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Meeting External Costs in the Aviation Industry

Report to the Commission for Integrated Transport (CfIT)

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Executive summary

1 The UK Government has launched a wide ranging consultation entitled "The Future Development of Air Transport in the United Kingdom", seeking views on the level of air transport demand that should be catered for over the next 30 years and including options for how this might be accommodated. Fundamental to answering this question is the degree to which the aviation industry can be expected to fully cover its operational costs, both internal and external. This question is the subject of the present report to the Commission for Integrated Transport (CfIT).

2 The first recommendation of this report is *not* to focus on the question of *full* coverage of the sector's external costs, but on how to develop solid incentives for increasing economic efficiency and social welfare. For this purpose it is *marginal*, rather than total, external costs that should be internalised, as in the shop street economy, where economic efficiency and optimal welfare are achieved by consumers paying (bread) prices that do not cover total production (bakery) costs, but merely the marginal price (of a loaf).

3 In this report, the list of externalities for which policy measures to internalise external costs can and should be developed comprises the following impacts:
1 Climate change.
2 Changes in local air quality.
3 Noise.
4 Congestion of runway slots and air space.

The existence of these external costs is virtually undisputed, both in the scientific literature and among key stakeholders, and there is sufficient quantitative evidence available for agreement to be feasibly reached on appropriate levels of internalisation.

4 It is recommended to intensify research on the following externalities, to improve understanding of their nature and magnitude in the aviation context and the units in which they can best be expressed:
1 Ozone layer depletion.
2 Water and soil pollution.
3 Odour nuisance.
4 Safety risks.
5 Impacts of airport infrastructure.
6 Ongoing impacts on nature conservation and landscape.

Although these cost items are all widely accepted as externalities, there is still insufficient quantitative data for estimating the associated costs.

5 It is *not* recommended to internalise the external costs arising outside the aviation sector (e.g. those of surface transport to and from airports) by means of policy measures impinging directly on the aviation sector. To increase economic efficiency it is recommended to internalise these external costs at source, where there is greatest reduction potential (e.g. in the surface transport sector itself).

6 Whether external costs are internalised by means of charges or through auctioning tradable permits, there will generally be revenues. It is recommended to be reserved with the recycling of these revenues to either the aviation sector or those who bear the external costs. Both options may lead to higher external costs than without recycling. However, in some cases there may be good reason to earmark some fraction for compensating parties to which external costs accrue or for subsidising environmental measures in the aviation sector.

7 All the available evidence supports the view that the external costs of aviation are at present not properly internalised. Although many stakeholders have cited the Air Passenger Duty as a suitable vehicle for incorporating these costs, the APD is not really suitable for this purpose. First, its structure as well as the political motives for its introduction suggest that the APD is a compensation for the VAT exemption on tickets and the tax exemption on fuel rather than a means to internalise external costs. Second, the structure of the APD makes it a very inefficient incentive for reducing external costs.

8 The available evidence suggests that internalising the externalities of the aviation industry will have only a minor impact on demand, in the order of a few per cent, which will be more than offset by projected sectoral growth. It is therefore anticipated that the environmental impact of aviation will continue to grow even after externalities have been internalised. It should be noted that this assessment is based upon the internalisation of the four externalities as recommended previously.

Below, for each cost item we report the policy instruments recommended in the present report.

Climate change (Chapter 4)

8 Taking economic efficiency as its point of departure, CE follows the principle that global problems require global solutions. This would automatically imply a preference for ICAO-level solutions. Global solutions take a long time, however, and CE's recommendations therefore address three scale levels:

- global level: First, ensure a cap is placed on the CO_2-emissions of international aviation. Second, champion introduction of an open emission trading system under supervision of the ICAO that is fully compatible with the UNFCCC trading guidelines and IPCC monitoring and reporting guidelines in place for other sectors. A tightening of NO_x-emission standards is also recommended;
- EU level: Implement a CO_2-emission based "en route" charge in EU airspace in the short term;
- include the CO_2-emissions of domestic aviation in the UK greenhouse gas-trading scheme;
- support further scientific research into the climatic impacts of other aircraft emissions such as contrails and NO_x.

Noise (Chapter 5)

9 CE recommends introducing noise charges or tradable noise permits, based on certified aircraft noise production (in EPNdB) and time of arrival or departure. Although there are no legal obstacles to introducing noise charges, the situation with regard to tradable permits is less clear and more research is required. The appropriate charge level or scale of the trading scheme should be determined at each airport individually. It is recommended that the cost of lost welfare due to land remaining vacant because of noise nuisance also be included in estimates of external noise costs.

Local air quality (Chapter 6)
10 CE recommends introducing emission charges for NO_x, HC and PM_{10} on the basis of aircraft emission data available from e.g. ICAO, in analogy to current Swiss and Swedish systems. This report gives incentive levels per emitted kilogram for the various pollutants. It is recommended, however, to adapt these values to the specific population density in the vicinity of the various airports.

Congestion of runway slots and air space (Chapter 7)
11 CE recommends managing peak-time demand by means of congestion charging or slot auctioning.

Table 1 Policy instruments and incentive levels based on external costs

External cost	Policy instrument	Incentive level	Strength and weakness
Climate Change	Global, open CO_2-emission trading system and tightening of NO_x-emission standards.	Price of tradable CO_2-emission permits determined by international market price for trade among all economic sectors.	Strength: best option, encompassing global CO_2-emissions and therefore most efficient. Furthermore, compatible with flexible mechanisms under Kyoto Protocol. Weakness: global solutions take a long time.
	CO_2-emission based "en route" charge in EU airspace.	DEFRA value of £ 19 per tonne of CO_2 (£ 70 per tonne of carbon).	Strength: implementation possible in medium term. No economic distortions. Weakness: requires agreement among all EU member states.
	Inclusion of domestic aviation CO_2-emissions in UK GHG trading scheme.	Price of tradable permits determined by national market price.	Strength: domestic measure requiring no international negotiations. Furthermore, no economic distortions. Weakness: covers only small fraction of aviation CO_2-emissions.
Noise	Charges differentiated according to certified aircraft noise production (in EPNdB) and time of arrival or departure.	£ 2.50 per noise unit per arrival and £ 25 per noise unit per departure; one unit represents the nuisance due to one aircraft with 90 - 92.9 EPNdB certified noise production and arriving or departing in the daytime.	Strength: no legal barriers. Weakness: relation between charge level and noise targets unclear.
	or: Tradable permits, differentiated according to certified aircraft noise production (in EPNdB) and time of arrival or departure.	Price of tradable permits determined by demand.	Strength: noise levels predictable. Weakness: possible legal barriers require further study.
Local Air Quality	Charges on NO_x, HC and PM_{10}-emissions, based on aircraft emission data.	£ 6 per kg NO_x £ 100 per kg PM_{10} £ 2.70 per kg HC	Strength: proven feasibility in Switzerland and Sweden. Weakness: for PM_{10}, discussion about emission data still required.
Congestion	Congestion charging.	Unknown in advance.	Strength: no legal barriers. Weakness: trial-and-error required to determine charge level.
	Slot auctioning.	Price determined by demand.	Strength: effect known. Weakness: possible legal barriers require further study.

1 Background and aim

1.1 Background

1 In July 2002, the UK Government launched a wide ranging consultation entitled "The Future Development of Air Transport in the United Kingdom", seeking views on the level of air transport demand that should be catered for over the next 30 years and including options for how this might be accommodated. Fundamental to the question of determining the appropriate level of demand to cater for is the degree to which the aviation industry is expected to fully cover its costs, both internal and external. The Government has already made clear that aviation should meet the external costs, including environmental costs, that it imposes (DETR, 1998).

2 This general policy principle is endorsed by the Commission for Integrated Transport (CfIT), an independent body advising the UK Government on integrated transport policy. However, to advise the Department and Ministers how this principle can be turned into a practical policy, CfIT requires a more in-depth understanding of the key issues and the existing evidence base on which to make decisions.

1.2 Aim of this report

3 CfIT has commissioned CE to assist and advise on the full range of issues associated with meeting the external costs of aviation so that CfIT can provide formal advice to the Department for Transport and Ministers by May 2003.

4 For this purpose CE has prepared the present report. Its objectives are to give a substantiated recommendation:
- how and why to meet external costs;
- which external costs to consider;
- how to design the instruments (the incentive structure) for an internalisation policy;
- what incentive levels to use.

Furthermore, the report offers an outline assessment of whether the aviation industry covers its external costs, given the current policy regime.
In two annexes, an analytical framework for designing instruments is given and the present subsidies to aviation are discussed.

1.3 Methodology

5 This report is completed within 10 weeks and is fully based on a concise analysis of existing (inter)national sources and oral and written information from key stakeholders in the United Kingdom. Besides use of existing specific knowledge of the authors on externalities and policies to internalize these costs, it was not the task of the authors to execute new primary research for this report.

6 More specific, the following sources were used[1]:

- national and international literature;
- previous consultation material published by the Department for Transport;
- evidence based position papers from key stakeholders in the aviation industry (see below);
- discussions and comments during three meetings of the Aviation Working Group of CfIT;
- consultation with experts of the Department for Transport;
- results from a cross-examination of written and oral evidence of seven invited key stakeholders during a Hearing on 10 April 2003 in London.

7 Conclusions and recommendations in this final report regarding (i) the list of externalities to be considered, (ii) existing evidence on external costs levels and (iii) the optimal policies to internalize these, are to a large extent based on and influenced by evidence provided by the key stakeholders. Remarkable opinions or (dis)agreement of key stakeholders on specific topics are indicated throughout the text of this report.

8 Evidence from the following key stakeholders has been consulted for this report[2]:

- British Air Transport Association (BATA)*;
- Airport Operators Association (AOA)*;
- Civil Aviation Authority (CAA);
- British Airport Authority (BAA)*;
- Department for Transport (DfT)*;
- Institute for Public Policy Research (IPPR)*;
- Royal Commission for Environmental Pollution;
- Greener by Design (Department for Transport (DTI), The society of British aerospace companies (SBAC), BATA and the Royal Aeronautical Society)*;
- Sustainable development Commission;
- Strategic Aviation Special Interest Group of the Local Government Association (SASIG)*;
- Aviation Environment Federation (AEF)*;
- Institute for Transport Studies, University of Leeds (ITS)*.

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1 See the literature annex of this report for a complete list of sources used for this report.

2 Organizations marked with * have been attending the Hearing on 10 April.

2 The objective of internalising external costs

2.1 The definition of external costs

1 People take many things into consideration when deciding to perform activities, such as travelling. For example, the personal benefits of travelling, the benefits for the person to whom one is travelling, or the private expenditures on travelling, such as the costs of travelling time and fuel. Some costs and benefits may fall outside the decision scope, however. This may be the case if unintended side effects occur, such as environmental pollution. In that case, the welfare of other people may be effected, without the one responsible taking these costs into account in his decision-making process. If such costs occur, we refer to them as *external* costs. This term is the opposite of *internal costs*, such as the costs of fuel, which do have an influence on the decision to perform the activity or not.

2 Related to the discussion about external costs is the issue of subsidies, such as public expenditure for infrastructure, where it is not fully paid for by the aviation sector. These are also costs, which are borne by other parties (the taxpayer) than the aviation sector or the passengers[3]. Depending on the preferred definition, one can either consider subsidies a component of external costs or consider external costs a component of subsidies. Generally, however, as in this report, subsidies and external costs are treated separately. Subsidies are therefore treated separately at the end of this report in Annex B.

2.2 Three objectives of meeting external costs

3 Costs, such as the results of environmental pollution, do not necessarily have to remain external. The moment people have to pay for the unintended side effects of their activities, the external costs become internal costs. In other words, they are met by the industry.

4 In discussing this internalisation of external costs, in particular when economic instruments such as charges are used for this purpose, there is often confusion about the exact objective that is pursued. A clear distinction is crucial, however, since different objectives for internalisation require different policy instruments. Three objectives may be distinguished:
- social welfare (allocative efficiency);
- environmental targets; and
- compensation (equity).

[3] Of course, financial support to economic sectors may increase their economic activities, their competitiveness, their profit and the employment they generate. *However*, there is no such thing as a free lunch. The government finances the support by raising general taxes, such as income tax. Where these taxes are raised, they have the opposite effect: they *decrease* economic activity, competitiveness, welfare and employment. Economic theory suggests that the positive effects for the subsidised sector and the negative effects for those producing the means for the subsidy generally do not balance. Generally, society as a whole loses welfare. The reason is that both subsidies and the taxes necessary to produce the means distort markets. The use of resources becomes inefficient.

