute to climate change?; how much more fuel-efficient have aircraft become?; how climate-intensive is aviation? how important is aviation economically?; and how well does the sector pay its way?

178 The questions asked in part 1 are: Should the EU go it alone, or is this a matter for ICAO?; will EU airlines suffer it if the EU goes it alone?; is a kerosene tax 'blunt and ineffective'?; should Value Added Tax be paid on international tickets?; are ticket taxes to fund development aid a good idea?; is emissions trading the best solution?; and are environmental measures for aviation bad for the poor?

179 European Federation, *supra*, note 176, p 4.

180 Mal Gormley, "Will Climate Change Challenge BizAv?," *Aviation Week*, 13 March, 2007.

181 IATA, "UN Guidelines on Emissions Trading Welcomed," *Press Release*, 17 February, 2007: http://www1.iata.org/pressroom/pr/2007-02-17-01.htm. Reports refer to IATA's increasingly strident tone: see, for example, Gormley, *supra*. On the problems associated with IATA's various climate-related statements and positions see note 57. Interestingly, at a May, 2007 ICAO Colloquium on Aviation Emissions, the ICAO Council president, Roberto Kobeh Gonzalez, opined that recent studies showed that the climate impacts of aviation emissions were *not* as severe as previously thought: see Turner, *supra*, note 133.

182 See Daniel Cusick, "US airlines gird for battle over growing emissions," *Greenwire*, 17 January, 2007. Cusick notes that "[t]o date, little attention has been paid in Congress or in corporate boardrooms to airlines' role in global warming as the industry and its supporters have been consumed with the burden of remaining profitable during an era of rapidly escalating costs:" *supra*. See also Doug Cameron, "US airlines warned of environmental backlash," *Financial Times*, 15 May, 2007.

183 See Roger Blitz, "US cool on climate change," *Financial Times*, 14 May, 2007. Blitz writes that "Sabre Airline Solutions, an airlines services consultancy, asked the leaders of 197 airlines around the world about their views on a range of issues, and found only three out of 62 North American airlines surveyed thought environmental concerns were a significant challenge. That compared with 31 out of 72 airline executives in Europe, the Middle East and Africa who described environmental issues as one of the three biggest challenges they would face in 2007."

184 Mal Gormley, *supra*, note 180.

185 *Supra*.

186 Brian Straus, "Star Alliance looks to shape environmental debate," *ATW Daily News*, 16 May, 2007: "SAS Group CEO Mats Jansson said the environment is the 'single most important question for aviation to deal with right now in order to achieve sustainable growth.' While the alliance reaffirmed its support for new airframe and engine technology and its demand for improved infrastructure, the newly announced Biosphere Connections tie-up with UNESCO's Man and the Biosphere Program gives the airline group both the opportunity to play its part in environmental protection and greater legitimacy when calling for more reasonable analysis of aviation's adverse impact:" *supra*.

187 Marion C Blakey, "Environmental Issues and Partnership," Emissions Colloquium, Quebec, Canada, 15 May, 2007.

188 Doug Cameron, "US airlines warned of environmental backlash," *Financial Times*, 15 May, 2007.

189 *Supra*.

190 Stern, *supra*, note 30.

191 These airlines include Continental, Virgin Blue, Delta, SAS and BA; see Bill Hensel, Jr, "Getting on board on emissions," Houston Chronicle, 22 April, 2007 (Continental); Wendy Frew, "Virgin's latest deal: cut-price carbon offsets," *The Sydney Morning Herald*, 22 March, 2007 (Virgin Blue); Associated Press, "Fly Delta, plant a tree," 18 April, 2007 and "Delta carbon offset program to take flight," *Atlanta Business Chronicle*, 18 April, 2007 (Delta).

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A regular contributor to international journals, David has been published in journals including *Air & Space Law*, the *Virginia Journal of International Law*, the *Loyola of Los Angeles International and Comparative Law Journal* and *Asia Law*. He is a member of the Editorial Board of the *World Review of Intermodal Transportation Research* and is a contributor to *Air & Space Law* on aviation developments in Australia and New Zealand. David has authored, co-authored or edited four monographs or books and is a regular speaker at aviation law conferences.

In 1997 he was the recipient of an Evans Grawemeyer Fellowship awarded by the Australian Government for research and activities aimed at improving the global order. Earlier in his career he was Senior Legal Research Officer at the High Court of Australia and a senior associate and partner at national Australian law firms.

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The focus of Alex's current research is on strategic choice (game) theory, optimisation theory and formal modeling with reference to transportation – aviation in particular - and problems of conflict over resources and resource sharing. He also works on problems involving differential games.

Alex has held a number of academic appointments including Visiting Professor, University of Chicago, and Visiting Professor of Economics, Institute for Advanced Studies, Vienna. He has also advised the Victorian Government's Department of Infrastructure on transport policy. The author of *State Anarchy and Collective Decisions: Some Applications of Game Theory to Political Economy* (Palgrave Macmillan, 2001), Alex has published over 30 papers in international journals.

The Hodgkinson Group (www.hodgkinsongroup.com) is an 11-member aviation consulting practice with advisors located in Australia, Canada, the United States and the United Kingdom. It provides regulatory, operational and strategic advice and reports, and legal advice through its law firm affiliate, to aviation industry participants. The Group's advisors have either held senior executive positions with or advised international and domestic airlines, governments, international organisations (including IATA and ICAO), air traffic control providers, airports, aircraft lessors, global corporations, financial institutions and aviation law firms.

The present focus of much of the Group's work is on aviation and climate change - or the environmental effects of air transportation - and possible responses the aviation industry might make to increasing demands for reductions in aircraft emissions.

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