The characteristics and compatibility of these objectives are considered in the following paragraphs.

2.2.1 Objective 1: increasing social welfare ('allocative efficiency')

5 A first objective of meeting external costs is to increase economic efficiency and thus social welfare. In other words, the existence of external costs gives rise to a loss of social welfare (the aggregated welfare of all individuals). The reduction of external costs can often be achieved by the acceptance of an internal cost lower than the resultant benefits For example, a “cleaner” engine costing £ 1 million extra may prevent £ 10 million of external costs due to air pollution (hypothetical figures for illustration only). However, as long as the environmental costs remain *external* costs, the operator will not consider the possible benefits and therefore not consider replacing the engine.

6 To increase social welfare, it is essential that policy instruments give incentives to reduce external costs. To this end, it is necessary to relate policy instruments as closely as possible to the source of the external costs. Therefore, it is generally not recommended to simply divide total external costs equally over the sector. For example, if external climate change costs were to be internalised through the imposition of a fixed charge[4] per flight movement, society could be compensated, but no precisely targeted incentive would result to make aviation emit less greenhouse gas emissions. A better incentive would be a charge related as closely as possible to the level of greenhouse gases produced. If such a charge 'works', its collector’s revenues will decrease, together with the emissions.

2.2.2 Objective 2: achieving environmental targets

7 Economic instruments, like charges and tradable emission allowances, could help achieve environmental targets. They offer an additional incentive to sectors to reduce their emissions.

8 To achieve environmental targets, the levels of the incentives are set such that the targets are achieved. The targets do not have to be socially *optimal*, however. If the target is too strict, charges based on that target will lead to the implementation of measures which are more costly than the environmental benefits. If the target is too loose, measures which could have been implemented against lower costs than the environmental benefits will not be introduced.

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[4] Or other instrument related to flight movements without irrespective of length of haul.

Environmental targets and internalisation of external costs

9 Often, meeting external costs and reaching environmental targets are considered as two separate issues. However, this is only the case if one considers meeting external costs solely as an issue of cost recovery without offering an incentive to change behaviour. If external costs are met so as to obtain optimal social welfare, meeting external costs with economic instruments is compatible with reaching environmental targets. How do the two approaches relate to each other?

10 If external costs are met, part of these costs will be prevented. To stick to the earlier example, cleaner engines will be introduced. However, not all costs will be prevented. After all, sometimes the costs of prevention will be higher than the gains. A cleaner engine could cost £ 1 million, while the reduced costs of air pollution may be only £ 100,000. From the point of view of optimal social welfare it is wise only to prevent those external costs, for which the prevention costs are lower than the external costs themselves. The conclusion is that to obtain optimal social welfare, part of the negative side effects, such as environmental pollution, will remain. In other words, emissions at the social optimum are not necessarily zero.

11 How does the social optimum relate to environmental targets insofar as they are already in place in present environmental policy (e.g. the air quality standards or the 57 dB noise emission threshold for significant community annoyance)? Generally, environmental targets are somewhere in between 'business-as-usual' and zero emissions. In principle, if the environmental targets set by governments are efficient, they are about equal to the environmental pollution, which remains after internalising external costs. Or, if emissions are reduced *further* than would be achieved by internalising external costs, this leads to sub-optimal welfare; measures are implemented that are more expensive than the environmental benefits.

2.2.3 Objective 3: compensating those affected by external costs ('equity')

12 When external costs exist, society at large or some specific sub-groups bear costs caused by a specific party, in this case aviation. A further justification for internalising external costs is therefore that those affected are compensated by those responsible. This is often referred to as to present the 'unpaid bill' to those responsible, or to 'shift the burden'. This reason is strongly related to the 'polluter pays principle' and the concept of 'cost recovery'.

13 To compensate those bearing the external costs, the *total* external costs due to aviation have to be determined and these costs collected from the aviation sector. The total external costs by aviation due to all types of effects could for example be equally divided over all flight tickets, resulting in a fixed charge per ticket. The level of revenues from any charging instrument, and their use, play a central role; the environmental impact and the precise design of the instrument less so.

2.3 Recommendation

14 The distinction between three different policy goals offers a clear choice to policy makers. The discussion often focuses on the issue of cost recovery, and thus charge *levels*.

15 CE Delft recommends taking economic efficiency (increase of social welfare) as a starting point for an external cost policy. By offering the right incentives, social welfare can be increased and environmental goals are reached more easily. This approach we define as internalising the external costs.

Trade-offs between different externalities

16 In some cases, measures to reduce one type of externality may increase another type (see e.g. RCEP, 2002). For example, measures to internalise the costs associated with local air quality may increase the size of the external costs arising from noise. As long as both types of externalities are internalised, an efficient optimum in the reduction of both externalities will be achieved. However, if one of the externalities is not internalised, inefficient transfer of costs may occur to this externality.

3 Which external costs to consider?

3.1 External costs due to aviation

1 Numerous studies have been done listing external costs of transport. Only a minority of these studies have paid serious attention to aviation[5]. From these studies we can draw the following list of external effects, and therefore costs, in the air transport sector[6].

1. Climate change. In the case of aviation, not only CO_2 is relevant in this respect. Emissions of NO_X and water vapour, and the phenomenon of condensation trails ('contrails') play a substantial role in the climatic impact of aviation (IPCC 1999).
2. Ozone layer depletion.
3. Local Air Quality. Local air pollution during the landing and take-off cycle (LTO) may lead to health and environmental impacts. Most important components are:
   - nitrogen oxides (NO_X), related to high combustion temperatures;
   - particulates (PM_{10}), related to fuel and combustion quality;
   - hydrocarbons (HC), related to fuel and combustion quality;
   - sulphur dioxide (SO_2) related to the sulphur content of the fuel.
4. Water and soil pollution, for example from de-icing.
5. Noise. Two components should be distinguished:
   - nuisance and health impacts of aircraft noise;
   - indirect land use impacts, due to restrictions around airports to prevent noise nuisance.
6. Odour nuisance.
7. Safety risks. Two components should be distinguished:
   - the risks of accidents;
   - indirect land use impacts due to restrictions around airports to reduce risks.
8. Congestion of runway slots and air space.
9. Impacts of airport infrastructure, such as land use, impacts on nature, wildlife, and heritage (e.g. listed buildings, conservation areas), and division of the countryside leading to habitat fragmentation and barrier effects for both nature and communities.

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[5] Examples include (Bossche 2002, CE Delft 1999, CE Delft 2002a, COWI 2000, DETR 2000, INFRAS/IWW 2000, ITS 1996, Schipper 1999).

[6] Not included in this list is the issue of Deep Vein Thrombosis (DVT). DVT is a serious condition where blood clots develop in the deep veins of the legs and may be caused by long haul air travel. In some discussions, DVT is considered as an external cost, but in our view it does not fall within the strict definition of external costs. The health costs of DVT are not unintended side effects to a third party, but costs to the passenger making a transaction with an airline company.

Where the National Health Service covers the medical costs of DVT, this can be regarded as a subsidy to the passengers, rather than an external cost to society.

Although one could argue that passengers can recognise such risks when boarding an aircraft and thus internalise these risks into their decisions, one could also follow a more 'paternalistic' approach. Society could protect a passenger against the risks he/she takes. Governments could prescribe a certain seat pitch (space between seats) of an aircraft in order to minimise the risks of DVT. In this case we do not talk about 'internalisation' of external costs, but about 'protection' of an actor against risks of decisions taken by him or herself. A similar example can be found in road transport, where governments prescribe safety belts in cars.

10 Ongoing impacts on nature conservation (eg, disturbance to migratory or nesting birds) and landscape (eg, loss of tranquillity in some areas).

External costs induced *outside* the air transport sector

2 Apart from the direct external costs due to aviation, there are also indirect external costs induced outside the aviation sector. One could think of the external costs of energy production, aircraft production, maintenance and disposal, and the external costs from surface transport to/from airports[7].

3 We propose not to include such indirect external costs outside the air transport sector, because internalisation of these costs by the aviation sector would not lead to economic efficiency. The aviation sector is not in the best position to reduce the external costs outside the sector. Economic theory suggests that internalisation of these costs should take place at the source, where the external costs can best be diminished. Charging aviation for these external costs would not put the incentive at the right place, which would lead to sub-optimal welfare. If surface transport leads to external costs, these costs should be reflected in the costs of motoring or of public transport tickets. If energy production leads to external costs, these costs should be internalised in the fuel price by the power plants and refineries.

3.2 Recommendation

4: Both evidence from the Hearing with key stakeholders[8] and policy reports show that there is hardly any controversy about the existence of the following external costs (see e.g. DETR, 2000; DfT, 2003):
1 Climate change.
2 Local Air Quality.
3 Noise.
4 Congestion of runway slots and air space.

Furthermore, international literature and different stakeholders confirm that sufficient quantitative evidence is available to be able to reach agreement on levels of internalisation (see next chapters). CE therefore recommends to start developing instruments for the internalisation of these four types of external costs.

5 CE emphasises that its recommendation to start developing internalisation instruments for a selection of external costs does not imply that the other cost components (5 to 10) are considered negligible. The choice of external costs to focus on is in part a pragmatic one due to a current lack of research results on the other cost components, for which much less quantitative evidence is available. Therefore, CE recommends intensifying investigations on the external costs components for which quantitative evidence is weak or lacking in the scientific literature:
1 Ozone layer depletion.
2 Water and soil pollution.
3 Odour nuisance.
4 Safety risks.
5 Impacts of airport infrastructure (see box).
6 Ongoing impacts on nature conservation and landscape.

7 See e.g. Response to CfIT by HertsEssex, 27 February 2003.

8 AOA, ITS, IPPR, AEF, SASIG and DfT.

For these types of external costs, more research is necessary on the nature of the impact, the units in which this impact is to be expressed and the size of the impact.

Impacts of airport infrastructure and expansion

6 There is a wide range of external costs associated with the *existence* of airport infrastructure apart from the external costs associated with its *use*. These include:

- loss of wildlife, habitats and bio-diversity, through e.g. barrier effects;
- loss of countryside;
- loss of landscape;
- harm to visual amenity.

7 The financial valuation of these effects is still in its infancy. Studies exist in which the willingness to pay for various types of landscapes and nature is analysed. However, these results can seldom be translated directly to specific situations under investigation. For many external effects, such as harm to visual amenity, even the units in which to express the effects are under discussion. More research is therefore necessary to establish the external costs of these kinds of effects. IWW/INFRAS (2000) gives a value of € 166 million in 1995 as a first estimate of the external costs for nature and landscape due to aviation in the UK.

8 In addition to uncertainty on the level of external costs that may arise due to airport expansion, there is also a lack of information on the impacts of current incentive schemes on the level of external costs with regard to nature. One may consider the following regulations as instruments that aim at internalisation of external costs connected to the existence of (new) infrastructure:

- Bird and Habitat Directives of the European Union;
- environmental Impact Assessment (EIA) requirements;
- criteria used in the process of Project Appraisal;
- nature protection laws; and
- spatial planning procedures.

9 Finally, it should be noted that the external costs due to additional infrastructure are *fixed* one-off costs, which should preferably be taken into account in cost-benefit analysis of airport construction and expansion, rather than in the context of instruments for the internalisation of external costs due to airport *activities*.

4 Climate change

4.1 Evidence on external costs

1 There is no *scientific* evidence of external climate costs which could directly be translated into an incentive level to let aviation meet its external climatic costs. A translation of the scientific evidence to policy instruments (charge levels or emission reduction targets), requires *inevitable* political choices, for example with respect to the discount rate and the handling of risks.

2 Such political choices underlie both the authoritative publication by DEFRA, in which a monetary valuation is given of carbon dioxide emissions, and the emission reduction targets, which have been endorsed by the UK government.

3 Fortunately, the financial valuations of carbon dioxide emissions are of the same order of magnitude. Therefore, we recommend to use the DEFRA value of £ 70/tC as a central value, which lies in the middle of the marginal abatement costs of the two emission reduction targets for the UK.

4.2 Detailed discussion evidence on external costs

4 In the case of climate change, it is impossible to speak of *the* evidence of external costs in the sense of a simple value, which has to be met by aviation. The reason for this statement is *not* that there are no external costs related to climate change or that there is too much scientific controversy. The reason is that a translation of the scientific evidence to values to be met by aviation, requires *inevitable* political choices.

5 First, climate damage due to present emissions may occur many years from now. However, to let the aviation sector meet these costs, the costs have to be translated into a present value by means of so-called *discounting*. Which discount rate to use is a political choice. Nevertheless, the discount rate is the most important explanatory parameter for the wide range of optimal incentive levels reported in the literature (see Table 2).

Table 2 Central estimates of the marginal cost of CO_2-emissions[9]. The values are in US Dollar per tonne of carbon emitted between 2000 and 2010, base year prices: 2000

	Discount rate			
	0%	≈ 1-2%	≈ 3%	≈ 5-6%
Ayres and Walter (1991)		38 – 45		
Cline (1992, 1993)		197	17-37	10
Peck and Teisberg (1993)				15 – 18
Maddison (1994, 1996)				10
Fankhauser (1994)		68		10
Nordhaus (1991, 1994)[10]				9
Plambeck and Hope (1996)		440	46	21
Eyre et al. (1999) [11] Tol (1999)	191 (392)	92 (201)	26 (61)	9 (23)

6 Second, thorough external cost studies do not present single values, but present various estimates with different probabilities. There is such a thing as the *most probable* climate damage, but also such things as less probable climate *catastrophes*. Public debate shows that, although climate catastrophes are unlikely, the fear of such catastrophes strongly feeds the social demand for climate policy. Only on the basis of *political* choices with respect to the handling of risks, such as the precautionary principle, can these different external cost estimates with different probabilities be translated to a single incentive level for climate policy such as a target or a charge.

7 Since different political choices lead to very different incentive levels, making such choices can not be recommended in the context of environmental policy making for a single economic sector such as aviation. Such choices have to be made at the level of public debate, implying the national level. Therefore, it is recommended that the incentive level be deduced as far as possible from evidence of incentive levels that have been set or discussed at the international or national level.

8 This recommendation leads to two approaches to set an incentive level for the internalisation of external costs of greenhouse gas emissions. In the first approach, the incentive level is based on national assessments of the damage due to climate change. In the second approach, the prevention costs made to reach policy targets are determined. We discuss both approaches below.

[9] The table includes all estimates, which play a central role in the international literature. Not included in this review is a recent discussion paper by Tol and Downing (2000), because it has not yet been published and discussed in other publications.

[10] In recent updates Nordhaus arrives at the same results (Nordhaus, 1999).

[11] Eyre *et al*. and Tol estimates are for 2005-2015. Between brackets the estimates are given including *equity weighting*.

4.2.1 Financial valuation of greenhouse gas emissions

9 So far, the UK government has set no official guidelines on financial values of greenhouse gas emissions. However, an authoritative publication by DEFRA exists, in which a monetary valuation is given of carbon dioxide emissions[12]. In 2002, DEFRA published an extensive assessment of the existing scientific literature on damage estimates of carbon dioxide emissions. The Working Paper concluded that in terms of damage costs per tonne of Carbon equivalent (/tC) "a value of approximately £ 70/tC (2000 prices, with equity weighting[13]), seems like a defensible illustrative value for carbon emissions in 2000. This figure should then be raised by £ 1/tC for each subsequent year"[14].

10 The value of £ 70/tC (£ 19 per tonne of CO_2) recommended by DEFRA is based upon a discount rate of 3%. Furthermore, the value is based upon the most probable climate damage only and takes no account of the risk of climate catastrophes.

11 DEFRA adds, however, that "it is still important to note the huge uncertainty surrounding this estimate and to bear in mind the fact that it takes no account of the probability of so-called ‘climate catastrophe’. As such a pragmatic solution may be to employ two other values in sensitivity analysis. One of which could be half the size of the central estimate (i.e. £ 35) and another twice as big as the central estimate (i.e. £ 140) …"[15].

12 Although the recommended value by DEFRA is not an official and politically endorsed obligatory guideline, it is remarkably free of debate in both the evidence papers by the various stakeholders to the CfIT Working Group and the Aviation Hearing at April 10, 2003[16] [17]. It is important to stress, however, that present consensus among stakeholders over the DEFRA value of £ 70/tC may be deceptive and evaporate when the factual introduction of instruments to meet external costs is at hand.

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[12] Of course, many other assessments exist, such as IPCC (1996) and FESG (2003). However, no evidence can be found in these reports on the decisions by the UK government with respect to the handling of climate risks.

[13] Equity weighting is used to take account of differences in income between geographical regions of the world, and the fact that a Pound means less to the rich than to the poor.

[14] Furthermore, the Working Paper recommended periodic reviews of its estimates as new evidence becomes available. In the light of new developments, the Government has decided to follow this recommendation. In the summer of 2003, a workshop is planned to make an inventory of the issues that have to be addressed in such a review.

[15] These values can be compared to the values given by Pearce et al. (1999) used in the Pearce & Pearce study (2000): £ 106/tC (£ 48/tC - £ 161/tC). The DEFRA study is more recent, however.

[16] Exceptions are the Airport Operators Association, according to whom "No robust evidence has been published to date which allows a confident calculation of aviation’s external costs" and HertsEssex, according to whom the DEFRA assessment is inadequate and needs to be updated.

[17] It should be noted that it is not the DEFRA assessment itself to which is referred in the evidence papers, but the earlier published publication *Valuing the External Costs of Aviation* by the then-DETR (2000) for which the DEFRA assessment has been input.

4.2.2 Targets

13 The UK government has endorsed two targets for greenhouse gas emission reduction. First, the UK has ratified the Kyoto Protocol. If this Protocol is ratified by a sufficient number of countries, the UK would have a legal obligation to reduce greenhouse gas emissions by 12.5% by 2008 to 2012 from 1990 levels. Second, the UK government also has set itself domestic targets to cut CO_2-emissions by 20% by 2010 and 60% by 2050 (DTI, 2003).

14 Contrary to the previously discussed recommended values by DEFRA, the climate policy targets are politically endorsed. Therefore, these *set* targets offer stronger evidence of the political decisions with respect to the handling of climate change than the *discussed* charges.

15 Furthermore, the climate targets will determine the price of emissions for other economic sectors in the UK than aviation. To ensure economic efficiency and a level playing field for the various sectors of the UK economy, incentive levels for aviation should be set equal to the incentive levels which result from the climate targets for the rest of the economy.

16 In a study carried out for the then-DETR by Dames and Moore (1999), it was estimated that the cost to the UK and the rest of the world of meeting Kyoto targets in 2010 would be around £ 45/tC (2000 prices).

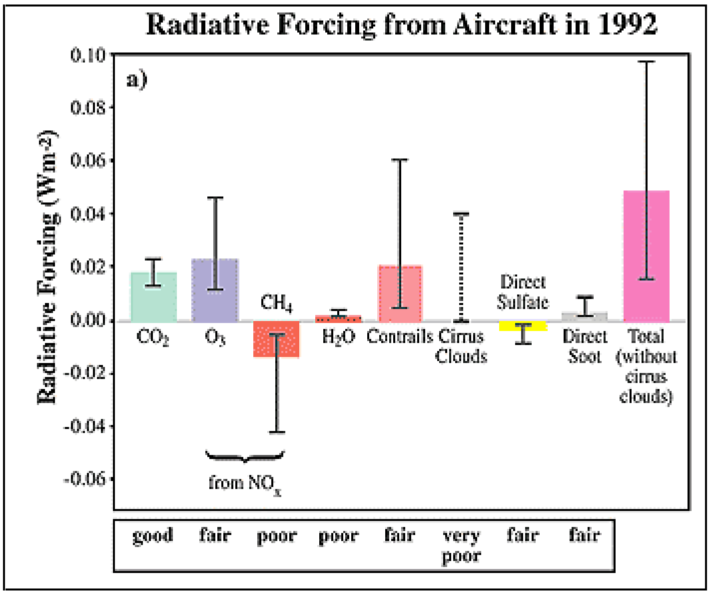
17 The Dames and Moore study estimated that the UK manifesto target for a 20% reduction in carbon dioxide emissions in the UK by 2010 could increase marginal abatement costs to as much as around £ 100/tC (2000 prices).

4.3 The incentive structure

18 Climate change is regularly found to be the most important external effect of aviation (CE 2002a, DfT 2003). In 1992, aviation's contribution to global warming was 3.5% (IPPC, 1999). The Royal Commission on Environmental Pollution (RCEP, 2002) predicts that aviation’s contribution to global warming might be as high as 6-10% in 2050. An estimate for the current UK situation is 5% (DfT 2003).

19 The climatic impacts of aviation are extensively discussed in the IPCC's 1999 Special Report on Aviation and the Global Atmosphere. While investigations have continued since then, an authoritative and multi-party reassessment of the state of global atmosphere has not appeared since. Therefore, we base this section mainly on the IPCC's Special Report. An important graph from the report is shown below.

Figure 1 Impact of aviation emissions on the earth's radiative balance and hence on the forced greenhouse effect, in 1992. O_3 is not a direct emission, but is formed by atmospheric reaction triggered by NO_X. The lifetime of the potent greenhouse gas CH_4, on the other hand, is reduced as a result of NO_X-emissions



20 The graph shows that climatic impacts of aviation do not come from CO_2 alone. In fact, a middle estimate is that the sum of radiative impacts is 2.7 times the impact of CO_2 alone. Besides CO_2, the most important impacts come from NO_X-emission and contrail formation. Unlike CO_2, the climatic impacts of NO_X and contrails are very much dependent on local circumstances, like temperature, humidity, altitude, and ozone background concentration. It should be stressed that new scientific evidence since 1999 shows large scientific uncertainty and a large bandwidth on the climatic impact of contrails

21 Therefore, simply multiplying the CO_2-impacts by 2.7 and using the values acquired to design instruments for CO_2-reduction is not the most efficient way forward. Such a simplification would give over-incentives to CO_2-reduction and insufficient incentives to reduce NO_X-emissions and contrails.

4.3.1 Instruments for CO_2-reduction

22 As a first step, one could consider the development of instruments for CO_2-reduction. This can be done at multiple levels: domestic, EU and global.

23 As this report takes economic efficiency as a starting point, it follows the principle 'global problems require global solutions'. This would automatically imply a preference for ICAO-level solutions.

24 However, global solutions take a long time to agree and implement. For the short and medium term it is therefore recommended for individual countries or regions, such as the EU, to take a more pro-active approach and take domestic or regional action. In fact, the EU and several Member States adopted emission reduction targets that should be met without usage of the flexible mechanisms that 'Kyoto' allows for. Such policies, which in principle are not cost effective, could be adopted for a number of reasons:

- as a 'backstop': to ensure emission reduction even if global solutions fail or do not deliver expected reductions;
- for strategic reasons: to become a fore-runner in clean technologies;
- for moral reasons: as rich countries we are obliged to take action ourselves.

25 Therefore, this report treats possibilities at three levels: domestic, EU and global (ICAO).

Domestic

26 BA joined the voluntary UK emissions trading system with respect to its domestic emissions. In the future, this system could be expanded to other airlines and made mandatory. Domestic emissions are those emitted by UK flights with origin and destination within the UK.

27 Some countries like the US apply a fuel tax for domestic flights. In a relatively small country like the UK however such an instrument would probably lead to tax evasion and distortion of competition by carriers flying from abroad and subsequently flying a domestic 'leg' with cheap fuel.

EU level

28 At EU level, currently the only realistic[18] economic instrument under discussion to reduce CO_2-emissions is the so-called 'en route emission charge'. In addition to the navigation charges collected by EUROCONTROL, an environmental component of a charge could be collected. Such a charge could either raise revenues or be a revenue neutral 'performance standard incentive' (PSI). A recent CE Delft report (CE 2002b) assessed the feasibility of both options. Both have their pros and cons:

- the primary problem with the revenue-raising charge is the distributional issue; who will collect the revenue and what will be done with it?;
- the primary problem with the PSI is the fact that it is in principle less efficient because it does not offer an incentive for cost-effective volume measures (see section A.3.2), and that there is a problem of identifying and agreeing a performance standard as a basis for measurement.

29 The principal choice with this option is whether it should be considered a temporary action, until an ICAO-based solution is implemented, or a permanent solution, in line with the pro-active EU approach.

ICAO level

30 At ICAO level, preference has been expressed to arrive at a so-called 'open emissions trading regime'. At the end of 2003 the results are expected of a study, initiated by ICAO, on the design of such a regime. So far most countries support an open emission trading regime because of its expected (cost)effectiveness and its compatibility with climate policies developed under the Kyoto Protocol for other economic sectors. All stakeholders expressed their support for this global solution during the hearing.

31 It should be stressed, however, that in contrast with other sectors, no emission reduction commitments or targets are set yet for greenhouse gas

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[18] An EU kerosene tax, while acknowledged as desirable in principle, appears unlikely to be implemented in the air transport field in the foreseeable future due to its potential economic distortions and legal implications.

emissions from international aviation[19]. Establishment of mitigation policies, such as an open emission-trading regime including a “cap”, is only possible after setting a target. The Kyoto Protocol states only that Parties should work *through* ICAO on ways to mitigate the emissions of aviation, leaving the question of allocating the responsibility of emissions from international aviation open. Two key options are allocation to ICAO in the form of a stand-alone target or integration into national assigned amounts of the Parties under the Kyoto Protocol. Any progress on internalising external climatic costs of international aviation can only be made by first setting an emission reduction target in case of open emission trading. We recommend therefore to start the following two actions: (i) to put the question on the agenda[20] who is responsible for setting a target for international aviation and (ii) to allocate the responsibility of greenhouse gas emissions from international aviation and to actually set a target.

4.3.2 Instruments for reduction of other impacts

NO_X

32 The exact chemistry and climatic contribution of NO_X-emissions, which can vary depending on circumstances, are still not perfectly known. Therefore, there are some risks in including NO_X in an emission trading or charging regime, although the overall impact of NO_X-emissions is to contribute to global warming. Further, the calculation of NO_X-emissions at high altitudes is much more complex than that of CO_2-emissions. For these reasons, one could argue that starting with CO_2 alone would be preferable until more certainty is achieved over NO_X-impacts and calculation methodologies.

Contrails

33 The formation of contrails is becoming better understood, though research is still in progress. It depends on the temperature and humidity of exhaust gases and the local atmosphere, and the presence of condensation nuclei (CE, 2002a). Relatively simple technical and meteorological information enables military aircraft - for visibility reasons - to fly routes and altitudes at which no contrails appear. In principle, usage of such information offers an interesting opportunity for civil aviation also to significantly reduce its climatic impact. At this stage it is impossible to say whether economic instruments could play a role, or whether regulation should offer the solution, or both.

[19] Greenhouse gas emissions from international marine are also not covered by national targets of Parties under the Kyoto Protocol.

[20] This question could be put on the agenda of negotiations of the Conference of Parties under the United Nations Framework Convention on Climate Change (UNFCCC).

4.3.3 Recommendation

34 CE recommends the following with regard to internalising the external climatic costs of air transport:

- global level: As a first best solution, to support the introduction of an open emission trading system under supervision of ICAO which is fully compatible with UNFCCC trading guidelines and IPCC monitoring and reporting guidelines that also are in place for other sectors;
- EU level: To implement a CO_2-emission based “en route” charge in EU airspace in the short term;
- include CO_2-emissions from domestic aviation in the UK greenhouse gas-trading scheme;
- support further scientific research into the climatic impacts of other emissions such as contrails and NO_x.

4.4 Present external cost internalisation

35 The emission of greenhouse gases, such as CO_2, is strongly related to the use of fuel. It goes without saying that aviation has many incentives to use fuel economically. First, fuel is not free, but has a price. Second, fuel adds to the load aircraft have to transport. However, these incentives are entirely determined by internal costs and benefits of aviation. The external costs of climate change are not internalised. The aviation sector in common with other transport modes and users of fuel does not pay a charge for emitting greenhouse gases, nor does it have to buy tradable emission allowances. Finally, there is no regulation whatsoever to make aviation more fuel-efficient.

36 Some argue that the external costs of climate change are (partially) internalised via the Air Passenger Duty (APD), which generates yearly revenues in the order of £ 800 million. On the basis of the structure of the APD and the argumentation for the APD by the UK government, we consider the APD a compensation for the VAT-exemption on fuel and not an instrument for the internalisation of external costs. This issue will be discussed in more detail in Annex B when financial support to the aviation sector is discussed.

37 However, *if* APD were considered as an incentive to reduce the emission of greenhouse gasses, it would certainly be an inefficient tool for the purpose. The APD does not offer an incentive to make aircraft more fuel-efficient or increase their load factor.

5 Noise

5.1 Evidence of external costs

1 In a study by Pearce & Pearce (2000) the (marginal) external noise costs have been determined for various types of aircraft. The values range between £ 15 to £ 256 per aircraft movement, depending on the type of aircraft (excluding the Concorde). At the core of the methodology lie estimates from the international literature on the reduction in house prices as a result of an increase in noise. Pearce & Pearce use a value of 0.6% reduction in house prices per dBA. Pearce & Pearce estimate the total external costs due to noise at £ 37.4 - 66.2 million per year for Heathrow airport.

2 The results by Pearce & Pearce were used in the publication *Valuing the External Costs of Aviation* by the then-DETR (2000). The results of the DETR publication are virtually free of debate in both the evidence papers by the various stakeholders to the CfIT Working Group and the Aviation Hearing at April 10, 2003.

3 The SERAS study, which uses the methodology by Pearce & Pearce, arrives at external noise costs of 36 to 40 pence per passenger at Heathrow; at all other airports, values never exceeded 5 pence per passenger (DETR, 2000).

4 A recent CE Delft study (CE Delft 2002a) arrived at substantially higher estimates of marginal noise costs, ranging between £ 60 to £ 800 per aircraft movement, depending on the type of aircraft. Partially this can be explained by the fact that the CE Delft study takes indirect land use from noise contours into account in the costs calculations (see box).

Are external noise costs already internalised in house prices?

5 Generally, aviation noise influences house prices around airports. Without the noise the house prices would be higher. Some people argue that because house prices are lower around airports, the residents are already compensated for the noise nuisance[21]. Although this is partly true, the fact that residents are compensated does not mean that the external costs are *internalised*. The external costs are only shifted to the landowners. After all, it is not aviation which pays for the compensation, but the owner of the land on which the houses stand. He loses money with respect to the situation where no noise would have existed. Only in the case where the airport owns the land, are the external costs internalised. Since airports generally do not own all the land where noise nuisance occurs, (Flughafen Düsseldorf is one airport, which has pursued a policy of house purchase in noisy areas) economic instruments are generally necessary to internalise external noise costs.

[21] See e.g. response to CfIT by Flybe.

External costs of noise include more than *nuisance* costs

6 It is common practice to deduce the external costs of noise from the noise nuisance which actually occurs. However, there are more external costs related to the production of noise. If in the vicinity of an airport no houses are built because of *potential* noise nuisance (either by government regulation or by private decisions), there are still genuine external costs connected to the noise *production,* although no noise *nuisance* occurs. It is clear that the value of the land has been decreased by the occurrence of noise. Therefore, in determining the external costs of noise one has to add to the external costs of noise *nuisance* the decrease in the value of land, which has been left vacant due to noise, actual or potential.

7 Generally, these additional costs are not reflected in hedonic pricing studies. Most studies look at the actual number of houses exposed to a certain level of noise and multiply these numbers with the depreciation of house prices at that noise level. By doing so, the houses are neglected, which would have been built in the absence of noise emissions. For these *potential* houses, the depreciation of prices is 100%. Although the houses do not exist and no noise nuisance occurs, the related external costs are real for the owner of the land.

8 Furthermore, the impacts of noise on *nature* should not be neglected.

5.2 Instruments for internalisation

9 Of all types of unintended side effects of aviation, the social costs due to noise are the most internalised. There are various instruments presently applied, both regulatory and economic, ranging from limitations to flight movements at night to differentiation of landing charges on the basis of noise production. As will be argued later on in this chapter, a more efficient incentive can be designed to cover all types of measures which airlines can apply to reduce noise costs:

1. Flying less (volume measures).
2. Changing operating techniques (e.g. close-in steep climb at a relatively high noise level affecting fewer people, or far-out relatively slow climb at a relatively low noise level affecting more people).
3. Changing the aircraft type or technology (technological measures).
4. Changing the time of flight (operational measures).
5. Changing the approach or departure route, and the runway (also operational measures, but requiring airport and/or ATC decisions).

10 In practice, it is virtually impossible to design a single instrument which offers a perfect incentive for all measures. The incentive basis should be feasible in practice. Much can be learnt, however, from existing instruments[22]. We discuss them below.

[22] The Boeing Airport Noise Regulation Information Web Site contains information for over 600 airports throughout the world: http://www.boeing.com/commercial/noise/.

5.2.1 Limitation of movements

11 A number of UK airports (e.g. Heathrow, Gatwick, Luton, Manchester and Stansted) have movement limits for the night-time from 23.30 to 6.00 hours. Limitation of noise during night-time is the main aim of the movement limitations.

12 Limitation of flight movements is a blunt instrument for internalising external costs due to noise. It only gives an incentive for volume measures, that means flying less; and does nothing to encourage technological or operational measures.

5.2.2 Differentiation of landing charges

13 Some UK airports, including Heathrow, Gatwick and Stansted apply differentiated noise charges. Within the 'Chapter 3' classification[23] two aircraft types are distinguished: Chapter 3 'base' and Chapter 3 'high'. There are also differentiation's for daytime and night-time landings and take-offs.

14 The purpose of the differentiation of landing charges is to discourage noisy aircraft and to discourage landing at night. Because of the differentiation, the landing charge for a noisy aircraft may be more than double the charge for a less noisy aircraft. This differentiation varies between airports.

15 Often the differentiated landing charge is called a noise surcharge. Since clearly we can not know what the landing charges would have been without noise regulation, it is difficult to separate the landing charges from the noise surcharge. It is also unknown whether the differentiated landing charges raise any revenues dedicated to noise prevention. For example, it can be difficult to establish what part of the revenue is used for noise insulation schemes in the local communities around the airports and land compensation claims.

16 Differentiation of landing charges on the basis of (subdivided) ICAO noise categories offers a slightly more efficient incentive to internalise external noise costs than limitations to flight movements, since it puts an incentive on the use of quieter *types* of aircraft. However, the subdivision applied is generally very rough and it does not offer an incentive to make a given type of aircraft quieter, unless it is subsequently reclassified. Nor is there an incentive to take operational measures. Overall it would appear that the potential for differentiate landing charges is not fully used.

5.2.3 The Quota Count System

17 Aircraft movements are restricted at night at certain airports by means of a quota count system. Aircraft are assigned quota counts (QC) on the basis of their certified noise level (in EPNdB) with a –9EPNdB adjustment for arrivals.

[23] 'Chapter' Classification used by ICAO to categorise noise classes.

Certificated Noise Level (EPNdB)	*Quota Count*
More than 101.9	16
99-101.9	8
96-98.9	4
93-95.9	2
90-92.9	1
Less than 90	0.5

18 Total noise production is restricted by setting noise quota for the various airports, a maximum permitted sum of the quota counts of all aircraft taking off from or landing at the airport in question during any one season in the night quota period. At Heathrow, for example, the UK government has set a noise quota of 4140 for the winter season. The total ’noise emission cap’ (the total number of allowed quota points) is initially distributed over the airlines on the basis of their noise production in the past. Airlines can determine themselves how to use their ’noise emission allowances’. Redistribution among airlines is possible, but permission is required from the slot co-ordinator. It is not known whether noise emission allowances are traded between airlines.

19 The use of certificated noise production as an incentive basis offers an incentive for both volume measures and technological measures. It does not offer an incentive for operational measures. Potentially, it can be differentiated for time to offer an incentive for the choice of time of departure and arrival.

5.2.4 Financial penalties

20 Financial penalties are applied to departing aircraft which exceed noise limits. The noise level is actually measured. At Manchester, for example, the following penalties apply:

Night Noise Limit	87dB(A) (100 PNdB)
Daytime Noise Limit	92dB(A) (105 PNdB)

21 Minimum penalties of £ 500 for the first dB by which the noise limits are exceeded and £ 150 pounds for each full PNdB by which the limits are exceeded, are applied.

22 The airports use the revenue resulting from the penalties to fund community projects. For example, the noise penalty has raised £ 250,000 per annum for London Gatwick, which has been divided over nine surrounding municipalities (£ 10,000 directly to each municipality and the rest on the basis of project applications).

23 In addition to noise level based penalties, sometimes the accuracy with which aircraft adhere to preferred noise routes is monitored. Unacceptable deviations may result in a 'track deviation penalty'.

24 This incentive basis - measured noise production - can potentially offer an incentive for all types of measures.

5.3 Incentive structure

25 We recommend using certificated noise production as an incentive basis for economic instruments to internalise external noise costs, for the following reasons:

1. An instrument based upon certificated noise production may offer an incentive for all measures except operational measures such as choice of approach or departure route, and choice of runway. It is questionable, however, whether the choice of these operational measures can be left open to the airlines only to be determined by financial considerations. Most likely, these choices have to be centrally planned and made by the airport and ATC authorities.
2. The use of certificated noise production as a measure has already been proven to work for the quota count system, which is very comparable to a system of tradable noise allowances. Pearce & Pearce (2000) also use the certificated noise production as an incentive basis.
3. Theoretically, it is best to use the measured noise production. However, it requires an extensive measuring system. Its working could give rise to controversy.

26 The incentive structure could be given shape as follows: Aircraft are assigned noise units on the basis of their certificated noise level (in EPNdB).

Certificated Noise Level (EPNdB)	*Noise Unit*
More than 101.9	16
99-101.9	8
96-98.9	4
93-95.9	2
90-92.9	1
Less than 90	0.5

27 For flights between 18:00 and 8:00 the noise units are multiplied by a factor, compensating for the fact that noise at night leads to more nuisance than in daytime (hypothetical figures for illustration only):

Time	23:30-6:00	6:00-7:00	7:00-8:00	8:00-18:00	18:00-19:00	19:00-20:00	20:00-21:00	21:00-22:00	22:00-23:30
Factor	10	8	4	1	2	3	4	6	8

28 This incentive basis can be used for either a system of tradable noise allowances, or a system of noise charges. In the case of charges, the level is multiplied by the amount of noise units per flight. In the case of tradable noise allowances, the noise units give the amount of allowances required for a flight.

5.4 Incentive level

29 Since norms already exist for the production of noise at airports, there is a major choice to be made between basing the incentive level on present norms, and basing them on external cost estimates. Ideally, there would be no fundamental difference. *If* the noise targets are optimal *and* the external cost estimates are perfect, *then* internalising the external costs would lead to a level of noise production equal to the noise norms.

30 However, there is insufficient information to judge whether the present norms or the external cost estimates do more justice to the social optimum. It is also difficult to compare the two approaches. The level of noise production which would result from internalisation of external costs on the basis of present cost estimates is unknown.

31 Since the noise norms already exist, we recommend a hybrid system, in which present noise regulations, such as limitations of flight movements, remain, and simultaneously external costs are internalised on the basis of present estimates. If it turns out in the future that internalising the external noise costs gives an incentive to reduce noise much more or much less than the noise norms, then there is more information for a discussion about the desirability of the norms and the quality of the external cost estimates.

32 The results of the Pearce & Pearce study can be translated to values per 'noise unit'. One noise unit stands for the noise nuisance due to one aircraft with a certified noise production between 90 and 92.9 EPNdB, arriving or departing at daytime (see section 5.2.3). The external costs per noise unit are £ 2.50 per arrival and £ 25 per departure[24].

5.5 Do present instruments internalise external noise costs?

33 Based on information on current noise regulation, and studies on external noise costs, it is not possible to conclude whether all external noise costs are covered. There are two primary reasons for this conclusion. First, no sufficient data exist of disturbances below 57 dB noise level, i.e. below the flight path outside the direct vicinity of airports. Second, no exact estimations exist on the implications of current regulations, (such as noise quotas and movement limitations) on the external cost level at UK airports.

34 However, based on the design of current noise regulations we can conclude that the structure of some of the incentives is not efficient. Hence, internalisation according to the efficiency approach has not been reached yet.

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[24] The difference between arrival and departure is the result of an adjustment by Pearce & Pearce for the different relationship between certificated noise levels and noise footprints on arrival compared to departure – see Pearce, B.D. (1999).

6 Local Air Quality

6.1 Introduction

1 Local air quality is affected by various emissions during the landing and take-off cycle (LTO), such as:

- nitrogen oxides (NO_X), related to high combustion temperatures;
- particulates (PM_{10}), related to fuel and combustion quality;
- hydrocarbons (HC), related to fuel and combustion quality;
- sulphur dioxide (SO_2) related to the sulphur content of the fuel.

2 Of these emissions, NO_x and PM_{10} are the most important. On the one hand, the objectives and limits for these two emissions, such as the EU air quality standards, are the most difficult to meet around a major airport. On the other hand, the external costs due to NO_x and PM_{10}-emissions are estimated to be much more substantial than those of HC and SO_2 (CE, 2002). NO_x is important primarily because of the magnitude of emissions and the link with ground ozone concentrations, PM_{10} because of its relatively significant health impacts per unit of emission.

6.2 Evidence of external costs

3 The Pearce & Pearce study (2000) calculates external costs of several hundred UK£ for short-haul flights due to local air pollution. However, with respect to this study the DETR (2000) concludes that "the wide range of uncertainty surrounding both the quantification of effects as well as the values and the fact that local air quality is airport specific implies that these average figures would not be meaningful." Furthermore, the SERAS-study (DETR, 2000) draws the conclusion that external costs due to local air pollution "would be too low to be expressly represented in any environmental levy"[25].

4 Studies by CE (1998, 2002), however, confirm the major findings by Pearce & Pearce and arrive at values in the same order of magnitude, in the order of one Pound per passenger per landing and takeoff (LTO cycle). The CE study of 2002 contains the most up-to-date and extensive literature survey of external cost estimates of local air pollutants. Where the Pearce & Pearce study does not yet mention PM_{10} as a pollutant of interest, CE pays extra attention to PM_{10} in the light of the recent improvements in knowledge. Estimates for the external costs per pollutant are given in Table 3.

Table 3 Overview of middle estimates from recent European literature for valuation of NO_x, PM_{10}, HC, and SO_2, based on damage costs, in Euro (1999) per kg emitted (CE, 2002)

	Average	Urban	Rural
NO_x	9	12	7
$PM_{10}/PM_{2.5}$	150	300	70
HC	4	6	3
SO_2	6	10	4

[25] It should be mentioned that in the SERAS-study only respiratory hospital admissions are included in the absence of evidence on deaths brought forward from NO_x-emissions.

5 As the table above shows, population density plays an important role in the range of valuations found. This can be explained by the fact that the greater part of the financial value of emissions consists of damage to human health, which is of course highly dependent on population density. In its study, CE recommended using 'average' values, as large airports are generally located in suburban rather than urban or in rural areas. Better, however, is to take for each airport the specific population density into account.

6 Table 4 gives an indication of the importance of the various pollutants for the total external cost estimates.

Table 4 Financially valued LTO emissions for four aircraft types with an average fleet technology, in Euro (1999) per LTO cycle (CE, 2002)

	NO_x	$PM_{2.5}$	HC	SO_2	Total per aircraft
40 seater	10	20	3	0	33
100 seater	66	44	6	3	119
200 seater	186	44	6	5	241
400 seater	512	95	13	11	631

6.3 The incentive structure

7 The most appropriate instrument for internalisation of external costs would relate to actual emissions. In-flight measurement of emissions is not currently feasible on a large scale, however. Thus, calculated emissions have to be used as an alternative. Since 1981, ICAO has established standards for engine emissions as specified in Annex 16, Volume II, and Aircraft Engine Emissions. The standards cover NO_x, CO, HC and particles, based on the aircraft landing and take-off cycle (LTO). For the purpose of certification of aircraft, an ICAO database on engine emissions produced during the LTO is available (ICAO, 2002).

8 For NO_X, CO and HC the mass of emissions is known. In the case of particle emissions, the methodology used for measuring and computing resultant aircraft emissions results in a smoke number (SN) which is not directly useable to determine the mass of emissions. Several approximate measures have been developed to predict mass emissions using the smoke number (see IPCC, 1999). For example, AEA technologies has devised a methodology to derive approximate PM_{10}-emission factors from Smoke Number data for the DETR report *Air Quality at UK Regional Airports in 2015 to 2030* (DETR, 2002).

9 On the basis of emission data from the ICAO, the US Environmental Protection Agency and the engine manufactures, NO_x and HC-emissions are already charged at airports in Switzerland and Sweden[26]. Aircraft are divided into emission categories leading to emission related (revenue-neutral) surcharges on landing charges. These surcharges can be extended by PM_{10}-charges. Experience from Switzerland and Sweden has been used by ECAC in coming up with the ERLIG recommendation and collectively this information could perhaps form a basis for external cost internalisation in the UK.

[26] See for details: http://www.boeing.com/commercial/noise/.

6.4 Present external cost internalisation

10 Presently, the aviation sector does not pay a charge for emitting local air pollutants, nor does it have to buy tradable emission allowances. Regulation of local air pollution (e.g. NO_X-emission standards) exists, however. It may therefore be concluded that external costs due to local air pollution are not (efficiently) internalised at present.

7 Congestion

7.1 Introduction

1 Congestion pricing in aviation is a relevant issue because many airports are facing capacity problems. In 2000 one out of four flights was delayed due to air traffic management problems.

2 The issue of congestion has received ample attention in the road transport sector, and since the late sixties air and airport congestion is slowly becoming an issue in the international literature.

3 In this chapter, we will first discuss the question whether air(port) congestion can be considered an external cost or not.

7.2 Is air(port) congestion an external cost ?

4 It is often discussed whether congestion is an external cost, because at the macro-economic level, the aviation sector, like the road transport sector, pays the costs of its own delays. However, at a micro-economic level, the decision of one individual airline (motorist) to fly (or drive) during peak periods has an impact on the travel time of other airlines (or motorists).

5 Therefore, the conclusion from international literature is that if an airport is served by a monopolist airline, congestion costs are internal. Most airports, however, are served by an oligopoly of airlines. In that case, carriers internalise only the congestion they impose on themselves. An instrument that captures the uninternalised portion of congestion can then improve the allocation of traffic (Brueckner 2002).

7.3 Managing peak demand for capacity

6 Currently, peak demand for air and airport capacity is managed by regulation of EUROCONTROL and the individual airports that have a limited number of peak-time slots. Slots are generally allocated on the basis of historic rights ('use it or lose it'), in accordance with Community legislation. This system hampers an efficient peak capacity allocation, as there is no overt relationship between the value attached by airlines to flying in the peak and prices asked. These valuations may take place financially in the course of slot trading in the grey market, or implicitly in the choice of services which airlines decide to operate to use their scarce slot resources. For example, in the absence of Public Service Obligation (PSO) designation for domestic feeder services, their Heathrow slots have not been ring-fenced and airlines have used them for more lucrative routes.

7 In principle, there are two ways to better use scarce airport capacity. One is to introduce differential peak rates (congestion charging); the other is to auction peak-time slots. The first can be done on a UK-alone basis (and used to be practised on a seasonal, daily and hourly basis by BAA), the second requires EU legislation to be changed. It should be noted that peak/off peak differentials in airport charges already exist at BAA's London airports.

8 Both solutions are inter-related. The effectiveness of peak-time pricing depends very much upon on the alternatives from which airlines have to choose. When slots are auctioned instead of allocated on a 'historic rights' basis, airlines do not necessarily have to stick to their peak-time slots in order to be certain of any capacity. In brief, peak-time pricing as an economic but not necessarily a social policy instrument, works much better, if airport slots are allocated with an economic instrument.

7.4 Expanding capacity vs. optimising capacity utilisation

9 Of course, proper peak pricing is not the Holy Grail to airport capacity management. Basically three responses are possible to airport capacity problems:
1. Expand peak capacity by building new capacity.
2. Expand peak capacity by improving landing and take-off procedures.
3. Manage demand during peak times, for example by slot regulation, congestion charging or slot auctioning.

10 There is no single 'best' way forward. A recent CE Delft study (CE 2002c) elaborates theoretically and empirically how the combination of pricing and investment would look like in case of road transport. The analysis is strictly financial: an important proviso for the system developed is that the *marginal external costs of both traffic and capacity expansion are internalised.*

11 The road investment rule is as follows: under the proviso mentioned, *the time to expand capacity at a particular location is when the revenues from an optimised congestion charge levied on new, additional capacity are precisely sufficient to fund the capital costs of that capacity* (CE 2002c).

12 Of course, the proviso mentioned should be treated with extreme care. Also, it should be further investigated whether this rule holds equally for airports as for roads. However, the rule shows that optimal pricing and optimal capacity are interlinked issues, and it makes little sense to focus on pricing alone or investment alone.

8 Implications of internalising

8.1 Introduction

1 In this chapter, we discuss potential economic and environmental implications of internalising externalities in the aviation sector. Strong evidence of these impacts is, however, scarce, as experience with implemented internalisation policies is rare, and in devising new policies, many degrees of freedom exist[27].

2 It is important to note that the closer the internalisation instruments seize upon the external effects, the more opportunities for the aviation sector to reduce the external effects, the less costs have to be passed on to the customer, and the lower the economic implications will be. For example, if a certain level of noise is required, a fixed charge on tickets will have much more economic impact on the aviation sector than an instrument that directly seizes upon noise production.

8.2 Economic implications

3 Internalisation of external costs will have economic impacts, both at sectoral and macro-economic level. At both levels, three types of potential economic impacts can be distinguished.

4 The first type of economic impact stems from a possible net financial flow from the aviation sector to other economic actors, caused by potential *revenues* of economic instruments such as taxes, charges, and auctions to allocate emission permits or slots. This effect will thus not occur if revenue-neutral policy instruments are applied.

5 The second type of economic impact stems from the costs to the air transport sector of taking *environmental measures*, such as flying cleaner and quieter aircraft, or not being permitted to use an airport at the desired time for reasons of external costs such as noise and congestion.

6 The third type of economic impact stems from potential *distortions* in competition if triggered by internalisation instruments. These impacts are described on more detail in Section 8.2.3.

8.2.1 Macro-economic implications

7 The macro-economic impact of possible *revenues* from internalisation instruments is positive, provided the revenues are not earmarked for a specific purpose. This has already been argued earlier in this report in Section A.3.1. The reason is that such welfare-increasing taxation creates the opportunity to spend the money wisely or lower welfare-decreasing taxes such as those on labour.

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[27] An authoritative source in the field of transport is 'Efficient transport for Europe; Policies for the internalisation of external costs', ECMT, Paris, 1998.

8 The macro-economic impact of the costs of *environmental measures* taken in the air transport sector is probably negative unless economic distortions are relieved (see Section 8.2.3).

9 The macro-economic impact of *distortions* in competition is certainly negative.

8.2.2 Economic implications to the air transport sector

Impacts of revenues from economic instruments

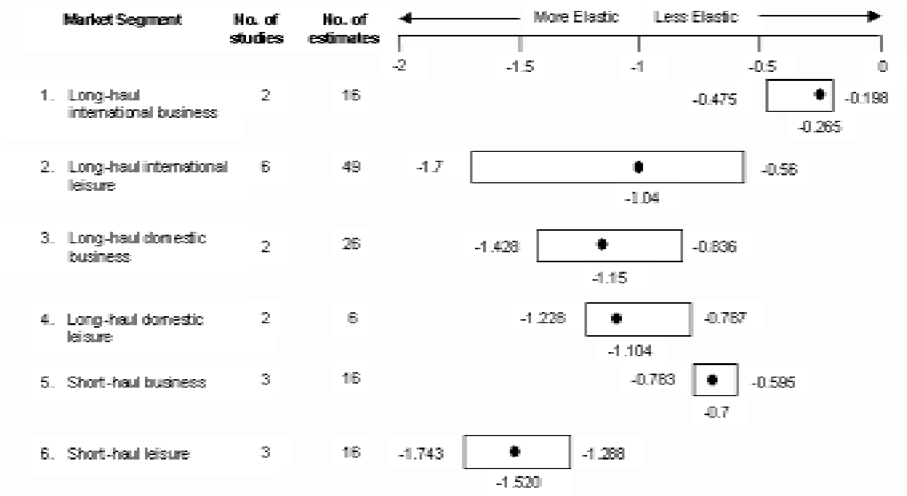
10 Although instruments that generate revenues to third parties may be attractive at macro-economic level as discussed above, it is a clear-cut case that the impact for the aviation sector is negative. Such financial transfers decrease room for investment, will generally lead to higher ticket prices and hence reduce demand for aviation.

11 Most important parameter in the estimates of the economic implications is the so-called price elasticity of demand: the degree to which demand reacts to changes in ticket prices. A price elasticity of -1.5 would imply that a ticket price increase of 1% results in demand decreasing by 1.5%.

12 Estimates of fare elasticities differ by market for air travel (see e.g. US Department of Transportation, 1995; IPCC, 1999; Brons *et al*., 2001; Gillen, Morrison and Stewart, 2003). In a recent literature survey of air travel demand elasticities in commission of the Canadian Department of Finance (Gillen, Morrison and Stewart, 2003) six markets for air travel air distinguished: business and leisure travel; long-haul and short-haul travel; and international and North American long-haul travel.

13 The report concludes the following: "Since the availability of alternative modes of transportation that are reasonably close substitutes for air transport diminishes with distance travelled, it is expected that the demand for air transport will be less elastic for longer flights than for shorter flights. Further, international travel tends to be spread over more time than domestic travel, so that the airfare is a smaller proportion of overall trip costs, which makes international travel less sensitive to changes in ticket prices. In addition, leisure travellers are more likely to postpone trips to specific locations in response to higher fares, or to shop around for those locations offering more affordable fares. Consequently, it is expected that the demand for air transport for leisure reasons will be more elastic than business travel." The results of the literature survey are given in Figure 2.

Figure 2 Own-price elasticities of demand (Gillen, Morrison and Stewart, 2003)



14 In the context of this report, it is not possible to distinguish between the various markets for air travel. As stated earlier, neither is it possible to distinguish between types of aircraft. Therefore, at present we can not present more detailed analysis of the impact on demand that performed by the DETR in *Valuing the External Costs of Aviation* (DETR, 2000). The DETR assumed an environmental charge, based on external cost estimates comparable to those discussed in this report, which is passed on in full to passengers through increased fares. The DETR estimated the increase in short-haul fares by around 3,5% and long-haul fares by about 6%. By taking an overall fare elasticity of demand of –0.8, the DETR arrives at a reduction of demand for short-haul and long-haul travel by around 3% and 5% respectively. It should be noted that the DETR used a price elasticity of -1.0 in its *Air Traffic Forecasts for the United Kingdom 2000*[28].

15 A price elasticity in the order of minus one is also in accordance with the estimated impact of the introduction of the Air Passenger Duty. According to the DETR (1997), analysis suggests that the initial level of APD reduced demand in 1995 by less than 2%. This is also the percentage change in ticket price due to the introduction of APD. Similar effects were estimated for the increase in APD.

16 A recent CE Delft report (CE Delft 2002b) calculated the volume impact of the introduction of an emissions charge to be levied in European airspace. This study shows that a charge level of € 50 per tonne CO_2 would decrease air transport volume by roughly 2% for EU carriers. Of course, this figure highly depends on the level of charges applied.

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[28] In *Air Traffic Forecasts for the United Kingdom 2000*, the DETR performed a sensitivity test for the impact on demand of a CO_2 tax, introduced globally and assumed to be fully in place by 2015. In the analysis the following assumptions were made. 1. Fuel costs constitute 10% of total airline costs; 2. The CO_2 tax doubles the fuel costs; 3. The cost increase is fully passed through to passengers; 4. The price elasticity is minus one. Under these assumptions, such a tax could depress national demand by up to 10 per cent.

Economic impacts of costs of environmental measures

17 Internalisation of external costs poses costs to the aviation sector, regardless of whether the instruments generate revenues or not. Internalisation instruments are designed to trigger environmental measures such as flying cleaner and quieter aircraft, and applying higher load factors. These measures come at a cost, which can potentially end up in ticket or freight prices. With respect to greenhouse as emissions, the impact of these costs on transport volume is unlikely to exceed 1% (CE Delft 2002b, MATG 2000)[29].

8.2.3 Distortions in competition

18 The aviation sector is concerned about the economic impact of internalisation on the sector as such. However, the major point of concern showing in the evidence papers is the effect of internalisation on economic competition between modes of transport and between the aviation sector in different countries. If external costs are internalised in one sector or country, but not in the other, distortions in competition may occur.

19 If external costs are internalised in all countries and sectors, this will also lead to changes in relative competitive position of different suppliers. Suppliers that are more environmentally efficient will see their competitive position improve with respect to environmentally less efficient suppliers. However, this is not to be regarded as an economic distortion. Instead, economic efficiency is *increased*. Let's consider the reduction of greenhouse gas emissions. There is no doubt that the current situation in which international aviation (and shipping) is excluded from the Kyoto Protocol commitments is economically inefficient, and that participation of these sectors would improve the efficiency of greenhouse gas emission reduction policies.

20 In the following, we distinguish between two types of distortions: between airlines and between transport modes.

Airlines
21 Changes in competitiveness are determined mainly by the profit margin per unit transported and the market share in combination with the size of the transport market (CE, 2002):

- If the economic incentives are applied equally to all suppliers in the specific market (e.g. flights within, to and from the UK), all carriers face the same cost increase and will be able to pass on this cost increase to customers. The profit margin will then remain unchanged.
- Internalisation of external costs may slow down the growth of the transport volume in the market where the economic instruments are introduced. This might lead to reduced economies of scale for the carriers for which the specific market is their *home* market. This in turn might weaken the competitive position of these carriers. This effect is not expected to occur for charters and low-cost carriers operating direct flights on origin/destination markets. Some effect may occur for carriers operating on both origin/destination markets and transfer markets. It is assumed, however, that if the internalisation of external costs leads to a delay in growth of one year or less, economies of scale will not be reduced significantly.

[29] This is on the basis of the DEFRA value of £ 70/tC.

Transport modes

22 If internalisation of external costs is limited to the aviation sector, this may lead to distortions in competition with other sectors offering the same product, that means other transport modes such as rail and road transport. It is therefore to be recommended to internalise external costs in all transport modes at the same time.

23 However, the distortions in competition should not be overestimated. Generally, aviation offers different products from other transport modes with respect to travelling time and distance. For example, in the case of international passenger transport, road and rail are no serious competition for aviation. In the case of short-haul business transport, travelling time is often decisive.

8.3 Environmental implications of internalising externalities by aviation

24 Aviation is a strongly growing economic sector, in absolute numbers but also relatively in comparison to the average growth of the UK or global economy. Even if we take into account the present economic difficulties for the aviation sector, the projected growth of both passenger and freight transport by air is substantial. According to the mid-range scenario by the DETR (2000), air traffic at UK airports will grow at an average of 4.25% per annum. This is based on 'unconstrained forecasts of the underlying demand for air travel' up to 2030 and is intended to cover all market segments. What does this mean for the environmental effectiveness of internalising external costs by the aviation sector?

25 The demand for air transport *without internalisation of external costs* is expected to grow so strongly that *even* if all external costs are properly internalised, the environmental impact by aviation may still increase in absolute terms (see also RCEP, 2002). For example, if greenhouse gas emissions are internalised throughout the UK economy against £ 70/tC (see section 4.1), the *aggregate* of national emissions may decline. Emissions by aviation may still grow, however. The strong demand for air transport may imply that people put *more* efforts in reducing CO_2-emissions in the rest of the economy in order to be able to keep flying. In that case, a growth in aviation emissions is accommodated by an increased effort by e.g. industry or road transport. This is not a recommendation to put lower environmental charges for aviation than in the rest of the economy, but only that the same charges could have less effect on aviation in environmental terms.

26 Sometimes, it is proposed that all sectors of the economy should contribute equally to national emission reduction targets in terms of emission reduction percentages. From that point of view, aviation should let its emissions decline as well as the other economic sectors.

This would imply that if the effects on emissions by charges to internalise external costs would be outstripped by projected growth in the aviation sector, this gives reason to set higher charges (see e.g. RCEP, 2002)[30]. However, such an approach would neither be beneficial from an environmental point of view, nor from the point of view of economic efficiency and costs.

27 For the environment, the result would be the same. Although the emissions by the various economic sectors would differ, the national emissions would not change. From the point of view of economic costs, the result would be quite different, however. To pursue comparable environmental targets throughout the UK economy would imply aviation making very high costs in Pounds per reduced kilo emission, while in other sectors cheap emission reduction options may be left unused. Given the strong projected growth of aviation, to require the same emission reductions by the aviation sector in terms of percentage as by other economic sectors, will most likely imply a reduction of demand beyond that driven by internalising externalities. This will imply an incentive to the aviation sector to implement measures of which the investment costs may be higher than the prevented external costs. This implies a loss of social welfare.

28 In particular in the case of noise, the strong growth of aviation may lead to a tension between the present noise targets and the noise emissions which will result from the internalisation of external noise costs.

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[30] In section 4.1, it was argued that the incentive level to let aviation meet its external costs due to global warming requires political choices. This may raise the question why the government could not choose the incentive level such that aviation's greenhouse gas emissions decline. The latter political choice is a matter of sectoral policy, however, which should not be confused with the political choices required to arrive at incentive levels to let sectors meet their external costs, e.g. with respect to the discount rate and the handling of risks. These political choices should be independent from the specific economic sector under consideration and even independent from the specific environmental issue at stake. Political choices with respect to the discount rate and the handling of risks should be the same in the case of global warming and the loss of bio-diversity.

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Meeting External Costs in the Aviation Industry

Annexes

Report to the Commission for Integrated Transport (CfIT)

Delft, August 25, 2003

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A Analytical framework for designing instruments

A.1 Introduction

1 To design instruments for the internalisation of external costs three choices have to be made with respect to the *structure* of the instrument[31]:

1 The *type* of instrument, such as regulation, charges or tradable allowances.
2 The *appropriation* of eventual revenues, such as addition to the national treasury, revenue-neutral recycling or compensation of external-cost bearers.
3 The incentive *basis* or the chargeable unit to which the instrument is.
4 related, such as quantity of emissions, volume of fuel use, numbers of flight movements or seats.

2 In this report, a clear distinction is made between the *structure* of the instruments used to internalise external costs and the *level* of the incentives, such as the precise amount of tradable emission allowances or the charge level. The reason behind this separation of issues is that the government is only at the beginning of the process of internalisation of external costs. Hardly any internalisation instruments are already in use in the aviation sector, largely due to the difficulties of action at individual State level in an international industry. At this stage of the process, it is more important to reach agreement on the structure of the instruments than on the exact levels. After all, incentive levels can be adapted more easily in the future on the basis of new insights than the structure of the instruments.

A.2 The *type* of instrument

3 In Section 2.3, it was recommended that economic efficiency be taken as a starting point for an external cost policy. This recommendation implies a strong preference for economic instruments, such as tradable allowances and charges. Generally, economic instruments offer the best incentives to make parties implement just those measures which are cheaper than the avoided external costs and let measures remain unimplemented which would be more costly than the avoided external costs. In other words: economic instruments offer the best incentives to reduce external effects against lowest costs. Regulation - very effective in terms of reaching environmental targets (in the field of aircraft noise reduction for instance) - is a much less effective incentive to the economic optimisation of implementation. Thus in our view economic instruments are to be preferred, *unless* there are strong reasons to apply other instruments. An example of such a reason is that operational measures to reduce noise emissions, such as changing the approach or departure route, often require airport and/or ATC decisions.

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31 A fourth choice is the 'addressee' of the instrument, such as airports, airlines or passengers. We assume in this report that airlines are the addressee of the internalisation instruments.

Tradable allowances and charges are much more interchangeable than is often thought

4 At first sight, tradable emission allowances and charges may seem quite different instruments with different functioning. The differences are very limited, however. There is no fundamental difference with respect to their efficiency, the financial burden they place on aviation or their capabilities to reach environmental targets:

- tradable emission allowances and charges both put a price on pollution and therefore offer an equal incentive to reduce emissions. In both cases, individuals decide whether it is cheaper to reduce emissions or to pay the price of pollution (buying a tradable emission allowance or paying the charge). The instruments are therefore equally efficient;
- it is often assumed that charges impose a financial burden on the sector, while tradable emission allowances do not. This idea explains the preference of companies for tradable emission allowances. However, if the government auctions tradable emission allowances, the financial burden on the sector is the same as in the case of charges, and in both cases the revenues are added to the national treasury. If the government distributes the tradable emission allowances for free (so-called grandfathering), this is comparable to the situation in which the revenues of charges are recycled to the sector (see also section A.3.2). After all, revenues can be recycled according to exactly the same distributive code, which would be the basis for the free distribution of tradable emission allowances;
- both tradable emission allowances and charges are suitable instruments for reaching environmental targets. In the case of tradable allowances, the emission level targets directly determine the quantification of emission allowances. In the case of charges, the charge level is chosen such that the emissions are reduced to the environmental targets.

5 There are two fundamental differences between charges and a system of tradable allowances, however. The first difference is related to the *predictability* of the instruments. In the case of tradable emission allowances, there is certainty about the environmental impact of the instrument. However, the economic impact is uncertain. It is difficult to predict the future price of the emission allowances, which will depend upon the costs of emission reduction and supply-side responses, and therefore the financial burden for the sector. In the case of charges, the situation is the opposite: there is certainty about the economic impact and the burden for aviation. However, the environmental impact is less certain and will depend on the scale of demand and supply responses.

6 The second difference has to do with transaction costs. The fact that emission permits can be traded leads to transaction costs which can be significant. In a simple parallel, imagine a road fuel charge being replaced by the complexities of a system in which every car owner has to acquire permits in a market to use a certain amount of petrol. Considerations of transaction costs can also stand in the way of emission trading systems.

Economic instruments improve competitiveness compared to regulation

7 It is often assumed that the introduction of economic instruments diminishes the competitiveness of the national aviation sector with respect to other airports, airlines or countries. However, it is important to note that this is only true when economic instruments are introduced in a situation where no environmental policy exists at all. If economic instruments replace regulation as an instrument to reach environmental targets competitiveness *increases*. The higher efficiency of economic instruments with respect to regulation facilitates more air activity with constant environmental effects, and reducing environmental effects against lower costs.

A.3 The *appropriation* of potential revenues

8 Economic instruments may generate revenues. These revenues can be generated by charges or by the auctioning of tradable allowances. Therefore, the second area of freedom of policy choice is the appropriation of eventual revenues, such as:

- addition to the general budget (or a reduction of distorting taxes, the other side of the coin);
- hypothecation to fund environmental improvement, e.g. noise insulation schemes or development of cleaner aircraft), compensation of external cost bearers, or revenue-neutral recycling.

9 The question what to do with the (potential) revenues of economic instruments is often answered on the basis of political considerations, such as social acceptability. However, in the next sections we examine the pros and cons of different options from an economic point of view.

A.3.1 Addition to the general budget

10 Addition to the general budget is potentially the option that leads to highest social welfare. This is because this option leaves open the maximum amount of opportunities to spend the money wisely. A good example is to spend the money for lowering distorting taxes such as taxes on income or labour taxes imposed on employers. Since such taxes distort optimal functioning of the economy, lowering income taxes leads to better economic efficiency than recycling revenues to the aviation sector (see Musgrave and Musgrave, 1984; Pearce, 1991). This is the often-mentioned 'double dividend': less pollution, more employment.

A.3.2 Revenue-neutral recycling to the aviation sector

11 Revenue-neutral recycling may introduce a further inefficiency. Sometimes, cancellation of a marginally profitable flight may be a cheaper and more efficient way of reducing external costs than taking technological measures or introducing new operating techniques. However, if the revenues of external cost internalisation are recycled in relation to the aviation activity, which gave rise to the external costs, no incentive results for such *volume measures*. This may be clarified by an extreme case of one airline making one flight only. When revenues are recycled, no charge will ever move the airline to cancel the flight. The result is that cost-effective volume measures are left unused. The same inefficiency occurs in the case of tradable allowances, if airlines receive free tradable allowances on the basis of past emissions (so-called grandfathering), but receive less if they reduce their aviation activities. Only when the received amount of tradable allowances is independent from their (future) aviation activities does the inefficiency not occur. Then airlines will consider cost-effective volume measures, since they will be able to receive the benefits by either trading their annual free emission allowances or trading the one-off right to receive free tradable allowances in the future (so-called grandfather rights or emission quota).

12 Furthermore, not recycling revenues to aviation pays more justice to the 'polluter pays principle': the idea that, irrespective of considerations of economic efficiency, polluters should pay for the use of the environment.

13 Finally, revenue-neutral recycling of revenues introduces the difficult question of how to recycle. In the case of tradable allowances, this is the well-known problem of finding a grandfather distribution key. How to ensure that companies, which lag behind in environmental policy, are not advantaged with respect to those leading in this field? How to ensure that new or growing companies do not face a competitive disadvantage with respect to the existing companies? How to ensure that recycling of revenues does not give rise to unwanted strategic behaviour[32]?

A.3.3 Compensation of the bearers of external costs

14 While economic theory suggests not recycling revenues to the polluters, neither does it suggest applying the revenues to compensate the 'polluted'. The reason is that not only the causer can reduce external costs, but also the bearer, and compensation takes away the incentive to the bearer. An example: in the course of time less noise-sensitive people - or at least those for whom proximity to the airport for work or travel convenience has a higher value than exposure to noise - come to live closer to the airport while more noise-sensitive people move away, which reduces external costs.
If the bearers of external costs are compensated for their costs, the incentive to avoid the costs is taken away. Therefore, although socially often justifiable, it is economically inefficient to compensate bearers of external costs.

15 However, in the case of *increasing* aviation noise, there may be reason to compensate house and land owners who see their property lose value. They should be compensated *once*, however, to preserve the economic incentive to move if this is economically optimal.

A.3.4 Hypothecation to dedicated funds

16 Hypothecation[33] to dedicated funds may increase the environmental effectiveness of external cost internalisation. In that case, the economic internalisation instrument does not only offer an incentive to reduce external effects, environmental measures financed from the revenues may lead to a further improvement of the environment. However, hypothecation to dedi-

[32] It should be noted that in the case of global instruments to internalise the external costs of global warming *not* recycling revenues also poses difficult questions. In the global case, addition to the general budget of a global institute such as the United Nations is not straightforward and revenues will probably have to be divided over the countries. Which distribution key to apply is controversial, however.

[33] As suggested by many stakeholders, such as Greener by Design, the Airport Operators Association and the British Air Transport Association.

cated funds may not lead to optimal efficiency. We distinguish between two types of dedicated funds. The first type of fund is for financial compensation of external cost bearers or to finance avoidance or adaptation expenditure, such as noise insulation of houses. This option has already been discussed in the previous section. We therefore focus on the second option, a fund to finance environmental measures in the aviation sector.

17 Although a fund to finance measures in the aviation sector may decrease emissions by aviation, it is not an efficient option. Internalisation of external costs should ensure that the most cost-effective measures are implemented, while the more expensive measures are refrained from. Subsidising measures from a dedicated fund distorts the optimal incentive to implement the most cost-effective measures. It tends to lead to measures being applied which are too expensive, and which would not have been implemented without aid from the dedicated fund.

18 Furthermore, the same problem is introduced as in the case of revenue-neutral recycling: who gets what? It is likely that airlines will demand that the dedicated funds should be divided over the sector in direct proportion to their contribution to the fund.

A.4 The incentive ***basis***

19 It has been argued that to obtain economic efficiency external costs should be internalised by instruments that seize upon the source of the external effects as closely as possible. This ensures the strongest incentive is offered to reduce the external costs. Therefore, the question is how close one can get to perfection, while maintaining the practical feasibility of the instrument. For example, if the issue is the internalisation of the external costs due to noise emissions, various incentive bases can be put in order of increasing indirectness or peripherality to the central effect in question: noise emissions differentiated to time and space, type of aircraft, passenger kilometres, aircraft kilometres, and passenger departures and arrivals (tickets).

A.5 The incentive ***level***

20 Since external costs are by definition not incorporated in market relations, neither do market prices arise. The market does not always give unequivocal answers to questions what financial value people attach to peace and quiet, and clean air. Consequently, the value of these public goods has to be estimated.

21 Many (international) studies already exist, however this has not led to a final answer on an exact price or level of external costs for each cost item under consideration. As far as possible, consensus ranges and recommended values are presented in this report.

22 The incentive levels can be expressed in two ways, either as the charge level or as the amount of tradable allowances. The relation between the two is that the charge level should be equal to the price of the tradable allowances if that instrument had been chosen. Conversely, the amount of tradable allowances should be equal to the level of emissions which would have resulted in the case of charges.

Do external costs and external benefits cancel each other out?

23 An often-heard argument against the internalisation of external costs is that they should be balanced against the substantial external *benefits* of aviation[34]. However, it would be unwise to do so. The reason is that the causes of the external costs generally differ from the causes of the external benefits. The need to internalise and reduce external costs remains, while at the same time any benefits can be increased. Cancelling external costs and benefits against each other takes away incentives to improve the situation. This can best be clarified with a simple example. Imagine an airline paints half of its fleet blue and the other half red. Now suppose society really enjoys the colour red (external benefits) and is to the same degree annoyed by the colour blue (external costs). By charging the airline for the colour blue and subsidising it for the colour red the airline will quickly paint all of its aircraft red. Social welfare is increased. However, if the external costs and benefits are cancelled against each other, the airline will have no incentive to change its colour policy and no improvement occurs. The conclusion is that internalising external costs is always efficient, independent of the existence of external benefits.

24 Moreover, it is important to note that it is highly doubtful whether the *external* benefits of aviation, that means benefits to third parties which are not already integrated into the market process, are substantial. Apart from the pleasure of plane spotting, the external benefits of aviation are fairly limited. The international scientific literature does not give evidence for such benefits. It goes without saying that the overall benefits of aviation are enormous, such as enabling export and tourism, job creation and regional cohesion. Such benefits are almost all integrated into the market process and therefore internal, however.

[34] See e.g. Draft Response to CfIT by BAA, 14 February 2003 and Flybe.

B Financial support to, and taxes on, aviation

B.1 Introduction

1 Financial support to economic sectors may increase their economic activities, their competitiveness, their profit and the employment they generate. *However*, there is no such thing as a free lunch. The government finances the support by raising general taxes, such as income tax. Where these taxes are raised, they have the opposite effect: they *decrease* economic activity, competitiveness, welfare and employment.

2 Economic theory suggests that the positive effects for the subsidised sector and the negative effects for those producing the means for the subsidy generally do not balance. Generally, society as a whole loses welfare. The reason is that both subsidies and the taxes necessary to produce the means distort markets. The use of resources becomes inefficient.

3 Economic inefficiency is one reason to rethink financial support. Another reason is fairness. On the one hand, fairness between economic sectors. One sector should not have an advantage over the other because of financial support. On the other hand, fairness to society. Just as the 'polluter pays principle' states that society should not have to bear the environmental costs for which it is not responsible, it could be argued that society should not have to bear the costs of financial support to economic production for which it is not responsible.

B.2 Direct and indirect financial support

4 The government supports the aviation sector financially, if the public expenditure is not fully paid for by the aviation sector. In that case costs exist, which are borne by other parties (the taxpayer) than the aviation sector or the passengers. There are two types of government expenditures to be distinguished[35]: direct and indirect.

B.2.1 Direct financial support

5 Direct financial support is defined as a government expenditure, which is directly paid to the economic subject in question without any market-based return-service of the recipient. It decreases the cost of producing a specific good or service and thus supports the production sale or purchase of a good or service.

[35] To evaluate subsidies given to the aviation sector, a broad definition of general subsidies as well as direct and indirect subsidies is used, which analyses all public interventions aimed at influencing economic structures. This means that all direct and indirect measures related to the public budgets at all political levels, e.g. federal, provincial and municipal level, which lead either to an increase of expenditures or to a decrease of revenues of public budget, are defined as subsidies. This also means that investments for government owned infrastructure are included. Furthermore, non-budget measures such as regulatory interventions should also analysed.

B.2.2 Indirect financial support

Definition

6 Indirect financial support is considered to be all governmental interventions and regulations which favour selected economic agents by reducing their costs or by guaranteeing purchases of their products. For example, these include tax subsidies, price reducing subsidies, purchase subsidies, regulatory subsidies and guarantees.

7 In this report, we focus on two areas, where direct and indirect financial support may exist: airline operation and airports (infrastructure provision).

Criteria for judging fair fiscal treatment

8 In discussions on this topic, there is a lot of confusion about what a 'fair' level of taxation should be and thus to what extent aviation currently receives indirect financial support.

9 The strictest, macro-economic, criterion is that fiscal treatment is fair if similar taxes are levied on similar activities throughout the whole economy. From this perspective, there is no reason to distinguish domestic air transport from international air transport, or to tax air transport differently from road or rail transport.

10 A less strict, sectoral, criterion is that fiscal treatment is fair as long as it does not distort competition in sectors that compete with each other. In concrete terms this would imply that exemptions from VAT etc. would not count as indirect financial support as long as competing modes of transport, such as high-speed rail transport, or long-distance coach transport, or maritime transport in case of freight, face the same exemptions.

11 In this report we will follow the first, macro-economic, criterion. The reason for this is that we take economic efficiency as a starting point. From an economic efficiency point of view, there is no reason, for example, to tax international air transport at a lower rate than domestic air transport.

Financial support to projects outside the air transport sector

12 In many cases governments spend money on projects outside the air transport sector but closely related to it, such as surface transport links from and to the airport. We do not take into account these government expenditures: economic instruments to optimise usage of these investments should ideally apply to the surface transport link, not to aviation (see also Section 3.1).

B.3 Financial support to, and taxation of, airlines

13 Financial support to airlines can be split in the following parts:
- fuel tax exemption;
- VAT exemption on international tickets;
- duty free sales on non-EU flights and on board aircraft (excise duty and VAT).

14 Furthermore, there could be direct state aid to airlines. However, in 1994 the EU developed rules aimed at preventing subsidies to commercial aviation.

15 On the other hand, the government levies the Air Passenger Duty (APD), a tax on passengers on flights departing from U.K. airports, at differential domestic/international rates. We discuss these issues below.

B.3.1 Fuel tax exemption

16 Although other modes of transport have to pay tax on fuel, aviation does not. It is not straightforward, however, to consider the fuel tax exemption as an indirect financial support to airlines. This depends upon the purpose of the existing fuel taxes.

17 If the purpose of the fuel tax is to raise revenues for the Exchequer to contribute to UK public finances, then the fuel tax exemption for aviation should be regarded as indirect financial support. Reasons for removing the tax exemption would then be to ensure a fair fiscal treatment and an economic level playing field between various modes of transportation. In that case, removing the fuel tax exemption would come *on top* of internalising external costs. However, if the government would consider removing the fuel tax exemption for aviation, there would be a case to consider the internalisation of external costs throughout the UK economy instead of singling out aviation.

18 However, if the purpose of the fuel tax is to internalise fuel-related external costs due to transport, then there is only a need to internalise the external costs due to aviation as discussed in the previous chapters. In that case, there is no need to remove the fuel tax exemption *on top* of internalising external costs.

19 In different countries different approaches are followed. As an example, we have calculated the approximate value of fuel tax exemption in the UK if it is assumed that fuel taxation would be regarded as a means to raise revenues for the Exchequer.

20 The amount of fuel tax exemption is the product of the number of litres burnt by an airline and an assumed fuel tax rate per litre. Bunkering of aviation fuel in the UK is in the order of 12 billion litres per year. Currently, the average fuel tax paid by European road transport is about Euro 445 per 1,000 litres[36]. However, as the other competitor of aviation, rail transport, generally pays lower fuel taxes, we choose to work with the current € 245 per 1,000 litres legislative minimum fuel tax rate for road diesel in the EU. On the basis of these figures, the total UK aviation fuel tax exemption is worth of the order of € 3 billion or £ 2 billion per annum.

B.3.2 VAT exemption on international tickets

21 In the United Kingdom, aviation does not have a competitive advantage due to VAT exemption, as both international air travel and international rail, sea and bus transport are exempt from paying VAT (KPMG 1997). From the point of view of fair competition between the various transport modes there is no reason to consider the VAT exemption as an indirect support. However, from the point of view of fair competition between different economic sectors, the VAT exemption should still be considered as an indirect support.

[36] Based on a sales weighted average fuel tax level in January 2001 across the EU, calculated with the database created for the CE study 'Fuel prices and excise duty policies in European road transport 1980-1999 (CE, Delft, 2000).

22 Revenue from tickets for UK airlines originates not only in the UK, but also in all countries from which these airlines fly. This means that not only the UK government supports these airlines but governments of countries from which these airlines fly. Similarly the UK government does not only support UK airlines but all airline companies that depart from British airports.

23 The amount of VAT exemption on international tickets is a product of the revenues from international passenger transport subject to VAT and a certain VAT rate.

24 To estimate the indirect support to British Airways due to VAT exemption, we estimate that approximately one half on turnover from EU international air transport is generated with a competitive advantage due to its VAT exemption. Furthermore, we assume an average 7% VAT rate advantage (CE, 2001). Given the £ 7.1 billion of revenues from passenger transport for BA in 2002 (BA, 2001/2002), we arrive at £ 250 million in indirect support to BA due to VAT exemption.

B.3.3 Duty free sales on board aircraft

25 There is presently insufficient information to assess the financial support to UK airlines implicit in tax-free sales on board aircraft[37].

26 Duty-free sales for flights outside the EU at UK *airports* are treated in Section B.4 because they indirectly support airports rather than airlines.

B.3.4 Air Passenger Duty (APD)

27 In November 1 1994, the Air Passenger Duty (APD) was introduced, a tax on flights departing from the U.K. The duty ranges from £ 5 to £ 40 per passenger. The total annual revenues are in the order of £ 800 million.

Table 5 Air Passenger Duty (April 17 2002)

Type	Destination	Duty
Lowest class	European	£ 5
Standard/Business/First Class	European	£ 10
Lowest class	Other destinations	£ 20
Standard/Business/First Class	Other destinations	£ 40

28 In the past, Treasury Ministers have justified the introduction of APD as compensating for the fact that aviation fuel is not subject to Excise duty and VAT. This is in recognition of the challenges that would be faced in imposing duty on aviation fuel as a result of the exemptions created by the Chicago Convention[38]. For example, Treasury Minister Kenneth Clarke justified the introduction of the APD as follows in his Budget Statement of 1993: "First, air travel is under-taxed compared to other sectors of the economy. It benefits not only from a zero rate of VAT; in addition, the fuel used in international air travel, and nearly all domestic flights, is entirely free of tax. A number of

[37] In the literature, data can be found for KLM in a 2002 study on external costs of aviation (CE 2002a). Tax losses were calculated as some € 64 million, or 1.5% of KLM's passenger transport turnover.

[38] See also Draft Response to CfIT by BAA, 14 February 2003.

countries have already addressed this anomaly. I propose to levy a small duty on all air passengers from United Kingdom airports"[39]. In his Budget Statement of 1996, he made the following remark: "Air travel has also been undertaxed, because it has proved difficult--still proves difficult--to get international agreement to tax its fuel. The rates of air passenger duty are to be increased"[40]. Since the APD in its elaboration seems more related to ticket price than fuel use, APD may primarily be considered a compensation for the VAT exemption.

B.4 Financial support to airports

29 Financial support to airports breaks down into two categories: direct and indirect support to airport infrastructure, and duty-free sales at airports at flights to non-EU destinations. They are treated separately.

B.4.1 Direct and indirect support to airport infrastructure

30 Direct and indirect financial support to airport infrastructure comprises[41]:
- direct financial support, generally for investments in infrastructure;
- indirect support: corporate tax exemptions;
- indirect support: real estate tax exemptions;
- indirect support: ground costs exemptions.

31 The CE Delft study (CE 2002a) furthermore suggests on the basis of Dutch and German case studies that direct financial support to finance airport infrastructure is rather limited, certainly compared with the various forms of indirect financial support dealt with in the rest of this chapter. There is no evidence, and we currently have therefore no reason to assume, that this situation is very different in the UK. As to indirect support, it may be noted that Schiphol Airport was until recently exempted from corporate taxation as a provider of public infrastructure. Following investigation by the European Commission, the Dutch Government was obliged to tax Schiphol's profits.

32 There is insufficient specific information available to make further precise judgements about the relevance of these kinds of support.

B.4.2 Duty free sales at airports for non-EU flights

33 Duty free sales at airports (excise duty and VAT) still exist for flights with destinations outside the EU. IPPR (2003) estimates that duty-free sales amount to an average of some £ 15 per passenger or £ 400 million annually.

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[39] Rt Hon Kenneth Clarke, Budget Statement, 30 November 1993, col 934. http://www.parliament.the-stationery-office.co.uk/pa/cm199394/cmhansrd/1993-11-30/Debate-2.html.

[40] Rt Hon Kenneth Clarke, Budget Statement, 26 November 1996, col 166. http://www.parliament.the-stationery-office.co.uk/pa/cm199697/cmhansrd/vo961126/debtext/61126-09.htm.

[41] CE (2002).

B.5 Conclusion and recommendation

34 The issue of taxation and financial support to aviation is strongly linked to the issue of external costs, in particular in the case of the fuel tax exemption and the Air Passenger Duty. Just as in the case of external costs, financial support to aviation also may imply costs borne by other parties (the taxpayer) than the aviation sector or airline passengers.

35 In the context of this study, it was not possible to investigate the issue of financial support in sufficient detail to arrive at specific recommendations with respect to the various types of subsidies. Therefore, further investigations on these issues are recommended.